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CHANGES IN THE PRODUCTION OF RAPESEED IN POLAND AFTER ACCESSION TO THE EUROPEAN UNION[2]

Key words: production, rapeseed, yields, harvest, prognosis

ABSTRACT. The aim of this study was to evaluate changes on the Polish rapeseed market after accession to the European Union (EU). Special attention was paid to the demand, supply, and prices of rapeseed in Poland relative to other EU member states. The performance of the rapeseed sector was analyzed based on market data for 2005-2022. Changes on the Polish rapeseed market were assessed with the use of descriptive statistics, the Augmented Dickey-Fuller (ADF) test, and the ARiMA model. In Poland, rapeseed production is spatially diverse and dominates in the western and northern Polish provinces. The largest rapeseed area in 2022 was recorded in the following voivodeships: Lower Silesia (129.1 thousand ha), Wielkopolska (104 thousand ha) and West Pomerania (115.5 thousand ha). In the years 2005-2022 there were changes in the plans and harvest of rapeseed in Poland. The highest rapeseed yields were recorded in 2014 (34.4 dt/ha), 2022 (33.8 dt/ha) and 2021 (32.1 dt/ha), while the lowest in 2011 (22.4 dt/ha) and 2010 (23.6 dt/ha). The harvest were the largest in 2014 (3,275.8 thousand tons) and 2022 (3,643.4 thousand tons). Poland is an important producer of rapeseed in the EU and in 2022 it ranked third (3,300 thousand tons), after France (4,506 thousand tons) and Germany (4,295 thousand tons). Statistical analysis showed changes in the area, yields and harvest of rapeseed. The highest coefficient of variation was recorded for rapeseed harvest (0.236) and the lowest for yields (0.115). In the case of area, yields and harvests, the coefficient of variation was high, which proves the non-stationarity of the time series. The forecast developed for the years 2023-2027 showed downward trends for the area, yields and harvest of rapeseed.

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INTRODUCTION

Rapeseed is the main oilseed crop in Poland and the European Union (EU). This plant species has relatively high soil and environmental requirements, and its production involves high-input technologies. Polish soils are relatively well suited for rapeseed cultivation, and climatic factors do not pose significant limitations.

The Polish rapeseed market, which supplies raw material for the production of first-generation biodiesel, underwent significant changes after Poland had joined the EU. At present, biodiesel is blended with conventional petroleum-based diesel oil. The above increases the demand for rapeseed and enhances competition on domestic and foreign markets because rapeseed is also used in fat and pharmaceutical industries, as well as in other industrial sectors.

Rapeseed is a highly demanding crop, and its yields are influenced by climatic factors [Chibowski et al. 2016, Kuś 2006]. Rapeseed yields differ across the European countries due to variations in soil conditions, climate, and agricultural mechanization. In general, rapeseed and other crop yields tend to be higher in countries with high levels of agricultural productivity.

In Poland, rapeseed is cultivated mainly in Upper and Lower Silesia, Sudeten Foreland, and Kłodzko Valley. This crop is also grown in northern Poland, in the Regions of Warmia and Mazury, and West Pomerania [Głębocki 2014].

Recent years have witnessed a steady increase in rapeseed production in Poland and other countries because this oilseed crop is processed into edible fat as well as biofuels [Boczar 2014]. According to EU regulations of 2009, 10% of transport fuels should come from renewable energy sources by 2020 [Directive 2009/30/EC]. In Poland, the share of biocomponents in transport fuels reached 7.1% in 2013, which increased the demand for rapeseed in the biodiesel sector [Rosiak 2014].

According to Jan Kuś [2007], around 1.0-1.1 million ha of arable land are available for rapeseed cultivation in Poland. Due to its high requirements, approximately 13% of soils of very high and high quality should be sown with rapeseed [Rudko 2011]. The optimal forecrops for rapeseed cultivation include early-maturing legumes grown for seeds and forage, early-maturing potatoes, and perennial legumes that are harvested in July. Spring wheat and oats are the least suitable preceding crops. Rapeseed should not be grown in monoculture [Rudko 2011].

The interest in biodiesel production surged after Poland had joined the EU. The EU's renewable energy policy has increased farmer interest in rapeseed which is the main component for biodiesel production. Rapeseed is also processed in other market sectors, including fat, feed, and pharmaceutical industries, which increased the demand for this oilseed crop and enhanced market competition.

Poland, France, Germany, United Kingdom, and Romania are the leading rapeseed producers in the EU. Farmer interest in rapeseed and agrimony is influenced by the profitability of rapeseed production and the relationship between rapeseed and wheat prices [Wójtowicz, Wielebski 2002]. Climatic factors also play an important role, in particular the risk of drought which can hinder plantation establishment and compromise rapeseed yields [Klepacki, Gołębiewska 2002].

In Europe, rapeseed accounted for more than 68% of total oilseed crop production in 2014/2015, 64% in 2015/2016, and 65% in 2016/2017. In the production structure, rapeseed accounted for 60.6% in 2022, compared to 55.9% in 2021 [IERiGŻ-PIB 2023].

