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CHALLENGES IN THE MILK MARKET (INVESTMENTS, DISRUPTIONS, LOGISTICS, COMPETITIVENESS, PRICES, AND POLICY)

Collective work, edited by  
Piotr Bórawski  
Andrzej Parzonko  
Ireneusz Żuchowski

## CHALLENGES IN THE MILK MARKET (INVESTMENTS, DISRUPTIONS, LOGISTICS, COMPETITIVENESS, PRICES, AND POLICY)

Wydawnictwo Ostrołęckiego  
Towarzystwa Naukowego  
im. Adama Chętnika  
w Ostrołęce 2021

ISBN 978-83-62775-45-3



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Scientific editors:

Piotr Bórawski, Andrzej Parzonko, Ireneusz Żuchowski

Wydawnictwo Ostrołęckiego Towarzystwa Naukowego im. Adama Chętnika  
Ostrołęka 2021

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ISBN 978-83-62775-45-3

The monograph was written by the project funded by the National Science Centre in Poland allocated on the project OPUS 15, number of the project: 2018/29/B/HS4/00392.

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im. Adama Chętnika  
Ostrołęka 2021

180 publikacja Ostrołęckiego Towarzystwa Naukowego im. Adama Chętnika

Wydawnictwo Ostrołęckiego Towarzystwa Naukowego im. Adama Chętnika  
07-410 Ostrołęka, ul. Traugutta 9A  
tel. 29 764-59-80  
[www.otn.ostroleka.pl/ct-menu-item-15](http://www.otn.ostroleka.pl/ct-menu-item-15)  
e-mail: [otn.ostroleka@o2.pl](mailto:otn.ostroleka@o2.pl)

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Skład: Ewa K. Czetwertyńska  
Druk: Drukarnia Kamil Borkowski, Łomża

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## FACTORS SHAPING PRICES OF DRINKING MILK AND DAIRY PRODUCTS IN POLAND AFTER ACCESSION TO THE EU<sup>2</sup>

*Piotr Bórawski*

University of Warmia and Mazury in Olsztyn, Poland

*Andrzej Parzonko*

Warsaw University of Life Science-SGGW, Poland

### 3.1. Introduction

Farmers do not have direct impact on dairy products prices. Location, production and the pace of development of dairy farms, which are responsible for the support of raw milk, have impacts on milk processors decisions and production scale (Parzonko 2013). Jarzębowski and Klepcki (2013) claim that the biggest impact on dairy products come from wholesalers and retailers, which are closest to the final consumers.

The price changes of milk and dairy products is the effect of increasing demand for milk in China and other countries of Asia and Africa. However, the level of milk consumption can be the result not only of price changes but also market conditions and consumer preferences (Seremak-Bulge and Bodył 2013).

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<sup>2</sup> This paper was funded by the project financed by the National Science Center (NCN) in Poland, Project OPUS 15, Project No.:2018/29/B/HS4/00392.

Dairy farmers are at the beginning of the dairy distribution chain. They are involved in the rearing of dairy cows and the production of milk, which is the raw material for the production of finished dairy products (Jarzębowski and Klepacki 2013).

The biggest milk and dairy products consumption countries are in the EU, USA, and they are almost three times the world average level. The consumption in China is increasing (Bórawski and Kowalska 2017). The milk consumption is varies widely in the world (Bórawski et al. 2020). The shortage of milk and dairy products in Asia is still high whereas the shortage of dairy products in Africa has not changed (Sere-mak-Bulge 2016).

The EU and U.S. are the main producers of milk and dairy products. However the conditions for the market differ. The average EU dairy herd is about 22 whereas in the U.S. it is 122. The U.S. is a leader in milk yield and low production costs, but some countries from the EU export milk to the U.S. These are the two largest milk producers and consumers play a key role in the world and have strong position in the World Trade Organization (WTO) negotiations creating the conditions for agriculture in the future (Bórawski et al. 2016).

