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Soil Quality versus the Economic Results of Farms Specializing in Milk Production – Case Study of Poland

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Abstract:

Purpose: *Poland's geographic position provides favourable natural conditions for cattle farming and milk production. The aim of this paper is to highlight differences in agricultural in-come levels and remuneration rates for own labour of farmers and their family members across farms with varying quantities and qualities of agricultural land.*
Design/Methodology/Approach: *A detailed analysis was conducted on the economic performance of 1,688 commercial farms that continuously maintained accounts of their agricultural activities from 2005 to 2022 for the purposes of the FADN system.*
Findings: *The study confirmed that farmers operating lower-quality farmland were more likely to specialize in milk production. At the same time, despite the relatively poorer quality of the land used, farms specializing in milk production achieved higher gross value added per unit of area, higher farm income, and greater potential remuneration for own labour compared to other farms.*
Practical Implications: *This pattern economically justifies the continued expansion of farm size and production concentration. The analysis results demonstrate that milk production can be a viable alternative to other agricultural activities, particularly in regions with lower soil quality.*
Originality/Value: *The analysis results demonstrate that milk production can be a viable alternative to other agricultural activities, particularly in regions with lower soil quality.*

Keywords: *Agricultural Economics, Livestock Farming, Land Development, Land Use, Household Finance.*

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1. Introduction

Poland's geographic location provides relatively favourable natural conditions for cattle rearing and dairy milk production. Historically, milk production was practised across the entire area of presentday Poland. This was mainly due to the vast proportion of land suited for forage crop cultivation, which is essential for cattle rearing (Parzonko, 2013; Bórawski *et al.,* 2022). Over the past three decades, socio-economic changes in Poland have led to the regional polarisation of agriculture and the regionalisation of cattle rearing, accompanied by farm specialization as well as the concentration of milk production and processing (Brodzińska, 2016).

In addition to socio-economic factors, the observed regionalisation of production also stems from the natural characteristics of different regions, such as soil quality, climate, water conditions, and topography. In well-managed agricultural production, soil-related factors should be prioritized to prevent soil degradation and the decline of its productive potential.

The strong connection between cattle rearing and corn cultivation, as well as the availability of grassland, has contributed to the regionalization of milk production in Poland (Wiza, 2020). As noted by Parzonko (2013), the observed regionalization of cow milk production is closely linked to the fact that regions with high dairy cattle concentrations tend to have lower-quality soils and a higher proportion of grassland within the overall agricultural landscape.

The aim of this paper is to highlight differences in agricultural income levels and own labour remuneration rates among farms with varying quantities and qualities of agricultural land. The focus is on farms specializing in dairy milk production. The following hypothesis has been tested:

H1: By specializing in milk production, farms with lower-quality soils can achieve better economic results compared to farms engaged in other types of production.

2. Materials and Methods

Income from farming is a fundamental category in assessing the efficiency of agricultural activity and is generally considered the primary measure of the dynamics and competitive capacity of agricultural farms. Agricultural income represents the remuneration for all factors of production involved in the activity, as well as compensation for management and the economic risk incurred. To estimate the remuneration for the labour of farmers and their family members, the income from the family farm must be adjusted by deducting the alternative costs of land and capital used in the farm. In this paper, the alternative cost of using owned land is assumed to be equal to the average ground rent paid by commercial farms in a given voivodeship.

This assumption is based on the premise that if farms in a particular region pay a set rate for ground rent, they would likely receive a similar amount if they chose to lease out their own land to other entities.

To estimate the alternative cost of owned capital (excluding land) invested in a farm, the study used the average interest rate on household deposits (for new contracts) with a term of six months to one year, as published annually by the National Bank of Poland in January.

Given that the capital available to farmers was relatively high compared to an average household, it was assumed that they would be able to negotiate a deposit interest rate 20–25% higher than the average rates offered by the National Bank of Poland. Consequently, for the periods 2005–2007 and 2020–2022, the capital interest rates were set at 5% and 2%, respectively (Wojewodzic *et al.,* 2024).

