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Original Research

Environmental and Economic Factors Shaping Efficiency of Rapeseed Farms in Poland

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Abstract

The objective of our paper was to present factors of the efficiency of farms cultivating rapeseed. The analysis included production and economic results for rapeseed cultivation. We used tabular, graphic, and descriptive methods to measure the research results. In addition, the authors used a regression model to measure the impact of selected factors on production and economic results of farms. The authors used correlation analysis and the classic method of least squares to measure homoscedasticity. Our research found that the value of production and income has increased in all farms. We observed from the survey that the production and income calculated per one ha. farmland increased. The income calculated per one employed person has increased as the result of hired labor on the farms.

Keywords: efficiency, economic results, farm area, rapeseed farms

Introduction

The economic situation of European Union agriculture is changing. Farmers have to adjust their practices to new requirements of the Common Market. Strong competition requires farmers to enlarge their farms and improve their incomes and efficiency. To survive in the market farmers have to introduce new production and more effective production technologies.

Agricultural income is the main source of cash for the farm and the basis for assessing economic efficiency [1]. Income earned by the person working on the farm is the most important indicator of the effects of agricultural activity and shows the status of farming families. Agricultural income must be adequate to ensure a decent standard of living. The highest net income is achieved when production on the farm is maintained at a satisfactory level. To have a positive balance of agricultural income, the cost of production per unit cannot exceed the net price received for these products.

The efficiency of agriculture depends on financial resources. As Carter [2] points out, financial resources flow out of agriculture during industrialization. Certainly the United States experienced this. However, Poland exhibited a different process, particularly when it joined the EU with the possibility of applying for money from the Rural Development Program and other sources.

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The efficiency of farming is also the result of the agrarian structure, which helps understand the economic process in history. It has been observed that land shifts from agriculture to other sectors having higher efficiency [3]. The agrarian structure is the weak point of Polish agriculture, because the vast majority of farms are very small. The agrarian structure in Poland and other countries of Europe was determined by history, wars, political and social relations, and the environment [4]. What's more, the "contraction of the agricultural area in the coming decades is inevitable and in line with the historic development where periods of expansion and contraction of agricultural area are intermingled. The new millennium will start with a period of change in land use to fulfill societal goals in an optimal way" [5].

The effectiveness of technology in agriculture is related to the level of knowledge and skills of producers and the quality of inputs used by farmers. The efficiency of allocation is described as "the relationship between the factors of production: land, labor, and capital. The same level of cost allows for different levels of production depending on the proportion of inputs." The efficiency of the scale of production is different and is described as "the size of a single, functionally separable, production process." According to Szymańska, [6] efficiency becomes a condition for the survival and development of economic entities, both in an operational and a tactical sense.

Production of rapeseed in Poland, the European Union, and the world is one of the most promising branches of agriculture. The effect on the development of rapeseed production is its use in the petrochemical, feed, and food industries, which forms a high market opportunity in relation to other crops, such as wheat. Farmers deciding on rapeseed production must take into account not only the expected benefits, but also the availability of good arable land.

In addition, research on energy efficiency of rapeseed was carried out by many authors. Jankowski [7] analyzed the energy efficiency of rapeseed of the family Brassicaceae. He found that rapeseed used in the production of biofuels in the first generation is the most energy-intensive crop for biorefining. Shen [8] measured energy efficiency in China. He found that China's energy efficiency level is influenced by external environmental variables such as industrial structure, government intervention, and marketization level.

The problem of energy efficiency has been a key challenge internationally. The European Union, for example, has established the target of 20% of final energy composition from renewable sources by 2020 [9]. Not all European Union countries have met this goal. In 2011 the renewable energy sector contributed 13% of total EU-27 energy consumption [10]. In 2013 19 EU countries achieved the interim targets, including Italy, Germany, Austria, Estonia, Denmark, Lithuania, Sweden, and Romania [11]. Other countries did not reach the goal, for example, France, the Netherlands, and the United Kingdom [12]. The demand for energy will be increasing and energy is mostly generated from fossil fuels. There is the need to look for alternative and environmentally friendly sources of energy. Most of the primary renewable energy (67%) in the EU comes from biomass, including 48% from wood biomass [7].

