
ANNALS OF THE POLISH ASSOCIATION OF AGRICULTURAL AND AGRIBUSINESS ECONOMISTS

ROCZNIKI NAUKOWE
STOWARZYSZENIA EKONOMISTÓW ROLNICTWA I AGROBIZNESU

Received: 24.09.2024
Acceptance: 09.12.2024
Published: 16.12.2024

Annals PAAAE • 2024 • Vol. XXVI • No. (4)

JEL codes: J21, K31, M54, N30, R23



DOI: 10.5604/01.3001.0054.8800

BEATA KALINOWSKA, PIOTR BÓRAWSKI¹

University of Warmia and Mazury in Olsztyn, Poland

FACTORS INFLUENCING GRAIN PRICES IN POLAND²

Key words: cereal market, international trade, cereal prices, demand, supply

ABSTRACT. The main aim of this study was to identify the factors that affected prices on the Polish grain market in 2005-2023. The analysis relied mainly on Statistics Poland data concerning the area under cereal production, grain yields, grain production, grain prices, grain imports and exports, and grain consumption. The research used the multiple regression method, which allowed to identify the factors determining the prices of wheat and rye. In Poland, the total area under cereal production decreased by 13.7% between 2005 and 2023. In the analyzed period, an increase was observed in the yields of wheat (36.2%), rye (47.3%), barley (39.4%), oat (25.2%), triticale (37.0%), mixed grains (19.5%), and grain maize (27.23%). Between 2005 and 2023, total grain yields increased by 33.1%, and the yields of the major cereal crops increased by 21.9%. Research shows that harvests in the world, in the EU and in Poland, as well as the area under wheat cultivation, are the factors shaping wheat prices in Poland. Wheat prices are therefore global and depend on changes in world markets. Global market trends determine wheat purchase prices and affect the profitability of production. The factors influencing the price of rye include the area of rye cultivation and bread consumption. Rye finds buyers mainly on the domestic market and is used in the food and feed industry. The reduction in animal production in the country resulted in reduced demand for rye for feed purposes.

¹ Corresponding author: pboraw@uwm.edu.pl

² The results presented in this paper were obtained as part of a comprehensive study financed by the University of Warmia and Mazury in Olsztyn, Faculty of Agriculture and Forestry, Department of Agrotechnology and Agribusiness (Grant. No 30.610.012-110).

INTRODUCTION

Prices in the agribusiness sector vary considerably because agriculture is far more sensitive to fluctuations in economic activity than other sectors of the national economy. The prices of agri-food products are determined mainly by differences between demand and supply. Price differences significantly affect trade and consumer decisions [Zaród 2017].

According to Agnieszka Hajdukiewicz [2014], among the factors influencing the prices of agricultural and food products, there are structural and cyclical factors. The author included the following structural factors: increase in world population; high rates of economic growth in developing countries; changes in dietary patterns in developing countries; slight increase in food production over the last 20 years; energy-intensive and raw-material-intensive nature of economic growth in newly industrialized countries, leading to increases in energy prices; growing production expenditure (including the production of fertilizers, plant protection products, fuels, irrigation) and transport costs resulting from the increase in fuel prices; creation and development of new sales markets, e.g. the biofuel market. Agnieszka Hajdukiewicz [2014] included short-term (cyclical) factors: anomalies and extreme weather phenomena that cause temporary problems in agricultural production (by limiting it) and international trade in agri-food products; changes in exchange rates; increased investment in the futures market (based on agricultural raw materials); cyclical fluctuations in oil prices and short-term trade and economic policy moves (customs duties, tariff quotas, export subsidies).

Cereal grain is a strategic resource because it is widely consumed and processed in various industries. Cereals not only play a key role in human and animal nutrition, but are also used in the pharmaceutical, textile, cosmetics, and energy industries. For this reason, grain market crises have significant economic and social consequences both on the domestic and global scale. The early 2020s witnessed the COVID-19 pandemic and the outbreak of the war in Ukraine. The Russian invasion of Ukraine had particularly serious implications for the grain market because both parties to the conflict are the world's leading producers and exporters of grain. Many Ukrainian farms have been destroyed, which disrupted Ukrainian grain exports and led to a rapid increase in grain prices on global markets in the first half of 2022. The Black Sea Grain Initiative [EC 2024] helped mitigate price shocks and reduce grain prices on international markets in successive months. This initiative promoted food and fertilizer exports from three key Ukrainian ports on the Black Sea: Odessa, Chornomorsk, and Pivdennyi (formerly Yuzhnyi) [Gołębiewski and Stefańczyk 2023]. According to the United Nations [ONZ 2023], more than 30 mln tons of Ukrainian grain had been exported through the Black Sea Grain Initiative by July 2023. In 2023, Russia announced its decision to end the initiative, arguing that its demands to improve Russian food and fertilizer exports had not been met and that too little Ukrainian grain had reached developing countries [Nichols 2023].

The Ukrainian crisis has significantly influenced the performance of grain markets and agricultural sectors in many countries, including Poland. As one of the leading grain producers in Europe and a significant exporter of wheat and maize, Poland is particularly vulnerable to changes on international markets. Consequently, any fluctuations on global markets directly affect the performance of Polish businesses that produce, process, and trade in grain [Gołębiewski and Stefańczyk 2023].

FACTORS INFLUENCING GRAIN PRICES IN POLAND

The prices of agricultural commodities, including grain, are determined by the factors that affect demand and supply, as well as exogenous shocks. In the longer term, changes in food demand are shaped mainly by population and income growth, but also by fluctuations in relative prices and changes in consumption patterns. The demand for agricultural products is also closely linked to business cycles in the economy [Hamulczuk et al. 2016].

A long-term increase in the supply of agricultural commodities is driven mainly by technological progress, which contributes to a decrease in production costs. In the past, the increase in food supply resulting from technological progress often outpaced the rise in demand, which, in turn, was determined by population and income growth. These factors were responsible for a long-term decline in the relative prices of grain. However, this situation began to change in recent years because the income-driven rise in demand for food and biofuels in emerging economies exceeded the increase in supply. The above led to an increase in grain prices, including relative prices. At present, supply-side expansion is constrained in the short term mainly by the prices and availability of key agricultural inputs, and in the longer term, by the availability of land, water, and labor, and climate change [Gołębiewski and Stefańczyk 2023].

