Abstract. The aim of the paper was to recognise price efficiency of milk and its products in Poland. The authors used data from the Main Statistical Office in Poland and the USDA data. The authors used statistical methods to measure the changes of prices. The authors presented a spatial differentiation of milk production in Poland. The highest production was observed in Mazowieckie province (543.42 thousand cows) in 2010 and Podlaskie province (457.68 thousand cows in 2010). The authors found the decrease in the number of cows and total milk production in Poland and the increase of milk yield per unit. The price of milk and milk products changed in the years 2003-2013. The prices of milk products were more volatile than the farm milk price. Therefore, the authors can conclude that milk products’ volatility depends on the market conditions, whereas, system intervention and milk quotas reduce the volatility of the farm milk prices. The price of milk depended on the price of milk products.

Key words: milk market, price volatility, milk, efficiency.

JEL code: Q11, Q14

Introduction

Dairy cattle provide a variety of valuable food products. Milk and dairy products can provide essential nutrients needed for proper development. One of these components is a protein called casein, a basic building block that is indispensable in the diet of each individual. Raising cattle for milk production is an important part of the agricultural economy of numerous countries. Raw milk is a valuable raw material in the manufacturing of various dairy products, creating food-processing employment, often in rural areas.

According to Majewski E. et al. (2007), Polish farms specialising in milk production had a slightly lower income than households with different specialties did. Nevertheless, dairy farms had less risk of loss. The reason for this stability was that the farm milk price was very stable. However, it changed in 2007.

According to Koloszycz E. (2012), one problem affecting milk producers is the continuing price volatility. It is essential for dairy farms to have a financial stability, because milk production is continuous, milk must be marketed immediately, and farms cannot change production levels easily or quickly.

The ratio of agricultural output prices to costs incurred for production determines the degree of profitability of production in agriculture and farm income. Often farmers respond to reduced income by increasing production. When a reduction in demand for agricultural products lowers prices, farmers may increase production, which is defined as an “anti-conjunctural reaction of farms” (Juchniewicz M., 2002).
Many changes in Polish dairy production can be observed, for example, the quality of milk has improved, farmers have adjusted farms and buildings equipment to the EU standards, and the number of farms with the fewest number of cows has decreased (Borawski P., 2006).

The aim of this paper is to present a differentiation of milk price and its products in Poland after integration into the European Union. The authors used statistical methods to present the changes of milk prices and dairy product prices. The results were presented in tables and figures. The authors wanted to answer the following questions to develop the problem of milk price volatility.

1. How did the price of milk change in Poland after integration with the European Union?
2. How is the production of milk diversified regionally?
3. How does the price of milk change during the year?
4. Are there any linkages between milk and dairy products’ prices?

The authors have used regression analysis to measure the impact of human capital on farms’ economic results according to the equation (Sobczyk M., 2005):

\[ \hat{Y} = F(X) = \beta_0 + \beta_1 X + \varepsilon \]  

where:
- \( \hat{Y} \) – theoretical value of regression function \( F(X) \) responsible for level of \( x \) variable;
- \( \beta_0, \beta_1 \) – parameters of the structural function of the regression on \( Y \) according to \( X \);
- \( X \) – matrix of explanatory variables;
- \( \varepsilon \) – residual or error term.

The authors measured the impact of prices of extra butter fabricated, Edam ripened cheese and whole milk powder on retail milk prices. The authors have put in the table the evaluation of regression, standard terror, \( t \) test to evaluate the regression equation and the level of importance (\( p=0.05 \) most important).

**Research results and discussion**

Since 2007, milk prices have shown wide fluctuations in Poland and on the world markets. Figure 1 reveals an example with the price of butter. Other dairy products and farm milk prices have shown a similar volatility.

The market economy has caused changes in the level and structure of livestock production. There has been a decline in population of dairy cows while increasing milk yield per unit (Figure 2). This trend is typical of changes in dairy production in many countries – more milk from fewer cows.