The main aim of the research was to recognize factors shaping the prices of drinking milk and dairy products in Poland. To achieve this goal, we wanted to answer following questions:

- What is the price volatility of milk and dairy products in Poland?
- Which factors determine the prices of milk and dairy products?

### **3.2. Methods**

The factors having an impact on milk and dairy products after accession to the EU were recognized. After accession to the EU, Poland gained access to the common market characterized by a broader customer base.

Descriptive statistics were used to analyze the changes in factors shaping the prices of milk and dairy products. The analysis included: the average, median, minimum, maximum, standard deviation, coefficient of variation, skewedness, and kurtosis.

Then the regression analysis was used. This method helps to discover relations between different factors and to realize the aim of the research (Wysokiński et al. 2016). It included dependent (Y) and independent (X) variables.

In this stage, historical data was used to estimate the development trend by the linear regression method of the dependent variable  $y$  based on the values of the independent variables  $x$  (forecast of the dependent variable based on the independent variable, e.g., year). The development trend was determined using a mathematical function:

$$y = \beta_0 + \beta_1 x + \xi, \quad (1)$$

where:  $\beta_0$  and  $\beta_1$  are structural parameters of the regression function, and  $\xi$  is a random component. The  $\beta_0$  parameter in the linear regression equation means the intercept, and the parameter  $\beta_1$  is the regression coefficient of the  $y$  variable relative to the  $x$  variable. Then we have analysed the impact of chosen independent variables (X) on dependent variables (Y).

The dependent variables were:

$Y_1$  – Retail prices of drinking milk 3-3.5% [PLN/1 liter],

$Y_2$  – Butter prices [PLN/ 200 g],

$Y_3$  – Prices of cream 30% fat [PLN/0.5 l],

$Y_4$  – Natural yogurt prices [PLN/150 g],

$Y_5$  – Prices of ripening cheese, Gouda [PLN/ kg],

$Y_6$  – Prices of processed cheese [PLN/100 g],

$Y_7$  – Prices for cottage cheese [PLN/1 kg].

The independent variables were:

$X_1$  – Milk yield [thousand liters],

$X_2$  – Cow numbers [thousand],

$X_3$  – Milk production [thousand tons],

$X_4$  – Purchase prices of milk [PLN/ 100 liters],

$X_5$  – Average prices paid to farmers for milk [EUR/100 kg],

$X_6$  – FAO global milk price index,

$X_7$  – Milk consumption [liters/person],

$X_8$  – Disposable income [PLN],

$X_9$  – Average monthly expenses on food per 1 person [PLN],

$X_{10}$  – The share of expenses on food (%),

$X_{11}$  – Exchange rate euro-PLN,

$X_{12}$  – Balance of foreign trade in dairy products [mln Eur],

$X_{13}$  – Exports of milk and dairy products [Mln Eur],

$X_{14}$  – Imports of milk and dairy products [Mln Eur].

The classical method of least squares was used to estimate the models. The  $R^2$  coefficient of determination was used to select the models.

### **3.3. Independent variables shaping milk and dairy products prices**

First, the descriptive statistics of factors shaping prices of dairy products in Poland were evaluated. The factors shaping milk and dairy products were chosen based on the available literature. Szajner (2017) analyzed the transmission of prices in milk market. The very important sources of information for the analysis were: production, processing, international trade, consumption, and self-sufficiency of milk. The factors were divided into four groups (table 1). The first group was the production stage. It was represented by milk yield, cow numbers and milk production

The coefficient of variation describes the dispersion of the analyzed variables. The dispersion creates greater uncertainty. The highest coefficient of variation was found in milk yield (15,87%) and cow numbers (10,07%). The increase in the milk yield of cows results mainly from genetic progress. Basic herds are genetically improved by artificial insemination with high quality semen and the purchase of better animals (Bórawski et al. 2020b).

