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DETERMINANTS OF FAMILY FARM INCOME DEPENDING ON FARM SIZE

Key words: family farm, income, panel regression

ABSTRACT. The aim of article is to present the key economic determinants of family farm income. The data from the Farm Accountancy Data Network (FADN) are used. These data include basic information about the situation of ca 1900 production types according to economic size in the EU in the years 2004-2017. Moreover, an attempt is made to use the panel models to evaluate the economic determinants of family farm income. The Gretl programme is used to evaluate fixed effect models, allowing to choose seven statistically significant variables among a potential twenty-two economic determinants of family farm income. Next, estimation of models depending on the farm size is made. These economic determinants are: utilised agricultural area, share of crop and livestock production in total production, subsidies per farm, net investment per hectare, cash flow per hectare and input calculated per hectare. The impact of variables varies according to the economic size of a farm, but all the models include two variables: cash flow per ha and subsidies. Therefore, these are the most significant economic determinants of family farm income in the EU, regardless of the economic size of agricultural farm.

INTRODUCTION

Family farming is the most common farming model in Europe[1]. Economists and practitioners generally agree that investing in agriculture is an effective strategy for reducing poverty, inequality and hunger. It is important especially in countries, where this sector employs a large share of the population. However, there is an ongoing debate regarding the type and scale of agriculture in order to achieve these goals most effectively [Lowder et al. 2016]. Significantly, growth in farmer incomes is fundamental to economic and social development and to a farmer's ability to reinvest in farms [SFL, BSP 2017].

[1] The concept of family farming covers various elements. From a sociological perspective, family farming is associated with family values, such as solidarity, continuity and commitment. In economic terms, family farming is identified with specific entrepreneurial skills, business ownership and management, choice and risk behaviour, resilience and individual achievement. Family farming is often more than a professional occupation because it reflects a lifestyle based on beliefs and traditions about living and work. Family farming is the most common operational farming model in Europe and thus of great importance in the EU. The majority of the EU's 12 million farms are family farms, passed down from one generation to another, and contribute to the socio-economic and environmental sustainability of rural areas [EC 2019].

A number of factors influences the level of income in agricultural holding: the size of the farm in hectares, the number of persons employed and living in the farm, the degree of their education, exposition to changing market circumstances, soil and climatic conditions in the region and the place where the farm is located. Studies on the variability of agricultural income in the FADN group of individual holdings underline a clear diversity of revenue depending on the grouping category adopted. Huge differences in income are observed in farms belonging to different economic size classes and different utilised agricultural area groups. A smaller impact on the diversity of income exerts regional conditionality and direction of production [Pawłowska-Tyszko, Soliwoda 2014]. For this reason, it is worth projecting to consider the problem of economic size of agricultural farms.

In terms of choice of economic determinant of family farm income, the literature provides a useful framework. Joanna Średzińska and Walenty Poczta [2012, p. 45-51] present the history of research on these factors, that have been carried out in Poland since the 80's. Next, it is worth recalling the latest research on this issue[2]. For example, Tomasz Felczak [2014, p. 83] enumerates the most important income determinants: current and quick liquidity, net working capital, level of equity and liabilities, balance of operating flows, level of current assets, cash level in current assets, age of farm manager, number of full-employees, operating subsidies, level of permanent capital, utilised agricultural area, total asset and total output. Only six determinants are proposed by W. Poczta et al. [2009, p. 19]. They include: utilised agricultural area, total assets decreased by land value, permanent crops and quotas, operating subsidies, technical devices as well as outlays of current and fixed assets. Similarly, Danuta Zawadzka et al., [2011, p. 74] consider: utilised agricultural area, total assets, operating subsidies, fixed assets on total labour input as well as intermediate consumption and depreciation. J. Średzińska [2017, p. 307] proposes such income determinants, as: total labour input, utilised agricultural area, value of assets decreased by land value, permanent crops and quotas, technical devices, outlays of current and fixed assets per hectare, commodity of production, operating subsidies, value of total output, crop production per hectare and livestock production per LU (Livestock Unit). Andrzej Czyżewski et al. [2018, p. 71] present determinants calculated per hectare: total workforce per hectare, total output per hectare, total subsidies per hectare, lag gross investment per hectare and the Economic Sentiment Indicator (ESI).