The production of biofuels is characterized by many advantages and disadvantages. Among the most important benefits in literature are:

- Renewable character and natural origin.
- Possibilities of reducing oil extraction and restrictions
- Dependence of the economy on this raw material and the possibility of partial construction of energy independence of the country.
- The development of agricultural raw materials in conditions of supply imbalance, which has a stabilizing effect on their prices.
- Creating additional demand for agricultural raw materials increases agricultural income and, consequently, it can also indirectly affect the development of rural areas.
- Thanks to the production of biofuels (processing of oilseeds) you can get significant amounts of middling digestive, which is a valuable component of animal feed and thus limits its import [13].

The most important threats to the production of biofuels are [14]:

- More land needs to be allocated (it is estimated that in Poland by 2020 it can be up to 1 million ha. of good soils) for cultivation of plants for energy purposes.
- A significant use of water in the production process of agricultural raw materials, which is a particularly serious problem in Poland.
- Competition for agricultural raw materials between the food and fodder industry on the one hand, and the biofuel industry on the other, and its consequences.
- Potential danger to safety and food supply.

In general, the use of first-generation biofuels provides smaller benefits than second-generation biofuels, which may be determined in the future development direction for the biofuels market [13]. The effect of the first generation biofuels is associated with concerns over food supply and demand and reduction of land for food production [15].

The current literature lacks data and analysis on the factors shaping efficiency of farms engaged in the cultivation of rapeseed in the context of land use. There were also no factors associated with land and its impact on the economic results of holdings engaged in the cultivation of rapeseed. Bearing in mind the importance of land used for rapeseed production, this paper attempts to evaluate the effectiveness of its use on farms in Poland.

This article is organized as follows. First, we present an introduction. Second, we describe the efficiency of rapeseed production. Next, we present our aims and methodology. The next part of our paper deals with the problem of land in rapeseed farms.

Material and Methods

The aim of the study is to investigate the effectiveness of holdings engaged in the cultivation of rapeseed.

The authors wanted to answer following questions:

1) What is the efficiency of farms engaged in rapeseed production?
2) Which factors determine the efficiency of farms engaged in rapeseed production?

We did the research in 151 farms in all voivodeships of Poland. The number of surveyed farms was largest in regions with higher rapeseed production. The farms were divided into four groups according to rapeseed area: up to 10 hectares, 10,01-20 ha, 20,01-30 ha, and above 30 ha. The surveyed farms belonged to the Farm Accountancy Data Network (FADN), the only available database in Poland, and the data collection was carried out by the Institute of Agricultural and Food Economics of the National Research Institute.

However, during the survey many obstacles were found. Some farmers did not want to take part in the research and some did not remember their accountancy data. That is why seven farms were eliminated from the research. The survey was carried out in 2015. We used purposeful selection to choose the farms and collect data. The farms were surveyed using the following criteria: at least 50% of revenue generated from rapeseed production and the farmer agreed to take part in the survey. The questionnaire was filled out by the farmer, who used accountancy data from the previous year. The questionnaire included questions and tables, which enabled conducting research, for example collecting information about fixed assets, current assets, sown area, revenues, expenditures, total production, taxes, etc. The second part of the questionnaire included 20 questions about each farmer's opinion concerning efficiency.

The obtained results of the questionnaire's figures on the farms have been developed using an analytical and descriptive method. This method was used in particular with regard to assessing the existing situation in the organization of production and production results. Using the computer program Statistica PL and Excel, we conducted statistical analysis for measurable traits. An important issue was to examine the combined effect of factors describing the indicators on the condition of the farm.

Assumptions of the classical method of least squares are:

1) The matrix of observation variables is non-random, has a full range of columns, and the number of observations (= number of lines) is not less than the number of estimated parameters (= number of columns).
2) The random component is fixed with an expected value of zero.
3) The random component is fixed and has a finite variance.
4) The random component does not exhibit autocorrelation.

In the classical least squares method, it is assumed that the variance of the random component ε is constant for all i, i.e.,

$$D^2(\varepsilon_i) = \sigma^2, \text{ for } i = 1,2,...,n. \quad (1)$$

Ownership of equal variance is called homoscedasticity of random components. Its opposite is heteroscedasticity.