Europe's share in global rapeseed production increased from 32.2% in 2016/2017 to 34.4% in 2017/2018. Therefore, the EU-28 has strengthened its status of a leading rapeseed supplier on the global market [IERiGŻ-PIB 2018]. The EU's share of the world rapeseed harvest in 2022/2023 decreased to 24.3%, compared to 25.8% in 2021/2022 [IERiGŻ-PIB 2023].

Poland's self-sufficiency rate for rapeseed reached 55.7% in 2005/2006, and it continued to increase in the following years to reach 57.1% in 2006/2007, 64.5% in 2013/2014, and 67.2% in 2014/2015. As a result, rapeseed had to be imported to cater to domestic demand. The EU's self-sufficiency in oilseed production (soybeans, rapeseed, sunflower) was 60% in 2022/2023 compared to 57.7% in the previous season [IERiGŻ-PIB 2023].

The main aim of this study was to assess changes on the Polish rapeseed market in 2005-2022 years. The following specific objectives were also formulated: to evaluate changes in land area under rapeseed cultivation, rapeseed yields, and rapeseed production, to analyze Poland's balance of trade in rapeseed.

An attempt was also made to answer the following research questions:

1. How did rapeseed yields, and the area under rapeseed cultivation change after Poland's accession to the EU?
2. What are the projections for the area under rapeseed, rapeseed yields?

MATERIAL AND METHODS

Poland's accession to the EU led to changes on the domestic rapeseed market. The performance of the Polish rapeseed sector was analyzed based on secondary market data from 2005-2022, coming from elaborations of Institute of Rural and Agricultural Development of the Polish Academy of Sciences, entitled "Rapeseed market".

The performance of the Polish rapeseed market was assessed with the use of statistical methods. In the first stage, data were analyzed with the use of descriptive statistics. In the second stage, the Augmented Dickey-Fuller (ADF) test and the Autoregressive Moving Average (ARiMA) model were applied to detect stationarity of time series data. Future trends in rapeseed production on the Polish market were predicted in the last stage of the study.

RESULTS

Rapeseed supply and demand are difficult to analyze due to fluctuations in yields and the high demand for rapeseed in various industrial sectors. Rapeseed supply was evaluated based on the area under rapeseed cultivation, rapeseed yields and production. Opening stocks and rapeseed imports were considered in the analysis. Changes in the above parameters were analyzed on the global market, followed by the EU and Polish markets.

Global rapeseed production and supply were highest in 2022/2023 (79.2 million tons) and lowest in 2006/2007 (47.8 million tons). In turn, rapeseed consumption was highest in 2022/2023 (74.1 million tons) and lowest in 2005/2006 (48.3 million tons). Rapeseed stocks were highest in 2023/2022 (9.9 million tons) and lowest in 2008/2009 (4.3 million tons) [IERiGŻ-PIB 2018, 2023].

These growth trends can be attributed to a higher demand for food to feed the world's growing population, a higher demand for renewable energy, and biofuel production [Rosiak 2014]. The observed increase in rapeseed production, supply, and consumption was also fueled by the emergence of new feed technologies in livestock rearing.

According to the Institute of Agricultural and Food Economics – National Research Institute (IERiGŻ-PIB) in Warsaw, rapeseed yields and production increased in most EU countries between 2021 and 2022. In 2022, the largest area under rapeseed cultivation was noted in France (1.23 million ha), Germany (1.09 million ha), and Poland (1.06 million ha). Between 2021 and 2022, the greatest increase in area under rapeseed was observed in France (25.2%), Germany (8.7%) and Poland (6.6%) [IERiGŻ-PIB 2023].

In 2022, rapeseed yields were highest in Denmark (4.52 t/ha), Germany (3.95 t/ha), and France (3.67 t/ha), and lowest in Latvia (2.06 t/ha), Romania (2.49 t/ha), and Hungary (2.50 t/ha). According to IERiGŻ-PIB, the greatest increase in rapeseed yields in 2021-2022 was noted in Denmark (12.7%) and Germany (12.9%), whereas the smallest increase was noted in Lithuania (1.4%). In 2005-2022 report a decrease in rapeseed yields: Latvia (-32.0%), Romania (-16.4%) and Hungary (-12.0%). Since 2007, Poland has been the third largest producer of rapeseed, rapeseed oil, and rapeseed meal in the EU.

In Europe, regional differences are also observed in rapeseed production. In 2022, the leading rapeseed producers were France (4,506 thousand tons), Germany (4,295 thousand tons), and Poland (3,300 thousand tons). Between 2021 and 2022, rapeseed production increased by 11.6% on average in the EU. In the analyzed period, the greatest increase in rapeseed production was noted in Denmark (37.3%), France (33.3%) and Germany (22.5%). A relatively high increase in the examined parameter was observed in Lithuania (14.9%), Sweden (13.1%) and Czechia (10.1%), whereas the smallest increase was noted in Poland (3.5%) and Slovakia (4.8%). Rapeseed production decreased in Hungary (-30.9%), Latvia (-25.8%) and Romania (-21.7%), mainly due to a decline in yields [IERiGŻ-PIB 2023].

