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THE BEST TIME TO SELL WHEAT. POLAND AS A CASE STUDY

KIEDY SPRZEDAWAĆ PSZENICĘ – STUDIUM PRZYPADKU DLA POLSKI

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Abstract: Seasonality is a typical phenomenon for agricultural markets, but its scale may be different for individual products. Climatic conditions cause differences in the supply of commodities throughout the year, and this generates price volatility. The aim of the study is to assess the distribution of seasonal fluctuations in wheat prices in Poland in the years 2000-2020 and to determine the optimal moment for selling wheat from the agricultural producer's point of view. The price distribution analysis also took into account the cost of storage. The analysis was based on descriptive statistics and confidence intervals for mean values. The conducted research made it possible to evaluate the price distribution over the subsequent seasons. It's difficult to clearly indicate the most favorable months for selling wheat. There are many indications that it may be January. However, market conditions are so volatile that the situation may change unexpectedly throughout the year.
Keywords: wheat, price, seasonality, storage

Abstrakt: Sezonowość jest zjawiskiem typowym dla rynków rolnych, jednak jej skala może być odmienna dla poszczególnych produktów. Warunki klimatyczne powodują różnice w podaży surowców w ciągu roku, a to generuje zmienność cen. Celem opracowania jest ocena rozkładu wahań sezonowych cen pszenicy w Polsce w latach 2000-2020 oraz określenie optymalnego z punktu widzenia producenta rolnego momentu sprzedaży pszenicy. W analizie rozkładu cen uwzględniono dodatkowo koszt przechowywania. Analizę oparto na statystykach opisowych oraz przedziałach ufności dla wartości średnich. Przeprowadzone badania pozwoliły na ocenę rozkładu cen w ciągu kolejnych sezonów. Jako miesiąc najkorzystniejszy do sprzedaży pszenicy wskazać można styczeń. Ostatecznie jednak kluczowe okazują się koszty przechowania. Warunki rynkowe są jednak na tyle zmienne, że sytuacja może w ciągu roku zmieniać się nieoczekiwanie.
Słowa kluczowe: pszenica, cena, sezonowość, magazynowanie

Introduction

The functioning of agriculture and the agricultural market depends on various factors, the nature of which causes the unpredictable effect of the activity. In this respect, we can talk about factors having the nature of environmental, weather, economic and even political conditions. Within these factors, agriculture is exposed to many threats, but also favorable conditions. A classic example of such a risk factor are weather conditions, which can both destroy the entire production, but also contribute to obtaining above-average and unexpected results. The seasonality of agricultural production is also associated with environmental and weather conditions. Depending on the specific activity, the work schedule during the year can be very different. The effects of this activity, in the form of a product intended for sale, also differ significantly throughout the year. A classic example of this is the production of cereals.

When observing the other side of the agricultural market, namely the demand side (consumers, processing industry, etc.), it can be noticed that the demand for agricultural products is stable and evenly spread over time. Thus, there will often be a gap between supply and demand. According to the laws of the market, this gap will be counterbalanced by prices. The mismatch between supply and demand causes prices in agriculture to fluctuate significantly. Adjusting supply over time makes it

necessary to store and develop food processing and preservation processes.

When analyzing warehouse management, it is noted that an agricultural producer who decides to store production (e.g. cereals after harvest), i.e. incurring the costs of shifting supply over time, expects to obtain some compensation for it. This comes down to expected higher prices over time after the harvest is over. The process of price change isn't so obvious here, however, because the future price isn't a simple sum of the harvest price and the carry-over of costs over time. It also depends on many other factors, e.g. the size of inventories, transport costs, fluctuating prices of other goods, prices on foreign markets, the exchange rate, as well as non-economic factors, such as the government's economic policy. The question arises as to whether the agricultural producer is able to determine the most favorable time to sell his products based on the seasonal distribution of wheat prices. The answer to this question was sought on the basis of the evaluation of wheat prices and their increases in the years 2000-2020 in Poland. From the scientific point of view, the research concerns the verification of the hypothesis of statistical significance of the distribution of seasonal price fluctuations.

