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SELECTED FACTORS AND PURCHASE PRICE LEVELS OF SOUR CHERRIES FOR PROCESSING IN POLAND

Key words: sour cherry purchase prices, fruits for processing, sour cherry production, price determinants, regression model

ABSTRACT. This study aims to identify the factors forming the purchase price levels of sour cherries for processing in Poland and determine the way such factors affect these price levels. The scope of the study covers the 2004-2019 period. The subject of the study were annual average purchase prices of sour cherries for freezing and sour cherries for pressing. These prices were published by the Institute of Agricultural and Food Economics in the magazine *Rynek Owoców i Warzyw* (*Fruit and Vegetable Market*). A multiple regression method was used for analysing the relationship between the purchase prices of sour cherries and their determinants. The estimation of the structural parameters of econometric models was done using the method of least squares. The estimated econometric models explain approximately 80% volatility in the purchase prices of sour cherries for processing. The sour cherry harvest both in Poland and Germany as well as the strawberry harvest in Poland proved to be significant for the purchase prices of sour cherries. Strawberries may be a substitute for sour cherries in food processing. The importance of this factor for the formation of the purchase prices of sour cherries is a significant result of this study.

INTRODUCTION

Sour cherries are valued fruit for their flavour properties as well as vitamin and mineral content, especially phenol content [Blado, Oomah 2019]. Because of their beneficial health-promoting properties, sour cherries belong to "superfoods" [Mayta-Apaza et al. 2017]. Sour cherries have high acidity, which makes them relatively rarely consumed when they are fresh, i.e. unprocessed. They are widely used in the processing industry for the production of juice, jam, frozen food and dried fruit [Wojdyło et al. 2014].

Sour cherries are primarily grown in Europe (65% of world production), Asia (26%) and North America (9%). Global sour cherry production increased in previous decades

and doubled from an average 0.5 million tonnes in the 1961-1970 period to more than 1.3 million tonnes in the 2011-2019 period [according to FAOSTAT – as on 20 December 2020] Poland is one of the largest sour cherry producers in the world. With a production of approximately 170,000 tonnes (average harvest in 2011-2019), it ranks fourth in the world, after Russia, Turkey and the Ukraine.

Sour cherry production in Poland developed dynamically – after the end of the Second World War, there was an increase in the area under cultivation from approximately 19,000 hectares before 1939 to 28,000 hectares in 1950 [Makosz 2006]. According to Stanisław Wyciór [1997], the increase in sour cherry production in Poland in the 1971-1995 period was caused by both natural and economic factors. Subsidised loans available in the 1971-1975 period allowed the Horticultural Cooperative (Spółdzielczość Ogrodnicza) to set up numerous well-run individual and cooperative sour cherry orchards. Facing increasing problems with apple sales in 1976 and later years, other fruit growers began to see the advantages of sour cherry production – sour cherry orchards were easier to protect compared to apple orchards and the fruit could be harvested earlier and sold immediately afterwards. Following the frosty winter of 1986/1987, which decimated a significant number of fruit trees – especially apple trees – there was an increase in areas planted with sour cherry trees. Fruit producers established new orchards, including sour cherry orchards [Wyciór 1997], to replace their frost-damaged apple orchards. In Poland, the area under sour cherries increased until 2001 and, by that time, it amounted to 40,000 hectares. In following years, despite some fluctuations, the area under cultivation for sour cherries decreased. In 2019, it amounted to less than 30,000 hectares.

The increase in the area under cultivation for sour cherries in Poland was accompanied by an increase in the sour cherry harvest. In 2004, the harvest reached its maximum, i.e. 202,000 tonnes of sour cherries. The volume of sour cherry production in Poland fluctuated significantly in the 2004-2019 period. While an upward trend could be observed until 2004, the subsequent sour cherry harvest exhibited high volatility with no noticeable trends. According to [Smoleński 2000], sour cherry production in Poland was profitable in the 1996-2000 period. He notes, however, that uncontrolled planting may result in excessive supply and a decline in prices.