The second group which was analyzed was prices. These included average purchase prices, average prices paid to farmers and the FAO global milk price index. The highest coefficient of variation was found in the FAO global milk price index (109%). However, the purchase prices had also a high coefficient of variation (16). The research conducted by Roman (2020) confirmed high differences of milk purchase prices in the voivodeships in Poland. The highest level of purchase prices of milk in the years 2009-2018 was observed in the western and northern-eastern voivodeships in Poland (Lubuskie, Zachodniopomirskie,



Warmińsko-Mazurskie and Podlaskie). The lowest purchase prices of milk occurred in Podkarpackie, Małopolskie, Świętokrzyskie and Łódzkie voivodeships. The reason for such differentiation is the highest milk production in the northern-eastern and western parts of Poland. These are the highest production regions where the farmers received lower purchase prices

The third group of independent variables concerned consumption. It is shown in the literature that domestic consumption generates the demand for milk and dairy products. According to Bouamra-Mechemach et al. (2008), demand is the main factor that drives dairy product market prices. The consumption of milk is slowly increasing in the EU (Popovics 2008). This is caused by four factors: milk consumption, disposable income, average monthly expenses of food per 1 person, and the share of expenses on food. As we can see the highest coefficients of variation were found in disposable income (117,04%) and average monthly expenses on food per 1 person (16,06%). The consumption of dairy products is the result of numerous factors including economic growth, demographic changes and increasing purchasing power of consumers.

Table 1. Descriptive statistics of independent variables in Poland in the years 2004-2019

Variable	Average	Median	Minimal	Maximal	Standard deviation	Coefficient of variation	Skewedness	Kurtosis
Production								
X <sub>1</sub> – Milk yield [liters per cow]	5147,6	4978,0	4140,0	6450,0	817,09	0,15873	0,33756	-1,3600
X <sub>2</sub> – Cow's number [thousand]	2432,6	2396,0	2130,0	2801,0	244,98	0,10071	0,16958	-1,5224
X <sub>3</sub> – Milk production [thousand tons]	12785,	12553,	11861,0	14400,	789,42	0,061745	0,76690	-0,48587
Prices								
X <sub>4</sub> – Purchase prices [PLN/100 liters]	113,98	112,09	87,360	139,05	18,192	0,15961	0,0073507	-1,3736
X <sub>5</sub> – Average prices paid to farmers for milk [EUR/100 kg]	27,897	29,130	19,250	32,340	3,5866	0,12856	-0,99069	0,25639
X <sub>6</sub> – FAO global milk price index	257,21	202,20	123,50	1297,0	279,74	1,0876	3,5059	10,585
Consumption								
X <sub>7</sub> – Milk consumption [liters/person]	197,44	193,50	173,00	225,00	18,633	0,094375	0,17936	-1,4228
X <sub>8</sub> – Disposable income [PLN]	1725,3	288,5	735,00	9229,0	2019,3	1,1704	3,5024	10,573
X <sub>9</sub> – Average monthly expenses per 1 person [PLN]	986,31	1043,5	697,00	1176,0	163,74	0,16601	-0,67338	-0,89979
X <sub>10</sub> – The share of expenses	83,131	83,000	73,600	95,400	6,4195	0,077222	0,17448	-0,83231
Exports, imports and balance								
X <sub>11</sub> - Exchange rate euro-PLN	4,1382	4,1909	3,5166	4,5640	0,25303	0,061146	-0,81009	0,64210
X <sub>12</sub> - Balance of foreign trade in dairy products [mln Eur]	883,01	870,40	505,00	1210,0	200,26	0,22680	0,015245	-0,78852
X <sub>13</sub> - Exports of milk and dairy products [Mln Eur]	1448,1	1422,2	617,9	2230,0	488,23	0,33716	0,093821	-1,0533
X <sub>14</sub> - Imports of milk and dairy products [Mln Eur]	565,01	529,15	111,90	1020,0	319,16	0,56487	0,051587	-1,4408

Source: Own elaboration on the basis of milk market (Milk Market 2019)

An important factor explaining the consumption of milk and dairy products is the purchasing power of households. The level of income which provides the average expenses on food is essential to meet demand for food (Kibicová et al. 2014). Another group of factors increasing consumption include facilitation of transfer of technology, which causes bigger and cheaper production and liberalization of capital flow (Pawlak 2014).