Price formation in agriculture

The demand for commodities is more evenly distributed over time than the supply. This causes periodic surpluses, shortages and requires the development of warehouse management (Emback, Raquet, 2011). According to the market law, the existing imbalance should be balanced by prices. On the supply side of agricultural products, three main drivers of price changes are assumed: weather phenomena; slowdown in the growth of grain production and rising oil prices (Flassbeck, Bichetti, Mayer, Rietzler, 2011). On the demand side, population growth and wealth growth are among the most important factors. This causes quantitative and qualitative changes in the demand for food (Nayyar and Dreier, 2017; Prakash, 2011).

Seasonal volatility accompanies many economic phenomena. This can be defined as the systematic movement of a certain amount over the year (Hylleberg, 1992). The sources of seasonal fluctuations are varied and generally result from changing supply and demand conditions throughout the year (Gill, 1991). One well-known example of seasonal fluctuations is the price movement of agricultural products. Many of them are characterized by specific production cycles conditioned by climatic factors. Therefore, the maximum supply occurs during the harvest season.

Seasonality is typical for all agricultural markets, but its scale may differ from product to product (Canova, Hansen, 1995). The increase in the market supply of cereals or potatoes takes place immediately after the harvest, and the increased demand for meat, eggs, fruit and vegetables occurs in the pre-holiday periods. This situation causes prices to behave in an unstable manner throughout the year: lowest during the harvest seasons, followed by a rise, reaching the highest level in the periods before the next harvest. Over the years, a downward trend in seasonal price fluctuations has been observed. This is mainly related to the use of new production and storage technologies (Rembeza, 2015).

Managing the seasonality of agricultural production is very important as the agricultural sector affects other areas of the country's economy. Planning of production and the development of warehouse management should minimize the effects of seasonality of production and consumption (Cetinkaya, 2006).

Part of the price formation is the result of the free market. In periods of increased supply, prices drop, and in periods of lower supply, the price increases. Generally, demand is more stable than supply, which is natural and results from the nature of agricultural production. Prices regulate the market, but this mechanism can be distorted by institutions. The problem of the demand for agricultural products is related to the fact that it is dependent on the consumption of processed food (Rembisz, 2007). A growing national income causes changes in priorities pertaining to the nourishing of society; and thus changes in the structure and volume of demand for agricultural products. Only a small part of the production produced on farms becomes the final good. The vast majority of them are further processed, both by the food industry and by the fuel, textile, paper and other industries. The processing of agricultural commodities involves additional costs of labor, means of production, other commodities, etc. In the final product, the agricultural commodity is only a component part of the product with different, new functional and / or taste qualities, which is used to meet the consumer's needs. As a result, there are significant differences in the prices that consumers pay for their final food products. This phenomenon is referred to as vertical price transmission in marketing traffic. There is no strong relationship between price changes in the vertical structure of the marketing chain (Hamulczuk, Stańko, 2015). As a rule, the prices of final products are more rigid than the prices of agricultural commodities (Świetlik, 2008).

As unprocessed products, such as grains and potatoes, can be stored unprocessed, demand also depends on expectations about future prices. In this respect, the most important role is played by intermediaries and traders managing the warehouse.

Another factor influencing the demand on the domestic market is the demand for products reported from foreign markets. Usually, the size of such demand is determined by the needs of foreign markets and price relationships that take into account changes in exchange rates. However, as economic practice shows, very often non-economic considerations, or more precisely political ones, are involved here. The problem of price relations is quite serious here, as there are many trading companies in the market that take advantage of the price difference. Depending on the situation, they import or export agricultural products. The importing of products manufactured in a given country is particularly controversial.

Fluctuations in prices in the agricultural commodity market over the past decade have been a topic of interest for many researchers. Some of them concern the influence of fundamental factors, others indicate that apart from fundamental factors - the specificity of the agricultural market, macroeconomic and financial factors, there are also others (Flassbeck, Bichetti, Mayer, Rietzler, 2011). Most often among these other factors there is the so-called financing of forward agricultural markets (Mayer, 2009). It manifests in the significant role of financial markets and financial entities in the functioning of agricultural commodity markets.

