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EFFICIENCY OF DAIRY AND BEEF CATTLE FARMS DIFFERING IN LAND AREA SIZE

Key words: efficiency in agriculture, factors of production, productivity, profitability, milk production, production of beef cattle

ABSTRACT. The increasing size of farms, specialisation and growing scale of production are the primary factors in the improvement of resource utilisation in agriculture. In this context, the aim of this study is to assess and compare the efficiency of resource management in farms differing in land area size and specialising in the production of milk and cattle for slaughter. This assessment was based on data from farms participating in the FADN agricultural accountancy system in 2019. The efficiency of utilised factors of production in the researched farms was evaluated based on indexes of productivity and profitability of land, labour and capital. In dairy farms, the productivity of land was considerably higher and was growing with an increase in their size, whereas in beef cattle type farms it generally deteriorated. Productivity of labour and capital was also much greater and was growing faster in dairy farms. The highest profitability of land was recorded for medium-sized farms of both production types, while the profitability of labour and capital was highest in the largest farms. It needs to be stressed that the income and economic efficiency of farms specialising in the production of cattle for slaughter are determined by financial support within the EU Common Agricultural Policy.

INTRODUCTION

Analysis of the development paths observed in agriculture worldwide indicates that the primary factor in its development has been the maximization of efficiency of factors of production in farms [Kowalski et al. 2011, Kołodziejczak 2015]. Production processes in farms need to be organized to ensure the highest possible efficiency of utilized factors of production [Kulawik et al. 2009, Ball et al. 2010]. The efficiency of management in the case of factors of production is relative in character – this is the ratio of the obtained effects to used inputs. Basic and commonly applied measures of efficiency of factors of

production include the relationships of outputs and the income of farms to the inputs of individual factors in production processes [Józwiak 1998, Kulawik 2007, Kapusta 2012, Sass 2017]. These relationships are illustrated by indexes of productivity and profitability of land, labor and capital.

Many researchers indicate that a method to improve the efficiency of production resource management in farms is to grow the size of farms, their specialization and increase their scale of production [Vollrath 2007, Fried et al. 2008, Latruffe 2010, Sass 2018, Wicki 2019]. In turn, Jerzy Marzec and Andrzej Pisulewski [2020] stated that a vast majority of Polish farms exhibit increasing economies of scale.

It results from numerous studies that, in the case of milk production, the intensity of production increases with the growing scale of production, farms attain a higher income as well as greater productivity and profitability of resources [Mosheim, Lovell 2009, Wilczyński 2012, Ziętara 2012, Hemme et al. 2014, Sass 2017, Skarżyńska 2020]. However, in some EU countries, large-scale milk production is inefficient. An increase in the productivity of dairy farms is not manifested in an advantageous direction of changes in profitability, primarily as a result of the faster increase in production costs compared to milk prices [Gołaś 2017].

In the case of beef cattle production, the conducted analyses indicate evident economies of scale, since the variation in the level of animal rearing costs in relation to the size of scale is considerable [Porter, Jones 2005, Tsakiridis et al. 2016, Skarżyńska, Abramczuk 2018]. Moreover, the economic outcomes of farms specializing in the rearing of beef cattle are determined by the system of production, i.e., the type of used feeds and the adopted animal feeding system. The more extensive the animal management system, the better the results [Anderson et al. 2005, Wójcik 2011, Iurchevici, Chetroiu 2014]. Aldona Skarżyńska [2017] showed that a condition determining income from the production of beef cattle in Poland is to run it at a sufficiently large scale.

Poland has good natural and climatic conditions for cattle rearing [Parzonko 2013]. As a result, this country is a major producer and exporter of milk and dairy products as well as beef. It results from the statistical data of Statistics Poland (formerly the Central Statistical Office, GUS) that, in recent years, the production of milk and cattle for slaughter has been increasing considerably [GUS 2021]. This increase in milk production is caused by growing domestic consumption and a dynamic increase in the export of dairy products [Szajner 2021]. Growth in the production of cattle for slaughter also results from market conditions related to developing beef exports, primarily to other EU countries thanks to the lower prices of Polish beef on the EU market, leading to its competitive advantage [Zawadzka, Pasińska 2021].