To verify the assumption of constant variance, among others, the Breusch-Pagan test (BP) is used, where it uses an estimated regression with the dependent variable being the square of the normalized residuals (divided by the standard deviation). The null hypothesis of this test is that the random component of the model is homoscedastic. The alternative hypothesis is that the random component of the model is heteroscedastic.

Stability of the variance of random components is verified by the hypothesis of equality of variances for two extreme sub-samples of observation:

$$H_0: \sigma_1^2 = \sigma_2^2$$
$$H_1: \sigma_1^2 \neq \sigma_2^2 \quad (2)$$

…where σ^2_1 is the variance in the first subsample, and the σ^2_2 is the variance in the second subsample.

The economic efficiency of agricultural production was assessed using the following results:

– Y1: total production
– Y2: agricultural income

Economic results are presented in per one ha. farmland, one full-time employee working, and one working hour of the farmer.

The tables assess the significance of the regression coefficients (t-test), assessment of significance (p-value), standard error, and correlation coefficient. The value was considered important in which the p-value was ≤0.05.

Selection factors were made using factor analysis, which can be divided into two phases: separation factors and their rotation and interpretation of separate systems. The first step is to collect a certain number of measurement variables that characterize the analyzed entities. The next step is to measure interdependencies between variables and create a correlation matrix. We used variables presented by the Institute of Agricultural and Food Economics – National Research Institute, and then we did the statistical selection. Variables showing small relationships were eliminated. The last step was to choose the factor model by the method of principal components [16-17]. This method assumes the "need to appoint a reduced correlation matrix, eliminating the specific factor of consideration by the resource estimate volatility of the common features." This happens because each new factor will have less and less influence. Therefore, the choice is made by using the most important factors to reduce variation using the following criteria:

– The criterion of sufficiency ratio, assuming a minimum of 75% degree of explained variance.
– Kaiser criterion, involving the elimination of variables with values below unity.
– A plot which is determined on a line chart of successive values and then eliminate factors to the right of the point of a mild decline in their value [18-17].

The following explanatory variables (selected using factor analysis) were chosen by substantive justification:
X_1: Agricultural area (ha)
X_2: Percentage of rape in the crop structure (%)
X_3: Share of grains in the sown area (%)
X_4: Soil valuation indicator (points)
X_5: Value of current assets (PLN)
X_6: Value of investments (PLN)
X_7: Cultivated area of rapeseed (ha)

Based on the regression equation, the strength of the relationship (regression coefficient) between the described variables (dependent) and individual describing variables (independent) was calculated. The results of the studies are in three types of tables with appropriate means and standard deviations of survey characteristics, the linear correlation coefficient between the studied traits, and the multiple regression equation. The regression equation was rated by an F test, and to evaluate the correlation coefficient we used Student's t-test. Evaluation of significance was made at level 0.05. We also calculated the regression equation with all the independent variables and the choice of the optimal subset of the independent variables.

Classical procedures were adopted for calculating all the indicators and economic categories. The explanation adopted for these assumptions was necessary to assess their logical correctness, as well as to gain a better understanding of the content of this work.

Results and Discussion

Agriculture is an activity that delivers not only agricultural products, but also income, increasing productivity and agriculture income while reducing poverty [19]. Large farms generate higher incomes and higher rents for their owners. Large-scale agricultural production delivers benefits for the consumers, who are provided with cheaper products of higher quality. Large farms are more technologically advanced and they use their resources more efficiently. That is why they are more likely to contribute to agricultural advancement, economic growth, and national development, and generate higher incomes than smaller agricultural estates.

Rapeseed farms have different conditions compared to other farms. The research conducted by Bełdycka-Bórawska [20] showed that in the development of farms engaged in the growing of rapeseed, the important determinants are EU policies for biofuels and the possibility of the use of funds under the RDP. Moreover, the research shows that the most important assistance sources are low-interest loans and funds from the EU. Among the barriers to farmers in the largest number of cases are a high demand for land and a small supply of land, which is strongly linked with the cultivation of rapeseed.