Supply and demand shocks constitute the second group of factors that contribute to price volatility. In the short term, the forces of demand and supply on agricultural markets, including the grain market, are relatively inelastic and unresponsive to price changes, leading to large price swings in the face of shocks. Supply shocks play a particularly important role on the grain market because agricultural production is highly dependent on agrometeorological conditions [Campbell et al. 2016]. According to Mariusz Hamulczuk et al. [2016], changes in agrometeorological conditions are less likely to affect specific countries than global markets, particularly the leading exporters and importers of agricultural products. The impact of demand and supply shocks on grain prices can be mitigated by controlling grain reserves. Therefore, prices are influenced mainly by the relationship between supply and demand – a low stocks-to-use ratio puts upward pressure on grain prices.

Other key factors that affect grain prices include tax regulations, agricultural and trade policies, food speculation [Kalkuhl et al. 2016], and oil prices [Roman et al. 2020]. It should also be noted that the markets and prices of agricultural commodities, including grain, do not respond immediately to demand and supply shocks. In most cases, the effects of supply shocks are less persistent than the effects of demand shocks [Gołębiewski and Stefańczyk 2023].

MATERIAL AND METHODS

The main aim of this study was to identify the factors that affected prices on the Polish grain market in 2005-2023. The analysis relied on Statistics Poland data concerning the area under cereal production, grain yields, grain production, grain prices, grain imports and exports, and grain consumption.

The factors that affect prices on the Polish grain market were identified with the use of a multiple regression model. A generalized regression model with endogenous and exogenous variables can be presented as the following equation [Krysicki et al. 1995]:

$$Y = \beta_0 + \beta_1 X_1 + \dots + \beta_k X_k + \gamma_1 Z_1 + \dots + \gamma_l Z_l + \varepsilon$$

where:

Y – dependent variable representing the examined phenomenon, β_0 – intercept, X_1, \dots, X_k – endogenous variables explained by other variables in the system, Z_1, \dots, Z_l – exogenous variables that are external to the model, β_1, \dots, β_k and $\gamma_1, \dots, \gamma_l$ – regression coefficients corresponding to explanatory variables, ε – residuals.

The following factors were analyzed to identify the key determinants of wheat prices: Y_1 – wheat price, X_1 – wheat yields, X_2 – area under wheat, X_3 – wheat production in Poland, X_4 – bread consumption, X_5 – balance of trade in wheat, X_6 – consumption of grain and cereal products (in kg of flour *per capita*), X_7 – global wheat production, X_8 – wheat production in the EU.

The following factors were analyzed to identify the key determinants of rye prices: Y_2 – rye price, X_1 – rye yields, X_2 – area under rye, X_3 – rye production in Poland, X_4 – bread consumption, X_5 – balance of trade in rye, X_6 – consumption of grain and cereal products (in kg of flour *per capita*), X_7 – global rye production, X_8 – rye production in the EU.

RESULTS

The world population increased by 20% in 2005-2021 (in 2005 it was 658.18 million, in 2021 790.93 million), in the EU-27 by 2.87% (in 2005 it was 432.63 million inhabitants, and in 2021 – 445.05 million). During the same period, the population in Poland decreased by 0.7% – in 2005 it was 38.58 million, and 38.31 million in 2021 (Figure 1). The presented data indicate that the increase in population will result in an increase in demand for food, including cereals and their products. Cereals are a basic food raw material that cannot be replaced by another substitute. An increase in the world's population will result in increased pressure on agriculture to increase production, which will have negative consequences for the natural environment.

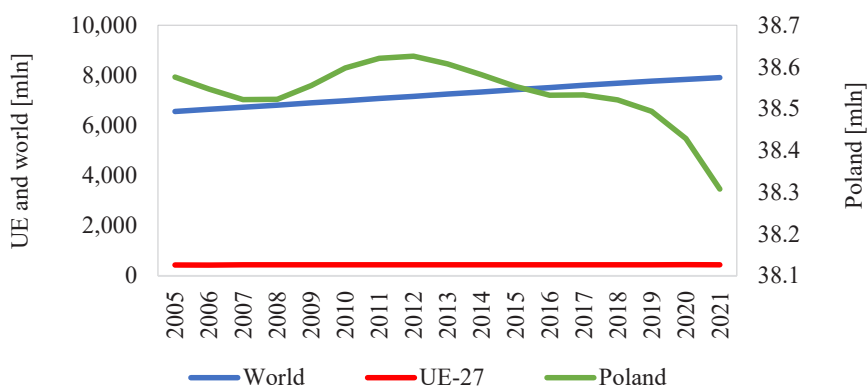


Figure 1. Population in the world, in the EU-27 and in Poland in 2005-2021

Source: own study based on FAO data [2005-2021]

In 2005, wheat production in Poland accounted for 1.40% of global wheat production and 7.24% of wheat production in the EU-27. In 2022, wheat production in Poland accounted for 1.63% of global wheat production (increase of 0.23% relative to 2005) and 9.82% of wheat production in the EU-27 (increase of 2.58% relative to 2005) (Figure 2). These data prove that wheat production in the world, in the EU and in Poland follows the growth of the world population

In 2005, rye production in Poland accounted for 22.37% of global rye production and 44.48% of rye production in the EU. In 2022, the above parameters decreased by 4.59% and 13.11%, respectively, relative to 2005. In 2022, rye production in Poland accounted for 17.78% of global rye production and 31.37% of rye production in the EU-27 (Figure 3).