Table 1. Rapeseed balance sheet for 2005-2022

Item	Rapeseed balance sheet [thousand tons]																	
	2005/2006	2006/2007	200720/08	2008/2009	2009/2010	201020/11	2011/2012	2012/2013	2013/2014	2014/2015	2015/2016	2016/2017	2017/2018	2018/2019	2019/2020	2020/2021	2021/2022	2022/2023
Opening stocks	107	39	52	15	159	139	14	161	19	8	8	15	24	26	11	14	12	19
Production	1,450	1,652	2,130	2,106	2,497	2,078	1,862	1,866	2,678	3,276	2,701	2,219	2,697	2,202	2,373	3,125	3,191	3,643
Imports	52	122	52	379	317	267	604	334	193	230	238	642	523	604	477	465	555	940
Total stocks	1,609	1,813	2,234	2,500	2,972	2,484	2,480	2,361	2,890	3,514	2,947	2,877	3,244	2,832	2,861	3,604	3,758	4,602
Domestic consumption	1,395	1,566	1,709	2,049	2,475	2,099	2,173	2,003	2,154	2,598	2,051	2,617	2,881	2,526	2,501	3,194	3,366	3,659
Processing	1,350	1,450	1,560	1,900	2,350	1,995	2,080	1,910	2,074	2,500	1,970	2,550	2,800	2,460	2,430	3,100	3,270	3,550
Losses	44	116	149	149	125	104	93	93	80	98	81	67	81	66	71	94	96	109
Exports	176	195	510	229	358	379	146	344	728	915	881	237	337	295	346	398	373	500
Total consumption	1,570	1,761	2,219	2,278	2,833	2,478	2,319	2,347	2,882	3,513	2,932	2,854	3,218	2,821	2,847	3,592	3,739	4,159
Ending stocks	39	52	15	222	139	6	161	14	8	1	15	24	26	11	14	12	19	443
Ending stocks/ domestic consumption [%]	2.8	3.3	0.9	10.8	5.6	0.3	7.4	0.7	0.4	0.0	0.7	0.9	0.9	0.4	0.6	0.4	0.6	12.1
Exports/ production [%]	12.1	11.8	23.9	10.9	14.3	18.2	7.8	18.4	27.2	27.9	32.6	10.6	12.5	13.4	14.6	12.7	11.7	13.7

Source: [IERiGŻ-PIB 2006-2023]

These trends suggest that farmers have a growing interest in rapeseed cultivation. Rapeseed yields fluctuated due to varied weather conditions in the studied period. Weather anomalies decreased rapeseed yields.

Rapeseed is the main oilseed crop in Poland, and it occupies 95-97% of the total area under oilseed crops. Regions in northern and western Poland are characterized by the optimal soil and climatic conditions for rapeseed cultivation [Rosiak 2004, Dzwonkowski et al. 2008]. Rapeseed production continues to increase in Poland. Between 2005 and 2022, the area under rapeseed cultivation increased by 95.2% to 1,077.5 thousand ha, rapeseed yields increased by 11.6% to 33.8 dt/ha, but production volume increased by 123.1% (Table 2). However, considerable variations in these parameters were observed in the studied period. The greatest decrease in area under rapeseed (23.9%) was noted in 2010-2012. In turn, the greatest decline in rapeseed yields (27.3%) was observed in 2009-2011, mainly due to unfavorable weather conditions in these years [Rosiak 2014].

Total rapeseed supply was defined as the sum of usable production, opening stocks, and imports (Table 1). Considerable variations in opening stocks were noted in the analyzed period. Opening stocks were highest in 2012/2013 (161 thousand tons) and 2009/2010 (159 thousand tons), and lowest in 2014/2015 and 2015/2016. In turn, rapeseed production increased by 151% in 2005/2006-2022/2023. As a result, total rapeseed supply increased from 1,609 thousand tons to 4,602 thousand tons (by 186%).

The demand for rapeseed is determined based on total consumption, including domestic consumption, processing, losses, and exports (Table 1). All of the analyzed demand-side factors increased in 2005-2022. Between 2005/2006 and 2022/2023, domestic consumption increased by 162.3%, rapeseed processing increased by 162.3%, losses increased by 147.7%, and exports increased by 184.1%. The demand for rapeseed was driven mainly by the Polish and European biofuel sector.

Poland's accession to the EU and the growing demand for rapeseed for biodiesel production were the key drivers of the Polish rapeseed market. Between 2005 and 2022, the area under rapeseed cultivation nearly doubled, from 550.2 thousand ha to more than 1,077.5 thousand ha. Adverse weather conditions were responsible for a decline in rapeseed yields in 2011-2012. In 2022, rapeseed yields peaked at 3.6 million tons and in 2014 to 3.3 million tons (Table 2), and the area occupied by rapeseed accounted for 9.1% of total cropped area [IERiGŻ-PIB 2015, 2023].