The empirical material for this research consisted of accountancy data from commercial farms collected for the Polish Farm Accountancy Data Network by Instytut Ekonomiki Rolnictwa i Gospodarki Żywnościowej – Państwowy Instytut Badawczy w Warszawie (the Institute of Agricultural and Food Economics – National Research Institute in Warsaw) (Farm Sustainability Data Network (Poland)).

The analysis covered 1,688 commercial farms that continuously maintained accounts of their agricultural activities for the purposes of FADN from 2005 to 2022. This long-term approach allowed for tracking the analysed issues over an extended period, providing a more precise presentation of the results. To minimize the impact of short-term fluctuations in climate and economic conditions on the analysed economic indicators, average values for three-year periods - 2005–2007 and 2020–2022 - were used.

The analysis utilized the nomenclature applied in the FADN system methodology. This means that a farm's agricultural type was determined based on the share of the standard output (SO) value from different agricultural production activities in relation to the farm's total SO value.

Consequently, the agricultural type reflects the level and direction of specialization (Pawłowska-Tyszko, Osuch and Płonka, 2022). The research results are presented using the average values of selected categories for farms specializing in dairy milk production, compared to the average values for all other farm types combined.

3. Results

3.1 Impact of Soil Quality of farms' Production Specialisation

Among the analyzed farms, those specializing in field production accounted for the largest share (nearly 40%), followed by farms specializing in milk production (22%) and mixed production (23%). Observed changes over the period 2005–2022 clearly indicate a progressive trend toward production specialization. While there was a significant decline in the number and proportion of farms engaged in mixed production (a decrease of 30 percentage points), the share of farms specializing in field production increased by 21.3 percentage points, and the proportion of dairy farms grew by 4.8 percentage points.

These shifts were accompanied by an increase in the average farm size. It is also worth noting that, given the limited availability of agricultural land for purchase, leasing has played a significant role in the farmland market. For instance, during the two successive research periods (A and B), the proportion of leased farmland within the total agricultural area was 37.1% and 31.5% for field farms and 29.5% and 35.5% for dairy farms, respectively (Table 1).

Table 1. *Differentiation of land resources in commercial farms by agricultural type**

Description	**Total area (ha of UAA)**		**Leased farmland (ha of UAA)**		**Share of leased farmland (%)**		**Soil quality index (WBG)**	
	A	**B**	**A**	**B**	**A**	**B**	**A**	**B**
Field scale crops	49.6	61.5	18.4	19.4	37.1	31.5	1.08	1.06
Horticulture crops	7.2	8.0	0.4	0.6	5.6	7.5	0.74	0.70
Permanent crops	11.9	15.4	0.6	1.7	5.0	11.0	0.93	0.91
Dairy cows	27.1	36.9	8.0	13.1	29.5	35.5	0.65	0.66
Graminivorous animals	21.6	32.2	3.0	9.9	13.9	30.7	0.43	0.47
Pigs	33.9	44.4	8.2	12.7	24.2	28.6	0.90	0.87
Poultry	20.4	20.5	0.7	0.3	3.4	1.5	0.71	0.69
Mixed	27.5	35.1	7.4	10.4	26.9	29.6	0.83	0.82
In total	30.8	39.4	9.1	12.1	29.5	30.7	0.84	0.83

Note: **A – Average for the period 2005–2007 B – Average for the period 2020–2022.*
Source: *Own elaboration based on data from the Polish FADN system.*

An interesting observation is that as a farm's average size increases, the average value of the soil quality index often decreases. This suggests that, in a given area, lower-quality plots are typically the ones available for sale. Some farms with poorer soil

quality see opportunities for growth by processing plant products into animal-derived products (e.g., milk, meat). This approach is also supported by empirical data (Table 2). Among farms with good or very good soil quality, a significantly larger proportion specialized in plant production. At the same time, there was a relatively small proportion of farms focused on raising herbivores, particularly other cattle.