In 2011, Poland produced about 4 100 million litres of milk. Average annual milk yield in 1990 was 3.1 thousand litres per cow, growing to 4.6 thousand litres by 2007; an increase in productivity was of almost 50% (Zietara W., 2009). The number of cows in 2010 was 2 657.39 thousand head. The analysis presented in Figure 3 shows the number of cows in thousands of animals in 2010, it can be seen that the largest number was in the Mazowieckie (543.42 thousand cows in 2010) and Podlaskie (457.68 thousand cows in 2010), while the region of Lubusz (28.28 thousand heads in 2010) had the fewest number of cows in Poland.
The Western provinces, for example, Lubusz (1.2%), Lower Silesia (1.8%), Opole (1.8%) and Silesia (2.0%), had very few dairy cows. The provinces of Mazowieckie and Podlaskie had almost 38% of the Polish population of cows in 2010. The size of the Polish dairy herd decreased and the number of milk producers also decreased. The number of farms with fewer than nine cows decreased sharply, reflecting the progressive process of concentration and intensification of milk production.

Source: Main Statistical Office data (MSO 2003-2012)

Fig. 2. \textbf{Index of the number of cows, milk production and milk yield in Poland for 2005-2011 (2005=1)}
After the Polish accession to the European Union, drinking milk quality regulations became much more stringent. Many owners of small farms were unable to meet the minimum standard of quality and this has led to their elimination from the market (Zietara W., 2012). The number of small producers fell by about one third, while holdings from 100-199 cows increased by more than 50%. Farms with more than 200 dairy cattle have increased their production (Milk Market, 2012). These changes were an expected result of joining the European Union (Dunn J. W, 2005, Pawlewicz, A., 2011). The stabilisation of the milk market took place in 2010. Since then, milk prices have improved steadily. From 2008 to 2012, the consumption of milk on farms decreased from 2.110 to 1.853 thousand tonnes.

The analysis of the imports and exports of cow’s milk indicates net exports. However, the trade balance in dairy products is deteriorating. The value of imports is steadily increasing, as opposed to exports. In 2008, the value of imports amounted to 585 thousand tonnes, while in 2012, it reached 1.050 thousand tonnes (Central Statistical Office, 2012).

Figure 4 shows the average monthly price of milk in 2012, and the price movement during the year. Beginning with February, prices gradually declined until July when prices climbed once again. The average price paid for milk in February of PLN 175.2 per 100 kg was 1.6% greater than the average price of milk recorded in July. After July, the average price of milk began climbing steadily, peaking in December with the highest price – PLN 175.6 per 100 kg. The reason for the highest milk prices in December reflects a lower milk supply and increased demand for dairy products for the holidays (Matysik-Pejas R., 2007). This pattern is typical for a dairy because milk production is highest in spring and then declines as the year progresses. When children go back to school, the demand increases, and after mid-summer factories build inventories of storable products, which are used around Christmas and
until production increases again in spring. These price differences are not large but are a typical seasonal pattern. The year-to-year changes are the important ones.

Source: authors’ construction based on the data from the Statistical Yearbook of Agriculture and Rural Areas, MSO, Warsaw

Fig. 4. Average monthly price of retail milk in 2012 in Poland (PLN/100kg)

The price indices in Figure 5 show that the price of milk in Poland is the least variable and the most stable of the agricultural products illustrated for the period of 2003-2013.

Source: authors’ construction based on the data from the Statistical Yearbook of Agriculture and Rural Areas, MSO, Warsaw

Fig. 5. Price indices of agricultural products in Poland in the years 2003-2013 (2003=1)
The stability of milk price is the result of the milk quota system which does not allow manufacturers to produce too much milk. The situation may change with the abolition of production quotas. Price volatility will likely be larger, as farmers are able to produce more, which will lower the price of milk. However, if the price of milk falls, farmers can reduce or completely abandon the breeding of dairy cows, which will induce a deficit of milk on the market, followed by an increase in its price. Since drinking milk has a very inelastic own-price elasticity of demand, and other dairy products have inelastic demand as well, relatively small changes in production can lead to wide swings in milk prices. Certainly, that is the experience in the world markets (Figure 1).