Since, in Poland, the production of milk and cattle for slaughter has been increasing and these are the directions of cattle production, which may be undertaken alternately as they require identical natural and climatic conditions, it is advisable to compare them in terms of

the generated outcomes. In turn, in the context of improved utilization of factors of production in agriculture, it is essential to evaluate and compare the efficiency of factors of production in those agricultural holdings depending on their scale of production, which is closely related to their size. Literature lacks studies presenting such comparative analyses for cattle farms, although there are numerous publications concerning the efficiency of one type of these agricultural holdings. In view of the above, this study presents an attempt to fill this gap by providing an assessment and comparison of the efficiency of resource utilization in farms differing in land area size and specializing in the production of milk and cattle for slaughter.

MATERIAL AND METHODS

The aim of this study is to assess and compare the efficiency of production resource management in farms specialising in the production of milk and cattle for slaughter differing in land area size. The research the efficiency of farms specializing in the production of milk and cattle for slaughter was based on data from farms participating in the FADN agricultural accounting system¹ in 2019. Obtained data, in accordance with FADN methodology, were only collected from commercial farms [Goraj, Mańko 2009]. In simple terms, farms specializing in milk production were termed in this paper as a type of dairy cows, while farms with cattle for slaughter production as a type of beef cattle farms. Since the investigated population of farms contained no dairy or beef cattle farms with an area of max. 5 ha agricultural area (UAA), the investigations were conducted on farms with an area exceeding 5 ha according to the following UAA groups: 5-10 ha (small), 10-20 and 20-30 ha (medium), 30-50 ha (large) and over 50 ha (very large).

The analyzed types of cattle farms (i.e., dairy cows vs. beef cattle) differing in size were evaluated and compared in terms of their resources of factors of production, as well as the organization and intensity of production, obtained outputs and the efficiency of factors of production. The efficiency of utilized factors of production was evaluated based on indexes of productivity and profitability. Productivity was determined by referring the value of output to inputs of individual factors of production:

- productivity of land = total output/UAA;
- productivity of labor = total output/total labor input;
- productivity of capital = total output/value of capital (total assets).

Profitability was determined using the ratio of income to inputs of factors of production:

- profitability of land = farm income/UAA;
- profitability of labor = farm income/own labor input;
- profitability of capital = farm income/value of capital (total assets).

¹ FADN (Farm Accountancy Data Network) is a system for the collection and application of accounting data from farms in EU member countries.

In this study, the adopted measures followed the FADN methodology, including total output in the assessment of output outcomes, while for economic outcomes, it was income from a family farm, termed, in short, as farm income.

RESULTS

The compared farms specializing in the production of milk and beef cattle different in size varied slightly within individual UAA groups in terms of their land resource potential (Table 1). In all the farms, some of their UAA was leased. With an increase in their UAA, the share of leased land increased markedly (from approx. 10% in small farms to approx. 40% in very large farms).

Table 1. Factors of production in compared farms depending on UAA

Type of farm	Area size groups of farms [ha UAA]				
	5-10 (small)	10-20 (medium small)	20-30 (medium large)	30-50 (large)	above 50 (very large)
Number of farms					
Dairy cows	129	687	650	618	331
Beef cattle	173	520	270	200	86
Mean UAA [ha]					
Dairy cows	8.5	15.6	25.0	38.6	74.8
Beef cattle	8.0	14.6	24.4	38.0	76.9
Total labour inputs [AWU]					
Dairy cows	1.60	1.76	1.94	2.07	2.54
Beef cattle	1.40	1.57	1.63	1.67	1.97
Share of hired labour [%]					
Dairy cows	0.6	0.6	2.1	2.9	15.6
Beef cattle	0.7	0.6	0.9	2.3	6.3
Total labour input per 100 ha UAA [AWU]					
Dairy cows	18.8	11.3	7.8	5.3	3.4
Beef cattle	17.5	10.8	6.7	4.4	2.6
Total assets per 1 ha UAA [thousands PLN]					
Dairy cows	56.5	53.9	48.9	44.7	40.9
Beef cattle	55.7	50.1	42.0	38.8	28.6