Rapeseed is a plant that is sensitive to changes in temperature, soil, and hydration. Rapeseed for the proper course of germination needs 10-20 mm of precipitation. Other energy crops like arundo, miscanthus, and poplar have different water requirements. Arundo and miscantus need irrigation during planting. Poplar needs irrigation on an annual basis [9]. For the cultivation of rapeseed, soils with a good structure are required, which are characterized by the properties of water absorption and its discharge. Fertile, undigested soils, maintained in good agricultural and fertile nutrients are particularly desirable. Rapeseed hardly tolerates flooded soils. In the temperature range, rapeseed is a sensitive plant. Rapeseed sowing at the optimal time optimizes the role of the thermal factor in the process of germination and formation of a leaf rosette [21].

Total production is the sum of the value of crops and livestock produced on the farm. The value of total production increased with the sown area of rapeseed in the farm. Similar results were observed for total production calculated per full-time employee and hours worked by the farmer. The value of total production calculated per 1 ha. also grew with the expansion of the crop area on the farm, but for farms with an area above 30 ha. yields were lower than on farms sowing 20,1-30 ha. of rapeseed (Table 1).

The research conducted by Jankowski [7] shows that the energy efficiency of high-yielding perennial crops (maize, sweet sorgum, giant miscanthus) used for

Table 1. Total production and agricultural income in the surveyed farms, depending on the area of rapeseed (PLN).

Specification	Total production				Agricultural income			
	Till 10	10,1-20	20,1-30	Above 30	Till 20	20,01-30	30,01-40	Above 40
Average on farm	204574,6	467429,4	1020424,0	1865908,0	123896,7	202727,1	446247,5	989262,9
Per 1 ha farmland	5275,5	6959,8	8083,2	6998,9	3193,2	3018,6	3534,9	3710,7
Per 1 employed	113652,6	233714,7	408169,6	746363,2	68 814,8	101363,6	178 499,0	395 705,2
Per 1 hour	62,3	108,6	135,0	204,6	37,70	47,1	59,0	108,5

Source: own survey

Table 2. Correlation analysis of variables.

Variables	Variables						
	X_1 (Agricultural area (ha))	X_2 (Participation of rapeseed in crop structure (%))	X_3 (Share of grains in sown area (%))	X_4 (Soil valuation indicator (points))	X_5 (Value of current assets (PLN))	X_6 (Value of investments (PLN))	X_7 (Cultivation area of rapeseed (ha))
X_1 (Agricultural area (ha))	1,000	-0,076	0,072	-0,054	0,452	0,185	0,903
X_2 (Participation of rapeseed in crop structure (%))	-0,076	1,000	0,087	0,115	-0,051	-0,072	0,126
X_3 (Share of grains in sown area (%))	0,072	0,087	1,000	-0,010	0,171	0,049	0,162
X_4 (Soil valuation indicator (points))	-0,054	0,115	-0,010	1,000	-0,150	-0,033	-0,049
X_5 (Value of current assets (PLN))	0,452	-0,051	0,171	-0,150	1,000	0,326	0,461
X_6 (Value of investments (PLN))	0,185	-0,072	0,049	-0,033	0,326	1,000	0,182
X_7 (Cultivation area of rapeseed (ha))	0,903	0,126	0,162	-0,049	0,461	0,182	1,000

Source: calculations based on own survey

producing second-generation biofuels depends mostly on mineral fertilization. To achieve the highest efficiency, several things should be done; for example improving fertilization strategies, abandoning monocultures of annual plants, increasing the share of legumes in crop rotation, and integrating agricultural production methods.

Rapeseed crops that are used for the production of first-generation biofuels (biodiesel) are the most energy intensive crops for biorefining. The production of second generation biofuels from high-yielding energy crops are characterized by significantly higher energy efficiency than rapeseed.

Gross value added includes the production from a total net of direct and indirect costs. Its value is calculated on average grown per farm with the growth of the sown area of rapeseed in the farm. Similar results were observed in the case of growth of gross added value calculated per man-hour of work by a farmer and one full-time employee. In turn, the gross value added calculated per one ha. farmland was the highest in the farms of the area 10 ha. of rapeseed sown.

Net value added includes the gross value-added, less depreciation. Net value added grew with the growth of the sown area of rapeseed in the farm. Also, the net added value calculated per full-time employee and net value-added calculated on one man-hour of work by a farmer grew with the growth of the sown area of rapeseed.

