

The Forecast of Economic Processes of Selected Agricultural Products in the Development of Bioenergy and Agritourism Activity in Poland

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Abstract. The article aims to present the forecast of economic processes in the development of bioenergy in Poland exemplified by rape and cereals. Biomass supply from food industry can be easily processed for heat and energy production purposes. For example, the rapeseed meal is a product that can be used as a source of bioenergy. The study highlights the use of these factors in agritourism activity. In agritourism, the energy sources can be obtained from the animal breeding or local plant production. Bioenergy can be also the factor that provides the right development of agritourism farms. The data contained in the article come from the Central Statistical Office of Poland from the period 2008 to 2015. The forecast covers the period 2016-2030. The cereal production in the analysed years will show a tendency to decrease, in the opposite to grain crops that growing trend was noticed. In addition, the information from a review of literature is taken into account.

Keywords: Forecasting, Economics, Rural Areas, Bio-energy, Rural Tourism Activity

1 Introduction

The concept of biomass characterises a biodegradable waste substance that is made in production processes in agriculture and forestry [1]. Biomass can be liquid or solid, and depending on the state of matter, it has different calorific value [11]. Food industry is one of the main sources of biomass that can be easily processed for the purpose of heat and energy production [13]. It can also be used in agritourism, e.g. to insulate buildings or as fodder (e.g. rapeseed meal) [15].

The paper lists industries that are the biggest sources of waste and match the government's action plan concerning renewable energy carriers' management. Due to that, the balance of management possibilities will refer to raw materials in the form of bran and rapeseed meal.

2 Objective, material and research methods

The article aims to present a forecast of economic processes in the development of bioenergy in Poland exemplified by rape and cereals. The paper draws attention to the use of these factors in agritourism. The data utilised in the article come from the Central Statistical Office of Poland in the period 2008-2015. The forecast is made for the period 2016-2030. In addition, the information from a review of literature is taken into account. The calculation is made with the use of Microsoft, Excel and Statistica programs. To provide a forecast for particular years the following formulas are used:

$$Y_t = f(t, \mathcal{E}_t) \text{ for } t = 1, 2, \dots, n, \quad (1)$$

$$\text{or } Y_t = f(t, Y_{t-1}, Y_{t-2}, \dots, Y_{t-i}, \mathcal{E}_t) \text{ for } t = i + 1, i + 2, \dots, n, i = 1, \dots, p < n. \quad (2)$$

where: \mathcal{E} is a random component (of random fluctuations).

The forecast of an explanatory variable Y in period $T > n$ is calculated following the formula:

$$Y^*_T = f(T) \text{ or } Y^*_T = f(T, Y_{T-1}, Y_{T-2}, \dots, Y_{T-i}). \quad (3)$$

3 Balance of particular types of biomass from food industry in Poland from 2008 to 2015 and a forecast for 2016-2030

The statistical analysis aims to estimate the amount of biomass [15]. Available from food industry in comparison to agricultural land used as basic cropland. The first part of the paper presents the acreage used for the production of cereals and rape and their crops in the period 2008-2015, and a forecast for 2016-2030. Table 1 presents selected data on cereal crops.

As Table 1 shows, the acreage of cereals in Poland in particular years was decreasing. One can see that cereal crops have a tendency to grow in particular years. Cereal grain production was different in Poland in particular years. There were small fluctuations in the average rape crops in Poland within the range of 27 cwt./ha. One can see a growing trend in the acreage of rape cultivation in Poland in particular years. A big decrease in the production of rape was recorded in Poland in the period 2011-2012.

The analysis of cereal production determines the potential resulting from the acreage used for sowing and the amount of crop. About 70% of seed allocated for food is subject to cereal processing.

Table 1. Selected data on agriculture in Poland [2].