Source: own study based on [FADN 2021]

In cattle farms milk production requires a greater labor input than it is in the production of cattle for slaughter, thus the total annual labor input per 1 person employed full time in a year (in AWU²) was markedly greater in dairy farms, particularly in the case of large farms (by over 20%). The share of hired labor was comparable and slight in both types of small farms, while it was higher in medium-sized and large specialist dairy farms, particularly those with an area over 50 ha UAA (by 150%).

In cattle farms the production of milk is also more capital intensive than the production of beef cattle, which results from differences in the production technology of these products. Capital intensity of production represents the value of fixed and operating means of production per 1 ha UAA, i.e., total assets per 1 ha UAA. In the investigated farms, the capital intensity of production was relatively greater in all the area size groups of dairy farms (Table 1), with the greatest differences observed among the largest farms (by over 50%).

With an increase in farm size, a decrease is recorded both in capital intensity and labour intensity (measured by the labour input per 100 ha UAA) of agricultural production. In the compared farms, labour and capital intensities decreased much faster in farms specialising in the production of beef cattle than in dairy farms (Table 1), which was determined by the organisation and intensity of production in those farms.

The organisation of production in the analysed farms was characterised based on the following indexes: the share of cereals and fodder crops in the cropping area, the share of permanent grassland in UAA, total stocking density and total cattle stocking density in LU³ per 100 ha UAA and fodder area per 1 LU of ruminants (Table 2).

The analysed types of farms differing in size varied in terms of production organisation. In dairy farms, the share of cereals in the cropping area was lower and decreased markedly with an increase in farm size, whereas the share of fodder crops was much greater and was growing relatively faster than in farms specialised in rearing beef cattle (Table 2). In dairy farms, the share of permanent grassland in UAA was also higher, but generally decreased with an increase in their land area size, while in farms specializing in the production of beef cattle no such trend was recorded. The greatest share of permanent grassland in UAA of farms rearing beef cattle was observed in the largest farms with an area exceeding 50 ha UAA, which resulted in a higher share of roughage in animal feeding in those farms. In terms of economic outcomes, in the production of cattle for slaughter, as a rule, a low-input production system should be used, in which animal nutrition is, first of all, based on natural grassland and roughage at limited rations of concentrates [Wójcik 2011, Iurchevici, Chetroiu 2014, Skarzyńska 2017].

² AWU – a reference unit of labour input: 1 AWU = total 2,120 hours of work/year. Total labour input includes the input of own labour of the farmer and his/her family (FWU) as well as input of hired labour (AWU).

³ LU – a reference unit equivalent to 1 dairy cow or culled cow, or a male bovine aged 2+.

In view of the above, both total stocking density and total stocking density of cattle were relatively lower in farms rearing beef cattle. In both types of farms, the highest stocking density was recorded in medium-sized farms, while it was lowest in the largest farms.

In farms rearing beef cattle, the fodder area per 1 livestock unit (LU) of ruminants was relatively higher and generally increased with an increase in the land area of farms. In those with an area exceeding 50 ha UAA, it was much greater than in smaller farms of this type, which was related to a much higher percentage of permanent grassland as well as a lower stocking density of animals in that area size group of farms. In dairy farms with an increase in their size, the fodder area per 1 livestock unit of ruminants also typically grew, which was connected with an increased share of fodder crops in the cropping structure and a reduction in stocking density.