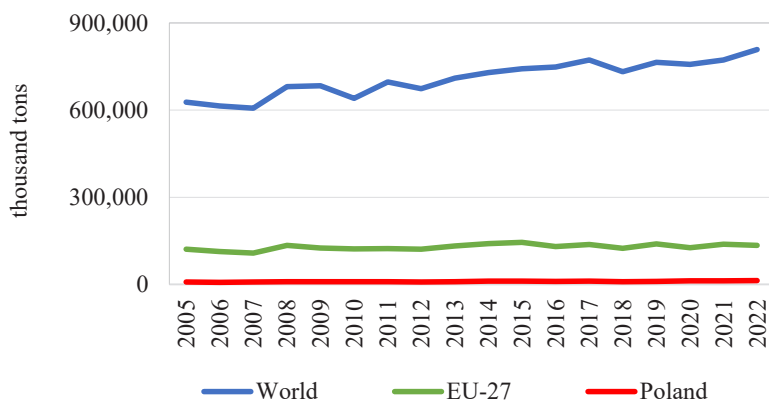


Figure 2. Wheat production in the world, EU-27, and Poland in 2005-2023

Source: own elaboration based on FAO data [2005-2022]

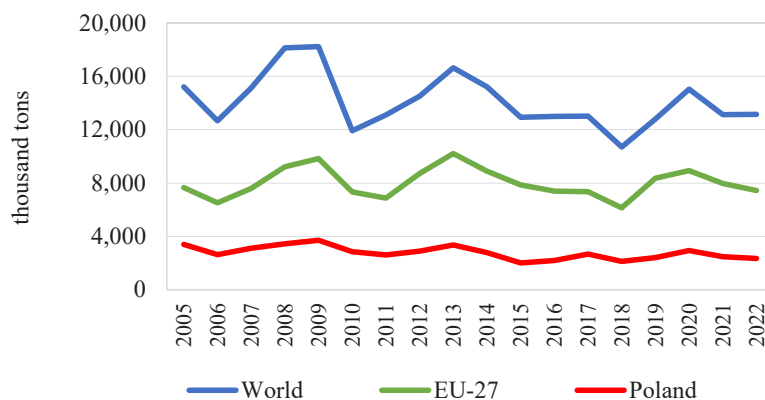


Figure 3. Rye production in the world, EU-27, and Poland in 2005-2023

Source: own elaboration based on FAO data [2005-2022]

Due to its high calorific value and high prices, rye is a less popular raw material than wheat, but it is widely used in the food industry for the production of e.g. flour, pasta and cakes. However, products derived from rye are more often consumed by wealthier consumers.

The population in Poland in the years 2005-2023 decreased by 0.52 million people (in 2005 it was 38.16 million, in 2023 – 37.64 million), while the average monthly disposable income per person increased by 1,916, PLN 84 (in 2005 it was PLN 761.46, and in 2023 – PLN 2,678.30) (Figure 4). These data prove that Polish society is becoming richer. The pursuit of prosperity results in a decrease in the birth rate. Moreover, after

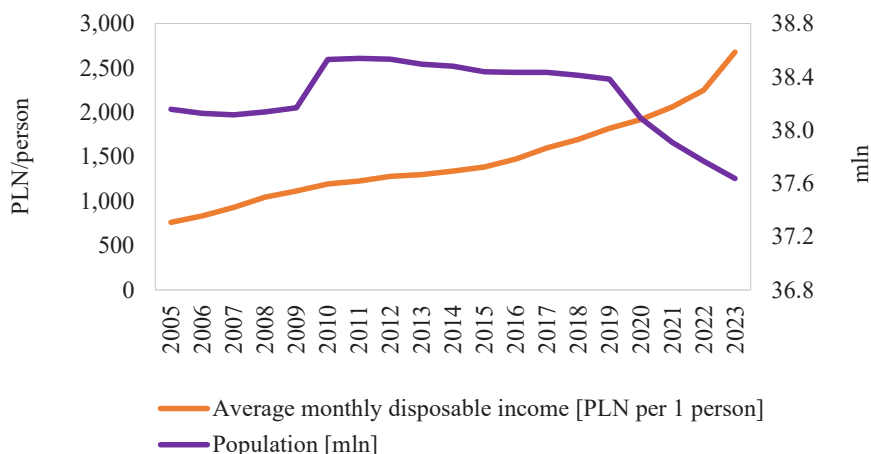


Figure 4. Population and average monthly disposable income per person in Poland 2005-2023
Source: own study based on GUS BDL data [2005-2023]

accession to the EU, part of the population emigrated to EU countries, contributing to the economies of these countries.

Total area under cereals in Poland decreased by 13.70% between 2005 and 2023. The area under major cereal crops also decreased by 14.76% in the analyzed period. Between 2005 and 2023, an increase was observed in the area under wheat (by 10.42%), triticale (by 0.56%), and grain maize (by 270.02%). In turn, a decrease was noted in the area under rye (by 48.56%), barley (by 41.83%), oats (by 7.70%), and mixed grains (by 80.21%) (Table 1).

The increase in the cultivation of wheat and corn for grain indicates a greater demand for these raw materials and products. Corn is increasingly used in the petrochemical industry to produce bioethanol. However, the increase in the area under wheat cultivation results from the increased demand for bread and other cereal products. The area of feed grain cultivation decreased mainly as a result of limited demand for feed, which in turn results from the decreasing share of animal production.

Between 2005 and 2023, wheat was a cereal crop with the largest acreage in Poland. The smallest area was occupied by grain maize in 2005 and by mixed grains in 2023. The yields of all examined grain crops increased in the analyzed period (Table 2). In 2023, yields per hectare were highest in maize (72.9 dt/ha) and lowest in oats (30.8 dt/ha). Poland has good climatic conditions for growing cereals. The increase in cereal yield also results from breeding progress, thanks to which new, more resistant varieties of cereals are introduced, including: to changing climatic conditions, lodging and cereal diseases. Another factor determining the increase in cereal yields may be the correct use of mechanization, tillage and chemicalization by farmers.