The variables implemented in this study are chosen on the basis of aforementioned concepts, as they can be calculated with the use of FADN data. It should be underlined that the research proposed here fits current research trends, as there is no common view on the list of universal farm income determinants. Therefore, this article attempts to identify the most important economic factors among different groups of farms classified

[2] It's worth reading the article on the relationship between income and cash flow based on FADN data [Spicka et al. 2019].

according to their economic size[3]. This article fills the research gap, because research on factors influencing farmer incomes has focused so far on describing their impact irrespective of farm size.

This study presents models estimated for different economic size classes of agricultural farms with the use of panel regression. The following research hypothesis is formulated: the determinants affecting income vary depending on economic farm size.

MATERIAL AND METHODS

Research is based on data obtained from the Farm Accountancy Data Network (FADN). The FADN has developed a detailed methodology for calculating family farm income. The FADN data provides a detailed presentation and analysis of main determinants of family farm income [FADN 2019].

These data include basic information about the economic situation of ca 1900 production types according to economic size[4], in the EU, in the years 2004-2017 (Table 1). FADN data has a panel data character. A particular production type according to economic size is an aggregate unit. This average volume is calculated on the basis of many individual farms with the same production direction and economic size in each country in the EU-28.

The most general formulation of a panel data model can be expressed by the following equation[5] [Baltagi 2005]:

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[3] It should also be noted that a completely different choice of determinants is present in the foreign literature. For example, Ademoye Fadipe et al. [2014, p. 401] estimate models of agricultural income sources based on: age and gender of the household head, years of education of the household head, household size in number, farm size in hectare, access to credit and electricity. An even wider set of variables is presented by Pratap Birthal et al. [2014, p. 44]. They encompass among others: land possessed, proportion of leased land, land productivity, number of persons on the farm and their age, proportion of female workers in total workers, age and sex of the household head, type of education, and also: access to farm and non-farm credit, social group. Jayson Beckman and David Schimmelpfennig [2015, p. 391] study long time series (1929-2010) and propose macroeconomic variables. These include, among others: demand and supply prices, interest rates, GDP, agricultural land prices, agricultural income stability. Due to the construction of the FADN and the information contained therein, it has been decided not to use these concepts in this research.

[4] The economic size of farms is one of the criteria used to classify agricultural holdings according to community typology. In line with Commission Regulation (EC) No 1242/2008, the economic size of an agricultural holding is measured as the total Standard Output (SO) of the holding in euro. The Standard Output is the average monetary value of the agricultural output at a farm-gate price of each agricultural product (crop or livestock) in a given region. According to the Farm Accountancy Data Network, the Standard Output is calculated by Member States per hectare or per head of livestock, by using basic data for a reference period of 5 successive years. 6 classes of economic size can be distinguished [FADN 2019].

[5] Parameter α_i is time invariant and accounts for any individual-specific effect not included in the regression equation. Two different interpretations may be given to the α_i. Two different basic models may be distinguished: Fixed Effect Panel Data Model (FEM) and Random Effect Panel Data Model (REM) [Arbia, Piras 2005].

Table 1. Panel data from FADN according to economic size in 2004-2017

Details	Class of economic size						Total
	1	2	3	4	5	6	
Value of Standard Output [EUR]	2,000 ≤ 8,000	8,000 ≤ 25,000	25,000 ≤ 50,000	50,000 ≤ 100,000	100,000 ≤ 500,000	≥ 500,000	-
Name of class	very small	small	medium-low	medium-large	large	very large	-
Number of observation	188	303	373	377	377	272	1,890

Source: own work based on FADN [2019]

$$y_{i,t} = \alpha_i + X'_{i,t}\beta + u_{i,t} + \varepsilon_{i,t}$$

with i ($i = 1, ..., N$) denoting individuals, t ($t = 1, ..., T$) denoting time periods, and $X'_{i,t}$ denoting the observation of K explanatory variables in country i and time t.

Conducting analysis, the Random and Fixed Effect Model can be estimated[6]. It should be stressed that other characteristics of the test sample should also have an influence on the choice between these models. The estimator in the FE model may not be compatible for short panel time series, but the FE model appears to be more appropriate if the analysed objects are not selected randomly and it is important to estimate individual effects for each objects [Dańska-Borsiak 2011]. The face of the FADN data is not original data, thus it was decided to estimate the FE models, i.e. models with fixed effects. In addition, the Variance Inflation Factors (VIF) is used to measure how much the variance of the estimated coefficients is increased over the case of no correlation among independent variables[7].

The main target of research is to obtain a model that characterizes determinants of the family farm income according to economic size. In order to estimate the model, a set of variables is used (Table 2). It is based on a literature review presented in the Introduction. Social and institutional determinants are excluded, because the FADN database did not contain this kind of information. The developed determinants are standardized to offset the influence of different units on model results.