The fourth group included exchange rates, balance of foreign trade of dairy products, exports, and imports (Table 1). The elimination of the trade barriers made it possible for new member states to access the

Common Market. This helped the processing enterprises and agricultural producers to develop opportunities to sell overproduction. Poland achieved in 2017 the highest positive trade balance in intra-EU milk and dairy products (765,596 thousand tons). Other countries with the high positive balance of dairy trade in intra-EU were: the Czech Republic (732.9 thousand tons), France (647.3 thousand tons) and Austria (603.6 thousand tons). In turn, the largest deficits in trade balance on milk and dairy products in 2017 were achieved by: Italy (-1.649.9 thousand tons), Belgium (-779.38 thousand tons) and Ireland (-489.08 thousand tons). This data shows the importance of the dairy sector in the EU market to meet consumer demand (Bórawski et al. 2020a).

The highest coefficient of variation was in imports of milk and dairy products (56,49%) and exports (33,72%). The kurtosis has reached the negative values indicating that they were different in relations to the mean. The positive skewedness showed that the tail of variables is on the right side of the distribution and is longer and flatter in comparison to the left side.

As we can see from table 2, the highest coefficient of variation was found in the prices of natural yogurt (45,16%) and butter prices (24,14%). The kurtosis has reached the negative values, which shows that they were different in relation to the mean. The negative skewedness showed that the tail of variables is on the left side of the distribution and is longer and flatter in comparison to the right side.

The results demonstrate the existence of single common trend. This trend was observed in other EU countries. The degree of market integration is almost perfect. It was the effect of the CAP which resulted in similar prices in the EU area. Dairy farmers who stay in the market have to cooperate with other dairy producers in the EU. The same situation is observed in the USA where farmers cooperate with market players. It does not lead to price increases but help to compete and not to lose market share (Novakovic and Walf 2016).

Table 2. Descriptive statistics of prices of dairy products in Poland in the years 2004-2019

Variable	Average	Median	Minimal	Maximal	Standard deviation	Coefficient of variation	Skewedness	Kurtosis
Y <sub>1</sub> – Retail prices of drinking milk 3-3.5% [PLN/1 liter]	2,7006	2,7500	2,3800	2,9900	0,16711	0,061879	-0,59910	-0,36164
Y <sub>2</sub> – Butter prices [PLN/ 200 g]	4,2687	4,1300	3,0300	6,1900	1,0304	0,24138	0,71810	-0,48654
Y <sub>3</sub> – Prices of cream 30% fat [PLN/0,5 l]	5,5675	5,7450	4,1200	6,9500	0,85947	0,15437	-0,24738	-0,83360
Y <sub>4</sub> – Natural yogurt prices [PLN/150 g]	1,2069	1,0150	0,96000	2,6100	0,54499	0,45157	2,2490	3,0958
Y <sub>5</sub> – Prices of ripening cheese, Gouda [PLN/ kg]	18,711	18,770	15,830	21,990	2,0280	0,10838	0,020868	-1,2636
Y <sub>6</sub> – Prices of processed cheese [PLN/100 g]	1,9456	2,0350	1,6000	2,1400	0,18290	0,094006	-0,89640	-0,78053
Y <sub>7</sub> – Prices for cottage cheese [PLN/1 kg]	12,799	13,520	9,7600	14,340	1,6090	0,12571	-0,92592	-0,72823

Source: own elaboration on the basis of milk market (Milk Market 2019)

### 3.4. Factors shaping prices of milk and dairy products

The changes in milk and dairy products depends on crop production. In many countries of the EU crop production dispersion is observed. Moreover, price volatility is an important problem not only for farmers, but also for consumers and processors. Stable prices are needed because they provide increased planning security (Buleca et al. 2018).

