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PRICE DIFFERENTIATION OF AGRICULTURAL PRODUCTS IN POLAND – REGIONAL APPROACH[2]

Key words: selected agricultural products, prices, regional price differentiation, production and consumption analysis, regression model

ABSTRACT. The main aim of the research was to assess the price differences of selected agricultural products in the area of the first degree administrative division of Poland. The study focused on the analysis of the dynamics of price changes in individual regions, specified the impact of the production volume and consumption of a given product on the retail price, and an attempt was made to define a regression model in terms of the price of an agricultural product. The years 2010-2019 were assumed as the research period, and four products were analyzed: sugar, eggs, flour and milk. It was found that the average annual dynamics of changes was similar for all voivodeships, in particular for products such as flour, eggs and sugar. In the case of the correlation analysis, it was found that there was a certain interdependence of prices in relation to production and prices for consumption, which is not coherent on a regional basis. The regression model analysis proved ineffective in trying to forecast future market behavior as well as consumer behavior.

INTRODUCTION

In the literature on the subject, one can encounter a number of problems related to the production and demand of agricultural products, but the main problem is the instability and volatility of prices obtained [Constanc et al. 1990]. In the realities of a free market economy, the determinants of the economic system are the supply and demand elements, where an important factor is the demand for the produced good [Czyżewski, Guth 2016]. In the case of the agri-food market, agricultural producers operate in terms of competitive equilibrium and it can be assumed that the level of income of agricultural producers is

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ultimately determined by the consumer [Rembisz et al. 2011], who decides on the size of the purchase of food products. Demand for food products is usually inelastic [Podkaminer 2017], which may suggest that an increase in the price of a product does not cause a significant change in demand. Another researcher in his work came to a slightly different conclusion, who indicated that the increase in the prices of agricultural raw materials reduces the level of food consumption [Kubala, 2019]. Another team of researchers [Rembeza, Seremak-Bulge 2010], came to interesting conclusions as well, who stated that the real drop in prices is particularly visible in the case of agricultural product prices, rather than retail food prices. Augustyn Woś presented it in a similar way much earlier [1996] stating that the prices of agricultural products are more volatile than the prices of non-agricultural products. The impact of agricultural raw material prices on retail prices of food products is diversified and results from the process of its processing and storage [Hamulczuk et al. 2016]. It should be borne in mind that price fluctuations in agri-food markets result mainly from the specificity of the market itself, where the characteristics of agricultural production relate to biological and natural factors [Świetlik 2019]. Therefore, it is assumed that buyers prices are determined by the supply and demand relations at the retail level [Firlej, Stanuch 2022], but the choice of factors influencing the final price may be more extensive.

RESEARCH MATERIAL AND METHODOLOGY

The research area covered units of the administrative division of Poland, i.e. all 16 voivodeships. The study focused on an attempt to analyze the price differences of selected agricultural products, such as: sugar, eggs, flour and milk. The study was conducted using
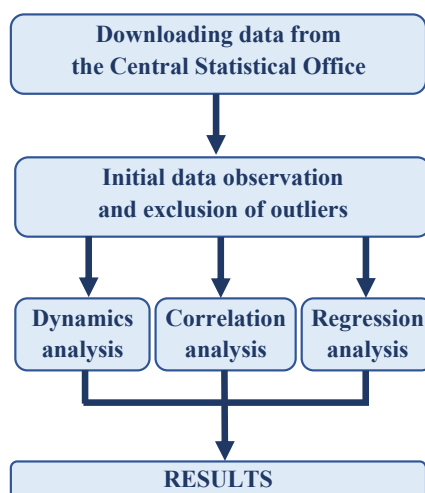

Figure 1. Research methodology

Source: own study

data from the Central Statistical Office [GUS, 2022a] for the 10-year period 2010-2019. The implementation of the research goal is illustrated in Figure 1.

At the initial stage of the analyzes, using the quantile criterion, the data was analyzed in order to eliminate the so-called outliers [Tukey 1977]:

$$< Q_1 - 1.5 \times IQR, Q_3 + 1.5 \times IQR >$$

where:
Q_1, Q_3 – first and third quantiles,
IQR – quarter range.