Table 2. *Structure of commercial farms by agricultural type depending on soil quality (%)*

Description	**Agricultural types of farms (TF8)**							
Year	**Field scale crops**	**Horticulture crops**	**Permanent crops**	**Dairy cows**	**Graminivorous animals**	**Pigs**	**Poultry**	**Mixed**
Structure of farms with good and very good soils WBG > 1.20								
2005	35.8	2.3	2.9	4.9	0.0	6.8	0.0	47.3
2022	62.5	2.0	4.9	7.8	0.3	3.6	0.0	18.9
Structure of farms with average quality soils WBG=(0.81-1.20)								
2005	24.0	2.1	2.6	9.8	0.4	7.5	0.5	53.1
2022	48.2	3.2	4.0	12.8	3.5	3.5	0.5	24.3
Structure of farms with poor and very poor soils WBG <0.80								
2005	8.3	1.6	2.3	26.9	0.6	5.1	0.9	54.3
2022	25.6	3.3	2.7	33.7	6.4	4.0	1.2	23.1

Source: *Wojewodzic,Czekaji and Drab, 2025.*

In areas with lower-quality soils, the proportion of milk farms was significantly higher compared to other types of farms, and it was steadily increasing. There was also a dynamic rise in the proportion of farms raising other herbivores. The combination of lower soil quality, the inability to earn rent from high-quality land, and the limitations on growing commodity crops that require better conditions forces farmers to seek alternative ways to improve their farm's economic performance. This explains the growing im-portance of farms specializing in milk production and livestock farming, as these activities enable the use of so-called absolute feed (primarily grass).

3.2 Production Scale

One possible measure of farmland use intensity is productivity, defined as the value of a farm's total output per unit of area. In the analyzed group of commercial farms, farmland productivity increased with both the size of the farm and the quality of the land being cultivated (Table 3). However, within the group of farms with up to 20 ha of Utilized Agricultural Area (UAA), milk farms showed lower productivity compared to the rest of the analyzed population.

This was mainly due to the presence of commercial farms raising poultry and pigs, as well as horticultural farms in this group. Farms specializing in granivorous livestock farming typically rely on purchased feed, which, given the small size of the farmland, enables them to achieve high production value per unit of area.

At the same time, it was found that farmland productivity on milk farms with an agricultural area of over 20 ha was higher than that of other farm types. This supports the thesis that farms producing cow milk use farmland more effectively, even when the land quality is lower. It can therefore be concluded that converting roughage into animal products – in this case, primarily milk – significantly enhanced farmland productivity. This also led to an increase in the gross value added per hectare of agricultural area (Table 4).

Table 3. *Production value on farms with different soil quality*

Area groups of farms	**Milk farms by WBG value**				**Milk farms in total**	**Other farms in total**
	<0.80 poor soils	**0.80-0.99 average soils, worse**	**1.00-1.20 average soils, better**	**>1.20 good and very good soils**		
	Total output (PLN thousand/ha of UAA)*					
<20 ha	10.6	x	x	x	12.0	14.2
20-50 ha	11.9	13.0	15.9	x	12.9	9.2
50-100 ha	13.7	x	x	x	14.6	8.8
>100 ha	x	x	a	a	x	9.2
In total	12.7	15.0	17.0	x	13.8	9.7

Note: ** average values for the period 2020–2022, a – no farms in this group, x – the size of the group is too small to publish the results,*
Source: *Own elaboration based on data from the Polish FADN system.*

Table 4. *Gross added value in farms with various agricultural land resources*

Area groups of farms	**Milk farms by WBG value**				**Milk farms in total**	**Other farms in total**
	<0.80 poor soils	**0.80-0.99 average soils, worse**	**1.00-1.20 average soils, better**	**>1.20 good and very good soils**		
	Gross added value (PLN thousand/ha of UAA)*					
<20 ha	7.0	x	x	x	7.8	5.0
20-50 ha	7.5	8.5	9.6	x	8.1	3.4
50-100 ha	8.1	x	x	x	8.5	2.8
>100 ha	x	x	a	a	x	2.2
In total	7.7	8.9	10.1	x	8.2	3.1

Note: ** average values for the period 2020–2022, a – no farms in this group, x – the size of the group is too small to publish the results.*
Source: *Own elaboration based on data from the Polish FADN system.*

The analysis confirmed that, on farms specializing in cow milk production, better-quality farmland contributes to higher productivity and gross value added per unit of area. It is also worth noting that the gross value added on milk farms was over 2.6 times higher than the average across the rest of the analysed farm population: PLN 8,200/ha of UAA compared to PLN 3,100/ha of UAA.