While sour cherries are sold on the dessert fruit market, most of them are sold for processing (72% of the production volume) [GUS 2013]. They are frozen (sour cherries for freezing) or processed into concentrated juice (sour cherries for pressing). In such a form (substrates for further production), they are typically delivered to customers on foreign and domestic markets. In the 2001-2004 period, according to [Świetlik 2005], from 64% to 77% of the sour cherry harvest in Poland was intended for processing – from 52% to 63% of the produce was intended for freezing and from 30% to 52% of the produce was intended for juice production.

Sour cherry is a soft, perishable fruit that must be picked and delivered to buyers within a short period of reaching its harvesting ripeness. Depending on the volume of fruit deliveries, sour cherries are either delivered to collection points (intermediaries), in the case of small quantities, or, in the case of substantial deliveries, they are directly delivered to processing plants from large commercial orchards [Borowska, Rejman 2008]. Purchase prices are determined during the purchase season. Fruit producers typically learn about the final price no sooner than the moment they deliver their produce to collection points. Acting as intermediaries in the delivery of produce to processing plants, collection points set their purchase prices based on the price levels established by end recipients, i.e. the fruit and vegetable processing plants. For this reason, sour cherry producers are forced to sell their products at prices offered by fruit collectors.

The purchase price levels of sour cherries for processing are not always satisfactory for the producers themselves, who must bear the costs of producing and harvesting the fruit. A too low level of purchase prices was repeatedly the reason for protests of producers and the subject of the intervention of state administration bodies and the Ministry of Agriculture, as well as the reason for non-harvesting fruit and the neglect of plantations. To preserve traditional sour cherry production regions and secure the possibility of obtaining produce by fruit and vegetable processing companies and consumers, sour cherry production should enable fruit producers to earn a fair income. As the purchase price (of sour cherries) is an important factor in determining the profitability of production, both fruit producers and state policy concerning agriculture need to know whether and what factors other than the volume of the sour cherry harvest influence the purchase price levels of sour cherries for processing in Poland.

The purchase price levels of sour cherries for processing in Poland are determined by fruit collectors. Due to binding contracts with recipients of processed and semi-processed products, fruit and vegetable processing companies must procure the raw material for production. They can purchase cherries both in Poland and abroad. In addition to Poland, the largest producers and exporters of sour cherries include Hungary and Serbia [Radosavljević 2008, Apáti, Gonda 2010, Nosecka et al. 2012, Lukać et al. 2013]. Hence, the sour cherry harvest in Hungary and Serbia are factors that may affect the purchase prices of the said fruit in Poland. Furthermore, the volume of the sour cherry harvest in Germany and the USA, which are not only sour cherry producers but also buyers of frozen and chilled sour cherries from Poland [Nosecka et al. 2017], may affect the demand of these countries for sour cherries from abroad, also from Poland. However, previous studies [Kierczyńska 2017, 2019] revealed a significant correlation between sour cherry harvest levels in the largest sour cherry producing countries (Poland and Hungary), as well as in importing countries of the said fruit (Germany and the USA), and the purchase prices of sour cherries for both freezing and pressing. On the other hand, correlations between the

levels of sour cherry exports from Hungary, Serbia and Poland and the purchase prices of sour cherries for processing in Poland were weak and statistically insignificant.

Processed and semi-processed fruit (not only sour cherries) products are frequently added to other food products of the processing plant and can be replaced by other fruit in the case of shortage of certain fruit species [Sadyogrody 2019]. Therefore, a low harvest of other fruits for processing (strawberries, blackcurrants and raspberries) may cause increased demand for sour cherries and contribute to higher purchase prices of the said fruit. Moreover, according to [BGŻ 2014], stock levels and prices of processed sour cherries may affect the purchase prices of sour cherries for processing in Poland.