In the next step, the study was divided into 3 stages:

1. Examination of the average annual dynamics of product price changes in regional terms. For this purpose, the dynamics index (chain index) was used) [GUS 2022b]:

$$i_{t/t-1} = \frac{y_t}{y_{t-1}} \times 100\%$$

where:
y_t – the level of the phenomenon during the period considered,
y_{t-1} – the level of the phenomenon in the period immediately preceding it.

2. Analysis of the level of production and consumption of agricultural products and their influence on the retail price in the region. For this stage, the Pearson's linear correlation coefficient was used:

$$Correl(X, Y) = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2}\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

3. An attempt to estimate the impact of selected factors on the prices of agricultural products in the national scope. In order to describe the correlation between the explanatory variable and the dependent variable, a regression analysis was used [Woźniak 2002]:

$$y = \alpha_0 + \alpha_1 x + \varepsilon$$

where:
α_0 – y-intercept,
α_1 – regression coefficient,
x – explanatory variable,
ε – aleatory component of the model.

To determine the accuracy of the estimated model, the coefficient of determination was used:

$$R^2 = \frac{\sum_{t=1}^{n}(\hat{y}_t - \bar{y})^2}{\sum_{t=1}^{n}(y_t - \bar{y})^2}$$

where:
y_t – the actual value of the dependent variable,
$\hat{y}_t$ – predicted value of the dependent variable,
$\bar{y}$ – average value of the actual dependent variable.

In order to increase the accuracy of the model prediction, the Granger causality test was performed, which allows to estimate whether the variable *X* is the cause of the variable *Y*. For this purpose, the VAR model was used [Granger 1969]:

$$Yt = a_0 + \sum_{i=1}^{p} ay_i\, Yt - i + \sum_{i=1}^{p} ax_i\, Xt - i + \varepsilon Yt$$

$$Xt = \beta_0 + \sum_{i=1}^{p} \beta x_i\, Xt - i + \sum_{i=1}^{p} \beta y_i\, Yt - i + \varepsilon Xt$$

where:
Yt, Xt – study variables,
α_0, β_0 – *y*-intercept,
p – row of delays.

RESULTS

When analyzing the results of the research presented in Table 1, it can be concluded that the average annual dynamics of changes in selected prices of agricultural products in terms of regions was not differentiated. The average tendencies and the level of price volatility in the case of sugar and eggs fluctuate in each voivodship within 2-3%, where this value was twice lower than in the case of flour (the obtained results are in the range of 4-6%). Milk deserves attention here, where in most voivodships the average dynamics of changes in the price of this product has not changed significantly, and in the case of Pomorskie and Świętokrzyskie voivodships it was even negative. Such results may be due to the maintenance of a constant price relation between Poland and the member states of the European Union, where the research [Firlej, Stanuch 2021] has shown that Poland has a very high price correlation for milk with most European Union countries. In the case of the Pomorskie and Świętokrzyskie voivodeships, a slow decline in the prices of this

Table 1. Tendencies and volatility of selected prices of agricultural products in 2010-1019

Voivodeship	Milk	Flour	Eggs	Sugar
	%			
Dolnośląskie	0	4	3	2
Kujawsko-Pomorskie	2	4	2	3
Lubelskie	1	4	3	2
Lubuskie	0	6	3	3
Łódzkie	0	5	2	2
Małopolskie	0	4	3	2
Mazowieckie	0	4	3	2
Opolskie	0	5	2	3
Podkarpackie	0	4	3	2
Podlaskie	0	6	3	2
Pomorskie	-2	6	3	2
Śląskie	1	5	3	2
Świętokrzyskie	-1	3	2	2
Warmińsko-Mazurskie	2	4	3	3
Wielkopolskie	0	4	3	2
Zachodniopomorskie	0	4	3	2

Source: own study based on data from the Central Statistical Office

product can be observed, where, in conjunction with the research of Jadwiga Seremak-Bulge [2016], it was found that the determinant of such a situation could be lower foreign exports with high domestic supply for this type of raw material. It should also be noted that in the Pomorskie Voivodeship, milk production was gradually increased, where over the years 2010-2019 its value increased by over 30%.