3.3 Farms' Economic Performance

The analysis showed that the profits from agricultural activities earned by the farms varied, with three distinct trends emerging. First, within both the group of milk farms and the other farms, average profits increased as farm size grew (Table 5). Another key observation concerns the impact of soil quality on profit levels. In this case, higher soil quality also contributes to higher profits. The third important conclusion is that the average profits earned by farms specializing in milk production are significantly higher than the average for the other farms analyzed.

As earlier analyses have demonstrated, during the period 2005–2022, milk farms generally achieved higher profits than the average across the entire population of farms conducting agricultural accounting in the Polish FADN system (with the exception of 2009). An increase in farm income was observed both in nominal and real terms. This was largely due to the increased size of farms, as well as the growing scale and concentration of agricultural production and the shift toward greater production specialization.

Table 5. *Farm's income*

Area groups of farms	**Milk farms by WBG value**				**Milk farms in total**	**Other farms in total**
	<0.80 poor soils	**0.80-0.99 average soils, worse**	**1.00-1.20 average soils, better**	**>1.20 good and very good soils**		
	Income from farm (PLN thousand)*					
<20 ha	87.6	x	x	x	97.1	65.6
20-50 ha	200.9	235.7	270.6	x	218.0	136.2
50-100 ha	458.0	x	x	x	470.9	275,3
>100 ha	x	x	a	a	x	698.5
In total	246.0	274.8	272.2	x	256.5	171.6

Note: ** average values for the period 2020–2022, a – no farms in this group, x – the size of the group is too small to publish the results.*
Source: *Own elaboration based on data from the Polish FADN system.*

Table 6. *Farmland profitability*

Area groups of farms	**Milk farms by WBG value**				**Milk farms in total**	**Other farms in total**
	<0.80 poor soils	**0.80-0.99 average soils, worse**	**1.00-1.20 average soils, better**	**>1.20 good and very good**		

				soils		
	Income from farm (PLN thousand/ha of. UAA)*					
<20 ha	6.0	x	x	x	6.7	5.3
20-50 ha	6.3	7.2	8.3	x	6.8	4.3
50-100 ha	6.7	x	x	x	7.0	4.0
>100 ha	x	x	a	a	x	4.2
In total	6.4	7.2	8.5	x	6.9	4.3

***Note:** * average values for the period 2020–2022, a – no farms in this group, x – the size of the group is too small to publish the results.*
***Source:** Own elaboration based on data from the Polish FADN system.*

A larger farm size can lead to decreased efficiency, productivity, and even profitability per unit of area, partly due to lower production intensity and the use of lower-quality soil released from other farms. Research shows that in the "Other farms in total" group, farms with smaller agricultural areas achieved higher farmland profitability (Table 6).

On dairy farms an opposite trend is observed. The so-called economies of scale become evident, as larger farms are able to run more intensive production, and likely benefit from better organization. Additionally, with a higher production scale, these farms can secure better prices for the milk they produce.

Farms specializing in milk production were able to generate higher incomes per unit of area, despite having lower-quality farmland compared to the rest of the analyzed population. Moreover, milk farms with better-quality land achieved higher farmland profitability compared to those farming poorer soils.

Milk production is considered an activity that requires substantial labour input. On dairy farms the remuneration rate for own work, estimated according to the assumptions given in the methodological section, was higher than in the remaining group of entities included in the analysis. This suggests that milk production is significantly more profitable than most other agricultural activities. In fact, the compensation for labour on milk farms was higher than the average across the remaining group of entities (Table 7).

Higher-quality farmland can contribute to higher rates of remuneration for the farmer and their family. This trend was observed within the group of entities farming 20 to 50 ha of UAA, but it was not confirmed for all the commercial milk farms selected for the study.