[6] In order to choose between the Random and Fixed Effect Model, the Hausman test is used. The idea is that one uses the random effects estimates unless the Hausman test rejects. In practice, a failure to reject means either that the RE and FE estimates are sufficiently close so that it does not matter which one is used, or the sampling variation is so large in the FE estimates that one cannot conclude practically whether significant differences are statistically significant [Wooldridge 2013].

[7] If VIF = 0 there is no multicollinearity, but if VIF ≥ 0 there is multicollinearity [Ergün, Göksu 2013]. If the VIF is greater than 1, regressors may be moderately correlated. A VIF between 5 and 10 indicates a high correlation that may be problematic [Akinwande et al. 2015]. If the value of the VIF test of variable exceeds 10, then there is evidence of a collinearity problem [Adkins 2014].

Table 2. Potential variables used in panel models

Variable name	Variable characteristic [measurement units]	Symbol in FADN
Y	Family farm income [EUR]	SE420
X01	Utilised agricultural area [ha]	SE025
X02	Labour input [AWU]	SE010
X03	Total assets [EUR]	SE436
X04	Fixed assets without land value, permanent crops and quotas [EUR]	SE441 – SE446
X05	Current assets [EUR]	SE465
X06	Output per hectare [EUR/ha]	SE131/SE025
X07	Share of crop production in total production	SE135/SE131
X08	Share of livestock production in total production	SE206/SE131
X09	Share of other production in total production	SE256/SE131
X10	Inputs per hectare [EUR/ha]	SE270/SE025
X11	Subsidies per farm [EUR/farm]	SE406+SE605
X12	Liabilities per farm [EUR/farm]	SE485
X13	Gross investment per hectare [EUR/ha]	SE516/SE025
X14	Net investment per hectare [EUR/ha]	SE521/SE025
X15	Cash flow per hectare [EUR/ha]	SE526/SE025
X16	Current liquidity (current assets/short-term liabilities)	SE465/SE495
X17	Quick liquidity ({current assets – stocks}/short-term liabilities)	(SE465-SE475)/ SE495
X18	Technical devices (fixed assets/full-time employees) [EUR/AWU]	SE441/SE010
X19	Technical utilities (fixed assets/ha of UAA) [EUR/ha]	SE441/SE025
X20	Work equipment of land (UAA/full-time employees) [ha/AWU]	SE025/SE010
X21	Outlays of current assets per ha (intermediate consumption/ha) [EUR/ha]	SE275/SE025
X22	Outlays of fixed assets per hectare (depreciation/ha) [EUR/ha]	SE360/SE025

Source: own work based on FADN [2019]

RESULTS

The first stage of empirical research is to present family farm income and chosen economic characteristics according to the economic size of farms in 2004 and 2017[8] (Table 3). In 2017, the average family farm income in the EU-28 equalled EUR 21 thousand, made on ~35 ha, EUR 76 thousand of output and about EUR 353 thousand of assets. At the same time, the average liabilities of a farm was equal to EUR 55 thousand, and total obtained subsidies – about EUR 12 thousand. The level of net investment was very low. As compared to 2004, output and assets increased about 25% and liabilities about 33%. Income only increased by 17% and subsidies only by 12%. Meanwhile, area and labour input slightly decreased (Table 3). After calculating the results proportionally to 1 hectare, an increase in output, liabilities and investments can be observed as the economic size of EUR 1,300 of output per ha, while large and very large farms over EUR 2,300 per ha. Holdings with a SO exceeding EUR 100,000 occurred to be more than 7 times more indebted than holdings exceeding EUR 25,000 of SO, but their income and subsidies per 1 hectare were comparable. There was also a noticeable improvement in 2017 compared with 2004 in this category, especially in the case of very large farms (Table 3).

In order to fulfil the main target of research, forward stepwise variable selection is introduced. Using the Gretl Programme, FE Models are obtained (Table 4). In the estimated models all variables are characterized by a level of significance below 0.05. Seven variables have a statistically significant influence on the dependent variable, namely: agricultural area, share of crop and livestock production in total production, subsidies per farm, net investment per hectare, cash flow per hectare and inputs per hectare. The highest positive influence on a dependent variable is exerted by cash flow per hectare and received subsidies. Family farm income is also negatively impacted by variable inputs per hectare[9]. Overall correctness of classification is satisfactory and above 50%. The values of the VIF test for all variables are below 4.0 (Table 4).