Year	Acreage of land used for the cultivation of cereals [thousand]	Average cereal crops [cwt./ha]	Cereal grain production [thousand t]	Rape cultivation acreage [thousand ha]	Average rape crops [cwt./ha]	Rape production [thousand t]
2008	8604	33	27685	771	26.7	2105
2009	8583	35	29817	810	29.2	2496
2010	7646	36	27216	946	22.7	2228
2011	7803	35	26779	830	22.6	1862
2012	7704	38	28541	720	25.8	1866
2013	7479	38	28463	921	28.2	2678
2014	7478	38	28439	871	25.6	2257
2015	7301	38	27708	905	25.2	2307
2016	7170	38	27361	905	25.5	2316
2017	6993	39	27379	907	26.9	2462
2018	6914	39	26882	877	26.8	2385
2019	6753	40	26817	920	26.1	2415
2020	6707	40	26753	914	26.0	2374
2021	6647	40	26630	925	26.7	2462
2022	6494	40	26459	925	26.3	2455
2023	6416	40	25745	930	26.7	2480
2024	6338	41	25933	937	26.4	2471
2025	6134	41	25083	947	27.0	2511
2026	6106	41	24763	946	26.4	2508
2027	6038	40	24406	934	26.8	2497
2028	6015	41	24910	948	27.0	2530
2029	5909	41	24550	951	26.8	2530
2030	5830	42	24835	952	27.1	2543
Average	6916	39	26659	883	26.3	2380

The balance of cereal production takes into account estimates of equalizing amounts of needs and resources. The input values are initial stocks possessed, production and import of raw material. Demand takes into account consumption, sowing, industrial use, use for livestock feed, losses and shrinkage and export. Table 2 presents amounts characteristic of annual production of cereals in particular years.

Table 2. Balance of cereals production in Poland (mln t) [2].

Year	Initial stock	Production	Import	Resources in total	Consumption	Sowing	Industrial use	Livestock feed	Loss and shrinkage	Export	Final stock
2008	2.4	27.7	2.4	32.5	5.2	1.8	2.1	16.1	1.2	2.4	3.7
2010	5.0	27.2	2.2	34.4	5.2	1.7	2.9	17.1	1.2	2.0	4.3
2015	4.7	28.3	1.7	34.7	5.0	1.7	3.1	15.5	1.2	3.0	5.3
2020	7.8	27.9	1.7	37.4	5.0	1.6	3.1	14.9	1.1	2.8	8.8
2025	10.6	26.0	1.7	38.2	5.0	1.5	3.2	14.3	1.1	2.7	10.4
2030	9.4	25.4	1.6	36.4	5.0	1.4	3.3	13.6	1.0	2.6	9.4

Cereal such as wheat, oats and barley are mainly grown for consumption, however, waste resulting from milling, defined as bran, is used for energy production purposes. Calculation is to define detailed indicators characterising the percentage of particular by-products obtained from cereal cultivation. In conventional industry, 700-750 kg of flour and 250-300 kg of bran is made from one tonne, i.e. the rate is 25%.

The use of bran in energy production is limited by the use of the material to feed livestock, as a substrate in food concentrates and for direct sale in food processing industry. It has been decided that a small part, 5-10%, depending on demand and supply, in accordance with the European Union policy, can be used for energy production. Following the above-mentioned guidelines, average production was defined for whole Poland in the period from 2008, and a forecast was made until 2030. The production of bran in industrial milling and estimated energy potential is presented in Table 3.

Table 3. Production of bran in industrial milling and estimated energy potential in Poland in the period 2008-2030 (thousand t) [2].

Year	Bran production in industrial milling	Estimated energy potential 5-10%
2008	917.3762	68.80321
2010	1067.811	80.08583
2015	1323.003	99.22526
2020	2205.145	165.3859
2025	2595.921	194.6941
2030	2343.171	175.7378

Based on the presented calculation, one can assume that the forecasted potential for energy production may fluctuate around an average of 140 thousand tonnes annually. Rape is cultivated in a crop rotation system. It is dedicated for oil industry. Rapeseed

meal is a by-product of the extraction of oil from crushed and pre-conditioned rapeseed. During the process of extraction of one tonne of rapeseed, about 410-420 kg of oil is produced, i.e. the rate of rapeseed meal obtained is 0.58-0.59 t.