In the next stage, the focus was on the attempt to correlate the retail prices of the product in relation to its consumption and production per 1 person. Correlation analysis not only allows you to examine whether the selected two variables are significantly related to each other, but also allows you to decide on the selection of variables for model estimation, where you should select those variables that are strongly correlated with the dependent variable and poorly correlated with each other [Omiotek, Wójcik 2014]. The results of the calculations are presented in Figure 2, which shows a strong differentiation of the correlation results depending on the region of Poland. In the case of flour, a strong, negative correlation in terms of the price and consumption of bread was noticeable in all
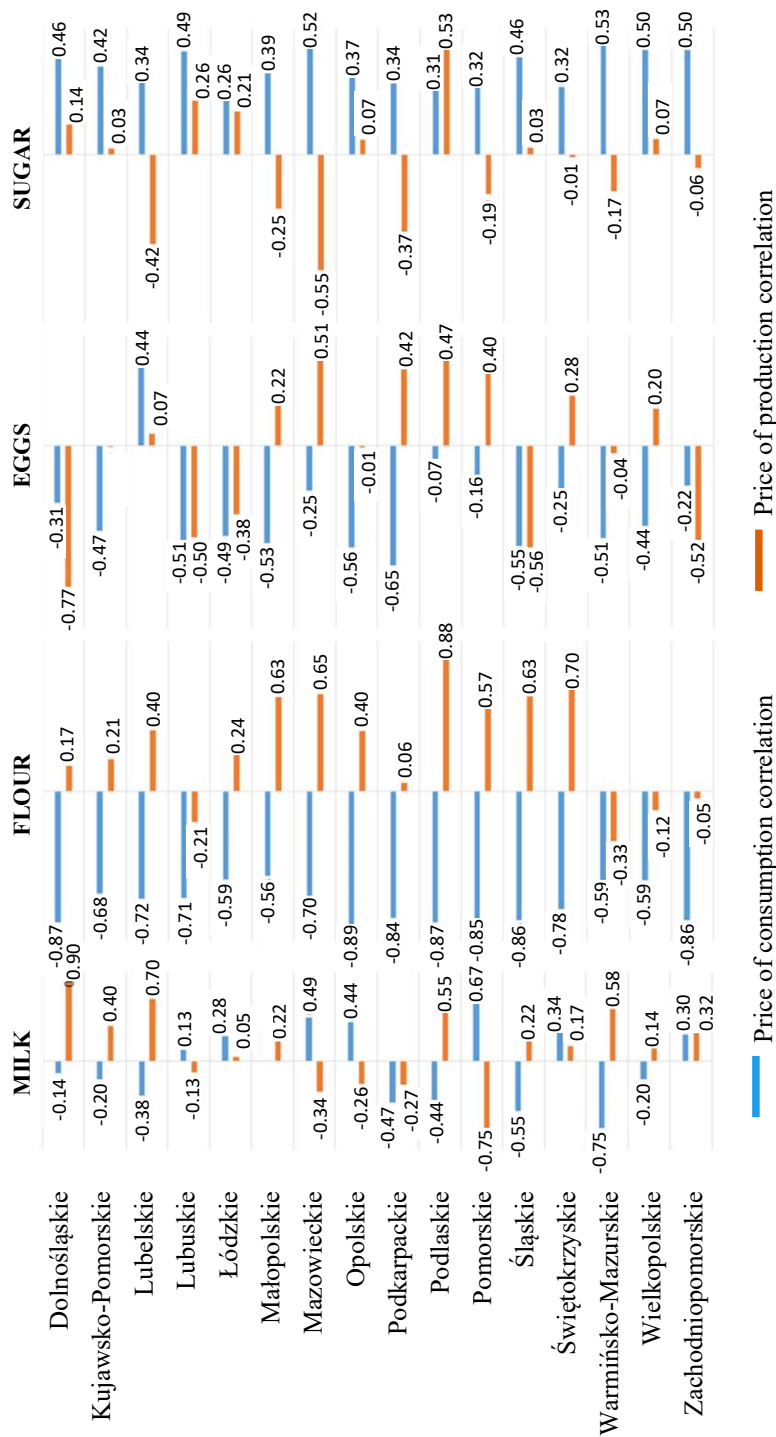
Figure 2. Results of the correlation coefficient for selected agricultural products. In the case of sugar, the production aspect concerns sugar beet