Financial investors have been active in the agricultural commodity contract markets since the early 1990s. After the stock market bubble in 2000, widespread perceptions began to emerge that commodities hedged positions in capital markets (Mayer, 2009). This encouraged financial investors to expand their activities in forward agricultural markets. The belief in the possibility of securing a position on the commodity market was supported by empirical research, which showed that the rates of return on commodity futures markets were negatively correlated with the rates of return on the stock and bond markets (Gordon, Rouwenhorts, 2004).

It turned out that the activities of institutional financial investors, sometimes called index funds, by others referred to as speculators, make the traditional functions of the futures markets less attractive to farmers and other agricultural producers. Investing for hedging purposes has become too expensive due to the unpredictability of quotes. Long-term hedging against the risk of changes in agricultural commodities become more costly and complicated (Basu, Gavin, 2011).

On the demand side, the most important factors that influenced agricultural prices in the 21st century are related to the growth of the world's human population, economic growth and patterns towards quality agricultural products (Rezitis, Sassi, 2013). The sharp increase in population incomes in emerging economies, together with accelerated economic growth, especially in China and Southeast Asia, has changed the consumption habits of the population. There has been a noticeable increase in meat consumption in these countries. On this basis, it can be concluded: grains are animal feed, and meat consumption in the period 1995-2005 in Asia increased by 50%, this factor can be seen as the main reason for the increase in food prices, as well as volatility, especially in the absence of stocks (Prakash, 2011). Gross Domestic Product is responsible for a significant part of the volatility of agricultural prices between 1971 and 2008 (Gilbert, 2008). This regularity demonstrates the fact that along with further economic development the demand for agricultural commodities will continue to grow, which will result in a further increase in prices.

The instability of risk factors makes it difficult to forecast prices based on fundamental indicators; sometimes simple models based on seasonality can be more effective. This concept was adopted in this study. In the literature there are studies indicating that the phenomenon of price seasonality on agricultural markets is statistically significant (Borowski, Łukasik, 2015). This fact can be used in investment strategies.

Research methodology

Taking into account the presented aspects of price formation in agriculture, it is difficult to forecast future prices. It may turn out that grain sold immediately after the harvest will be more expensive than the harvest that will be stored. Meanwhile, even before the pre-2008 price movements, storage was recommended as potentially more profitable (Schnepf, 2006). On the basis of statistical analyzes of price time series and their increments, an answer was sought concerning the most favorable moment of selling wheat during the season.

In Poland, July is the month when the harvest begins. In the study, the year was adopted as the period from July of a given year to June of the following year (VII-VI). A series of n = 20 years was

analyzed; from t = 1 (2000/2001 season) to t = 20 (2019/2020 season). June is considered the last month in which an agricultural producer will consider selling grain from the last harvest. The analysis was performed in two variants:

1. Prices without correction;
2. Prices adjusted for storage. It was assumed that the monthly cost of storing 1 ton of wheat is PLN 5 (PLN 0.5 for a quintal). It is the average monthly cost of storing wheat, calculated on the basis of observations of prices from plants providing this type of service. July and August are the harvest season, therefore the storage costs are taken into account from September. Thus, the cost of storing 1 quintal from September to June preceding the next harvest is PLN 5 per quintal. The price series are divided into 12 sub-series for each month, respectively:

$$P_{t;l}(l = VII, VIII, \dots, VI)$$

The basic analysis was based on the average values (no price adjustment):

$$\overline{P_l} = \frac{\sum_{t=1}^{n} P_{t;l}}{n}(l = VII, VIII, \dots, VI)$$

where: n - number of years (here n = 20 from the season 2000/2001 (t = 1) to the season 2019/2020 (t = 20))

Additionally, a correction for storage was introduced, then the average value was as follows:

$$\overline{P_l} = \frac{\sum_{t=1}^{n} P_{t;l}}{n}(for\ l = VII, VIII)$$
$$\overline{P_l} = \frac{\sum_{t=1}^{n}(P_{t;l} - 0{,}5)}{n}(for\ l = IX)$$
$$\overline{P_l} = \frac{\sum_{t=1}^{n}(P_{t;l} - 1)}{n}(for\ l = X)$$

etc., up to:

$$\overline{P_l} = \frac{\sum_{t=1}^{n}(P_{t;l} - 5)}{n}(for\ l = VI)$$

For each of the months (l = VII, VIII,…, VI), the standard deviation, positional statistics (min, Q25, median, Q75, max) and 95% confidence interval for the mean value were calculated.

