

FACTORS AFFECTING INCOMES OF SMALL AGRICULTURAL HOLDINGS IN POLAND

Agnieszka Strzelecka¹, Danuta Zawadzka² and Agnieszka Kurdyś-Kujawska³

^{1,2,3} Koszalin University of Technology, Faculty of Economics, Department of Finance, Poland

¹agnieszka.strzelecka@tu.koszalin.pl, ²danuta.zawadzka@tu.koszalin.pl, ³agnieszka.kurdys-kujawska@tu.koszalin.pl

Annotation: The level of income obtained from agricultural activity depends on many factors. The literature emphasizes that these are, among others: resources possessed by a given unit and their rational and effective use, specialization (the direction of production), farm location, natural conditions, prices of production factors and sales prices, as well as socio-economic and climatic factors. The force and direction of the individual factors' influence on farm incomes may vary, among others, depending on the type of activity and the size of the entity. Undoubtedly, however, it is the resources of land, labor and capital forming the basis of the farm's production potential, which to a large extent determine the development opportunities of agriculture and the scale of its operations and thus affect the value of production and the level of income obtained. There is an ongoing discussion in the literature about very small and small farms. Some researchers argue that there is a negative relationship between the income and the value of assets in this group of entities. Due to the observed relationships, it is important on the cognitive basis to conduct research on factors determining the level of agricultural income, with particular emphasis on small farms. The main objective of the study is to assess the impact of factors related to production potential and the efficiency of its use on income obtained by small farms in Poland. The basic source of data were the results of 239 small farms that in 2015 ran agricultural accounting for the needs of the Polish Farm Accountancy Data Network. It was assumed that a small farm is one whose economic size does not exceed 8,000 EUR SO. The logistic regression model was used to verify empirical factors affecting the income of small farms. The obtained results show that in the case of small farms included in the study, the productivity of plant production and livestock production, as well as the productivity of the labor factor, were of significant importance for the level of obtained income. Moreover, it was found that too high value of fixed assets per one employee and too high intensity of production (measured by the use of fixed and current assets per hectare) have a negative impact on the level of agricultural income.

Key words: logistic regression, family farm income, small agricultural holdings

JEL classification: Q1, Q12, Q14

1. Introduction

Our previous study (Strzelecka, Zawadzka and Kurdyś-Kujawska, 2018) showed that the production potential has a significant impact on the income generated by agricultural holdings. This confirms the results of the research presented in the literature, according to which the farm resources and their rational and effective use have an impact on the level of agricultural income (e.g. Sadeghi, Toodehroosta and Amini, 2001; Safa, 2005; Poczta, Średzińska and Mrówczyńska-Kamińska, 2009; Zawadzka, Ardan and Strzelecka, 2011; Średzińska, 2018). Potential factors affecting the income obtained from an agricultural holding include: direction of production (e.g. Orłowska, 2010; Szafraniec-Siluta, Zawadzka and Strzelecka, 2011; Kalabisova and Kristkova, 2007), location of the farm (e.g. Orłowska, 2017; Średzińska, 2018), natural conditions (e.g. Józwiak, Zieliński and Ziętara, 2016), prices of production factors and sales prices (e.g. Beckman and Schimmelpfennig, 2015; Bohacikova et al., 2017) and socio-economic and climate factors (e.g.. Balarabe, Kasim and Muhammad, 2018; Bohacikova et al., 2017). At the same time, it is pointed out that the impact of some factors

on the income amount earned from agricultural activity may be diversified, depending on the economic size of the agricultural holding. The results of Średzińska's research (2017) prove that the value of assets of an agricultural holding (reduced by the value of land, permanent crops and production quotas) is a factor determining the amount of its income. This is consistent with the results of research presented so far in the literature (cf. Zawadzka, Ardan and Strzelecka, 2011). However, in the case of very small and small farms (separated on the basis of the economic size criterion), there is a negative relation between income and the value of assets (Średzińska, 2017). Due to the observed relations, it is important to continue the research on factors determining the level of agricultural income, with particular emphasis on small farms. The main objective of the study is to assess the impact of factors related to production potential and the efficiency of its use on income obtained by small farms in Poland.