Source: own study based on data from the Central Statistical Office

voivodeships. Such a result may prove that along with an increase in the price of a given product, its consumption decreases [Żuchowski, Brelik 2007], however, as researchers define it, after some time it may adapt to the new conditions and consumption will return to the previous level. A slightly different result was obtained in the case of sugar, where an increase in the price of the product may increase its consumption, which corresponds to the Giffen paradox. In terms of the correlation of prices to production, the law of the supply curve has been well illustrated in the case of flour, where a change in the price of a given product causes an increase in the supply of a given commodity. In terms of milk and eggs, a certain regional differentiation is noticeable, where the attempt to link the price to consumption or the price to production is determined depending on the place of occurrence. For example, the following voivodeships: Lubuskie, Łódzkie, Małopolskie, Świętokrzyskie, Wielkopolskie and Zachodniopomorskie showed a low correlation in terms of the discussed factors for the milk quoted in the study, while the Pomorskie and Warmińsko-Mazurskie voivodeships showed medium and high correlation. In the case of Lubuskie and Śląskie voivodships, a similar correlation was observed in terms of prices for consumption and prices for production, which may suggest certain consumer behavior related to the production capacity of farms. The last stage of the study was an attempt to define a regression model on a group of nationwide data. At this stage, the focus was on examining the relationship between the price and average consumption or production of a given good, and the results of the calculations are shown in Figure 3. Analyzing the presented results, it can be concluded that there are certain trends in the national perspective that determine consumer behavior in terms of consumption and shape the prices and production of a given good. Eggs and flour are good examples, as falling prices of these products can increase consumption. Therefore, a certain relation can be concluded that the price attractiveness of a product causes an increase in its consumption among consumers. The opposite tendency was noticed in the case of sugar, where an increase in consumption causes an increase in the price. Such a situation may be affected by growing incomes and changing consumption patterns regarding the adoption of consumption patterns from Western European societies [Hryszko, Szajner 2013]. In the case of milk, no particular behavior was found, as the regression line remained relatively constant, suggesting that the increase in consumption did not significantly affect the price of the product.

When analyzing the results in terms of production and price, it was found that there was no significant impact, especially in the case of sugar, where the regression line remained relatively constant at PLN 3. In the case of eggs, there is a slight slope of the regression straight towards the positive direction, where an increase in production may be dictated by an increase in the price of the product. In terms of milk, this relationship is more visible and may result from the situation on farms, where an increase in milk yield has been observed with a decreasing number of cows, because larger producers may receive

MILK

Price to consumption:

y = 0.005939x + 2.80

R^2 = 0.0002609

Price to consumption:

y = 0.000073x + 2.76

R^2 = 0.008928

FLUOR

Price to consumption:

y = 0.1588x + 3.39

R^2 = 0.2391

Price to consumption:

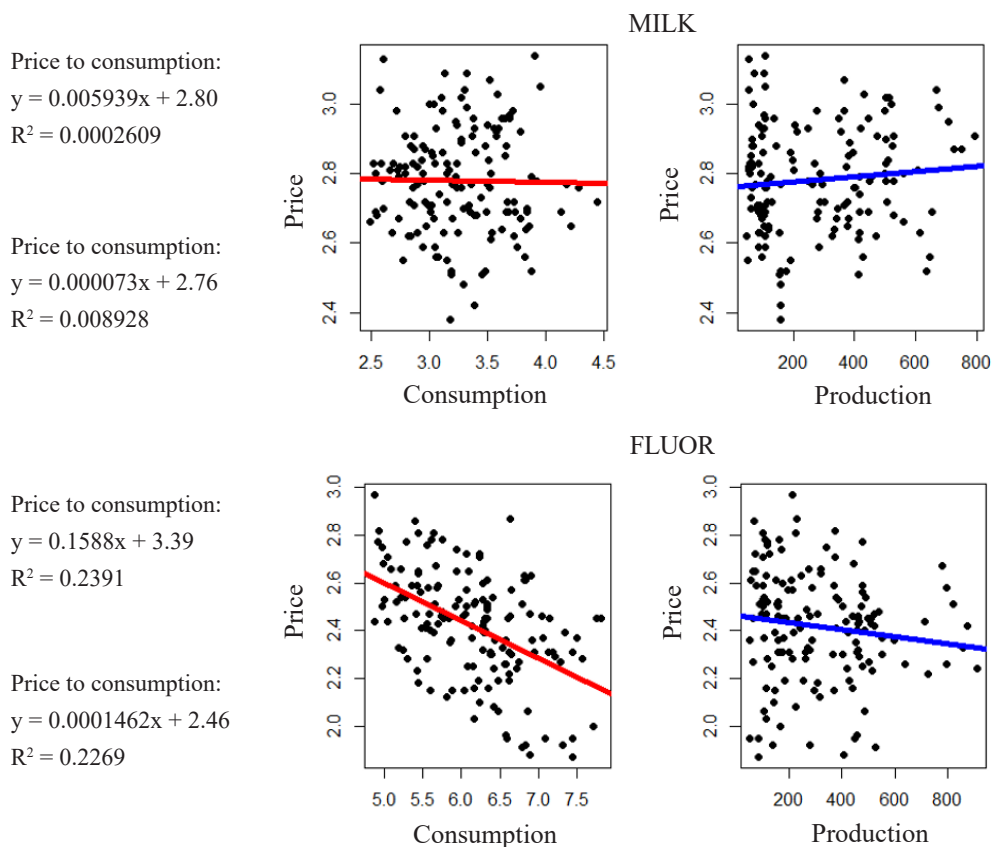y = 0.0001462x + 2.46

R^2 = 0.2269

Figure 3. Regression charts between retail price and average consumption or production of a given commodity

Source: own study based on data from the Central Statistical Office

higher milk prices [Bórawski, Kowalska 2017]. In the case of flour, a reverse trend was recorded, where an increase in cereal production causes a decrease in the price of flour. It should also be borne in mind that the changing needs of society in recent years in the consumption of bread and cereal products may be a determinant of the eating style, the trend of which may exclude the consumption of bread in the daily diet [Stanisławska, Kurzawa 2016]. Unfortunately, an attempt to forecast future price movements may turn out to be unsatisfactory, because the result of the coefficient of determination (which determines what part of the data is translated by the model) for all the above-mentioned analyzes oscillates below 0.3, making the attempt to match the future values of the variables to the model unsatisfactory.
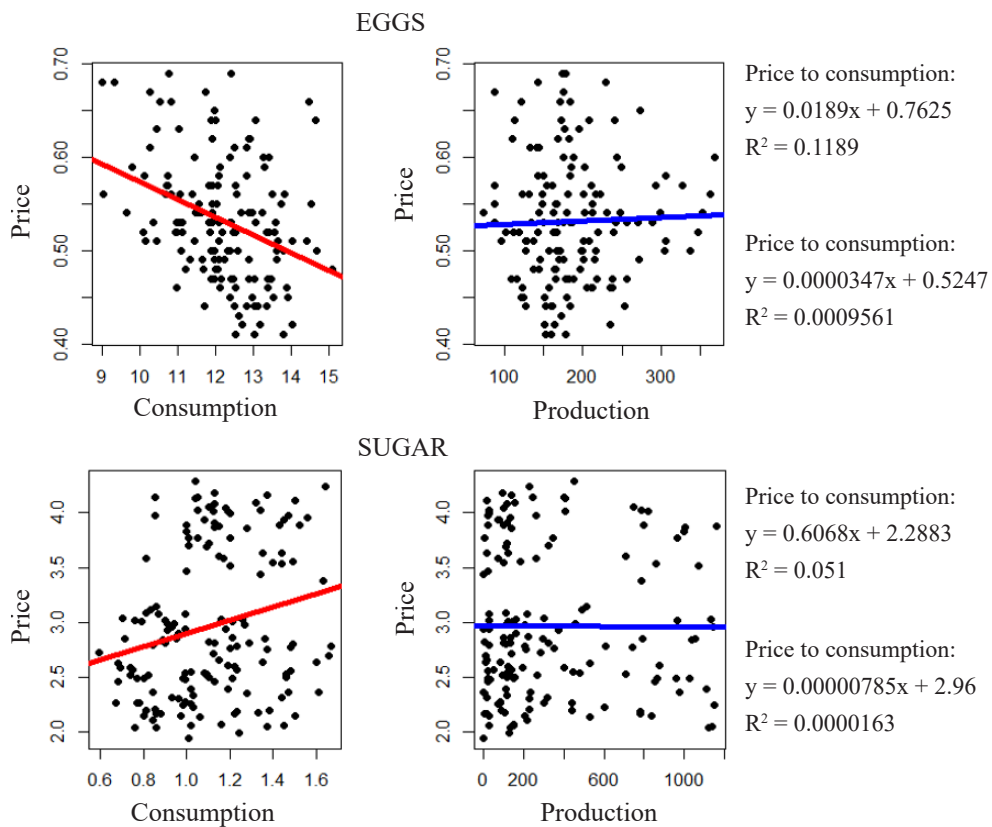
EGGS