Agricultural income is the net economic category on the income statement on a farm. It arises as the difference between net added value and the cost of external factors, which include the cost of credit, loans, and labor. The value of agricultural income increased together with the sown area of rapeseed on the farm. Also, the value of agricultural income calculated on one full-time employee and per one hour of work by the farmer grows with the sown area of rapeseed in the farm (Table 1).

The level of income in the EU countries varies and is changing. In 2014 agricultural incomes in comparison to 2013 decreased in 20 EU countries. For example, agricultural income fell in Finland (-22,8%), Lithuania (-19,4%), Belgium (-15,2%), Italy (-11%), and others, whereas income increased in 2014 in comparison to 2013 in the following EU countries: Slovenia (13,3%), Hungary (9,1%), Czech Republic (7,2%), Great Britain (6,9%), Greece (4,4%), Cyprus (1,8%), France (1,2%), and Germany (0,2%). The agricultural income in Poland decreased by 5,7% in the analyzed period [3].

We wanted to examine if there is a correlation between variables (Table 2). We found a large correlation between the analyzed variables. That is why we decided to analyze the individual impact on the efficiency of agriculture. We cannot measure the impact of all variables together on the economic efficiency of agriculture. Agricultural area X_1 is correlated with X_8 (production volume of rapeseed in d_t). Cultivated area of rapeseed (X_7) is correlated with X_1 (agriculture area) and X_5 (volume of current assets), which suggest common relations in the agricultural economy.

Homoscedasticity, or stability variance, is another assumption that we need to verify for the classical method of least squares. The prevalence of heteroscedasticity

Table 3. Results of the classic method of least squares between the dependent variable Y_1 (total production) and the explanatory variables for data from 2015.

Variable	Coefficient	Std. error	Test T-Student	P value
X_1 (Agricultural area (ha)	5653,42	621,25	9,10	0,122
X_2 (Participation of rapeseed in crop structure (%))	379043,00	328732,00	1,15	0,251
X_3 (Share of grains in sown area (%))	-4498,49	3070,82	-1,47	0,145
X_4 (Soil valuation indicator (points)	-62,56	378,43	-0,17	0,869
X_5 (Value of current assets (PLN)	1,22	0,09	13,36	0,270
X_6 (Value of investments (PLN)	-0,23	0,18	-1,31	0,192
X_7 (Cultivation area of rapeseed (ha)	-5659,55	3913,60	-1,45	0,151

Source: Compiled on the basis of their own survey

does not always mean a bad model choice or low quality of statistical data.

The rest of the work was analyzed for homoscedasticity between variable Y_1 (the value of total production) and the explanatory variables using the least squares method. Research shows that the homogeneity of variance, or homoscedasticity (the variance of residuals is constant), does not significantly change with the change in value of other variables $p \geq 0.05$ at the assumed level of significance. Therefore, there is no reason to reject the hypothesis Ho: of homoscedasticity (Table 3).

The impact of selected determinants for liquid biofuels production in Poland after 2006 was measured by Borychowski [22], who found in his survey that there is no evidence to reject the null hypothesis of normal distribution of the variable.

The rest of the work was analyzed regarding homoscedasticity between variable Y_2 (agricultural income calculated per one ha farmland) and the explanatory variables using the least squares method. Research shows that the homogeneity of variance, homoscedasticity (where the variance of residuals is constant), does not significantly change with the change in the value of other variables $p \geq 0.05$ from the assumed level of significance. Therefore, there is no reason to reject the hypothesis H_o of homoscedasticity (Table 4).

The survey proved that the efficiency measured by agricultural income depends on X_2 – participation of rapeseed in crop structure, X_6 – value of investment, and X_7 – cultivated area of rapeseed. These variables can be classified as economic and environmental factors. Zografidou [23] measured the efficiency of renewable energy production network using the DEA model. He found that the social and environmental criteria are more important than economic factors in order to achieve maximum efficiency. Borychowski [22] found that the growing sales of biodiesel are the most important incentive for a production increase. Moreover, increasing prices of oil are the most important factors for the development of the biodiesel sector in Poland. He also claims that lower prices of oil should lead to a decline in the production of biodiesel.