The correlation analysis is a useful tool to measure the reaction between variables. As we can see from table 3, four variables were negatively correlated with the prices of analyzed dairy products. The following variables were eliminated from the analysis: X<sub>2</sub> – Cow numbers, X<sub>6</sub> – the FAO global milk price index, X<sub>8</sub> – Disposable income, and X<sub>10</sub> – The share of expenses on food. After elimination of negatively correlated variables, the analysis included ten variables positively correlated with prices of dairy products. The rest of the independent variables have a positive impact on the prices of dairy products. It allows us to conclude that the variables were properly chosen. The high coefficients of correlation allow the inclusion of the independent variable in the model.

During the analysis it was found that the prices of dairy products were positively correlated between one another. Therefore, the impacts of the independent variables were analyzed individually.

Table 3. Correlation between independent variables and dairy products prices in Poland in the years 2004-2019

Independent variables	Y <sub>1</sub>	Y <sub>2</sub>	Y <sub>3</sub>	Y <sub>4</sub>	Y <sub>5</sub>	Y <sub>6</sub>	Y <sub>7</sub>
X <sub>1</sub>	0,6318	0,8920	0,9030	0,6370	0,7786	0,7987	0,8175
X <sub>2</sub>	-0,7453	-0,7774	-0,8776	-0,3977	-0,7759	-0,8659	-0,8959
X <sub>3</sub>	0,5798	0,9288	0,9055	0,7825	0,7559	0,7582	0,7605
X <sub>4</sub>	0,7157	0,8672	0,8684	0,4598	0,9632	0,7815	0,8046
X <sub>5</sub>	0,5392	0,5905	0,6316	0,2816	0,6776	0,6184	0,6278
X <sub>6</sub>	-0,3814	-0,2851	-0,3284	-0,1286	-0,3054	-0,3473	-0,3761
X <sub>7</sub>	0,6645	0,8614	0,9074	0,5933	0,7625	0,8331	0,8488
X <sub>8</sub>	-0,1556	-0,1137	-0,1661	-0,0504	-0,0341	-0,2401	-0,1775
X <sub>9</sub>	0,8319	0,8433	0,9565	0,4322	0,8003	0,9574	0,9734
X <sub>10</sub>	-0,7282	-0,8834	-0,9319	-0,5201	-0,7949	-0,8738	-0,8962
X <sub>11</sub>	0,0310	0,3064	0,2842	0,2668	0,1160	0,2111	0,2247
X <sub>12</sub>	0,6189	0,8552	0,8066	0,6064	0,9096	0,6627	0,6674
X <sub>13</sub>	0,7242	0,9332	0,9393	0,6233	0,9244	0,8307	0,8464
X <sub>14</sub>	0,7197	0,8913	0,9311	0,5733	0,8437	0,8552	0,8762

Source: own elaboration on the basis of the milk market (Milk Market 2019)

The regression analysis shows the impact of independent variables on prices of dairy products. The variable X<sub>5</sub> – Average prices paid to farmers for milk have the impact on Y<sub>1</sub> – Retail prices of drinking milk 3-3.5%, Y<sub>4</sub> – Natural yogurt prices and Y<sub>7</sub> – Prices for cottage cheese. The findings confirm the transmission of prices in milk market. Average prices paid for milk for farmers have an impact on prices of dairy products.

The next variable X<sub>9</sub> – Average monthly expenses on food per 1 person also has an impact on dairy product prices. It shows that consumer spending determines the prices of dairy products. Consumer spending is the effect of achieved income. Although the milk and dairy products are basic products, the increase of their prices will not change the demand dramatically. People need milk to meet their nutritional

needs and the increase of their income increases prices even though the quantity demanded may not change.