Table 1. Area under cereals in Poland in 2005-2023

Year	Area [thousand ha]								
	total	major cereals	wheat	rye	barley	oats	triticale	mixed grains	grain maize
2005	8,329	6,480	2,218	1,415	1,113	539	1,195	1,436	339
2006	8,381	6,448	2,176	1,318	1,221	539	1,194	1,544	303
2007	8,353	6,503	2,112	1,316	1,232	583	1,260	1,505	262
2008	8,599	6,765	2,278	1,397	1,207	551	1,333	1,444	317
2009	8,583	6,889	2,346	1,396	1,157	525	1,465	1,340	274
2010	7,638	6,086	2,142	1,063	974	577	1,330	1,100	334
2011	7,803	6,178	2,259	1,085	1,018	546	1,269	1,199	333
2012	7,704	5,785	2,077	1,042	1,161	514	992	1,278	544
2013	7,479	5,741	2,138	1,173	820	434	1,177	1,012	614
2014	7,485	5,818	2,339	886	808	479	1,306	881	678
2015	7,512	5,937	2,395	725	839	461	1,516	813	670
2016	7,462	5,953	2,384	761	926	478	1,404	806	595
2017	7,602	6,062	2,392	873	954	491	1,352	880	562
2018	7,806	6,072	2,417	894	976	497	1,288	993	645
2019	7,891	6,201	2,511	904	975	495	1,315	932	665
2020	7,467	5,815	2,391	851	676	506	1,391	590	946
2021	7,451	5,682	2,391	762	721	527	1,282	654	998
2022	7,197	5,519	2,518	662	639	466	1,233	345	1,196
2023	7,188	5,524	2,449	728	648	498	1,201	284	1,256
Change 2023/2005	86.3	85.2	110.4	51.4	58.2	92.30	100.6	19.9	370.0

Source: own elaboration based on Statistics Poland data [GUS 2005-2023]

Cereal harvests are a result of yields and area. In 2005-2023, total grain production in Poland increased by 33.14%, and the production of major cereals increased by 21.89%. The greatest increase was reported in maize (+370.45%) and wheat (+50.23%) production and resulted from the increased use of these plants in the food, feed and petrochemical industries. A decrease was noted in the production of mixed grains (-76.44%), barley (-18.88%), and rye (-24.18%). This is due to the fact that more and more farms in Poland are ceasing animal production, which causes a decrease in interest in growing feed grains (Table 3).

Table 2. Grain yields in Poland in 2005-2023

Year	Grain yields [dt]								
	total	major cereals	wheat	rye	barley	oats	triticale	mixed grains	grain maize
2005	32.3	32.4	39.5	24.1	32.2	24.6	32.7	27.3	57.3
2006	26.0	26.5	32.4	19.9	25.9	19.2	26.8	21.9	41.6
2007	32.5	32.4	39.4	23.7	32.5	25.1	32.9	28.3	65.7
2008	32.2	32.6	40.7	24.7	30.0	22.9	33.4	25.4	58.1
2009	34.8	35.0	41.7	26.6	34.4	26.9	35.7	29.0	62.3
2010	35.6	35.7	43.9	26.8	34.9	26.3	34.4	30.3	59.7
2011	34.3	33.8	41.3	24.0	32.7	25.3	33.4	28.1	71.8
2012	37.0	35.4	41.4	27.7	36.0	28.6	33.8	30.7	73.5
2013	38.0	37.0	44.4	28.6	35.8	27.4	36.3	29.8	65.8
2014	42.7	41.9	49.7	31.5	40.5	30.5	40.2	33.2	65.9
2015	37.3	37.9	45.7	27.8	35.3	26.5	35.2	27.7	47.1
2016	40.0	38.5	45.4	28.9	37.2	28.4	36.4	30.0	72.9
2017	42.0	41.1	48.8	30.6	39.8	29.8	39.3	32.3	71.5
2018	34.3	33.4	40.6	24.2	31.2	23.5	31.7	25.2	59.9
2019	36.7	36.6	43.9	27.2	34.6	24.9	34.9	26.5	56.2
2020	47.8	45.8	53.3	35.1	44.4	33.1	44.6	35.2	72.1
2021	46.5	43.6	50.7	33.1	41.8	31.4	42.5	34.1	74.7
2022	49.5	46.6	53.4	36.0	44.3	32.8	45.0	34.5	71.1
2023	49.9	46.3	53.8	35.5	44.9	30.8	44.8	32.5	72.9
Change 2023/2005	154.5	142.9	136.2	147.3	139.4	125.2	137.0	119.1	127.2

Source: own elaboration based on Statistics Poland data [GUS 2005-2023]

In Poland, in the years 2005-2023, the most wheat grains were collected (in 2005 it was 877 thousand tons, and in 2023 – 1,318 thousand tons), while in 2014 the least oat grains were harvested – 1,324 thousand tons, and in 2023 grains of cereal mixtures (923 thousand tons). Wheat was the leading cereal crop in Poland throughout the analyzed period (877 thousand tons in 2005, 1,318 thousand tons in 2023). In 2014, the lowest production was noted in oats (1,324 thousand tons), whereas in 2023, mixed grains were characterized by the lowest production volume (923 thousand tons). The prices of all examined grain crops increased between 2005 and 2023 (by 169.26% in

Table 3. Grain production in Poland in 2005-2023

Year	Grain production [thousand tons]								
	total	major cereals	wheat	rye	barley	oats	triticale	mixed grains	grain maize
2005	26,928	20,984	8,771	3,404	3,581	1,324	3,903	3,916	1,945
2006	21,776	17,074	7,060	2,622	3,161	1,035	3,197	3,379	1,261
2007	27,143	21,060	8,317	3,126	4,008	1,462	4,147	4,257	1,722
2008	27,664	22,065	9,275	3,449	3,619	1,262	4,460	3,673	1,844
2009	29,827	24,136	9,790	3,713	3,984	1,415	5,234	3,884	1,707
2010	27,228	21,749	9,408	2,852	3,397	1,517	4,576	3,339	1,994
2011	26,767	20,883	9,339	2,601	3,326	1,382	4,235	3,373	2,392
2012	28,544	20,493	8,608	2,888	4,180	1,468	3,349	3,920	3,996
2013	28,455	21,241	9,485	3,359	2,934	1,190	4,273	3,021	4,040
2014	31,945	24,401	11,629	2,793	3,275	1,459	5,247	2,922	4,468
2015	28,003	22,491	10,958	2,013	2,961	1,220	5,339	2,250	3,156
2016	29,849	22,929	10,828	2,200	3,441	1,358	5,102	2,415	4,343
2017	31,925	24,909	11,666	2,674	3,793	1,465	5,312	2,847	4,022
2018	26,780	20,287	9,820	2,167	3,048	1,166	4,086	2,506	3,864
2019	28,990	22,664	11,012	2,461	3,374	1,233	4,583	2,472	3,734
2020	35,695	26,623	12,752	2,985	3,004	1,678	6,203	2,078	6,821
2021	34,641	24,763	12,119	2,520	3,018	1,656	5,451	2,232	7,461
2022	35,651	25,734	13,445	2,381	2,835	1,529	5,543	1,191	8,503
2023	35,851	25,578	13,178	2,581	2,905	1,532	5,383	923	9,152
Change 2023/2005	133.14	121.89	150.23	75.82	81.12	115.69	137.91	23.56	470.45

Source: own elaboration based on Statistics Poland data [GUS 2005-2023]

wheat, by 162.19% in rye, by 135.46% in barley, by 201.72% in oats and mixed grains, by 182.43% in triticale, and by 115.18% in grain maize) (Table 4).