This study aims to identify the factors forming the purchase price levels of sour cherries for processing in Poland and determine the way such factors affect these price levels. The scope of the study covers the 2004-2019 period.

MATERIAL AND TEST METHODS

The study material consists of the annual average purchase prices of sour cherries for freezing and sour cherries for pressing published by the Institute of Agricultural and Food Economics – National Research Institute in the magazine *Rynek Owoców i Warzyw* (*Fruit and Vegetable Market*) [IERiGŻ-PIB 2005-2020]. The data concerning the sour cherry harvest in individual countries were obtained from the FAOSTAT database, while the data concerning the harvest of strawberries, raspberries and currants in Poland were obtained from the statistical yearbooks of the Statistics of Poland [GUS 2004-2019]. The sales prices of processed sour cherries (frozen sour cherries and canned sour cherries) were obtained from the monthly magazine *Rynek Rolny* (*Agricultural Market*) [IERiGŻ-PIB 2004-2020].

The analysis aims to find determinants of the purchase price levels of sour cherries for processing in Poland. Potential variables that explain the formation of the purchase prices of sour cherries for processing were identified based on the literature review. Subsequently, following formal and statistical criteria [Zeliaś et al. 2003], such as a significant correlation with an explained variable and lack of multicollinearity between explanatory variables, a set of explanatory variables was selected. Single-equation econometric models were determined as functions of multiple factors when applying the multiple regression analysis method. To determine the analytical form of the model, scatter plots were drawn up between the specific explained variable and explanatory variables. Graphical analysis showed that such relationships did not differ from linear ones, hence, it was assumed that the formation of the purchase prices of sour cherries for processing in Poland could be described as a linear function of individual explanatory variables.

Estimators of the model's structural parameters were estimated using the method of least squares. The obtained econometric models were also formally and statistically verified [Stańko 2013]. The model's suitability for empirical data was evaluated based on the level of the coefficient of determination (R^2), coefficient of random variation (v_e), standard error of model evaluation (s_e) and mean absolute percentage error (MAPE). The absence of multicollinearity of the estimated regression coefficients were verified by the variance inflation factor (VIF). The Student's t-test was used to assess the significance of the econometric model's individual structural parameters. The Fisher-Snedecor test was performed to assess the significance of the entire model. The properties of the random component in terms of the randomness of residuals (the Wald-Wolfowitz runs test), autocorrelation (the Durbin-Watson test), symmetry and normality of distribution (the Shapiro-Wilk test), and the homogeneity of variance (the Goldfeld–Quandt test) [Maddala 2001, Stańko 2013] were also examined. The statistical package Statistica PL ver. 13.3 was used for the analysis.

STUDY RESULTS

THE PURCHASE PRICES OF SOUR CHERRIES FOR PROCESSING IN POLAND

The purchase price levels of sour cherries for pressing in the 2004-2019 period varied from 0.6 PLN/kg in 2009 to 2.9 PLN/kg in 2012. In the case of sour cherries for freezing, the purchase price levels varied from 0.8 PLN/kg in 2009 to 5.1 PLN/kg in 2017. The annual average purchase prices of sour cherries for freezing were higher than those for pressing (Figure 1). The difference was 5% and 7% in 2008 and 2012, respectively, when the purchase prices of sour cherries for pressing were similar to the purchase price levels of cherries for freezing. In 2017, however, the purchase prices of sour cherries for freezing were twice as high as the purchase prices of sour cherries for pressing. The year 2017 was unique for fruit production in Poland. During the flowering period and fruit setting period, ground frosts occurred across the country – particularly in eastern Poland, a region with a high number of fruit tree orchards. They caused buds to freeze and prevented trees from bearing any fruit. In 2017, fruit harvest in Poland reached a record low level, which resulted in high purchase prices of fruit for processing. Therefore, in 2017, the purchase prices of sour cherries for freezing are significantly different from the average purchase prices of the said fruit.