The balance of rapeseed production results from the amount of demand and supply. The input value includes possessed initial stock, production and import. The supply takes into account processing, loss and shrinkage and export. In case of rapeseed, the estimated value of the rate was 58%. Table 4 presents amounts characteristic of annual production of rapeseed in the period 2008-2030.

Table 4. Balance of rapeseed production and estimated energy potential of rapeseed meal in Poland in the period 2008-2030 (thousand t) [2].

Year	Initial stock	Production	Import	Resources in total	Processing	Loss and shrinkage	Export	Final stock	Estimated energy potential of bran
2008	0.0	2.1	0.4	2.5	2.0	0.1	0.2	0.2	0.1
2010	0.1	2.2	0.3	2.6	2.1	0.1	0.4	0.0	0.0
2015	0.2	2.3	0.4	2.9	2.1	0.1	0.2	0.4	0.2
2020	1.2	2.4	0.4	4.0	2.1	0.1	0.3	1.4	0.8
2025	2.3	2.5	0.3	5.1	2.1	0.1	0.3	2.6	1.5
2030	3.6	2.5	0.3	6.5	2.1	0.1	0.4	3.9	2.2

Constant demand for bio-components has led to intensive development and increase in demand for products from the production of biofuels in recent years. It is connected with the increase in the domestic production of rape, which translates into a growth of cultivation acreage. The 2009 was a record year with a big growth in comparison to 2008: rape supply was almost 2.5 thousands of tonnes in 2009 and 2.1 thousands of tonnes in 2008. This trend was accompanied by the increase in crops reaching even 31 cwt./ha in 2009. In the two successive years (2010 and 2011), there was a decrease in production directly connected with bad weather conditions. However, 2013 was a very successful year with rapeseed production reaching 2.6 thousands of tonnes.

4 Physical and chemical characteristic of biomass, its composition and energetic value

Cereals cultivation is widespread in the territory of Poland. Particular cereal types produce grain with high starch content and are broadly used in food industry. Cereal products include flour, groats, bread, pasta etc. The by-product of milling is bran, mostly the outer layer of cereal grain.

Bran contains grain, spore remnants and aleurone layers [6]. They contain high level of fibre, vitamins as well as macro and micro-elements [20]. Thanks to its nutrition value, it is also used as cattle and pig feed. Cereal bran is rich in vitamins from group B and D. The energetic value of cereal bran is 5.3 kJ·kg [12, 20]. Table 5 presents selected physical parameters of cereal bran.

Table 5. Physical parameters of cereal bran [14].

Parameters	Value
Oil content, %	max. 3
Moisture content, %	max. 12.5
Protein content, %	32 – 36
Raw fibre, °C	min. 11–12
Solvent content, ppm	max. 300
Bulk density, g/cm ³	0.550
Mineral pollution, %	2

Rapeseed meal is a by-product from the process of extracting fat from crushed and pre-conditioned rapeseed with the use of solvents [6]. The technology of oil pressing consists in initial extraction of rapeseed with the use of a screw press. The product obtained is called extra virgin oil and rapeseed pomace that is next processed with the use of solvents in order to obtain the remaining oil. The products may be classified as raw oil, post-extraction oil, rapeseed pomace and rapeseed meal. Table 6 presents selected physical parameters of rapeseed meal.

Table 6. Physical parameters of rapeseed meal [4].

Parameters	Unit	Value
Moisture content	%	12.5
Solvent content	ppm	300
Raw protein content	%	35
Fibre content	%	13
Bulk density	g/cm ³	0.550
Mineral pollution	%	2

5 Current prices of particular types of biomass and a price forecast until 2030

One can notice that the price of plant products depend on the season and the demand at the time. Domestic prices of cereal compared to world market in the season 2012/2013 maintained at a high level. It was reflected in the sales of cereal milling waste. The current price of rye bran is about 680 PLN/tonne and wheat bran: 800 PLN/t. In comparison: the price of rye is about 830 PLN/t and wheat about 1000 PLN/t on average (<http://www.rolpetrol.com.pl>). The forecast is that the future price of bran will be about 1000 PLN/t. The above-mentioned prices are net ones. Table 7 presents average purchase prices of cereal bran and a forecast until 2030.