Investment in agriculture plays an important role in increasing efficiency. Some farms introduce investment in renewable energy production, which should consider economic, social, and environmental aspects [24]. The economic aspects include financial appraisal and return on investment. The social aspects include local society's preferences concerning employment and other benefits.

Table 4. Results of the classic method of least squares between the dependent variable Y_2 (agricultural income calculated per 1 ha farmland) and the explanatory variables for data from 2015.

Variable	Coeffcient	Std. error	Test T-Student	P value
X_1 (Agricultural area (ha))	-10,63	13,63	-0,78	0,437
X_2 (Participation of rapeseed in crop structure (%))	2980,18	7209,74	0,41	0,680
X_3 (Share of grains in sown area (%))	-65,69	67,35	-0,98	0,331
X_4 (Soil valuation indicator (points))	1,34	8,30	0,162	0,872
X_5 (Value of current assets (PLN))	0,01	0,00	5,09	0,121
X_6 (Value of investments (PLN))	0,03	0,00	8,53	0,305
X_7 (Cultivation area of rapeseed (ha))	3,13	85,83	0,04	0,971

Source: Compiled on the basis of their own survey.

Table 5. Results of the Breusch-Pang test for heteroscedasticity between the dependent variable Y_1 (total production) and the explanatory variables for data from 2015.

Variable	Coeffcient	Std. error	Test T-Student	P value
X_1 (Agricultural area (ha))	0,02	0,00	4,63	0,870
X_2 (Participation of rapeseed in crop structure (%))	3,27	2,56	1,28	0,20
X_3 (Share of grains in sown area (%))	-0,00	0,02	-0,20	0,839
X_4 (Soil valuation indicator (points))	-0,00	0,00	-0,07	0,946
X_5 (Value of current assets (PLN))	2,71	7,14	3,80	0,00
X_6 (Value of investments (PLN))	-1,46	1,38	-1,07	0,289
X_7 (Cultivation area of rapeseed (ha))	-0,04	0,03	-1,30	0,20

Source: Compiled on the basis of their own survey

Environmental aspects of investment in renewable energy should not disturb the ecological homeostasis of flora and fauna [25].

The same results were observed in a second analysis concerning the assumption of a constant variance using the Breusch-Pang test (P-B). We estimated regression with the dependent variable (Y_1 – total production), which is regulated by the square of the residuals (divided by the standard deviation). The null hypothesis of this test tells you the random component of the model is homoscedastic, while the alternative hypothesis assumes that the model error is heteroscedastic. In the present case, all the variables obtained a high probability value $p \geq 0.05$, which allows us to accept the hypothesis of a homoscedastic random component. It was observed from our own survey that total production depended mostly on X_2 – participation of rapeseed in crop structure and X_5 – value of current assets (Table 5).

Similar results were achieved by Borychowski [22], who measured the impact of selected factors on biodiesel production in Poland. Using a different methodology, he achieved similar results. He did White's test for heteroscedasticity of residuals and found that the null hypothesis of the variance being constant over time was not rejected. Using regression coefficients, he found that the most important variables contributing to the increase of biodiesel production volumes in Poland were total sales of biodiesel and the import price of palm oil.

To verify the assumption of a constant variance the Breusch-Pang test (P-B), the authors estimated a regression with dependent variable (Y_2 – agricultural income calculated per one ha. farmland), which is regulated by the square of the residuals (divided by the standard deviation). The null hypothesis of this test tells you that the random component of the model is homoscedastic, while the alternative hypothesis assumes that the model error is heteroscedastic. In the present case all the variables obtained a high probability value $p \geq 0.05$, which allows us to accept the null hypothesis of a homoscedastic random component. We observed from our survey that agricultural income calculated per one ha. farmland depended mostly on X_5 – value of current assets, X_6 – value of investment, and X_7 – cultivated area of rapeseed (Table 6).

Conclusions

The analysis of land management in farms engaged in rapeseed production proved they exhibit good

Table 6. Results of the Breusch-Pang test for heteroscedasticity between the dependent variable Y_2 (agricultural income calculated per one ha farmland) and the explanatory variables for data from 2015.