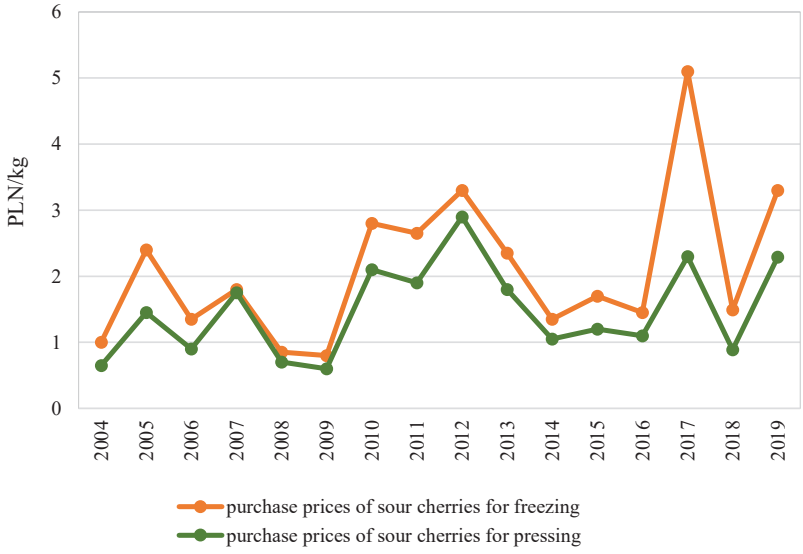

Figure 1. Purchase price of sour cherries for processing between 2004-2019
Source: own calculations based on [IERiGŻ-PIB 2005-2020]

SELECTION OF EXPLANATORY VARIABLES

Based on the information available in the literature concerning the purchase prices of sour cherries for processing in Poland, a set of potential factors (potential explanatory variables) affecting the purchase price levels of sour cherries was determined (Table 1). Based on Pearson correlation coefficients, the strength and direction of the relationship between those factors and two explained variables were determined: the FREEZ variable (the purchase price of sour cherries for freezing) and PRESS variable (the purchase price of sour cherries for pressing). When it comes to potential explanatory variables, the following variables were significantly correlated with the FREEZ explained variable: the sour cherry harvest in Poland, the sour cherry harvest in Germany, the strawberry harvest in Poland. In the case of the PRESS explained variable, those variables were the sour cherry harvest in Poland, the sour cherry harvest in Hungary, the sour cherry harvest in Germany, the sour cherry harvest in the USA and the strawberry harvest in Poland (Table 1).

To identify multicollinearity between the explanatory variables, a critical value of the correlation coefficient r*[1] was determined. The STR_PROD variable (the strawberry

[1] $(r^* = \sqrt{\frac{t^2_{\alpha,k,}}{t^2_{\alpha,k}+(n-2)}} = \sqrt{\frac{2.145}{2.145+(16-2)}} = 0.497346)$

Table 1. Basic information concerning explained variables and potential explanatory variables