Table 7. Cereal and bran purchase prices in Poland in the period 2008-2030 (PLN/t) [18, 19].

Year	Price of rye		Price of wheat		Price of rye bran		Price of wheat bran	
	net	gross	net	gross	net	gross	net	gross
2008	346	426	431	530	283	348	339	417
2010	350	431	470	579	287	352	370	455
2015	763	938	935	1150	624	767	736	905
2020	1096	1348	1331	1637	897	1103	1047	1288
2025	1430	1759	1728	2125	1170	1439	1359	1672
2030	1764	2169	2124	2612	1443	1775	1671	2055

Average price of rapeseed in Poland is at the level of 2000 PLN/t. The price usually depends on the place of purchase. Polish oil production market ensures the supply of rapeseed meal and pomace. The difference between the two raw materials consist in the fact that rapeseed pomace is made in the process of pressing and is mainly used as animal feed and rapeseed meal is made as a result of oil extraction with the use of solvents. The difference between the two raw materials is small and the price of both is 1.140 PLN/t on average.

6 Analysis of the use of biomass from food industry, including other sectors' demand for edible biomass

Food industry in Poland is a producer of considerable amount of waste in the form of biomass. As biomass, the waste can be used in many ways, e.g. as energy carriers. Thus, biomass for energy use may be obtained from oil production companies (rapeseed meal) and milling industry (cereal bran).

The main milling industry centres in Poland include mills in Bolesławiec, Jarosław, Kalisz, Stargard, Stoisław, Warsaw and Wrocław. The industry purchases cereals from local farmers and mills them for consumption purposes. There are about

140 milling companies with about 2.400 mills registered. The scale of production mainly depends on mills' production capacity and demand for a particular type of flour. Food industry uses cereal bran to produce fodder and as a raw material to produce concentrates. The demand for cereal to produce fodder may constitute competition for obtaining waste from milling of about 3 m. tonnes of cereals. Cereal is mainly used to produce pasta (ca. 100 thousand t.) and bread (ca. 3 million t.) and to store (ca. 2.5 million t.).

Oil industry is a substantial source of renewable energy. It is necessary to consider current and future possibilities of processing rapeseed and seed meal of other oil plants. At present, an increase in sowing rape is recorded, which is connected with the Act on biofuels in Poland, which regulates basic issues connected with the production and sale of biofuels. It regulates the introduction of bio-components and liquid biofuels [9]. The Council of Ministers established the National Indicative Target (NIT) in the regulation of 15 June 2007. It lays down an obligation to introduce a specified amount of bio-components called NIT and this way, starts a sale of bio-components and biofuels as well as agricultural raw materials used for their production. Poland should work out a strategy for biofuels development until 2020. The national road map to energy from renewable resources establishes that [10]. Therefore, in 2014, food industry will need about 1.5 million tonnes of rapeseed, which will provide ca. 875 thousand tonnes of bio-components. Table 8 presents estimated demand for rape and rape esters until 2020.

Table 8. Estimated demand for rape and rape esters and a forecast until 2020 [5].

Year		2014	2016	2018	2020
National Indicative Target	Energetic value %	8	8	9	10
		8.9	8.9	8.9	8.9
Diesel fuel	tonne	80	80	80	80
		10	10	10	10
Diesel fuel	thousand m ³	627	627	627	627
Demand for bio-components	thousand m ³	87	98	10	12
		5	7	98	16
		14	16	18	20
Demand for rape	thousand t	70	57	44	42

As the above data show, rape crops should increase considerably and culminate in 2020.