Variable	Coeffcient	Std. error	Test T-Student	P value
X_1 (Agricultural area (ha))	-0,00	0,00	-0,85	0,398
X_2 (Participation of rapeseed in crop structure (%))	-0,07	2,58	-0,03	0,979
X_3 (Share of grains in sown area (%))	-0,02	0,02	-0,96	0,341
X_4 (Soil valuation indicator (points))	0,00	0,00	0,18	0,850
X_5 (Value of current assets (PLN))	2,57	7,18	3,58	0,000
X_6 (Value of investments (PLN))	1,76	1,39	12,67	1,430
X_7 (Cultivation area of rapeseed (ha))	0,02	0,03	0,59	0,558

Source: Compiled on the basis of their own survey management of land resources. The production and economic results of farms increased with the enlargement of rapeseed area in the farms. The production and economic results calculated per one ha. farmland increased according to rapeseed area enlargement.

The estimated results show that most of the variables used in statistical analysis are homoscedastic and there is no need to reject the H_0 hypothesis. The research shows that economic and environmental criteria are the most important in achieving efficiency. Similar results were achieved by Zografidou [23], who proved that 35% of economic and environmental criteria determine most of efficiency. Only 25% of the cases have been assigned to social criteria.

The estimated model gives an answer to the question of which factors determine variables Y_1 – total production and Y_2 – agricultural income calculated per one ha. farmland. We observed that total production (Y_1) depended mostly on X_2 – participation of rapeseed in crop structure and X_5 – value of current assets. The Y_2 – agricultural income calculated per one ha. farmland depended on X_5 – the value of current assets, X_6 – value of the investment, and X_7 – cultivated area of rapeseed. According to Borychowski [22], the most significant variables in the growth of biodiesel production were total sales of biodiesel and prices of rapeseed oil.

Although Poland is a big owner of land in the EU, the supply of agricultural land is limited. There are regions in Poland where it is very difficult to buy land for agricultural purposes. Some small farms sell land because they do not have successors, but investors want to buy land for other purposes. That is why good land management requires government help. This problem affects rapeseed cultivation, too. The bioenergy industry requires a big supply of rapeseed. Not all farms in Poland fulfill the requirements of the bioenergy industry in terms of production. That is why policy makers should undertake actions including incentives for the adoption of energy crops in Poland and other countries of the EU, such as Greece [9].

The low efficiency of agriculture can be explained by poor adjustment of agriculture to the global economy. This is the effect of a bad adjustment of the agricultural structure of farms and production. The EU policy has difficulties in elaborating the common policy, which is an obstacle in agriculture improvement and investment. This problem will probably lead to national policies for individual countries [26].

The utilization of land in rapeseed production will increase because of the growing demand for biofuels and biodiesel. This, however, will create stronger competition between the petrochemical, nutritious, and fodder industries. This will also create good conditions for land owners as it will increase land prices [27]. Another advantage of locally grown perennial energy crops such as rapeseed, arundo, Miscanthus, and poplar is that they provide a source of income for farmers [9].

After 2020 the biofuel policy is not certain and this uncertainty about the future development in the EU biofuels policy is directly reflected in both a lack of investment in biofuel production, such that the fulfillment of the present mandates is not achieved, and an ongoing debate concerning the sustainability of first-generation biofuels [28-29]. The whole energy system should be organized in EU countries to achieve the new desired state. Not only economic, but also environmental, social, and cultural aspects should be taken into consideration in creating the whole bioenergy supply chain [9]. Investing in the energy sector should be based on such criteria as environmental pollution, social acceptance, gas emission, economic aspects, and tradeoffs [23].

To achieve success in renewable energy, education should be introduced. This education should stress the importance of renewable energy sources as a way to improve the living conditions of populations, as a response to environmental issues, and strategies including local and regional development. The level of knowledge of societies in these aspects should be broadening. This education will play an important role in promoting sustainable development [30].

The use of renewable energy sources may increase the efficiency of resources of raw materials used for energy purposes, and this increase may contribute to a reduction in the amount of generated waste [31]. Renewable energy reduces exploitation and pollution of the environment.

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Conflict of Interest

The authors declare no conflict of interest.

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