In the second part, the series of price indices were analyzed for the month of July:

$$R_{t;VII} = \frac{P_{t;VII}}{P_{t-1;VI}}$$

and for the remaining months:

$$R_{t;l} = \frac{P_{t;l}}{P_{t;l-1}}(for\ l = VIII, IX, \dots, VI)$$

Price indices were calculated for a series without price adjustment and for a series with storage price adjustment.

As for the price series, the average values and other statistics (standard deviation, min, Q25, median, Q75, max) and the 95% confidence interval for the mean value were also determined for the price index series.

Data subject to analysis

The data subject to analysis are shown in Figure 1. In the period July 2000 – June 2020, wheat prices were subject to high volatility. The lowest level was during the harvest season in 2005, when the quintal was paid for about 35 PLN. In turn, the highest levels were recorded at the turn of 2012 and 2013, when prices exceeded PLN 100 per quarter. Comparing the prices from the period 2000-2013 with the prices from the period 2013-2020, there is a significant difference in their volatility. After 2013, prices stabilized at 60-80 PLN per quintal.

The price adjustment for storage doesn't significantly change the price level. Trends and turning points remain unchanged. The correlation coefficient between the buying-in price of wheat and the buying-in price, taking into account the storage adjustment, is 0.9949.

Month-on-month movements in wheat prices proved to be significant. In one month, the prices could change incidentally even above 20%. The standard deviation of the price indices was 6.13 p.p. over the period under review, and 6.16 p.p. with the storage adjustment. The storage adjustment doesn't significantly change the performance of the price indices. The correlation coefficient between price indices and price indices with the storage adjustment was 0.9067.