The chain-base indicators of the area under rapeseed cultivation, rapeseed yields, and rapeseed production in Poland in 2006-2022 are presented in Table 2. The analyzed data indicate that the greatest increase in cropped area took place in 2007, 2010, 2013, 2021 and 2022. The above parameter decreased in 2008, 2011 and 2016, which could be attributed to a reduction in rapeseed prices in the preceding seasons. Rapeseed yields were highest in 2014 (34.4 dt/ha), 2022 (33.8 dt/ha) and in 2021 (32.1 dt/ha), and lowest

Table 2. Fixed-base and chain-base indicators of the area under rapeseed cultivation, rapeseed yields, and rapeseed production in Poland

Year	Area			Yield			Production		
	thousand ha	change from 2005 = 100%	previous year = 100%	dt/ha	change from 2005 = 100%	previous year = 100%	thousand tons	change from 2005 = 100%	previous year = 100%
2005	550.2	100.0	-	30.3	100.0	-	1,632.9	100.0	-
2006	623.9	113.4	113.4	26.5	87.4	87.4	1,651.5	101.1	101.1
2007	796.8	144.8	127.7	26.7	88.1	100.7	2,129.9	130.4	129.0
2008	771.1	140.1	96.8	27.3	90.1	102.2	2,105.8	129.0	98.9
2009	810.0	147.2	105.0	30.8	101.6	112.8	2,496.8	152.9	118.6
2010	946.1	171.9	116.8	23.6	77.9	76.6	2,228.7	136.5	89.3
2011	830.1	150.9	87.7	22.4	73.9	94.9	1,861.8	114.0	83.5
2012	720.3	130.9	86.8	25.9	85.5	115.6	1,865.6	114.2	100.2
2013	920.7	167.3	127.8	29.1	96.0	112.3	2,677.7	164.0	143.5
2014	951.1	172.9	103.3	34.4	113.5	118.2	3,275.8	200.6	122.3
2015	947.1	172.1	99.6	28.5	94.0	82.8	2,700.8	165.4	82.4
2016	822.6	86.8	149.5	27.0	94.7	89.1	2,219.3	135.9	135.9
2017	914.3	111.1	166.2	29.5	109.3	97.3	2,697.3	165.2	165.2
2018	845.1	92.4	153.6	26.1	88.5	86.1	2,202.4	134.9	134.9
2019	875.2	103.6	159.1	27.1	103.8	89.4	2,373.2	145.3	145.3
2020	980.9	112.1	178.3	31.9	117.7	105.3	3,124.8	191.4	191.4
2021	993.4	101.3	180.5	32.1	100.6	105.9	3,191.2	195.4	195.4
2022	107.5	108.5	195.8	33.8	105.3	111.6	3,643.4	116.6	223.1

Source: own elaboration based on [IERiGŻ-PIB 2005-2018]

in 2011 (22.4 dt/ha) and 2010 (23.6 dt/ha). Rapeseed production peaked in 2014 and in 2022 at 3,275.8 thousand tons and to 3,643.4 thousand tons.

Descriptive statistics for the area under rapeseed cultivation, rapeseed yields, and rapeseed production in 2005-2012 are presented in Table 3. The value of the coefficient of variation was highest for rapeseed production (23.6%) and area under rapeseed (15.5%). Kurtosis values for cropped area, yields, and production were indicative of platykurtic distribution with less kurtosis than the normal distribution (negative kurtosis). Cropped area and yields were characterized by negative skewness, whereas positive skewness was noted for rapeseed yields. Standard deviation values indicate that yields were spread away from the mean, whereas cultivation area and rapeseed production were concentrated close to the mean.

Table 3. Descriptive statistics for the area under rapeseed cultivation, rapeseed yields, and rapeseed production in Poland in 2005-2022

Parameter	Descriptive statistics						
	median	minimum	maximum	standard deviation	coefficient of variation	skewness	kurtosis
Area under rapeseed [thousand ha]	860.15	550.20	1,077.50	132.27	0.155	-0.65	0.07
Rapeseed yields [dt/ha]	27.90	22.40	34.40	3.29	0.115	0.11	-0.64
Rapeseed production [thousand tons]	2,300.90	1,632.90	3,643.40	577.62	0.236	0.46	-0.68

Source: own elaboration based on [IERiGŻ-PIB 2023]

Changes in rapeseed area, yields and production were analyzed with the use of the ADF test which examines the stationarity of time series [Dickey, Fuller 1979]. The results are presented in Table 4, and they indicate that the p-value was relatively high for rapeseed area, yields and production. Therefore, the null hypothesis stating that the time series is not stationary and consists of a unit root could not be rejected. The values of the mean, variance, and autocorrelation function changed over time, which suggests that the time series is not stationary. These observations undermine the H_1 hypothesis postulating that the time series is stationary, i.e. the static and dynamic properties of the series do not depend on time, and the mean value and variance of the time series components are constant [Sobczyk 2005].