2. Materials and Methods

The study used data from 239 small farms which ran their agricultural accounting in 2015 under the national Farm Accountancy Data Network (FADN). Due to the lack of an unambiguous definition of small farms (more broadly: Strzelecka, 2018), in this work economic size was adopted² as a classification criterion³. A small farm was defined as a farm whose economic size does not exceed 8,000 EUR SO⁴. This assumption is justified due to the research subject - agricultural income (Strzelecka, 2018), because the economic size determines the income potential of the farm and the possibilities of its development (Wilkin, 2013).

The logistic regression model was used to empirically verify the factors affecting the income of small farms. The dependent variable was the probability that the farm would achieve annual income exceeding the median level of the surveyed farms, amounting to PLN 4,943.58 in 2015⁵. It is a dichotomous variable that accepts two possible values: 0 - lack of a given trait (120 cases), 1 - having a given trait (119 cases). The minimum income level adopted in the study was based on the estimation of its average level for the group of small farms surveyed. It was established that the average family farm income for this group of entities in 2015 amounted to PLN 5,325.38 (arithmetic mean), however, half of the units achieved income equal to or lower than PLN 4,943.58 (median), thus lower than the average value. The choice of variables to estimate the parameters of the model was based on the analysis of current research results in the field of determinants of agricultural income⁶. Based on substantial grounds and available data, the following variables were adopted to assess the likelihood of a small farm to generate income exceeding PLN 4,943.58, referring to the production potential of the farm and the efficiency of its use: x_1 - agricultural area (ha); x_2 - share of arable land in the area of agricultural land (%),

²*Economic size* is determined on the basis of the sum of Standard Output (SO) values of all agricultural activities that occur on a given farm and is expressed in EUR (Goraj and Olewnik, 2011). SO - *Standard Output* is an average value of production of a given agricultural activity (plant or animal), which was obtained in 1 year per 1 hectare or from 1 animal. 5 year average values are taken when calculating this parameter (Goraj and Olewnik, 2011).

³In the literature, among the criteria for discerning small farms, one can distinguish among others: the economic size of the agricultural holding, the area of arable land and the connection with the market (Dzun, 2013; Hornowski and Kryszak, 2016; Musiał and Drygas, 2013; Czudec, 2013; Żmija, 2016).

⁴Due to the basic source of statistical data which was used in this work, the analysis covered small farms with an economic size of 4,000 up to 8,000 EUR SO.

⁵It's equal to EUR1,181.88 using average exchange rate (FADN conversion rate) for 2015: EUR 1 = PLN 4.1828.

⁶Variables were selected based on: (Poczta and Średzińska, 2007; Poczta, Średzińska and Standar, 2008; Poczta, Średzińska and Mrówczyńska-Kamińska, 2009; Zawadzka, Ardan and Strzelecka, 2011; Floriańczyk, Osuch and Płonka, 2016; Średzińska, 2017; Orłowska, 2017; Średzińska and Standar, 2017; Średzińska, 2018; Strzelecka, Zawadzka and Kurdyś-Kujawska, 2018).

x_3 – livestock density (LU⁷/ha); x_4 - plant production per hectare (PLN/ha); x_5 - livestock production per 1 LU (PLN/LU); x_6 - assets minus land, permanent crops and production quotas (PLN '000); x_7 - productivity of total assets (relation of total production value to total assets, in %); x_8 - technical equipment of labor (relation of fixed assets to the number of full-time employees, PLN '000/AWU⁸); x_9 - productivity of labor (relation of total production value to the number of full-time employees, PLN '000/AWU); x_{10} - type of production (1 - mixed, 2 - specialized); x_{11} - expenditures of fixed assets per ha, measured by the value of depreciation per ha of arable land (PLN '000/ha); x_{12} - expenditures of current assets per ha, measured by the value of intermediate consumption per ha (PLN '000/ha); x_{13} - marketability of production.