Variable	Description	Mean	SD	Correlation coefficient for FREEZ (p)	Correlation coefficient for PRESS (p)
FREEZ	Purchase price of sour cherries for freezing [PLN/kg]	2.11	1.14	n/a	n/a
PRESS	Purchase price of sour cherries for pressing [PLN/kg]	1.47	0.69	n/a	n/a
PROD_PL	Sour cherry harvest in Poland [1,000 tonnes]	168.491	36.842	-0.7481 (0.001)	-0.5865 (0.017)
AREA_PL	Sour cherry cultivation area in Poland [1,000 hectares]	33.305	3.225	-0.4387 (0.089)	-0.2893 (0.277)
PROD_HU	Sour cherry harvest in Hungary [1,000 tonnes]	66.874	13.500	-0.3621 (0.168)	-0.5550 (0.026)
PROD_SE	Sour cherry harvest in Serbia [1,000 tonnes]	97.723	19.525	-0.1835 (0.496)	-0.1347 (0.619)
PROD_GE	Sour cherry harvest in Germany [1,000 tonnes]	20.497	8.436	-0.5574 (0.025)	-0.5126 (0.042)
PROD_US	Sour cherry harvest in USA [1,000 tonnes]	115.349	28.283	-0.3630 (0.167)	-0.5761 (0.020)
F_CH_P	Sales price of frozen cherries from Poland [Euro/kg]	0.94	0.25	-0.1310 (0.629)	-0.1333 (0.623)
C_CH_P	Sales price of canned cherries from Poland [Euro/kg]	1.34	0.34	-0.1351 (0.618)	-0.0026 (0.993)
STR_PROD	Strawberry harvest in Poland [1,000 tonnes]	184.707	16.973	-0.6221 (0.010)	-0.8114 (0.000)
CUR_PROD	Currant harvest in Poland [1,000 tonnes]	173.435	25.337	-0.4726 (0.065)	-0.3238 (0.221)
RAS_PROD	Raspberry harvest in Poland [1,000 tonnes]	92.757	27.526	0.2558 (0.339)	0.3095 (0.243)

Source: own calculations based on IERiGŻ-PIB, GUS, FAOSTAT data

Table 2. The correlations between selected explanatory variables (the significance level in brackets)

Variable	PROD_PL	PROD_HU	PROD_GE	PROD_US
PROD_HU	0.4725 (0.065)	-	-	-
PROD_GE	0.2424 (0.366)	-0.1514 (0.576)	-	-
PROD_US	0.1002 (0.712)	0.4971 (0.050)	0.1544 (0.568)	-
STR_PROD	0.4257 (0.100)	0.6862 (0.003)	0.1191 (0.660)	0.7286 (0.001)

Source: own calculations based on IERiGŻ-PIB, GUS, FAOSTAT data

harvest in Poland) is strongly and significantly correlated with variables such as PROD_HU (the sour cherry harvest in Hungary) and PROD_US (the sour cherry harvest in the USA) (Table 2). Due to a lack of substantive confirmation of the relationship between the strawberry harvest in Poland and the sour cherry harvest in the USA and Hungary, the relationships should be considered as spurious correlations. However, to ensure the efficiency of estimators of the econometric model's parameters, multicollinear variables should be eliminated from the model. In the group of explanatory variables, the STR_PROD variable was preserved because of its very strong correlation with the PRESS explained variable. The eliminated explanatory variables were PROD_HU and PROD_US, as they were less strongly correlated with the PRESS explained variable.

The variables strongly and significantly correlated with the explained variable and the ones poorly correlated with each other were kept as the variables explaining both the formation of the purchase prices of sour cherries for freezing and the formation of the purchase prices of sour cherries for pressing. The variables include PROD_PL (sour cherry harvest in Poland), PROD_GE (sour cherry harvest in Germany) and STR_PROD (strawberry harvest in Poland). Regression analysis was conducted for two explained variables such as FREEZ and PRESS.

ESTIMATION OF ECONOMETRIC MODEL PARAMETERS

The method of least squares was used for estimating structural parameters of the model. The estimation resulted in empirical assessments of structural parameters of FREEZ and PRESS models. In the case of the FREEZ model, all three explanatory variables were statistically significant at the significance level of $p < 0.05$. When it comes to the PRESS model, the PROD_PL explanatory variable (sour cherry harvest in Poland) turned out to be statistically insignificant. Hence, the PRESS model's structural parameters were re-estimated excluding the PROD_PL variable. The following empirical assessments of the model's parameters, obtained as a result of the estimation, were shown in Table 3.