Table 2. Organisation and intensity of production in analysed farms depending on UAA

Type of farm	Area size groups of farms [ha UAA]				
	5-10 (small)	10-20 (medium small)	20-30 (medium large)	30-50 (large)	above 50 (very large)
Share of cereals in cropping area [%]					
Dairy cows	64.3	52.3	50.9	46.9	41.3
Beef cattle	73.3	67.7	61.3	58.7	52.5
Share of fodder crops in cropping area [%]					
Dairy cows	29.7	43.2	44.8	48.7	50.4
Beef cattle	17.9	22.8	26.3	28.5	32.8
Share of permanent grassland in UAA [%]					
Dairy cows	44.6	36.2	37.7	35.8	29.9
Beef cattle	29.1	28.1	26.8	25.0	39.5
Total stocking density per 100 ha UAA [LU]					
Dairy cows	138.2	149.5	136.1	130.3	118.4
Beef cattle	88.6	95.2	93.2	94.3	72.2
Total stocking density of cattle per 100 ha UAA [LU]					
Dairy cows	136.8	148.0	135.0	129.5	117.7
Beef cattle	77.4	83.3	84.1	77.5	66.5
Fodder area per 1 LU of ruminants [ar/LU]					
Dairy cows	44.6	43.0	48.5	51.7	55.3
Beef cattle	53.6	53.1	54.7	59.6	88.3
Total costs per 1 ha UAA [thousand PLN]					
Dairy cows	5.80	6.51	6.38	6.59	7.01
Beef cattle	4.92	4.57	4.41	4.28	3.00

Source: see Table 1

The level of production costs per unit area of UAA in a farm is a measure of intensity of agricultural production [Goraj, Mańko 2009, Ziętara 2017]. Farms specializing in milk production have relatively much more intensive production and this trend was also observed in the investigated farms (Table 2), which was related e.g., with higher costs of animal feeding and keeping, as well as a larger number of animals in this type of farms.

With an increased size of the analyzed farms, the intensity of production generally increased in dairy farms, whereas it decreased in farms specializing in the rearing of beef cattle, which resulted from the organization of production in those farms and was reflected in their outputs. Roberto Mosheim and C.A. Knox Lovell [2009] as well as Artur Wilczyński [2012] also showed an increased intensity of production with the growing scale of milk production.

In relation with the low-input production system in farms specializing in the rearing of beef cattle and the high-input production of dairy farms – the output of these farms differed, respectively. Dairy farms obtained a relatively much higher level of total outputs.

With an increase in the size of farms, differences in outputs of the compared farms were becoming greater due to the diversification of the production intensity in those farms (Table 2). In small farms of 5-10 ha UAA, the value of total output in dairy farms was by 73% higher, whereas in farms of more than 50 ha UAA, it was higher by as much as 217% (Table 3).

Table 3. The value of output and the productivity of factors of production in analysed farms depending on UAA

Type of farm	Area size groups of farms [ha UAA]				
	5-10 (small)	10-20 (medium small)	20-30 (medium large)	30-50 (large)	above 50 (very large)
Total output [thousand PLN]					
Dairy cows	63.66	138.88	219.41	355.61	720.67
Beef cattle	36.78	65.26	108.59	157.70	227.36
Productivity of land resources [PLN/ha]					
Dairy cows	7,526	8,899	8,789	9,223	9,639
Beef cattle	4,602	4,478	4,458	4,152	2,957
Productivity of labour resources [thousand PLN/AWU]					
Dairy cows	39.72	78.70	112.85	172.15	285.00
Beef cattle	26.30	41.48	66.61	94.39	112.93
Productivity of capital resources [PLN/100 PLN total assets]					
Dairy cows	13.3	16.5	18.0	20.1	23.54
Beef cattle	8.2	8.9	10.6	10.7	10.4

Source: see Table 1

In farms keeping dairy cows, the productivity of land, labor and capital resources – analogously as outputs – was much higher than in farms rearing beef cattle (Table 3). The greatest and smallest differences in their levels between the compared groups of farm area size in those farms were observed in the same groups as differences in the level of outputs.

With an increase in the size of the investigated farms productivity of land resources, it generally increased in dairy farms, whereas in beef cattle type farms it deteriorated. The directions of changes in the productivity of land resources in these farms resulted respectively from changes in the intensity of their production.