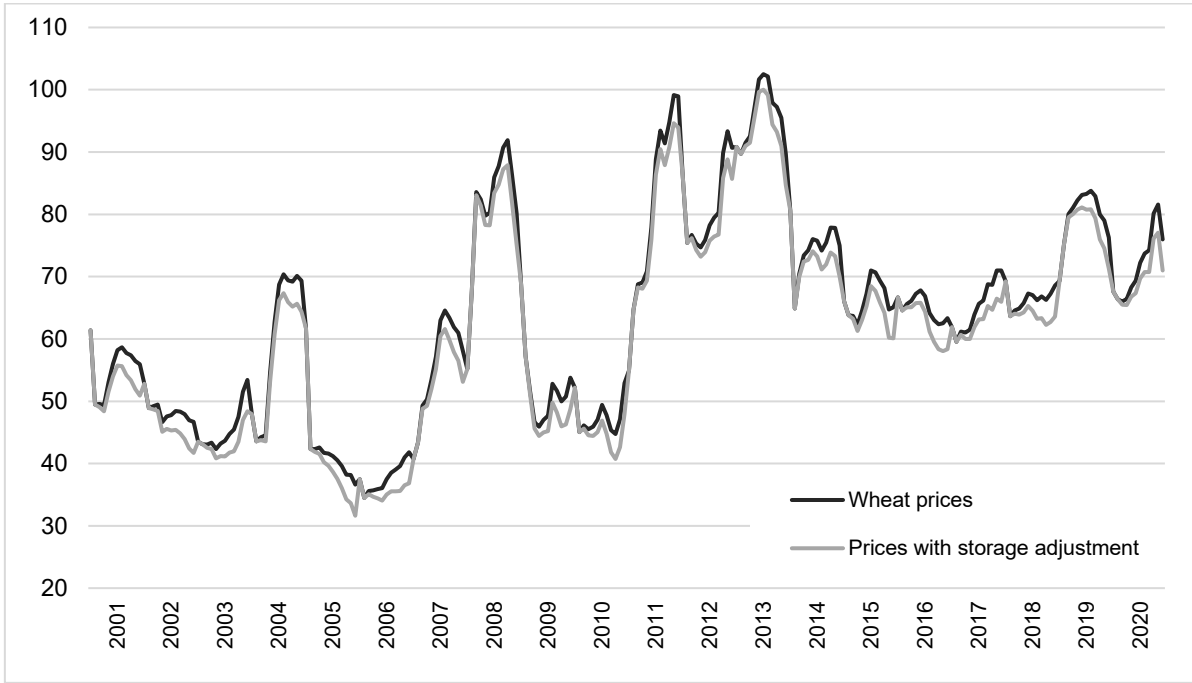

Figure 1. Wheat prices in the period July 2000 – June 2020
Source: own study based on GUS data.

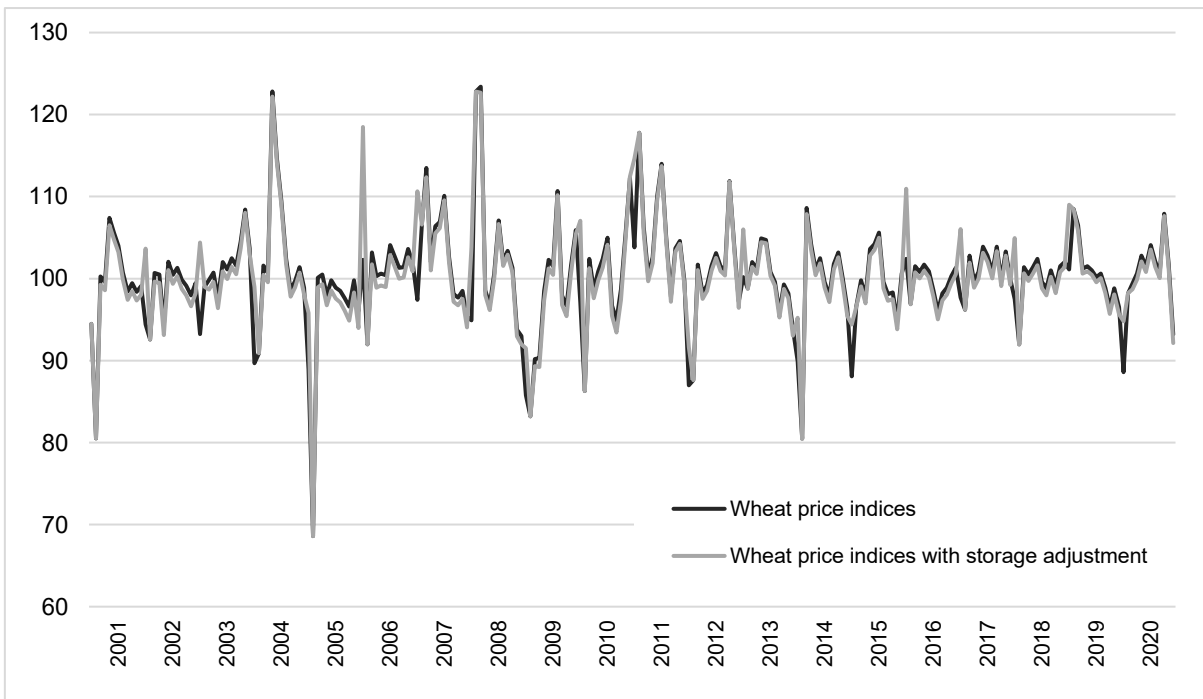

Figure 2. Wheat price indices in the period July 2000 - June 2020, month to previous month
Source: own study based on GUS data.