Prices in Poland result in particular from changes in prices quoted on the Matif exchange. Access to the EU market and, consequently, to world markets, has made external factors more important. One such factor was the outbreak of war in Ukraine in 2022, which in the initial period resulted in a reduction in production in this country and an increase in prices on world markets. At the same time, there were changes in global transport and after it was stopped by the Black Sea, grain transport was redirected through Poland and other EU countries. Additional large harvests in the world in 2023 caused by favorable

Table 4. Grain prices in Poland in 2005-2023

Year	Grain prices [PLN/ton]					
	wheat	rye	barley	oats and mixed grains	triticale	grain maize
2005	366.9	276.4	373.4	291.5	308.5	351.2
2006	447.6	385.2	402.4	348.5	368.8	447.5
2007	706.8	602.1	641.1	528.3	611.1	659.3
2008	642.4	516.5	643.7	503.4	529.0	527.9
2009	482.6	327.4	408.0	308.2	370.5	442.8
2010	598.4	421.2	489.8	343.0	466.5	589.8
2011	819.9	742.4	753.8	643.4	720.1	677.2
2012	893.4	742.3	819.1	650.7	800.0	728.5
2013	796.7	553.6	733.4	526.7	651.7	668.7
2014	683.6	533.4	626.7	503.9	590.0	541.3
2015	668.3	514.2	610.4	483.5	562.3	565.8
2016	620.2	517.3	582.1	512.9	571.9	529.4
2017	664.4	546.7	612.2	514.3	583.4	542.3
2018	726.2	596.7	679.6	582.4	660.6	619.3
2019	722.6	603.8	673.7	616.5	648.7	598.2
2020	748.6	559.7	636.3	572.7	626.3	599.0
2021	967.6	753.6	782.7	636.9	829.6	802.6
2022	1,519.9	1,207.9	1,299.6	1,131.5	1,354.0	1,169.5
2023	987.9	724.7	879.2	879.5	871.3	755.7
Change 2023/2005	269.26	262.19	235.46	301.72	282.43	215.18

Source: own elaboration based on Statistics Poland data [GUS 2005-2023]

climatic conditions resulted in a decline in grain prices in 2023 in Poland and other EU countries, causing consequences in the form of strikes.

Wheat grain was characterized by the highest prices throughout the analyzed period (PLN 366.9 per ton in 2005, PLN 987.9 per ton in 2023). The prices of all examined grains peaked in 2022 (Table 4).

The volume of grain processed in the food industry decreased in the 2023/2024 season, mainly due to a population decrease resulting from a negative migration balance (many war refugees returned to Ukraine). As a result, domestic demand decreased by more than 4% relative to the previous season. In addition, a rapid decline in the prices of cereal

products and lower inflation in the first half of the year decreased demand, in particular for cheaper foods, including cereal-based foods. The above contributed to a decrease in cereal consumption *per capita* [Łopaciuk et al. 2024].

In the analyzed period, monthly consumption of bread and cereal products decreased from 8.44 kg *per capita* in 2005 to 5.11 kg *per capita* in 2022 (Figure 5). In the analyzed period, the annual consumption of four cereal grains (cereal-based foods) decreased by 16 kg from 119 kg *per capita* in 2005 to 103 kg *per capita* in 2022 (Figure 6).

Total grain imports increased by 379.96% between 2005 and 2023. In the analyzed period, an increase was also observed in the imports of wheat (392.02%), rye (100.00%), barley (72.64%), oats (1020.00%), and grain maize (691.55%) (Table 5). Poland is a significant producer of cereals in the EU. Import is carried out by land, mainly from Poland's largest trading partner, Germany.

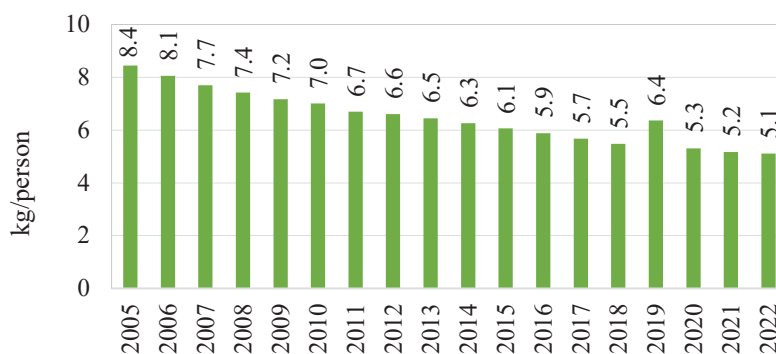


Figure 5. Average monthly consumption of bread and cereal products in Poland in 2005-2022
Source: own elaboration based on Statistics Poland data [GUS 2006-2022]

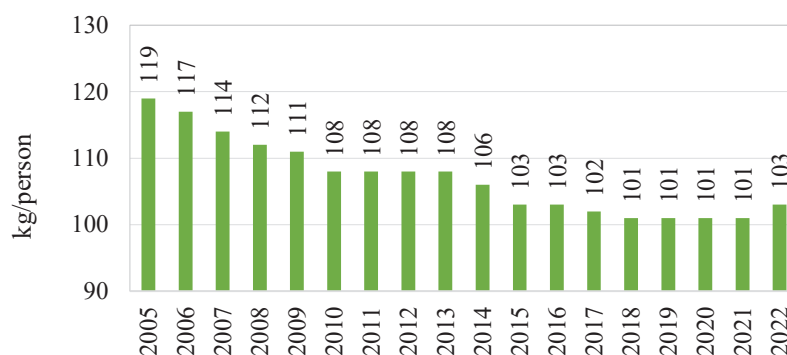


Figure 6. Annual consumption of four cereal grains (cereal-based foods) in Poland
Source: own elaboration based on Statistics Poland data [GUS 2006-2022]