Table 3. Structural parameters of FREEZ and PRESS models

Explained variable	Explanatory variables	Coefficient	Standard error	t-Student	p
FREEZ	Intercept	10.29084	1.541535	6.67571	0.000023
	PROD_PL	-0.01540	0.004307	-3.57591	0.003811
	PROD_GE	-0.05311	0.017142	-3.09839	0.009217
	STR_PROD	-0.02437	0.009135	-2.66806	0.020484
PRESS	Intercept	7.942928	0.863131	9.20246	0.000000
	PROD_GE	-0.034758	0.009381	-3.70525	0.002643
	STR_PROD	-0.031167	0.004663	-6.68444	0.000015

Source: own calculations based on IERiGŻ-PIB, GUS, FAOSTAT data

The F-test (Fisher-Snedecor) was conducted to assess the significance of the effect of the entire set of explanatory variables and the significance of the arrangement of the regression coefficients obtained. Both the FREEZ model and the PRESS model are statistically significant at the significance level of $p < 0.05$ (Table 4).

The obtained econometric models were substantively verified. Each of the estimators has a negative sign, which means that the increase in sour cherry and strawberry harvest in Poland and Germany are accompanied by a decline in the purchase price of sour cherries for freezing in Poland. It is consistent with economic theories, logic and economic reality. In the case of the FREEZ model, the increase in sour cherry harvest by 1,000 tonnes, with no changes in the levels of other factors, results in a decline in the purchase price of 1 kilogramme of sour cherries for freezing by 1.5 groszy (PLN 0.015). Analogously, the increase in the sour cherry harvest by 1,000 tonnes in Germany contributes to a decline in the purchase price of sour cherries for freezing in Poland by 5.3 groszy (PLN 0.053) per 1 kilogramme. Similarly, the increase in strawberry harvest by 1,000 tonnes in Poland causes a decline in the purchase price of sour cherries for freezing by 2.4 groszy (PLN 0.024) per 1 kilogramme. In the case of the PRESS model, the increase in sour cherry harvest in Germany reduces the purchase price of sour cherries by 3.4 groszy (PLN 0.034) per 1 kilogramme, and the increase in strawberry harvest in Poland contributes to a decline in the purchase price of sour cherries by 3.1 groszy (PLN 0.031) per 1 kilogramme (Table 3).

Formal and statistical verification also assessed how the models fit empirical data and properties of the random component. The results were shown in Table 4.

The coefficient of linear determination of the estimated econometric FREEZ model indicates that the model explained 77% of the total variance of the dependent variable. At the same time, 23% volatility of the purchase prices of sour cherries for freezing was not explained by the said model. It can be assumed that such fluctuations in prices are

Table 4. The assessment of structural parameters of FREEZ and PRESS models and properties of the random component

Item	Symbol	Assessment value for FREEZ	Assessement value for PRESS
The Fisher-Snedecor F-test	F	13.304	32.619
Coefficient of determination	R2	0.8180	0.8338
Adjusted R2	adj. R2	0.7725	0.8083
Standard error	Se	0.54327	0.30431
Variation estimator	ve	0.258	0.2065
Mean Absolute Percentage Error	MAPE	0.2136	0.2070
Variance Inflation Factor	VIF	for PROD_PL = 1.2795 for PROD_GE = 1.0627 for STR_PROD = 1.2216	1.0143
The Durbin-Watson test	d	2.1584	2.1265
	dL dU	0.86 1.73	0.98 1.54
The Goldfeld – Quandt test	F	1.864961	1.109466
The Shapiro-Wilk test	W	0.9774	0.9355
Run Test	Ke	9	8
	K1 K2	4 13	4 13

Source: own calculations based on IERiGŻ-PIB, GUS, FAOSTAT data

random or they result from factors that are not included in the model. The deviations between actual values of the purchase prices of sour cherries for freezing and theoretical values, which were estimated using the said model, are PLN 0.54 per 1 kilogramme of sour cherries. Hence, the standard error of the model's assessment is relatively large, which is reflected in the coefficient of variation of the random component (v_e). The average deviation of the model's residuals compared to the average is approximately 26%. The mean absolute percentage error (MAPE) between the estimated value and actual realization is approximately 21%. For the PRESS model, those scores are slightly better, indicating a better fit of the model to empirical data.