Assessment of the price level in the period of July 2000 – June 2020

The distribution of prices is presented using basic descriptive statistics. These statistics were compiled for each month from July (beginning of harvest) to June (last month before harvest). As expected, the lowest prices in the analyzed period were found in the summer and early autumn months. During this period, the supply of grain is highest. However, the

situation in July is interesting. This is the first month of the harvest and here the price depends on how quickly the harvest begins and how much stock is left in the warehouse. This is clearly visible when comparing the average value and median of July prices with the average value and median of August, September and October prices. It turns out that the average price in July (61.74) was clearly higher than the August (58.15) and September (60.16), and even October (60.09) price levels. However, the median of July (69.01) prices didn't differ significantly from the median of August (61.60), September (62.45) or October (62.45) prices. Meanwhile, when looking at the third quartile, it is noticeable that its level for July (69.01) clearly differs from the level of the third quartile for August (65.63). Thus, August should be considered here as the month with the lowest grain prices, and the situation of the remaining months, including July, strongly depends on the stock level and the date of the beginning of harvest. Incidentally, prices in July may be at high levels.

The highest cereal prices, in line with the observation of average values and medians, are recorded in the spring period. However, from January onwards, prices are clearly higher than during the harvest season. The maximum of the average price in the analyzed period was in May (67.06), and the maximum of the median of prices in the analyzed period was in March (67.81).

It is quite interesting that June isn't the leading month here. Although it is the last month before harvest, the expectation of a new harvest makes prices this month on average less attractive.

Table 1. Descriptive statistics of the price level in the period July 2000 – June 2020

Month	Price						
	Mean	Standard deviation	Min	Q25	Median	Q75	Max
VII	61.74	14.23	37.47	52.50	61.77	69.01	90.83
VIII	58.15	14.03	34.47	44.30	61.60	65.63	89.70
IX	60.16	15.50	35.58	47.67	62.45	69.62	91.50
X	60.09	15.77	35.68	46.07	61.66	71.23	92.51
XI	61.29	16.00	35.90	46.28	63.01	72.52	97.07
XII	63.44	16.64	36.04	47.31	65.56	75.97	101.68
I	65.72	17.48	37.52	48.59	66.95	77.01	102.50
II	66.40	17.66	38.53	50.60	66.19	76.81	102.13
III	66.04	17.52	39.03	50.01	67.81	77.87	97.94
IV	66.68	18.56	38.23	48.95	67.22	80.06	97.25
V	67.06	18.34	38.15	51.13	65.98	80.29	99.14
VI	66.17	16.63	36.63	53.58	66.85	76.14	98.94

Month	Price with storage adjustment						
	Mean	Standard deviation	Min	Q25	Median	Q75	Max
VII	61.74	14.23	37.47	52.50	61.77	69.01	90.83
VIII	58.15	14.03	34.47	44.30	61.60	65.63	89.70
IX	59.66	15.50	35.08	47.17	61.95	69.12	91.00
X	59.09	15.77	34.68	45.07	60.66	70.23	91.51
XI	59.79	16.00	34.40	44.78	61.51	71.02	95.57
XII	61.44	16.64	34.04	45.31	63.56	73.97	99.68
I	63.22	17.48	35.02	46.09	64.45	74.51	100.00
II	63.40	17.66	35.53	47.60	63.19	73.81	99.13
III	62.54	17.52	35.53	46.51	64.31	74.37	94.44
IV	62.68	18.56	34.23	44.95	63.22	76.06	93.25
V	62.56	18.34	33.65	46.63	61.48	75.79	94.64
VI	61.17	16.63	31.63	48.58	61.85	71.14	93.94

Source: own calculations.

Taking into account the cost of storage in the analysis clearly "flattens" the distribution of prices, it is clearly visible in Figure 3. Although the prices in the summer and autumn periods are still the lowest on average, they don't differ significantly in minus from spring prices. The lowest average price was recorded in August (58.15), and the highest in February (63.40). However, for the median, the difference is even smaller. The lowest median value was recorded in October (60.66) and the highest in January (64.45). In line with the average values obtained, the best months for selling wheat here are the winter months – January and February. The storage-adjusted price is the highest for these months. It should be noted, however, that each of the average prices for the given months is composed of a relatively high standard deviation, reaching about 14-18 PLN. The effect of this is such that the confidence intervals for the value of the average price for individual months "overlap". The phenomena discussed are shown in Figure 3. Here, we can see a flattened distribution of prices with an adjustment for storage and confidence intervals for the mean value with a significant spread.