Table 1 lists the prices of the main dairy products produced in Poland. After analysing the average annual price of butter extra fabricated, it can be seen that the butter price was unstable and fluctuated in 2004-2013. In 2011, the price of butter reached its highest level in the period and averaged PLN 15.7 per kilogram. In 2012, the butter price fell by 10.6%. The lowest average price of extra butter was recorded in 2006 at PLN 9.9 per kilogram.

Table 1

<table>
<thead>
<tr>
<th>Years</th>
<th>Extra Butter (PLN/kg)</th>
<th>Edam ripened cheese (PLN/kg)</th>
<th>Whole milk powder (PLN/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>10.4</td>
<td>11.5</td>
<td>10.2</td>
</tr>
<tr>
<td>2005</td>
<td>10.5</td>
<td>11.0</td>
<td>9.2</td>
</tr>
<tr>
<td>2006</td>
<td>9.9</td>
<td>10.9</td>
<td>8.9</td>
</tr>
<tr>
<td>2007</td>
<td>11.2</td>
<td>12.8</td>
<td>11.8</td>
</tr>
<tr>
<td>2008</td>
<td>10.5</td>
<td>11.4</td>
<td>9.2</td>
</tr>
<tr>
<td>2009</td>
<td>11.5</td>
<td>11.0</td>
<td>8.2</td>
</tr>
<tr>
<td>2010</td>
<td>13.8</td>
<td>12.0</td>
<td>10.6</td>
</tr>
<tr>
<td>2011</td>
<td>15.7</td>
<td>13.5</td>
<td>12.1</td>
</tr>
<tr>
<td>2012</td>
<td>14.2</td>
<td>13.4</td>
<td>11.4</td>
</tr>
<tr>
<td>2013</td>
<td>14.7</td>
<td>14.1</td>
<td>12.3</td>
</tr>
</tbody>
</table>

Source: authors’ construction based on the data from the Ministry of Agriculture and Rural Development

The greatest annual increase in the butter price occurred in 2010, when it increased by PLN 2.30 (20%). The overall increase in butter prices over the period shown was 41.3%.

After the Polish accession to the European Union, average annual prices of Edam ripened cheese initially fell. This situation continued until the year 2007, when the price of cheese rose to 12.8 PLN/kg (17.4%) over the 2006 value. The price of cheese decreased in 2008 once again (by 12.3%). The
average annual price of cheese has risen since 2009. The highest average annual price of Edam ripened cheese was 14.1 PLN/kg in 2013, and the lowest was in 2006 (10.9 PLN/kg). The largest increase in cheese prices occurred in 2007 compared with 2006. Average annual price of Edam cheese over the period 2004-2013 increased by 17.4%. The average annual price of whole milk powder was the most variable of these dairy products. Like the average annual price of cheese, after the accession to the European Union the whole milk powder price fell. In 2007, the price of milk powder increased sharply to PLN 11.8 per kilogram, or up to 32.6% from 2006. In 2008, powder prices fell once again, by 28.3%. The lowest average annual price of whole milk powder was in 2009 (PLN 8.2 per kilogram). The highest milk powder price was in 2013, when it reached PLN 12.3 per kilogram, about 50% higher than the lowest price in the period. The increase in the whole milk powder price over the period of 2004-2013 was PLN 2.1 per kilogram, which is 20.6%. These dairy product prices were highly volatile. Compared with the prices of farm milk, the dairy product price fluctuations during the period of 2004-2013 were greater. Over this period, the prices of all the analysed dairy products increased.

### Table 2

**Descriptive statistics of average prices of selected dairy products in Poland in 2004-2013**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Retail milk (PLN/100kg)</th>
<th>Extra Butter (PLN/kg)</th>
<th>Edam ripened cheese (PLN/kg)</th>
<th>Whole milk powder (PLN/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>153.68</td>
<td>12.24</td>
<td>12.16</td>
<td>10.39</td>
</tr>
<tr>
<td>Median</td>
<td>161.40</td>
<td>11.35</td>
<td>11.75</td>
<td>10.40</td>
</tr>
<tr>
<td>Minimum</td>
<td>117.20</td>
<td>9.90</td>
<td>10.9</td>
<td>8.20</td>
</tr>
<tr>
<td>Maximum</td>
<td>175.50</td>
<td>15.70</td>
<td>14.1</td>
<td>12.30</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>20.66</td>
<td>2.13</td>
<td>1.19</td>
<td>1.47</td>
</tr>
<tr>
<td>Coefficient of variation</td>
<td>0.13</td>
<td>0.17</td>
<td>0.09</td>
<td>0.14</td>
</tr>
<tr>
<td>Slant</td>
<td>-0.61</td>
<td>0.44</td>
<td>0.41</td>
<td>-0.05</td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-1.06</td>
<td>-1.43</td>
<td>-1.38</td>
<td>-1.46</td>
</tr>
</tbody>
</table>