In farms specializing in milk production, the productivity of labor and capital resources was also much higher than in beef cattle type farms. With an increase in farm size, the productivity of labor and capital resources was markedly growing in both types of farms, but it was, to a greater extent, in dairy cow type farms, especially the productivity of labor resources, which was connected with the organization and intensity of production in individual land area size groups of compared farms. In small farms (5-10 ha UAA), the difference in the productivity of labor resources amounted to approx. 50%, while in large farms of more than 50 ha UAA, it was 150%. In the case of the productivity of capital resources in farms of 5-10 ha UAA this difference amounted to approx. 60%, while in large farms with an area of more 50 ha UAA it was 126%.

The economic outcomes of the investigated farms are presented in Table 4. Farm income in agricultural holdings specializing in milk production, similarly as output, was relatively much higher. A comparative analysis of differences in the level of income within individual land area size groups in the investigated types of farms showed that these differences were generally decreasing with an increase in farm size.

In the case of the analyzed farms, both those keeping dairy cattle and rearing beef cattle, the level of final economic outcomes was determined to a considerable extent by the level of subsidies obtained by farms. According to the FADN methodology, subsidies to the production and investment activity of farms are included when calculating farm income.

In the case of the analyzed farms specializing in milk production, the share of subsidies in the income of these farms ranged from over 30 to 70% and decreased with an increase in the scale of production. In farms specializing in rearing beef cattle, subsidies determined income, since they covered losses and generated positive economic outcomes. In beef cattle type farms, the share of subsidies in the final economic outcome ranged from over 100 to approx. 160% and decreased with an increase in farm size (in farms with an area over 50 ha UR, it was the smallest). In the case of farms with an area exceeding 50 ha UAA, the most extensive production system was used and the most advantageous relationship of the level of costs to outputs was obtained, which means that the cost intensity of production

Table 4. Income and profitability of factors of production in analyzed farms depending on UAA

Type of farm	Area size groups of farms [ha UAA]				
	5-10 (small)	10-20 (medium small)	20-30 (medium large)	30-50 (large)	above 50 (very large)
Farm income [thousand PLN]					
Dairy cows	29.42	65.11	104.99	161.69	291.92
Beef cattle	8.99	22.40	40.41	56.83	98.22
Share of subsidies in farm income [%]					
Dairy cows	70.0	50.7	46.7	42.7	33.8
Beef cattle	158.9	141.4	117.6	116.9	102.2
Farm income per 1 ha UAA [PLN]					
Dairy cows	3,461	4,174	4,200	4,189	3,903
Beef cattle	1,124	1,534	1,656	1,496	1,277
Profitability of own labour resources [thousand PLN/FWU]					
Dairy cows	18.39	36.99	54.11	78.11	114.93
Beef cattle	6.42	14.27	24.79	34.03	49.86
Profitability of capital resources [PLN/100 PLN total assets]					
Dairy cows	6.1	7.7	8.6	9.4	9.5
Beef cattle	2.0	3.1	3.9	3.9	4.5

Source: see Table 1

was lowest in that area size group of farms. Thus, it confirmed earlier research results indicating that diversification in the level of animal management costs compared to the scale of beef cattle production is evident [Porter, Jones 2005, Skarżyńska, Abramczuk 2018].

The economic efficiency of resource utilization in the compared types of farms, i.e., profitability of land, own labor and capital resources (including subsidies), is presented in Table 4. Since the level of the obtained income was relatively higher in farms specializing in milk production, their profitability of production resources was also higher. Greater differences were generally observed in smaller farms.

The analysis of profitability of land resources in individual area size groups of the investigated farm types showed that the highest profitability of land resources was obtained in medium-sized farms (farms of 20-30 ha UAA). The recorded results do not confirm the findings presented by Artur Wilczyński [2012], Roberto Mosheim and C.A. Knox Lovell [2009] and Roman Sass [2017] indicating that increasing the scale of production leads to an improved profitability of land resources in dairy farms.