Table 5. Polish grain imports in 2005-2023

Year	Imports [thousand tons]					
	total	wheat	rye	barley	oats	maize
2005/2006	978.0	376.0	12.0	296.0	5.0	284.0
2006/2007	3,502.0	1,667.0	124.0	620.0	7.0	1,068.0
2007/2008	2,147.0	763.0	37.0	529.0	9.0	783.0
2008/2009	2,399.0	1,032.0	22.0	504.0	21.0	806.0
2009/2010	2,024.0	964.0	7.0	406.0	16.0	623.0
2010/2011	2,183.9	865.3	21.6	465.0	25.0	801.0
2011/2012	2,765.8	1,297.0	91.8	517.0	17.0	835.0
2012/2013	1,676.4	679.0	18.4	361.0	19.0	594.0
2013/2014	2,134.5	910.9	79.0	415.0	29.0	694.6
2014/2015	1,955.0	947.0	15.4	332.0	38.0	616.0
2015/2016	2,341.5	1,054.0	15.0	403.0	39.5	824.0
2016/2017	2,815.6	1,451.0	24.0	474.0	25.0	830.6
2017/2018	2,241.8	1,133.0	36.8	435.0	34.0	598.0
2018/2019	2,687.0	1,090.0	58.0	774.0	6.0	755.0
2019/2020	2,547.0	1,315.0	21.0	512.0	49.0	645.0
2020/2021	2,560.0	1,256.0	31.0	545.0	54.0	668.0
2021/2022	2,973.0	1,189.0	58.0	508.0	61.0	1,154.0
2022/2023	4,694.0	1,850.0	24.0	511.0	56.0	2,248.0
Change 2023/2014	479.7	492.0	200.0	172.6	1,120.0	791.6

Source: own elaboration based on [Łopaciuk 2015 and 2024]

Total grain exports from Poland during the period under study increased in 2023 compared to 2014 by 641.30% (Table 6). Among cereals, the highest increase in exports in 2023 compared to 2005 was recorded for corn (+995%), wheat (+939%) and triticale (+798%). Increasing foreign demand for cereals from Poland resulted in an increase in exports. It is delivered mainly to EU countries, especially Germany. In 2023, Poland exported over 60% of cereals to EU markets, including over 3.3 million tons to Germany, i.e. approximately 34%. In addition to EU countries, cereals are exported to developing countries, including Nigeria, Cameroon, Angola, Mauritania, Morocco and Congo [Łopaciuk et al. 2024].

Table 6. Polish grain exports in 2005-2023

Year	Exports [thousand tons]						
	total	wheat	rye	barley	oats	triticale	maize
2005/2006	1,741.0	681.0	272.0	128.0	104.0	92.0	464.0
2006/2007	1,151.0	624.0	55.0	169.0	49.0	24.0	232.0
2007/2008	1,066.0	506.0	66.0	166.0	51.0	17.0	262.0
2008/2009	2,431.0	1,596.0	352.0	84.0	13.0	98.0	288.0
2009/2010	2,700.0	1,498.0	520.0	130.0	42.0	216.0	294.0
2010/2011	1,971.6	1,081.8	230.0	255.0	34.4	145.0	225.4
2011/2012	2,196.1	1,055.6	99.0	323.0	28.5	68.0	622.0
2012/2013	4,500.0	1,654.0	570.0	585.0	85.0	147.0	1,459.0
2013/2014	5,697.0	2,901.4	1,054.9	268.5	34.4	261.5	1,176.3
2014/2015	7,272.0	4,921.0	606.0	294.0	89.0	585.0	777.0
2015/2016	6,140.0	3,991.0	528.0	281.0	91.0	531.0	718.0
2016/2017	7,393.6	4,667.0	392.0	190.0	87.0	383.6	1,674.0
2017/2018	4,854.0	2,453.0	445.0	223.0	118.0	421.0	1,194.0
2018/2019	4,905.0	2,356.0	506.0	256.0	123.0	330.0	1,334.0
2019/2020	8,637.0	4,925.0	812.0	458.0	99.0	677.0	1,660.0
2020/2021	10,560.0	5,032.0	1,449.0	579.0	224.0	1,074.0	2,202.0
2021/2022	9,225.0	3,600.0	680.0	574.0	192.0	665.0	3,514.0
2022/2023	12,906.0	6,397.0	522.0	509.0	124.0	735.0	4,619.0
Change 2023/2014	741.30	939.4	191.9	397.7	119.2	798.9	995.5

Source: own elaboration based on [Łopaciuk 2015 and 2024]

Poland had a positive grain trade balance in the analyzed period. The difference between total grain exports and total grain imports increased by 976.28% between 2005 and 2023 (Table 7). The positive grain trade balance results from many reasons. By gaining access to EU markets, Poland has strengthened its competitive advantage and exports more cereals than it imports. Moreover, Polish cereals and their processing products are characterized by high quality and value in relation to the competitive price. The costs of cereal production in Poland are relatively lower compared to other EU countries. Despite the relatively high level of cereal fertilization in Poland, it is relatively lower compared to other EU countries, which results in lower production costs. The labor factor and its costs are also important, which are lower in Poland compared to other EU countries.