In the case of both the FREEZ model and the PRESS model, the evaluation of the properties of the random component (Table 4) indicates that they represent correct parameters. Those parameters include the random distribution of residuals and correct analytical form of the model, no autocorrelation of the random component, the normal distribution of residuals and homogeneity of variance of the random component (homoscedasticity).

SUMMARY

The estimated econometric models – both the FREEZ model and the PRESS model – are statistically significant at the significance level of $p < 0.05$. The above-mentioned models explain approximately 80% volatility in the purchase prices of sour cherries for processing. The sour cherry harvest in Poland and Germany as well as the strawberry harvest in Poland proved to be significant for the formation of the purchase prices of sour cherries. When analysing the results obtained, it can be assumed that there is a causal relationship – between explanatory variables and each of the explained variables – based on economic theories. The market mechanism indicates that the increase in the number of products on the market shifts the supply curve to the right and results in a reduction of the equilibrium price at a specified level of demand [Mankiv, Taylor 2015, p. 121]. Therefore, the increase in sour cherry harvest in Poland contributes to a decrease in the purchase prices of the said fruit. Germany, in turn, is the main consumer of frozen sour cherries from Poland. In Germany, sour cherry production decreased for many years. The reason was, among other things, rising labour costs and the competition of other producers, especially Hungary and Poland [Schwartau 2010]. The supply of German fruit and vegetable processing plants with sour cherries is based on a local raw material base and import. The relatively high sour cherry harvest in Germany may be related to lower demand for imported sour cherries (including those from Poland) and contribute to a decline in the purchase prices of sour cherries in Poland. In turn, strawberries may be a substitute for sour cherries in their further use in processing. In Poland, the harvesting of strawberries takes place earlier than the harvesting of sour cherries, hence the insufficient supply of the fruit and vegetable processing plant with the produce (strawberries) may result in greater demand for their substitute, i.e. sour cherries. At a specified level of supply, the increased demand for sour cherries may contribute to an increase in the purchase prices of sour cherries for processing in Poland. The above-mentioned relationships logically justify the inclusion of all three explanatory variables into the econometric models.

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WYBRANE CZYNNIKI A POZIOM CEN SKUPU WIŚNI DO PRZETWÓRSTWA W POLSCE

Słowa kluczowe: ceny skupu owoców wiśni, owoce do przetwórstwa, produkcja wiśni, determinanty cen, analiza regresji

ABSTRAKT

Celem badań była identyfikacja czynników kształtujących poziom cen skupu wiśni do przetwórstwa w Polsce, a także określenie istotności ich wpływu na poziom cen. Praca swoim zakresem obejmuje dane za lata 2004-2019. Przedmiot badań stanowiły średnioroczne ceny skupu wiśni do mrożenia oraz wiśni do tłoczenia, opublikowane przez Instytut Ekonomiki Rolnictwa i Gospodarki Żywnościowej w miesięczniku *Rynek Owoców i Warzyw*. Do analizy związku pomiędzy cenami skupu wiśni a ich determinantami zastosowano metodę regresji wielorakiej. Estymacji parametrów strukturalnych modeli ekonometrycznych dokonano za pomocą metody najmniejszych kwadratów. Oszacowane modele ekonometryczne wyjaśniają około 80% zmienności cen skupu wiśni do przetwórstwa. Istotne dla kształtowania cen skupu wiśni okazały się zbiory wiśni w Polsce i Niemczech, a także zbiory truskawek w Polsce. Truskawki mogą być substytutem wiśni w przetwórstwie spożywczym, a znaczenie tego czynnika dla kształtowania cen skupu wiśni jest ważnym rezultatem niniejszych badań.

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