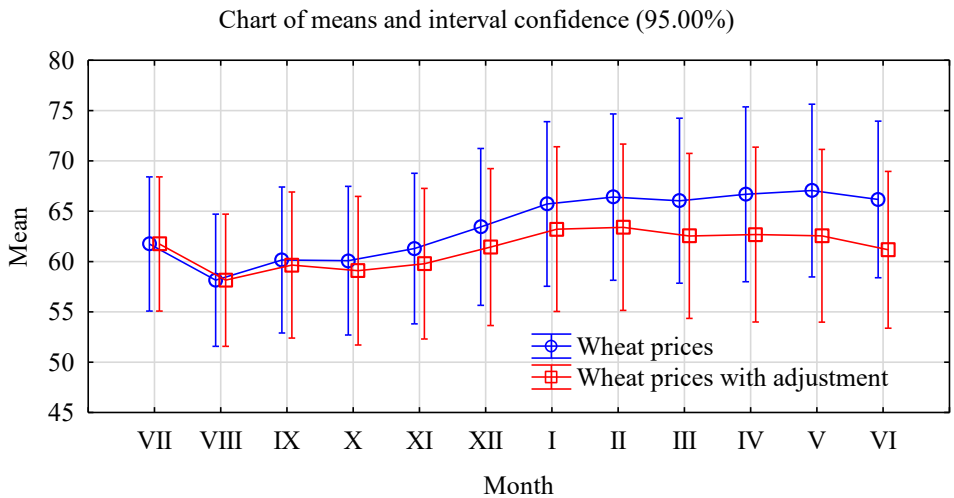

Figure 3. Distribution of average wheat prices with a confidence interval

Assessment of the value of price indices in the period July 2000 – June 2020

Apart from the price value itself, it is worth paying attention to price changes. The prices are presented as indices. Table 2 presents the basic descriptive statistics of price indices for individual months. The presented values show that the worst situation concerns July and August. The average prices dropped in these months by about 5% compared to the previous month. Accumulating the effects, August turns out to be the least favorable month for sale. At the same time, August is characterized by the greatest differentiation as measured by standard deviation. Comparing month to month, September turns out to be a good month for sales, as the average increase in relation to August exceeds 3% here.

December is also a good month compared to November, and January compared to December. During these months the average values are at high levels, but also the minimum values are slightly less than 100.

After adjusting for storage costs, the situation changes significantly. It turns out that the prices of the new grain in July are more attractive than the prices of last year's grain. This can be considered as an expected situation. The average values of price indices are clearly above 100, recorded for the months of September, November, December and January. Also until February and May they are close to 100. This situation suggests that January is the best month to sell.

Figure 4 shows the mean values of price indices along with the confidence interval. On its basis, the month of January can be defined as the most favorable month for selling wheat. Until this month, price increases are rapidly accumulating. Also the price index for February is on average higher than 100, but here the increase is not as large as it was until January.

Table 2. Descriptive statistics of price indices in the period July 2000 – June 2020

Month	Price						
	Mean	Standard deviation	Min	Q25	Median	Q75	Max
VII	94.72	5.64	85.80	89.30	94.69	98.95	103.80
VIII	94.78	12.74	68.60	86.95	94.39	98.91	122.80
IX	103.26	6.52	90.20	100.17	101.65	104.75	123.40
X	99.82	2.64	90.30	99.16	100.49	100.77	104.20
XI	102.15	5.81	94.29	98.85	101.25	103.20	122.80
XII	103.47	3.61	99.80	101.25	102.35	104.45	114.70
I	103.51	4.13	98.60	100.32	102.95	105.30	114.00
II	101.12	3.18	96.00	99.20	101.06	102.45	110.70
III	99.45	2.35	94.90	98.00	98.75	101.15	103.90
IV	100.69	3.91	96.50	98.50	99.36	102.30	111.90
V	100.80	3.51	93.80	98.44	100.85	103.45	108.40
VI	99.33	4.63	93.00	96.20	99.26	101.65	112.30