Table 7. Poland's grain trade balance in 2005-2023

Year	Trade balance [thousand tons]					
	total	wheat	rye	barley	oats	maize
2005/2006	763.0	305.0	260.0	-168.0	99.0	180.0
2006/2007	-2,351.0	-1,043.0	-69.0	-451.0	42.0	-836.0
2007/2008	-1,081.0	-257.0	29.0	-363.0	42.0	-521.0
2008/2009	32.0	564.0	330.0	-420.0	-8.0	-518.0
2009/2010	676.0	534.0	513.0	-276.0	26.0	-329.0
2010/2011	-212.3	216.5	208.4	-210.0	9.4	-575.6
2011/2012	-569.7	-241.4	7.2	-194.0	11.5	-213.0
2012/2013	2,823.6	975.0	551.6	224.0	66.0	865.0
2013/2014	3,562.5	1,990.5	975.9	-146.5	5.4	481.7
2014/2015	5,317.0	3,974.0	590.6	-38.0	51.0	161.0
2015/2016	3,798.5	2,937.0	513.0	-122.0	51.5	-106.0
2016/2017	4,578.0	3,216.0	368.0	-284.0	62.0	843.4
2017/2018	2,612.2	1,320.0	408.2	-212.0	84.0	596.0
2018/2019	2,218.0	1,266.0	448.0	-518.0	117.0	579.0
2019/2020	6,090.0	3,610.0	791.0	-54.0	50.0	1,015.0
2020/2021	8,000.0	3,776.0	1,418.0	34.0	170.0	1,534.0
2021/2022	6,252.0	2,411.0	622.0	66.0	131.0	2,360.0
2022/2023	8,212.0	4,547.0	498.0	-2.0	68.0	2,371.0
Change 2023/2005	1,076.3	1,490.8	191.5	1.19	68.7	1,317.2

Source: own elaboration based on [Łopaciuk 2015 and 2024]

RESULTS OF THE MULTIPLE REGRESSION ANALYSIS

In order to examine how selected factors shape the prices of wheat and rye in Poland, a multiple regression analysis was performed. The results of the study indicate that wheat prices in Poland are influenced mainly by global wheat production, wheat production in the EU, domestic wheat production, and area under wheat in Poland. The results therefore confirm the commonly held opinion in the scientific community that wheat prices are global and result from changes in world markets.

The factors that influence rye prices in Poland were examined in the second multiple regression model. The results of the analysis indicate that rye prices are driven mainly by bread consumption and area under rye.

The data proves that rye price changes are more driven by trends on the domestic market. When assessing both models, it must be concluded that they are well suited. In the case of wheat, the coefficient of determination $R^2 = 0.67936593$, and in the case of rye $R^2 = 0.50902350$. The significance level in both analyzed cases was below 0.05 (for wheat $p = 0.001202$, for rye $p = 0.002366$).

Dependent variable	
Wheat price	Rye price
X_3 – wheat production in Poland, $b^* = 0.181$	Z_4 – bread consumption, $b^* = -0.93$
X_8 – wheat production in the EU, $b^* = -1.1$	Z_2 – area under rye, $b^* = -0.65$
X_7 – global wheat production, $b^* = 2.97$	
X_2 – area under wheat, $b^* = -1.4$	
Multiple R = 0.82423657	Multiple R = 0.71345883
F = 7.945575	F = 8.812437
$R^2 = 0.67936593$	$R^2 = 0.50902350$
df = 4.15	df = 2.17
N = 20	N = 20
Adjusted $R^2 = 0.59386351$	Adjusted $R^2 = 0.45126155$
p = 0.001202	p = 0.002366
Standard error of the estimate: 178.66710011	Standard error of the estimate: 166.22753041
Intercept: 120.46319912	Intercept: 1,089.6274253
Standard error: 175.7533	Standard error: 164.2015
t(15) = 0.68541	t(17) = 6.6359
p = 0.5035	p = 0.0000

SUMMARY AND CONCLUSIONS

According to FAO data, the world population increased by 20% in 2005-2021, and in the EU-27 by 2.87%. During the same period, the population in Poland decreased by 0.70%. Statistical data from the Central Statistical Office also indicate that in the years 2005-2023 there was a decrease in the population in Poland by 0.52 million people, but there was an increase in the average monthly disposable income per person by PLN 1,916.84.

In 2005-2023, total area under cereals in Poland decreased by 13.70%, whereas total grain yields per hectare increased by 54.49%. These changes resulted in growth total

grain production by 33.14%. In the analyzed period, monthly consumption of bread and cereal products decreased from 8.44 kg *per capita* in 2005 to 5.11 kg *per capita* in 2022. In 2023, grain prices increased relative to 2014. Poland had a positive grain trade balance throughout the analyzed period. With accession to the EU, Poland gained access to a large market. Polish cereals and their products are characterized by high quality and value as well as competitive prices.

Wheat prices in Poland are determined mainly by wheat production in the world, the EU, and Poland, as well as the area under wheat. Wheat prices are therefore global and depend on changes in world markets. Global market trends determine wheat purchase prices and affect the profitability of production. The oversupply of raw materials in 2023 and 2024 caused by favorable weather conditions resulted in a decline in prices.

Grain prices are affected mainly by the area under rye and bread consumption. Rye finds buyers mainly on the domestic market and is used in the food and feed industry. The reduction in animal production in Poland resulted in reduced demand for rye for feed purposes.

Recently, the COVID-19 pandemic and the war in Ukraine also had an impact on grain prices in Poland. These events triggered a breakdown in supply chains and changes in grain supply. In the initial period of the war, grain exports from Ukraine to world markets decreased, which resulted in an increase in prices. However, after the stabilization of grain exports from Ukraine by land via EU countries, prices decreased. However, the oversupply of cereals on world markets is considered to be a factor determining changes in grain prices.

BIBLIOGRAPHY

- Campbell Bruce M., Sonja J. Vermeulen, Pramod K. Aggarwal, Caitlin Corner-Dolloff, Evan Girvetz, Ana Maria Loboguerrero, Julian Ramirez-Villegas, Todd Rosenstock, Leocadio Sebastian, Philip K. Thornton, Eva Wollenberg. 2016. Reducing risks to food security from climate change. *Global Food Security* 11: 34-43.
- EC (European Council). 2024. *Ukrainian grain exports explained*. Council of the European Union, <https://www.consilium.europa.eu/en/infographics/ukrainian-grain-exports-explained/>, access: 10.08.2024.
- FAO. 2005-2022. *Crops and livestock products*, <https://www.fao.org/faostat/en/#data/QCL>, access 10.09.2024.
- Gołębiewski Jarosław, Joanna Stefańczyk. 2023. Czynniki i kierunki zmian na rynku zbóż w Polsce w warunkach wojny w Ukrainie (Factors and directions of changes on the grain market in Poland during the war in Ukraine). *Annals PAAAE XXV* (4): 60-75. DOI: 10.5604/01.3001.0054.0103.