In order to find the best combination of factors significantly affecting the incomes of small farms in Poland, the method of backwards elimination was applied. The assessment of the degree of fit of the logistic regression model to the empirical data was carried out using the statistics of *Cox-Snell R²*, *Nagelkerke's R²* and *Count R²*. Verification of the significance of individual model parameters was made using Wald Test. To assess the goodness of fit of the obtained model, the AUC - *Area Under Curve* value was used. The quality of the logistic regression model was also evaluated using the ROC (*Receiver Operating Characteristic Curves*) curve.

3. Results and Discussion

This section consists of two parts. The first one contains the characteristics of the researched farms. The second one presents the results of logistic regression analysis. Half of the surveyed entities reached the economic size at the level equal to or greater than 6.97 thousand EUR (minimum and maximum values amounted to: 4.28 thousand EUR and 7.99 thousand EUR). The average area of arable lands of the examined small farms was 7.58 ha. The arable land dominated in the structure of the agricultural production space. In more than half of the farms, the share of arable land in the structure of agricultural land amounted to 80.93%. The value of the asymmetry coefficient indicates the existence of a strong left-side asymmetry, which means that the units with above average values predominate. The surveyed farms mainly ran specialized production, and given the low livestock density (average number of livestock units per ha was 0.63), it can be concluded that these were mainly farms with plant production. In half of the farms surveyed, farmers were only producing on land owned by them. The value of total assets in small farms was on average 319.61 thousand PLN. In these farms, a high level of fixed assets was maintained (on average 295.81 thousand PLN). Total labor expenditures and farmer's family members own labor oscillated around 1 full-time employee. The revenues from agricultural production were characterized by high diversification and ranged from 2.89 thousand PLN to 282.47 thousand PLN. Average income from crop production amounted to PLN 3,670.98/ha, while the average income from animal production amounted to PLN 2,249/LU.

The amount of received subsidies related to production was on average 8.84 thousand PLN. The difference between the minimum and maximum amount of subsidies received amounted to 31.65 thousand PLN. The diversity of the surveyed population in terms of the amount of income from agricultural activity is very strong (coefficient of variation = 213%). The income from the farm per one full-time family employee was slightly higher than

⁷LU - *Livestock Unit* - animal conversion unit. Average yearly count of equidae, cattle, sheep, goats, pigs and poultry kept on an agricultural holding.

⁸AWU- *Annual Work Unit* – labor conversion unit.

the average total income and constituted 5.82 thousand PLN on average. In the majority of small farms, farm income per one full-time family employee was below average. A coefficient of variation of 247% indicates a high variability of the examined feature.

In order to find the best combination of variables significantly affecting the income of small farms, by using the backwards elimination method, subsequent predictors were eliminated from the initial model and the change in the values of criteria adopted for the assessment of the model quality was made. Finally, seven independent variables were included in the final model, four of which had a statistically significant positive impact on the probability tested (variables: x_3 , x_4 , x_5 , and x_9), while three variables had a statistically significant negative impact on the analyzed phenomenon (variables: x_8 , x_{11} and x_{12}). The results of the final model determining the impact of selected factors on the incomes of small farms in Poland are presented in Table 1.