Future projections for the area under rapeseed cultivation, rapeseed yields and production were developed with the ARiMA model which is a useful tool for analyzing univariate time series [Box, Jenkins 1976]. The maximum number of lags and the maximum

Table 4. Augmented Dickey-Fuller (ADF) test for the area under rapeseed cultivation, rapeseed yields, and rapeseed production

Item	Coefficient	p-value	t-statistic
Area under rapeseed cultivation	-0.407	0.178	-2.315
Rapeseed yields	-0.602	0.178	-2.318
Rapeseed production	-0.289	0.582	-1.348

Source: own elaboration

Table 5. Estimation of the ARiMA model for the area under rapeseed cultivation, rapeseed yields, and rapeseed production

Parameter	Coefficient	Standard error	z	p-value
Area under rapeseed cultivation				
const	842.827	91.267	9.235	0.000
Phi_1	0.779	0.412	1.894	0.058
Theta_1	0.007	0.624	0.011	0.990
Rapeseed yields				
const	28.709	0.944	30.410	0.000
Phi_1	-0.317	0.273	-1.162	0.245
Theta_1	1.000	0.209	4.768	0.000
Rapeseed production				
const	970.807	661.259	1.468	0.142
Phi_1	0.642	0.264	2.432	0.015
Theta_1	0.180	0.342	0.527	0.598

Source: own elaboration

values of parameters P and Q were applied in the analysis. The resulting models were estimated for all combinations (p, q), where $p \leq P$ and $q \leq Q$. The ARiMA model with the minimum value of the Akaike's Information Criterion (AIC) was selected.

The model was evaluated by Kalman filtering. The analysis revealed that the assumption that the underlying residuals are normally distributed cannot be rejected. As demonstrated by the data in Table 5, the modeled parameters are significant at 0.05.

Polish regions differ in the area under rapeseed cultivation (Table 6). Rapeseed is grown primarily in western and northern Poland. In 2022, the three voivodeships with the largest area under rapeseed were Lower Silesia (129.1 thousand ha), Wielkopolska (104.0 thousand ha), and West Pomerania (115.5 thousand ha). These regions are characterized by the most favorable soil and climatic conditions for rapeseed cultivation, and the discussed crop is grown in large-scale farms. In 2022, the smallest area under rapeseed was noted in the voivodeships of Świętokrzyskie (25.0 thousand ha), Małopolska (12.5 thousand ha), and Silesia (21.9 thousand ha), where most crops are produced in small farms. It should also be noted that rapeseed had not been cultivated in many Polish regions, and the interest in this crop increased only in recent years.

In 2005-2022, rapeseed was produced mainly in the voivodeships of Wielkopolska (108.3 thousand ha), Kuyavia-Pomerania (98.8 thousand ha), and West Pomerania (99.9 thousand ha). The area under rapeseed was lowest in Małopolska (5.6 thousand ha), Świętokrzyskie (7.1 thousand ha), and Podlasie (7.9 thousand ha) [IERiGŻ-PIB 2023].

Table 6. Area under rapeseed cultivation in Polish voivodeships in 2005-2022

Voivodeship	Area under rapeseed cultivation [thousand ha]																	
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Poland	550.2	623.9	796.8	771.1	810.0	946.1	830.1	720.3	920.7	951.1	947.1	822.6	914.3	845.1	875.2	980.9	993.4	1,077.5
Lower Silesia	74.8	84.5	105.2	113.4	109.5	127.2	125.3	110.3	135.5	130.7	133.7	118.2	121.5	125.5	120.5	127.0	122.3	129.1
Kuyavia-Pomerania	65.4	79.7	103.7	105.5	119.4	126.0	104.9	49.3	105.5	115.3	127.4	83.1	99.0	63.7	83.5	90.0	90.0	100.5
Lublin	29.3	28.6	48.6	43.1	39.4	44.2	40.1	43.7	66.7	71.4	65.0	69.9	84.1	112.2	114.9	128.5	127.5	125.3
Lubusz	16.8	18.7	25.8	26.0	32.0	38.9	39.0	33.1	34.2	34.7	36.8	33.8	33.8	31.5	20.4	27.3	32.9	33.8
Łódź	8.6	11.5	17.0	15.4	16.9	21.1	17.8	10.4	20.8	29.8	23.3	15.7	21.6	21.2	28.1	26.8	30.1	33.8
Małopolska	2.8	3.0	4.1	4.5	4.7	5.4	3.9	4.9	7.0	7.5	7.8	7.9	9.5	10.8	12.4	13.3	12.5	12.5
Masovia	23.3	21.2	25.2	28.9	28.8	47.5	50.7	42.1	44.8	39.0	42.8	32.1	46.1	34.1	45.9	56.8	56.0	60.6
Opole	55.1	64.3	78.7	74.2	71.5	87.6	87.1	54.4	84.3	75.7	75.3	75.5	71.2	77.5	69.3	77.5	75.3	77.7
Podkarpacie	10.3	11.6	17.0	11.3	13.0	16.2	16.8	18.8	23.0	20.4	23.4	19.7	22.5	26.6	26.4	26.1	25.7	23.4
Podlasie	2.4	3.9	4.4	3.6	5.1	8.3	7.0	8.0	9.3	10.4	11.1	13.6	15.5	18.0	15.5	18.3	18.3	22.1
Pomerania	43.5	51.3	54.4	51.9	55.7	73.3	59.3	54.6	77.7	82.6	77.4	64.18	80.2	61.5	79.9	82.3	75.2	88.4
Silesia	13.8	15.0	20.1	18.2	19.4	20.7	16.0	19.0	22.3	21.1	19.7	21.0	19.9	25.3	18.1	24.5	21.8	21.9
Świętokrzyskie	3.4	4.1	8.3	6.3	8.1	6.0	5.3	8.3	9.4	8.4	9.8	7.7	7.5	12.1	10.7	18.6	22.3	25.6
Warmia and Mazury	45.8	56.1	66.5	58.2	60.8	69.0	59.5	70.1	70.2	75.6	75.8	55.8	67.8	46.4	75.3	86.9	94.9	103.3
Wielkopolska	72.0	83.7	112.9	112.4	123.6	138.2	127.5	86.5	106.3	117.6	114.6	103.9	109.2	98.9	84.1	91.0	92.4	104.0
West Pomerania	82.8	86.8	104.7	98.4	102.0	116.5	69.9	106.8	103.6	111.0	113.3	99.0	104.8	80.0	70.2	85.9	96.2	115.5