- GUS (Statistics Poland). *Dane według dziedzin dla lat 2005-2023* (Data by field for 2005-2023), <https://bdl.stat.gov.pl/bdl/dane/podgrup/tablica>, access: 10/09/2024.
- GUS (Statistics Poland). *Rocznik statystyczny rolnictwa i obszarów wiejskich za 2006-2007* (Statistical yearbook of agriculture and rural areas). Warszawa: GUS.
- GUS (Statistics Poland). *Rocznik statystyczny rolnictwa za lata 2008-2022* (Agricultural statistical yearbooks for 2008-2022). Warszawa: GUS.
- Hamuleczuk Mariusz, Justyna Kufel-Gajda, Stanisław Stańko, Grzegorz Szafrąński, Krystyna Świetlik. 2016. *Ceny żywności w Polsce i ich determinanty* (Food prices in Poland and their determinants). Warszawa: IERGiŻ-PIB.
- Kalkuhl Matthias, Joachim von Braun, Maximo Torero. 2016. *Volatile and extreme food prices, food security, and policy: An overview*. Bonn, Washington, DC: Springer Open. DOI: 10.1007/978-3-319-28201-5.
- Krysicki Włodzimierz, Jerzy Bartos, Waclaw Dyczka, Krystyna Królikowska, Mateusz Wasilewski. 1995. *Rachunek prawdopodobieństwa i statystyka matematyczna w zadaniach. Część II. Statystyka matematyczna* (Probability and mathematical statistics in problems. Part II. Mathematical statistics). Warszawa: PWN.
- Łopaciuk Wiesław (ed.), Tadeusz Chrościcki, Katarzyna Rola, Maria Włodarczyk. 2015. *Rynek zbóż. Stan i perspektywy* nr 49. Analizy Rynkowe (Cereal market. Status and Prospects no. 49. Market analysis). IERiGŻ-PIB.
- Łopaciuk Wiesław (ed.), Łukasz Chmielewski, Jadwiga Drożdż, Wiesław Dzwonkowski. 2024. *Rynek zbóż. Stan i perspektywy* nr 66. Analizy Rynkowe (Cereal market. Status and Prospects No. 66. Market analysis). IERiGŻ-PIB.
- Nichols Michelle. 2023. "Many may die" warns UN after end of Black Sea grain deal. Reuters, July 21, 2023, <https://www.reuters.com/world/europe/many-may-die-warns-un-after-end-black-sea-grain-deal-2023-07-21/>, accessed on 10 August 2024.
- ONZ (United Nations). 2023. *UN chief regrets Russia's decision to withdraw from grain deal*, <https://news.un.org/en/story/2023/07/1138752>, access: 10.08.2024.
- Roman Monika, Aleksandra Górecka, Joanna Domagała. 2020. The linkages between crude oil and food prices. *Energies* 13 (24): 1-18. DOI: 10.3390/en13246545.
- Zaród Jadwiga. 2017. Czynniki kształtujące ceny wybranych produktów rolno-żywnościowych (Factors shaping the prices of selected agri-food products). *Zeszyty Naukowe Szkoły Głównej Gospodarstwa Wiejskiego w Warszawie. Problemy Rolnictwa Światowego* 17 (3): 298-307.

CZYNNIKI KSZTAŁTUJĄCE CENY ZBÓŻ W POLSCE

Słowa kluczowe: rynek zbóż, handel zagraniczny, ceny zbóż, popyt, podaż

ABSTRAKT. Głównym celem badań było rozpoznanie czynników wpływających na zmiany cen zachodzące na rynku zbóż w latach 2005-2023. Podstawowym źródłem informacji były dane GUS dotyczące powierzchni uprawianych zbóż, plonów, zbiorów, cen oraz importu, eksportu i konsumpcji. W badaniach wykorzystano metodę regresji wielokrotnej, która pozwoliła na identyfikację czynników kształtujących ceny pszenicy i żyta. Powierzchnia uprawianych zbóż ogółem w Polsce w okresie od 2005 do 2023 roku uległa zmniejszeniu o 13,7%. W badanych latach nastąpił wzrost plonu pszenicy o 36,2%, żyta o 47,3%, jęczmienia o 39,4%, owsa o 25,2%, pszenżyta o 37,0%, mieszanek zbóż o 19,1% i kukurydzy na ziarno o 27,2%. Zbiór zbóż ogółem w Polsce w latach 2005-2023 zwiększył się o 33,1%, a zbiór zbóż podstawowych wzrósł o 21,9%. Z badań wynika, że czynnikami kształtującymi ceny pszenicy w Polsce są zbiory na świecie, w UE i Polsce, a także powierzchnia uprawy pszenicy. Ceny pszenicy mają zatem charakter globalny i zależą od zmian na rynkach światowych. Światowe trendy rynkowe determinują ceny skupu pszenicy i wpływają na opłacalność produkcji. Czynnikiem wpływającym na cenę żyta są powierzchnia uprawy żyta i spożycie pieczywa. Żyto znajduje odbiorców głównie na rynku krajowym i jest wykorzystywane w przemyśle spożywczym i paszowym. Ograniczenie produkcji zwierzęcej w Polsce spowodowało zmniejszenie zapotrzebowania na żyto na cele paszowe.

AUTHORS

BEATA KALINOWSKA, MSC

ORCID: 0000-0001-9380-4419

University of Warmia and Mazury in Olsztyn
Department of Agrotechnology and Agribusiness
e-mail: kalibeti@gmail.com

PIOTR BÓRAWSKI, PROF. DR.HAB. ENG.

ORCID: 0000-0002-6616-7140

University of Warmia and Mazury in Olsztyn
Department of Agrotechnology and Agribusiness
e-mail: pboraw@uwm.edu.pl

Proposed citation of the article:

Kalinowska Beata, Piotr Bórawski. 2024. Factors influencing grain prices in Poland. *Annals PAAAE XXVI* (4): 112-130.