The highest number of independent variables affect family farm income among the smallest farms. In this class of farms, the biggest impact on income is exerted by cash flow per ha, inputs per ha and subsidies, and subsequently the share of livestock production in total production and net investment per ha. However, in the class of very large farms only cash flow per ha, subsidies and utilised area of farm has statistical importance. The latter variable also has a noticeable impact on the income of medium-sized farms (class 3 and 4). It should also be noted that the share of livestock production in total production has a positive impact on the income of smaller farms, up to EUR 50,000 of SO (classes 1-3), and the share of crop production is relevant to the income of large farms (class 5). In the estimated models, the variable set differs as the strength of their influence varies (Table 4). Therefore, the results obtained confirm the hypothesis, according to which determinants affecting income vary depending on economic size of a farm.

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[8] The study range is 14 years – the most up-to-date data from FADN according to the SO. In Table 3, only extreme years are presented.

[9] Inputs per hectare are important only among very small farms. In other models they are not found because of their collinearity or statistical insignificance.

Table 3. Family farm income and chosen economic characteristics according to the economic size of farms in the EU in 2004 and 2017

Details	Value of factors per 1 farm								Value of factors per 1 hectare					
	income	utilised area	labour input	total assets	output	liabilities	net investment	subsidies	income	total assets	output	liabilities	net investment	subsidies
	EUR	ha	AWU	EUR					EUR					
2017 EU-28	21,049	34.87	1.51	353,435	76,188	55,454	588	12,339	603.64	10,135.79	2,184.92	1,590.31	16.86	353.86
Class 1	2,705	4.88	1.00	43,317	6,796	331	-845	1,509	554.30	8,876.43	1,392.62	67.83	-173.16	309.22
Class 2	9,492	15.18	1.17	164,062	19,554	3,752	-1,332	5,752	625.30	10,807.77	1,288.14	247.17	-87.75	378.92
Class 3	17,286	29.77	1.42	341,817	44,690	20,721	-1,327	11,607	580.65	11,481.93	1,501.18	696.04	-44.58	389.89
Class 4	28,983	55.72	1.65	508,592	82,715	49,278	903	19,477	520.15	9,127.64	1,484.48	884.39	16.21	349.55
Class 5	63,014	104.73	2.46	1,019,137	241,157	198,770	4,134	35,937	601.68	9,731.09	2,302.65	1,897.93	39.47	343.14
Class 6	207,008	292.94	8.71	3,241,236	1,166,938	1,066,346	40,281	103,290	706.66	11,064.50	3,983.54	3,640.15	137.51	352.60
2004 EU-25	17,940	35.08	1.66	276,862	60,630	41,585	523	11,007	511.40	7,892.30	1,728.34	1,185.43	14.91	313.77
Class 1	4,601	7.83	1.11	68,845	8,884	682	-1310	2,177	587.61	8,792.46	1134.61	87.10	-167.31	278.03
Class 2	9,074	15.43	1.34	128,883	18,152	4,521	791	4,545	588.08	8,352.75	1176.41	293.00	51.26	294.56
Class 3	17,319	34.07	1.54	259,463	41,679	20,344	-1164	10,597	508.34	7,615.59	1223.33	597.12	-34.16	311.04
Class 4	25,892	57.51	1.74	393,426	74,332	50,088	530	18,585	450.22	6,841.00	1292.51	870.94	9.22	323.16
Class 5	49,805	94.45	2.61	790,049	195,985	170,024	3363	31,472	527.32	8,364.73	2075.01	1,800.15	35.61	333.21
Class 6	125,970	290.10	11.58	2,192,785	887,820	668,462	19,426	82,977	434.23	7,558.72	3060.39	2,304.25	66.96	286.03

Source: own work based on FADN [2019]

Table 4. Panel Fixed Effect Models for family farm income according to economic size