Month	Price indices M/M with storage adjustment						
	Mean	Standard deviation	Min	Q25	Median	Q75	Max
VII	102.82	7.87	91.51	95.01	104.12	108.03	118.47
VIII	94.77	12.74	68.60	86.95	94.40	98.88	122.80
IX	102.35	6.55	89.33	99.15	100.91	103.73	122.66
X	98.93	2.69	89.23	98.29	99.52	99.95	103.50
XI	101.28	5.92	93.14	97.94	100.50	102.44	122.18
XII	102.67	3.74	98.55	100.63	101.30	103.90	114.17
I	102.75	4.30	97.58	99.47	102.27	104.55	113.71
II	100.31	3.31	95.04	98.39	100.17	101.51	110.19
III	98.57	2.49	93.44	97.19	98.03	100.31	103.34
IV	99.85	4.21	94.88	97.44	98.60	101.70	111.83
V	100.00	3.69	92.95	97.56	100.04	102.69	108.02
VI	98.45	4.91	92.00	94.75	98.14	100.71	112.43

Source: own calculations.

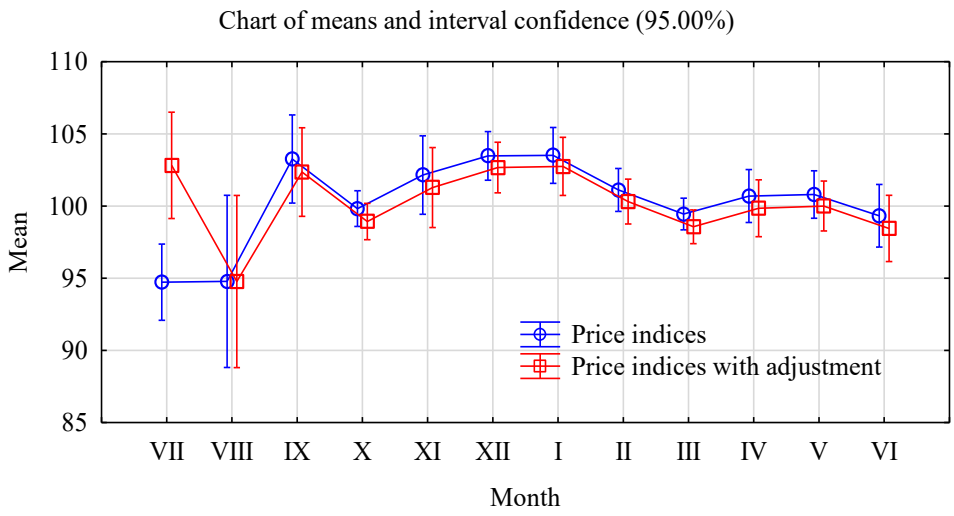

Figure 4. Distribution of average wheat price indices with confidence interval

Conclusions

The presented research focuses on one aspect of the problem of price formation in agriculture, i.e. seasonal fluctuations in wheat prices. A number of aspects that could potentially affect the price level were omitted, such as the volume of supply, prices abroad, stock levels in storage, grain quality, and others. An analysis limited to the price distribution itself doesn't require the estimation of econometric models. Of course, the use of econometric modeling allows for a better understanding of the pricing process. But it can't always be used for effective forecasting, as it requires estimating the size of the variables that explain the price. Sometimes this simple analysis, limited to the evaluation of the distribution, may prove more effective.

The obtained results give interesting conclusions:

1. Waiting to sell grain until June, so a strategy according to which the smaller the stocks in the warehouses, the higher the price, isn't effective. With the next harvest in the July-August period ahead, and thus a surge in supply, prices in June usually turned out to be unattractive.
2. Excluding storage costs, the highest average price was recorded in May; but after adjusting the price for storage costs, the most attractive prices were recorded in January and February on average.
3. On a yearly basis, the lowest prices were recorded on average in August, which is the month of the peak of the harvest work, when the supply of grain is the highest. This result can be considered as expected.
4. The month of August is the month with the greatest uncertainty as to price changes. It can be assumed that this is due to the prevailing weather conditions and the influence on the grain supply.
5. September is characterized by one of the highest monthly price increases on average. If long-term storage isn't possible (until January / February), it is worth considering delaying the sale from August to September.
6. All average prices (obtained for individual months) have relatively high standard deviations, which makes any strategy risky.

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