*Source: authors’ construction based on the data from the Ministry of Agriculture and Rural Development*

There are various factors having an impact on the price volatility of milk. The US price of class III of milk depends, for example, on export and import, price information, milk price scheme and cost settlement of milk futures contracts. The price of milk is also determined by feed cost, for example, corn price (Dong F. et al., 2011). Moreover, milk price volatility depends on dairy policies designed to help
farms and firms manage milk price volatility and help to insulate the US from global dairy price fluctuations. The policies help manage business risk of dairy products (Yonkers B., 2005).

The descriptive statistics of milk and milk products in Poland are presented in Table 2. The average price of milk in the years 2004-2013 was 153.68 PLN/100 kg. The prices of milk products changed in the years 2004-2013, too. The highest milk products’ prices were observed in extra butter 12.24 PLN/kg and Edam ripened cheese 12.16 PLN/kg. The highest coefficient of variation was observed in extra butter (0.17) and whole milk powder (0.14).

At the end of the analysis, the authors wanted to measure the relation between milk and milk products in Table 3. Therefore, the authors measured whether the milk product prices have impact on retail milk prices, while the impact was negative. One could see that Edam ripened cheese and whole milk powder had impact on milk price. When the price of milk powder and Edam ripened cheese rises, the price of milk decreases. It means that there are some linkages between the price of milk and milk products.

### Table 3

**Regression analysis for average prices of selected dairy products in Poland in 2004-2013**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Extra butter</th>
<th>Edam ripened cheese</th>
<th>Whole milk powder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coefficient</td>
<td>-0.580</td>
<td>-0.610</td>
<td>-0.610</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>8.319</td>
<td>8.127</td>
<td>7.8036</td>
</tr>
<tr>
<td>T statistics</td>
<td>19.233</td>
<td>19.743</td>
<td>20.424</td>
</tr>
<tr>
<td>$R^2$</td>
<td>0.339</td>
<td>0.3684</td>
<td>0.3727</td>
</tr>
<tr>
<td>P value</td>
<td>0.059</td>
<td><strong>0.047</strong></td>
<td><strong>0.046</strong></td>
</tr>
</tbody>
</table>

*Source: author’s calculations based on the data from the Ministry of Agriculture and Rural Development*

### Conclusions

There is a strong differentiation of milk production in Poland. Most of Polish milk is produced in Mazowieckie, Podlaskie, and Wielkopolskie provinces. The domination of these provinces will be bigger in the future because these are the regions with significant resources of meadows and pastureland.

In comparison with other farm products, the price of farm milk has the least volatility. The volatility of milk prices is the most similar to the volatility of beef. The price of pork behaves much differently.

The prices for dairy products are much more volatile than the price of retail milk. Market forces such as supply and demand regulate the prices of dairy products. Milk quotas and the Common Agricultural Policy regulate the price of retail milk.

Price volatility for extra butter, Edam ripened cheese, and whole milk powder is similar and does not exceed 50%. In the analysed period (2004-2013), there was an increase in milk product prices. For extra
butter fabricated, the price growth was the highest and amounted to 41.3%, whole milk powder was characterised by a rise in price by 20.6%, while the lowest increase in prices was characterised by Edam ripened cheese (17.4%).

The statistical analysis proved a relation between milk and milk products’ prices. The price of milk depended on the price of milk products. The impact was negative. Higher Edam ripened cheese, extra butter, and the price of milk powder reduced the price of retail milk.

Bibliography