Table 1. Results of the estimation of model parameters

Variable	Variable parameter	Standard error	z^2 Wald test	Significance level	Odds ratio
x_3 -livestock density (LU/ha)	0.451	0.220	4.218	0.040	1.570
x_4 - plant production per ha (PLN '000/ha)	0.001	0.000	25.804	<0.001	1.001
x_5 – livestock production per 1 LU (PLN/LU)	0.0003	0.000	7.375	0.007	1.0003
x_8 – technical equipement of labor (PLN '000/AWU)	-0.006	0.001	16.874	<0.001	0.994
x_9 – productivity of labor (PLN '000/AWU)	0.106	0.024	19.249	<0.001	1.111
x_{11} - expenditures of fixed assets per ha, measured by the value of depreciation per ha of arable land (PLN '000/ha)	-0.883	0.351	6.314	<0.001	0.414
x_{12} - expenditures of current assets per ha, measured by the value of intermediate consumption per ha (PLN '000/ha)	-1.896	0.313	36.778	<0.001	0.150
<i>Intercept</i>	1.911	0.582	10.777	0.001	6.760
AIC = 210.19 Cox-Snell R^2 = 0.4366; Nagelker's R^2 = 0.5822; count R^2 = 0.8243 AUC = 0.902 LR = 137.13 (df=7; p<0.01)					

Source: Own study based on FADN data, 2019

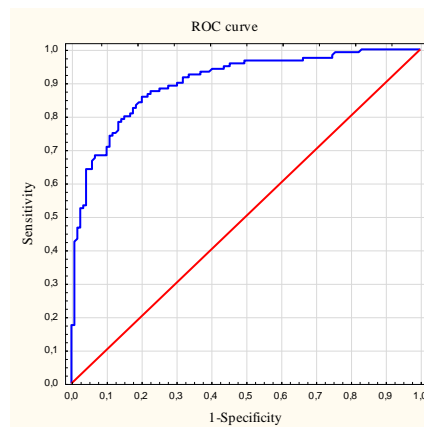
The estimated final model determining the impact of selected factors on the incomes of small farms in Poland is the following:

$$Prob(Y=1) = A(0.451x_3 + 0.001x_4 + 0.0003x_5 - 0.006x_8 + 0.106x_9 - 0.883x_{11} - 1.896x_{12} + 1.911) \quad (1)$$

where: $A(x) = \frac{e^x}{1+e^x}$ distribution function of logistic distribution

The model is statically significant at the 1% significance level. Based on the model, 82.43% of cases were correctly classified. The quality of the constructed model was based on the Cox-Snell R^2 ratio (0.19), Nagelkerke's R^2 (0.25), as well as using the ROC curve, which is presented in Figure 1.

Figure 1. ROC curve for the model



Source: Own study based on FADN data, 2019

The area under the ROC curve (AUC) is 0.825. Because a field larger than 0.5 and close to 1 was obtained, this indicates a good quality of the constructed model. Assuming constancy of other factors included in the final model (*ceteris paribus*), the probability that the farm in 2015 will exceed the income level of PLN 4,943.58 will: increase by 57% when increasing livestock density by one unit per 1 ha, increase by 1% with an increase in productivity of plant and animal production PLN '000/ha and 1 LU/ha and increase by 11% by increasing the productivity of labor PLN' 000/AWU. In turn, the chance of obtaining income exceeding the median value for the sample of farms will decrease with the increase of technical equipment of labor and an increase in expenditures of fixed assets per hectare (measured by the value of depreciation per ha of arable land), as well as with an increase in expenditures of current assets per hectare (measured by the value intermediate consumption per hectare of agricultural land) by 1%, 59% and 85%, respectively.

4. Conclusion

The study proves that the most significant positive impact on the level of income obtained by small agricultural holdings in Poland in 2015 had their potential of agricultural production in terms of livestock density, productivity in crop and animal production, and human factor productivity. The research confirmed that the negative impact on the income level of the examined small farms was related to the cost of agricultural production (technical labor equipment, expenditure of fixed assets per hectare of arable land, expenditures of current assets per hectare of agricultural land). The reason for such a high cost of production in these farms may be the fact that they do not have modern agricultural machinery and equipment. Therefore, they do not have the possibility to reduce production costs by replacing human labor with specialized technologies. In addition, the small scale of agricultural production prevents reduction in unit costs. This results in a lower, compared to larger farms, efficiency of agricultural production. There seems to be an interesting variation in the observed relationships with respect to the type of agricultural production, especially in relation to the problem of cost burden of production in these farms. This issue will be taken at further stages of research.

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