7 Competition for obtaining biomass

Every kind of waste obtained in cereal production should be looked at from the point of view of energy production. It is difficult to estimate the possibility of using grain for energy purposes. This results from unpredictable import (the European

Commission decision) – in case cereal crops are small, import increases. Whether conditions are also decisive (e.g. a curse of abundance and changes in planning cereal cultivation). Because of that it is difficult to forecast a stable policy of cereals use.

Most waste from cereals milling is used in fodder and food production. Cereal bran is used to produce livestock feed and many different concentrates.

Polish consumers' growing demand for vegetable fats is a key factor in the development of oil industry. Zakłady Tłuszczowe "Kruszwica" S.A. within Bunge Group is the major entity. It produces 80% of margarine and oil. It owns the biggest factories such as those in Kruszwica, Brzeg, Szopienice, Kobylniki and Warsaw. The factory in Brzeg processes seeds and refined oil and produces material for the biofuel sector. The factory in Kobylniki processes seeds and refined oil and the factory in Warsaw: oil, Kruszwica processes 1.5 thousands of tonnes of rape. High quality rapeseed oil may be a recipe for further development of biodiesel sector.

In 2008, a company in Kruszwica provided over 500 thousand tonnes of rapeseed meal. It signed an agreement with Energo Krak company to supply biomass in the form of post-extraction rapeseed meal. Seed meal was also sold abroad. Increased competition in energy production results from the fact that income from seed meal sales lower the cost of oil production. The biggest companies processing rapeseed oil are fat production factories and biofuel companies, including (<http://www.farmer.pl>): ZT Kruszwica (factories in Brzeg, Kruszwica and Warsaw), ADM Szamotuły Sp. z o.o. ZT Bodaczów, Elstar Oils S.A. Komagra Sp. z o.o. Tychy, Petroestry Sp. z o.o. (Greater Poland, Kuyavia-Pomerania, Western Pomerania Voivodeships), MOSSO Kwaśniewscy Sp. j. Mróz Oleje (Lower Silesia Voivodeship), Glencore (Elbląg, Kętrzyn, Pyrzyce, Czarnogłowy), ZCH Organika – Azot Jaworzno (Elewator Jarosław, Włodowice, Jaworzno, Zimno), Biomarol Sp. z o.o., Sieradz, Dalgety, Kamex (Lubus Voivodeship), Biopal (Greater Poland Voivodeship), PPHU Wilmar (Lower Silesia Voivodeship), Agro Corn, Bastik (Kozmin Wielkopolski), Agro-mat Ząbkowice, Agroproducts Wielkopolskie Składy Zbożowe Sp. z o.o. Lorgan Wejherowo, Chemirol (Grifice Nowy Staw, Gniezno, Wągrowiec, Orchowo, Samborowo, Bartoszyce, Kruszewiec, Siennica Rożana).

8 Seasonal cost of obtaining raw material per unit and a forecast

The cost of obtaining one unit of raw material depends on the cost of producing that material compared to the obtained income. Based on the database of Warmińsko-Mazurski Ośrodek Doradztwa Rolniczego, three technologies characterising particular crops are taken into account in the record sheet. The data are of September 2013 and all the amounts refer to one hectare.

The production cost of one cereal unit was 98.63 PLN/cwt. at a low intensity level, 83.28 PLN/cwt. at a medium intensity level and 69.68 PLN/cwt. at a high intensity level. One should add the cost of processing cereal to the cost of its production, because cereal bran is treated as waste. Sales of flour is the profit from the production. Figure 1 presents seasonal changes in cereal prices.