With an increase in the scale of production, the profitability of own labor and capital increased markedly in both types of farms, particularly in beef cattle type farms. This was related with a greater reduction in labor and capital intensities of production, as well as a greater increase in income with a growing size of farms specializing in beef cattle rearing. Dairy farms with an area of more than 10 ha of UAA obtained a similar level of income from their own labor to parity income, which in 2019 amounted to 39.39 thousand PLN/FWU, and farms focused on rearing cattle for slaughter with an area of more than 30 ha of UAA. The research shows that the ability to compete and develop, compared to farms from selected EU countries, is demonstrated by Polish dairy farms with an area of more than 30 ha of UAA and farms focused on slaughter cattle farming with an area of more than 50 ha of UAA [Ziętara 2018, Ziętara, Adamski 2018].

CONCLUDING REMARKS

The aim of this study was to assess and compare the efficiency of management of production resources in farms specializing in the production of milk and cattle for slaughter and differing in sizes. The theoretical framework indicates that the main factors determining the improved efficiency of utilized production resources include the enlargement of farms, specialization and an increased scale of production in farms.

It results from this study that farms specializing in the production of milk and beef cattle differ markedly in terms of the organization and intensity of production. The level of intensity of production increases in dairy farms with an increase in their size, while it decreases in the beef cattle type farms, which is reflected in the output and economic outcomes, as well as the efficiency of management in the case of production resources.

In dairy farms, the productivity of land resources was markedly higher and was increasing with growing farm size, whereas in the beef cattle type farms it deteriorated. The productivity of labor and capital was also much greater and was growing faster with an increase in the size of dairy farms, although milk production requires higher inputs of labor and capital than is the case with the production of beef cattle.

Farms specializing in milk production also obtained relatively much higher economic outcomes (income including subsidies). In turn, in beef cattle type farms, subsidies covered losses and determined income, although, with an increase in farm size, the share of subsidies in income generally decreased, since the cost intensity of production decreased. The highest profitability of land was recorded in medium-sized farms of both production types, whereas that of labor and capital was greatest in the largest farms. It needs to be stressed that the income and economic efficiency of farms specializing in the production of cattle for slaughter are determined by EU financial support within the CAP.

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EFEKTYWNOŚĆ GOSPODARSTW ROLNYCH O RÓŻNEJ WIELKOŚCI OBSZAROWEJ UKIERUNKOWANYCH NA PRODUKCJĘ MLEKA ORAZ BYDŁA RZEŻNEGO

Słowa kluczowe: efektywność w rolnictwie, czynniki produkcji, produktywność, dochodowość, produkcja mleka, produkcja bydła rzeźnego

ABSTRAKT

Powiększanie gospodarstw rolnych, specjalizacja i zwiększanie skali produkcji to główne czynniki poprawy wykorzystania zasobów w rolnictwie. Celem artykułu jest ocena i porównanie efektywności gospodarowania zasobami w gospodarstwach rolnych o różnej wielkości obszarowej, ukierunkowanych na produkcję mleka oraz bydła rzeźnego. Ocenę przeprowadzono na podstawie danych z gospodarstw objętych rachunkowością rolną w systemie FADN w 2019 roku. Efektywność wykorzystania czynników produkcji w badanych gospodarstwach oceniono na podstawie wskaźników produktywności i dochodowości ziemi, pracy i kapitału. W gospodarstwach nastawionych na produkcję mleka produktywność ziemi była znacznie wyższa i zwiększała się wraz ze wzrostem wielkości gospodarstwa. Natomiast w gospodarstwach typu bydło mięsne produktywność ziemi malała. Także produktywność pracy i kapitału była znacznie wyższa i szybciej zwiększała się w gospodarstwach mlecznych. Największą dochodowość ziemi uzyskały gospodarstwa średniej wielkości obu typów produkcyjnych, a pracy i kapitału – gospodarstwa największe. Należy podkreślić, że o dochodach i efektywności ekonomicznej gospodarstw rolnych ukierunkowanych na produkcję bydła rzeźnego przesądzało wsparcie finanse w ramach realizacji wspólnej polityki rolnej krajów Unii Europejskiej.

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