Source: [IERiGŻ-PIB 2006-2023]

Changes in the spatial distribution of rapeseed production were determined with the use of descriptive statistics (Table 7). The analysis revealed that the greatest changes in rapeseed area between 2005 and 2022 occurred in the voivodeships of Świętokrzyskie (60.1%), Podlasie (55.7%), and Małopolska (47.9%) (Table 7).

The smallest changes in rapeseed area were noted in the voivodeships of West Pomerania (15.1%), Silesia (15.0%), and Warmia and Mazury (22.2%).

Changes in rapeseed area were characterized by negative values of kurtosis in most Polish voivodeships, excluding Opole and Świętokrzyskie. These results indicate that the data were less concentrated around the mean [Sobczyk 2005]. Most voivodeships, excluding Lublin, Świetokrzyskie, Warmia and Mazury and Wielkopolska, were also characterized by negatively skewed distribution of rapeseed area (the data were scattered far and were not concentrated around the mean).

Table 7. Descriptive statistics summarizing the spatial distribution of rapeseed production in Polish voivodeships

Voivodeship	Descriptive statistics						
	median	min.	max.	standard deviation	coefficient of variation	skewness	kurtosis
Lower Silesia	121.9	74.8	135.5	16.2	0.138	-1.417	1.338
Kuyavia-Pomerania	99.7	49.3	127.4	21.6	0.227	-0.422	-0.499
Lublin	65.8	28.6	128.5	35.6	0.499	0.522	-1.208
Lubusz	33.0	16.8	39.0	6.6	0.217	-0.797	-0.424
Łódź	20.9	8.6	33.8	7.1	0.348	0.137	-0.839
Małopolska	7.2	2.8	13.3	3.6	0.479	0.354	-1.280
Masovia	42.4	21.2	60.6	11.9	0.297	-0.021	-1.088
Opole	75.4	54.4	87.6	9.1	0.123	-0.748	0.300
Podkarpacie	20.0	10.3	26.6	5.5	0.281	-0.317	-1.182
Podlasie	9.8	2.4	22.1	6.0	0.557	0.279	-1.153
Pomerania	68.7	43.5	88.4	13.6	0.202	-0.129	-1.374
Silesia	20.0	13.8	25.3	2.9	0.150	-0.272	-0.173
Świętokrzyskie	8.3	3.4	25.6	6.1	0.601	1.443	1.091
Warmia and Mazury	68.4	45.8	103.3	15.3	0.222	0.607	-0.022
Wielkopolska	105.1	72.0	138.2	17.2	0.165	0.200	-0.608
West Pomerania	100.5	69.9	116.5	14.6	0.151	-0.522	-0.828

Source: [IERiGŻ-PIB 2006-2023]

The performance of the Polish rapeseed market after 2022 was evaluated by predicting changes in rapeseed area, yields and production in the Statistica program. The analysis was based on rapeseed area, yields and production between 2005 and 2022, and it did not account for other factors that could have affected the examined parameters. The developed forecast indicates that the area under rapeseed, rapeseed yields and production are likely to change in the future (Table 8).