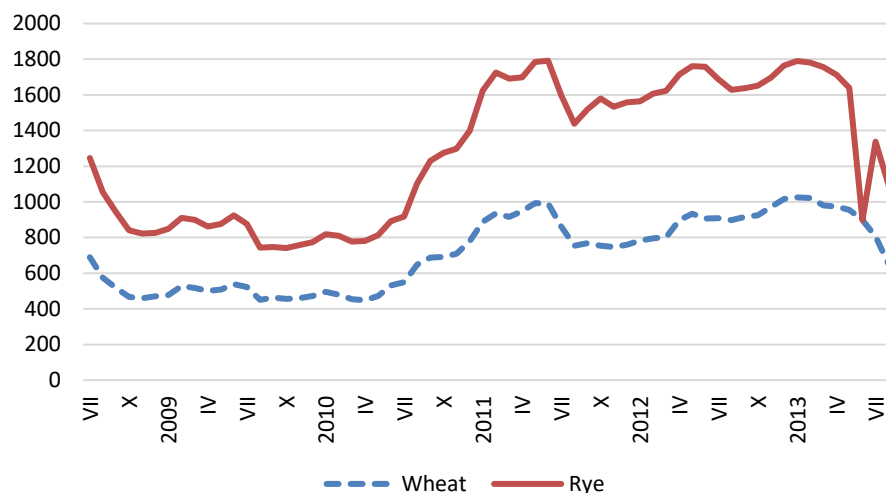


Fig. 1. Cost of cereal purchase in particular seasons (PLN/t) [2].

Cost of rape unit production was 229.94 PLN/cwt. at a low intensity level 181.89 PLN/cwt. at a medium intensity level, and 153 PLN/cwt. at a high intensity level. The total value of rape production is 3 279.02 at a low intensity level 4 057.52 at a medium level and 4 836.02 at a high level. The balance of cost of producing one unit of rape must take into account seasonal changes that are expressed in the forecast presented in the former part of the paper.

The total cost of rapeseed meal production should take into account the purchase of a screw press. As screw presses' specifications vary their prices may vary within the range of a few thousand.

9 Use of bioenergy in agriculture and agritourism

At present, we can observe the use of additional sources of energy in agriculture, including biomass. Vegetable oil may be obtained from rape, sunflower or soya beans. Bioethanol may be obtained from cereal and potatoes and biodiesel may be produced from rape, sunflower or soya.

The product mentioned earlier that may be used as a source of bioenergy is rapeseed meal obtained in the process of pressing oil from rapeseed. Because of a high content of protein, rapeseed meal constitutes a valuable component of farm animals feed. The product is mainly used as fodder for ruminants, pigs and poultry. Post-extraction rapeseed meal is a product from the extraction of oil from rapeseed. The use of rapeseed meal allows to reduce the cost of fodder. But rapeseed meal cannot be used to feed young animals. It is rich in sulphuric amino acids (methionine and cysteine), however the level of lysine is a little lower than in soya protein. That is why at least in the first period of animal fattening it is recommended that the level of

protein in fodder should be supplemented with two protein materials: rapeseed meal rich in sulphuric amino acids and soya meal with a considerable content of lysine. Other legumes that are rich in lysine may partly substitute for soya protein.

In agritourism, where animal (or plant) production is a very important factor it is essential to obtain additional sources of energy [17]. In this kind of business activity, renewable energy sources (bioenergy, photovoltaic batteries) are key elements. The use of renewable energy in rural areas may be an opportunity to compensate conditions of development in these areas. The diversity of resources in rural regions creates great opportunities for innovation renewable energy sources development (bioenergy) and non-agricultural business, inter alia, agritourism farms. The use of opportunities created by bioenergy may be the right direction in the pursuit of farm development including agritourism ones [3]. Agritourism has become one of the most popular forms of tourism recently [16].

10 Conclusions

Based on the presented analyses a few generalisations and conclusions are made. Food industry is one of the basic sources of biomass supply which can be easily processed for heat and energy production purposes.

Cereal production in the analysed years will show a tendency to decrease. There were small fluctuations in the average rape crops in Poland within the range of 27 cwt./ha.

We can see a growing trend in grain crops in the analysed years. Rapeseed meal is a product that can be used as a source of bioenergy. The use of rapeseed meal allows for a significant reduction of feed costs. It is a product produced in the process of extraction of rapeseed oil.

In agritourism, where animal (or plant) production is a key factor it is important to obtain additional energy sources. The use of opportunities created by bioenergy may be the right direction in the pursuit of farm development, including agritourism ones. Bioenergy is one of the innovations in agritourism.

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