Price to consumption:
$y = 0.0189x + 0.7625$
$R^2 = 0.1189$

Price to consumption:
$y = 0.0000347x + 0.5247$
$R^2 = 0.0009561$

SUGAR

Price to consumption:
$y = 0.6068x + 2.2883$
$R^2 = 0.051$

Price to consumption:
$y = 0.00000785x + 2.96$
$R^2 = 0.0000163$

Figure 3. Cont.

Table 2. The results of the Granger causality calculations for selected agricultural products

Causality	Effect	p-value	Value test
Milk consumption	milk price	0.0492	3.9332
Milk production	milk price	0.6383	0.2219
Eggs consumption	eggs price	0.5795	0.3085
Eggs production	eggs price	0.7333	0.1165
Sugar consumption	sugar price	0.0170	5.8265
Sugar production	sugar price	0.3246	0.9766
Flour consumption	flour price	0.4498	0.5742
Flour production	flour price	0.0169	5.8425

Source: own study based on data from the Central Statistical Office

An attempt to determine the causality between the price of the selected product and its consumption and production is presented in Table 2. If the p-value is less than 0.05, time series X was found to determine the future value of Y.

The results of the Granger causality test allowed for the specification of 3 relationships that may determine the price of the selected product and relate to: milk consumption, sugar consumption and flour production. In the analyzed period, no significant causal relationships were found with regard to the remaining elements of the study.

CONCLUSIONS

The study carried out several stages of the analysis of the relationship between the price of an agricultural product and its consumption and production. The analysis focuses on the regional analysis of the dynamics of price changes in individual voivodeships and the nationwide analysis of the search for general consumer trends. The conducted analysis allowed for a general assessment of price relations between selected agricultural products, thanks to which the following conclusions were drawn.

1. The average annual dynamics of changes was similar in all voivodeships, in particular for products such as flour, eggs and sugar. In the field of milk, there has been an increase in the diversity of price volatility trends.

2. In the aspect of research on the correlation of prices with consumption and production, it was found that there was a strong differentiation of the dependencies of the aforementioned factors in terms of the regional division, such as voivodeships. The results of this study show that there was a certain interdependence that was not consistent from a regional perspective.

3. Attempting to define a regression model for forecasting future price values based on production or consumption may prove ineffective. The results of the determination coefficient for the constructed models turned out to be extremely low, which makes it difficult to present the key dependence of the selected element, which ultimately translates into the problem of price prediction for a given product.

Therefore, it can be concluded on the basis of the selected research sample that the change in the prices of agricultural products will usually be similar for any selected regions. This allows for the conclusion that the modern agricultural economy operates in the so-called "connected vessels", where price changes in one voivodeship may be noticed in any other region of Poland.

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ZRÓŻNICOWANIE CEN PRODUKTÓW ROLNYCH W POLSCE – UJĘCIE REGIONALNE

Słowa kluczowe: wybrane produkty rolne, ceny, zróżnicowanie regionalne cen, analiza produkcji i spożycia, model regresji

ABSTRAKT

Głównym celem badań była ocena różnic cenowych wybranych produktów rolnych w zakresie podziału administracyjnego Polski I stopnia. W badaniu skupiono się na analizie dynamiki zmiany cen w poszczególnych regionach, określono wpływ wielkości produkcji oraz spożycia danego produktu na cenę detaliczną. Podjęto także próbę określenia modelu regresji w aspekcie kształtowania się ceny produktu rolnego. Za okres badań przyjęto lata 2010-2019, a przedmiotem analiz były cztery produkty: cukier, jajka, mąka oraz mleko. Stwierdzono, że średnia dynamika zmian w ujęciu rocznym była zbliżona dla wszystkich województw, w szczególności dla takich produktów, jak: mąka, jajka i cukier. W przypadku analizy korelacji, stwierdzono, że istniała pewna współzależność cen względem produkcji oraz cen do spożycia, która nie jest spójna w ujęciu regionalnym. Analiza modelem regresji okazała się nieskuteczna w zakresie próby prognozowania przyszłych zachowań rynku, jak również poczynań konsumentów.

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