Table 8. Predicted changes in the area under rapeseed cultivation, rapeseed yields, and rapeseed production in Poland

Year	Area [thousand ha]		Year	Yields [dt/ha]		Year	Production [thousand tons]	
	forecast	error		forecast	error		forecast	error
2023	1,026.7	97.65	2023	31.3	2.65	2023	3,419.4	408.19
2024	986.2	124.27	2024	27.9	3.20	2024	3,166.4	528.50
2025	954.7	137.97	2025	29.0	3.25	2025	3,004.0	570.77
2026	930.1	145.67	2026	28.6	3.26	2026	2,899.8	587.31
2027	910.9	150.17	2027	28.7	3.26	2027	2,832.8	594.00

Source: own elaboration based on [IERiGŻ-PIB 2005-2022]

Based on these predictions, the area under rapeseed cultivation, yields and production can be expected to decrease. These observations can be attributed to a growing interest in second- and third-generation biofuels derived from non-agricultural crops such as Virginia fanpetals and algae. The targets for advanced biofuels were imposed by the EU. The presented forecast is consistent with EU recommendations postulating that the share of first-generation biofuels (based on rapeseed) in transport fuels should decrease from 10% to 7% in 2020 [Rosiak 2014].

SUMMARY AND CONCLUSIONS

Poland's accession to the EU had transformed the domestic rapeseed market and affected the performance of fat and biodiesel producers.

The aim of this study was to evaluate changes on the Polish rapeseed market. Several specific objectives were also formulated. The main research aim and specific objectives were achieved in successive sections of the article. The research problem was thoroughly described and analyzed with the use of various data sources and research methods.

1. Between 2005 and 2022, the area under rapeseed cultivation increased from 550.2 thousand ha to 1,077.5 thousand ha, whereas rapeseed production increased from 1,632.9 thousand tons to 3,643.4 thousand tons. In the analyzed period, imports exceeded exports due to a growing demand for rapeseed for the production of edible oil and biofuels. Between 2005 and 2022, imports increased from 52 thousand tons to 940 thousand tons, and exports increased from 176 thousand tons to 500 thousand tons.
2. Poland is one of the largest rapeseed producers in the EU. In 2022, Poland ranked third in terms of the area under rapeseed cultivation after France and Germany. Poland was also the third largest rapeseed producer after France and Germany.
3. The area under rapeseed cultivation and rapeseed production increased between 2005 and 2022, but the balance of trade in rapeseed and rapeseed products did not show a growing trend in the analyzed period. The rapeseed trade balance was positive in 2007, 2013, 2014, 2015 and 2016, and negative in the remaining years. The market has a high growth potential.

BIBLIOGRAPHY

Boczar Paweł. 2014. *Możliwości produkcji rzepaku w Polsce i zmiany kierunków jego wykorzystania* (Possibilities of rapeseed production in Poland and changes in the directions of its use). Poznań: Uniwersytet Przyrodniczy w Poznaniu.

Box George E.P., Gregory M. Jenkins. 1976. *Time series analysis: forecasting and control*. San Francisco: Holden Day.

Chibowski Piotr, Waldemar Izdebski, Elwira Laskowska, Oksana Makarchuk, Jacek Skudlarski, Svetlana Aleksandrovna Zaika, Stanisław Zając. 2016. Stan i perspektywy produkcji roślin oleistych w Polsce i na Ukrainie w kontekście rozwoju sektora biopaliw transportowych (Condition and prospects of oilseed production in Poland and Ukraine in the context of the development of biofuels for transport). *Zeszyty Naukowe SGGW w Warszawie. Problemy Rolnictwa Światowego* 16 (1): 60-70.

Dickey Dawid F., Wayne A. Fuller. 1979. Distribution of the estimators for autoregressive time series with a unit root. *Journal of the American Statistical Association* 74 (366): 427-431.

Dyrektywa 2009/30/WE z dnia 23 kwietnia 2009 r. zmieniająca dyrektywę 98/70/WE odnoszącą się do specyfikacji benzyny i olejów napędowych oraz wprowadzającą mechanizm monitorowania i ograniczania emisji gazów cieplarnianych oraz zmieniającą dyrektywę Rady 1999/32/WE odnoszącą się do specyfikacji paliw wykorzystywanych przez statki żeglugi śródlądowej oraz uchylająca dyrektywę 93/12/EWG (Directive 2009/30/EC of the European Parliament and of the Council of 23 April 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC (Text with EEA relevance). Official Journal, L 140, 5.6.2009.

Dzwonkowski Włodzimierz, Wiesław Łopaciuk, Maciej Krzemiński. 2008. *Wpływ uwarunkowań prawnych, ekonomicznych, środowiskowych oraz zmian zachodzących na światowym rynku na rozwój rynku zbóż, roślin oleistych i wysokobiałkowych w Polsce* (The impact of legal, economic and environmental conditions and changes taking place on the global market on the development of the cereals, oilseeds and high-protein crops market in Poland). Warszawa: IERiGŻ-PIB.

Głębocki Benicjusz. 2014. *Zróżnicowanie przestrzenne rolnictwa*. *PSR 2010* (Spatial diversity of agriculture. 2010 National Agricultural Census). Warszawa: GUS.