Details	Class of economic size (farm size)					
	1 (very small)	2 (small)	3 (medium-low)	4 (medium-large)	5 (large)	6 (very large)
LSDV R^2	0.8602	0.7389	0.7284	0.5711	0.6540	0.5062
Within R^2	0.5664	0.5205	0.4715	0.1715	0.1331	0.1647
Variables in model (standardized β)						
X01 – Utilised agricultural area	-	-	0.4953 (0.0000)*** [2.063]	0.3201 (0.0221)** [1.871]	-	0.6357 (0.0331)** [3.735]
X07 – Share of crop production in total production	-	-	-	-	0.4181 (0.0005)*** [1.296]	-
X08 – Share of livestock production in total production	0.2853 (0.0062)*** [1.260]	0.4045 (0.0000)*** [1.144]	0.2587 (0.0000)*** [1.034]	-	-	-
X10 – Inputs per hectare	-0.4057 (0.0000)*** [1.766]	-	-	-	-	-
X11 – Subsidies per farm	0.3558 (0.0000)*** [1.315]	0.2169 (0.0334)** [1.108]	0.2402 (0.0041)*** [1.553]	0.2116 (0.0473)** [1.654]	0.4453 (0.0000)*** [1.165]	0.3850 (0.0031)*** [3.621]
X14 – Net investment per hectare	0.0775 (0.0130)** [1.049]	0.1877 (0.0000)*** [1.071]	-	0.1016 (0.0090)*** [1.042]	-	-
X15 – Cash flow per hectare	0.6895 (0.0000)*** [1.671]	1.2401 (0.0000)*** [1.163]	1.3406 (0.0000)*** [1.544]	0.9963 (0.0000)*** [1.313]	0.5098 (0.0003)*** [1.223]	1.5950 (0.0000)*** [1.202]
Hausman Test	χ^2 (5) = 21.5597 (0.0006)	χ^2 (4) = 28.0674 (0.0000)	χ^2 (4) = 35.4508 (0.0000)	χ^2 (4) = 19.0256 (0.0008)	χ^2 (3) = 20.3985 (0.0001)	χ^2 (3) = 40.6635 (0.0000)

The levels of significance in round brackets, the value of the VIF test in square brackets

Source: own calculations

CONCLUSIONS

It can be concluded that the following variables have a clearly positive effect on the value of family farm income: utilised agricultural area, share of crop and livestock production in total production, subsidies, and also cash flow and net investments per hectare. The negative impact exerts inputs per hectare. These results confirm the widespread view of the positive impact on income exerted by cash flow and investment. Subsidies are also an important factor in the process improving the income situation of farms. The impact of variables varies according to the economic size of a farm. This proves the need to use different strategies for the decision-making process dedicated to farms of different economic size. It is worth adding that in all the estimated models two variables are statistically significant: cash flow per ha and subsidies. Therefore, these are commonly significant economic determinants in most farms in the EU, regardless of economic size.

It should also be noted that the following pattern is observed: the higher the economic size of a farm, the weaker the explanation of income by the variables selected for this analysis. This means that the income of large holdings, exceeding EUR 100,000 of SO, are affected by determinants not included in the research. These can be exogenous variables, e.g. agricultural price shears or endogenous variables, e.g. the method of farm managing.

In conclusion, it can be noted that the selection of potential economic determinants affecting farm income depends on the adopted research perspective. This is an opportunity for new research in this field, as well as adopting new research perspectives, and instruments, similarly to the panel fixed effect models used in this article to analyse farms according to economic size.

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DETERMINANTY DOCHODU Z RODZINNEGO GOSPODARSTWA ROLNEGO W ZALEŻNOŚCI OD WIELKOŚCI GOSPODARSTWA

Słowa kluczowe: dochód, rodzinne gospodarstwo rolne, regresja panelowa

ABSTRAKT

Celem artykułu jest przedstawienie kluczowych uwarunkowań ekonomicznych kształtowania się dochodu z rodzinnego gospodarstwa rolnego za pomocą modeli panelowych. Wykorzystano dane z Sieci Zbierania Danych Rachunkowych z gospodarstw rolnych (FADN). Dane te obejmują podstawowe informacje o sytuacji około 1900 typów produkcyjnych według wielkości ekonomicznej w Unii Europejskiej w latach 2004-2017. Wykorzystano program Gretl do opracowania modeli o ustalonych efektach. Wskazano siedem determinant ekonomicznych, spośród potencjalnych dwudziestu dwóch, wpływających na wielkość dochodu z rodzinnego gospodarstwa rolnego, w zależności od wielkości ekonomicznej gospodarstwa. Są nimi: użytki rolne, udział produkcji roślinnej i zwierzęcej w produkcji ogółem, dopłaty na gospodarstwo, a także inwestycje netto na hektar, cash flow na hektar i koszty przeliczone na hektar. Wpływ zmiennych był zróżnicowany w zależności od wielkości ekonomicznej gospodarstwa, ale we wszystkich oszacowanych modelach wystąpiły dwie zmienne: cash flow na ha i dopłaty dla gospodarstwa. Zatem są to znaczące determinanty ekonomiczne dla większości gospodarstw w Unii Europejskiej, niezależnie od ich wielkości ekonomicznej.

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