The variable  $X_{11}$ - Exchange rate euro-PLN has an impact on dairy products such as  $Y_1$  – Retail prices of drinking milk 3-3.5%,  $Y_2$  – Butter prices,  $Y_3$  – Prices of cream 30% fat,  $Y_4$  – Natural yogurt prices,  $Y_6$  – Prices of processed cheese. The analysis confirms that the prices of dairy products depend on exchange rates. Poland has not adopted the Euro yet. That is why the increase of exchange rate of Euro-PLN can have positive impact on exports and encourage exporters to sell the dairy goods in the intra-EU market.

Each analyzed regression model has a high coefficient of determination  $R^2$ , which indicates a high level of fit of the models (Borawski et al. 2020b). Moreover, the price analysis helped to investigate the integration of the milk market. The level of price relations help to evaluate that the market is globalized and organized (Romam and Roman 2020).

Table 4. Regression analysis of independent variables and dairy products prices in Poland in the years 2004-2019

Independent variables	$Y_1$	$Y_2$	$Y_3$	$Y_4$	$Y_5$	$Y_6$	$Y_7$
$X_3$				0,308			
$X_4$					0,074		
$X_5$	0,041			0,055		0,044	
$X_9$		0,028	0,04				0,186
$X_{11}$	0,542	1,17	0,186	1,08		0,640	
$X_{13}$		0,053	0,024				
F	77968,78	38132,31	51063,41	27287,15	4018,05	97848,23	19132,42
$R^2$	0,999	0,999	0,999	0,999	0,999	0,999	0,999
p	0,000	0,000	0,000	0,000	0,000	0,000	0,000

Source: own elaboration on the basis of milk market (Milk Market 2019)

### 3.5. Summary and conclusion

The production stage in Poland and the EU was regulated by the milk quota system. The system helped to maintain the production at a stable level. However, it was difficult for the members of the market to adjust to a changeable situation. The overproduction resulted in fines that were paid by milk producers. Even such obstacles as self-sufficiency in Poland increased to 123% in 2017 (Zuba-Ciszewska 2019).

The number of cows decreased in the analyzed period. The number of cows decreased from 2778 thousand in 2004 to 2167 thousand heads in 2019 (a 22% decrease). The number of dairy cows was larger in 2019 only in Germany (4012 thousand head) and France (3486 thousand head).

The average milk yield of dairy cows in 2019 was (5399 kg/head). However, the biggest yield for dairy cows was found in 2019 in Denmark (9851 kg/head) and Netherlands (9079 kg/head) (Milk Market 2019).

The authors of the paper analyzed the changes in milk and dairy products in Poland in the years 2004-19. It is a very important and difficult issue because it requires knowledge of modern approaches of statistical analysis. The problem of creating price forecast became very difficult because it requires the assessment of seasonal price fluctuations (Kussaiynov and Zhakupova 2019).

The prices of milk and dairy products are determined by consumption. The consumption of milk and dairy products in the EU Member States from 2000 to 2016 increased annually by about 406 thousand tons, or 0.28%, which means that it is lower than the growth rate of milk production by 363 thousand tons. The result of such milk overproduction is the need to export milk to third country markets (Stańko and Mikuła 2018). The demand for milk and dairy products is balanced in Common Market of the EU, although saturated in many Member States (Chatellier 2017).

The market system efficiently transmits the price signals. Moreover, the values in prices paid to farmers equals the value to the dairy processors (Gillmeister et al. 1996).

The analysis indicates that four independent variables were negatively correlated with the prices of dairy products, in particular:  $X_2$  –

Cow numbers,  $X_6$  – the FAO global milk price index,  $X_8$  – Disposable income, and  $X_{10}$  – The share of expenses. The analysis confirmed the impacts of the following variables on dairy product prices:  $X_5$  – Average prices paid to farmers for milk,  $X_{11}$  – the Exchange rate between the euro and PLN and  $X_{13}$  – Exports of milk and dairy products. The results confirm existing transmission of prices in milk market in Poland.

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