GUS (Central Statisyical Office). *Rocznik statystyczny rolnictwa* za lata 2005-2022 (Statistical yearbook of agriculture for 2005-2022). Warszawa: GUS.

IERiGŻ-PIB. 2006-2023. *Rynek rzepaku. Stan i perspektywy. Analizy Rynkowe* (Rapeseed market. Status and prospects. Market analyses). Warszawa: IERiGŻ-PIB.

Klepacki Bogdan, Barbara Gołębiewska. 2002. Opłacalność produkcji rzepaku w Polsce w latach dziewięćdziesiątych (Profitability of rapeseed production in Poland in the 1990s). *Wieś Jutra* 2 (43): 3-4.

Kuś Jan. 2006. Uwarunkowania i możliwości zwiększenia produkcji rzepaku na cele energetyczne (Conditions and possibilities of increasing rapeseed production for energy purposes. *Nasz Rzepak* 11: 30-34.

Kuś Jan. 2007. *Uwarunkowania i możliwości wzrostu produkcji rzepaku na cele energetyczne na Lubelszczyźnie*. [In] Materiały z Konferencji „Odnawialne źródła energii na Lubelszczyźnie – promocja i możliwości rozwoju" (Conditions and possibilities of increasing rapeseed production for energy purposes in the Lublin region. [In] Materials from the Conference "Renewable energy sources in the Lublin region – promotion and development opportunities"). Puławy: IUNG-PIB.

Rosiak Ewa. 2004. Produkcja roślin oleistych. [W] *Polska wieś w Europie* (Production of oil plants. [W] Polish village in Europe). Warszawa: Fundacja Fundusz Współpracy, Biuro Programów Wiejskich.

Rosiak Ewa. 2014. Krajowy rynek rzepaku na tle rynku światowego (The domestic market of rapeseed compared to the global market). *Zeszyty Naukowe SGGW w Warszawie. Problemy Rolnictwa Światowego* 14 (1): 86-96.

Rudko Tadeusz. 2011. *Uprawa rzepaku ozimego. Rzepak – zasady uprawy – zdrowa żywność. Poradnik dla producentów* (Cultivation of winter rapeseed. Rapeseed – cultivation rules – healthy food. A guide for producers). Lublin: Wydawnictwo Instytutu Agrofizyki im. Bohdana Dobrzańskiego PAN w Lublinie.

Sobczyk Mieczysław. 2005. *Statystyka* (Statistics). Warszawa: PWN.

Wójtowicz Marek, Franciszek Wielebski. 2002. Zmienność powierzchni upraw, plonów i zbiorów rzepaku w Polsce w latach 1998-2001 (Variability of cultivated area, yields, and production of oilseed rape in Poland in the period of 1998-2001). *Rośliny Oleiste* XXIII: 581-589.

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ZMIANY W PRODUKCJI RZEPAKU W POLSCE PO AKCESJI DO UNII EUROPEJSKIEJ

Key words: produkcja, rzepak, plony, zbiory, prognoza

ABSTRAKT. Celem badań była ocena zmian na rynku rzepaku w Polsce po akcesji do Unii Europejskiej (UE). Szczególną uwagę zwrócono na podaż rzepaku w Polsce na tle innych krajów UE. Do analiz wykorzystano dane dotyczące rynku rzepaku za lata 2005-2022. Do oceny zmian zastosowano metody statystyki opisowej, test ADF, model ARiMA, a także opracowano prognozę zmian produkcji rzepaku. W Polsce produkcja rzepaku jest zróżnicowana przestrzennie i dominuje w województwach zachodniej i północnej Polski. Największą powierzchnię rzepaku w 2022 roku odnotowano w województwach: dolnośląskim (129,1 tys. ha), wielkopolskim (104 tys. ha) i zachodniopomorskim (115,5 tys. ha). W latach 2005-2022 wystąpiły zmiany wielkości plonów i zbiorów rzepaku w Polsce. Najwyższe plony rzepaku odnotowano w latach 2014 (34,4 dt/ha), 2022 (33,8 dt/ha) i 2021 (32,1 dt/ha), natomiast najniższe w 2011 (22,4 dt/ha) i 2010 (23,6 dt/ha). Zbiory były największe w latach 2014 (3275,8 tys. ton) i 2022 (3643,4 tys. ton). Polska jest ważnym producentem rzepaku w UE i w 2022 roku zajmowała trzecie miejsce pod względem produkcji rzepaku (3300 tys. ton), po Francji (4506 tys. ton) i Niemczech (4295 tys. ton). Analiza statystyczna wykazała zmiany w powierzchni, plonach i zbiorach rzepaku. Najwyższy współczynnik zmienności odnotowano w przypadku zbiorów rzepaku (0,236), a najniższy dla plonów (0,115). W przypadku powierzchni, plonów i zbiorów, współczynnik zmienności był wysoki, co świadczy o niestacjonarności szeregów czasowych. Opracowana prognoza dla lat 2023-2027 wykazała tendencje spadkowe dla powierzchni, plonów i zbiorów rzepaku.

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