***Table 7.** Rate of own labour of farmers and their family members remuneration in agricultural farms*

Area groups of farms	**Milk farms by WBG value**				**Milk farms in total**	**Other farms in total**
	<0.80 poor soils	**0.80-0.99 average soils, worse**	**1.00-1.20 average soils, better**	**>1.20 good and very good soils**		

	Rate of own work remuneration (PLN/hour)*					
<20 ha	19.0	x	x	x	21.3	17.5
20-50 ha	36.7	42.8	51.9	x	40.3	31.3
50-100 ha	83.9	x	x	x	82.0	62.5
>100 ha	x	x	a	a	x	140.7
In total	45.3	53.4	49.5	x	47.6	38.8

***Note:** * average values for the period 2020–2022, a – no farms in this group, x – the size of the group is too small to publish the results.*
***Source:** Own elaboration based on data from the Polish FADN system.*

Previous analyses conducted by Wojewodzic et al. (2024) showed that improvements in the remuneration for own labour on milk farms were observed starting in 2017. Between 2017 and 2022, the average remuneration rates for the work of the farmer and their family were higher not only than the average remuneration for employees in the analyzed farms, whose labour was included in the operating costs, but also higher than the mini-mum wage set by Polish national regulations.

4. Discussion

A critical review of the literature available in global scientific databases revealed a significant gap in empirical analyses aimed at identifying ways to compensate for the economic results achieved by farms with low-quality soil by modifying the focus of agricultural activities. At the same time, numerous studies on the functioning of milk farms and the economic results they achieve are available. These were used in the discussion of the findings to provide a rationale and help explain the patterns observed during the research.

The key factor in the development of agriculture in a given area are land resources understood as quantity and quality of land (Tomczak, 2006). However, Del Corral, Perez and Roibas (2011) argued that the more land a farm has, and the greater the proportion of work performed by the farmer and their family, the less technically efficient the farm becomes. The quality of land significantly influences the farmer's decisions regarding crop structure and the soil's potential to generate profits from agricultural activity. Non-agricultural factors also have a substantial impact on land use (Nilsson and Johansson, 2013).

Madau, Furesi and Pulina (2017) even suggest that external factors may play a larger role in determining the economic outcomes of farms than the farmers' ability to utilize their assets. This view is partially supported by Britt et al. (2018), who predicted a significant increase in air temperatures in temperate regions over the coming decades (up to 2067), arguing that this phenomenon would likely lead to an expansion of global land used for dairy cattle farming. This, in turn, could contribute to an increase in global milk production.

However, Britt *et al.* (2018) also predicted that the modernization of milk farms and genetic improvements in dairy cattle internal factors would positively affect output levels and, consequently, farm profits. Referring to the present research, it can be concluded that external factors, such as product demand and related production profitability, can sometimes be more influential in farmers' decisions regarding production specialization than internal conditions, including land quality. In the case of farms, the growing interest in milk production often arises from the higher economic viability of this activity (Komorowska, 2018), relatively stable prices offered by milk collectors (GUS, 2023), and the positive impact of milk sales on farms' financial liquidity (Guth, 2016), especially in farms with large dairy herds (Wysokiński, 2014).

At the same time, in areas with lower-quality soils that limit the possibility of obtaining differential rent I, some farms abandon agricultural activity altogether (Wojewodzic, 2017). This allows the released farmland to be transferred to economically stronger farms, which can benefit from differential rent II arising from production scale and intensity. As a result of transferring the poorest farmland to larger entities, the average quality of farmland in these larger farms decreases, as confirmed by the presented findings.

Research by Clark and Tillman (2017) also confirmed that land used as pasture for cattle was often less fertile than land used for cultivating forage crops such as corn or soybeans. Thus, it can be concluded that soil quality, along with economic factors, remains a key criterion in crop selection and, consequently, influences the focus of production on many farms. Lower-quality soils are more frequently used as meadows and pastures, with the resulting production playing a crucial role in feeding ruminants.

In Polish regions with a high concentration of milk production, such as the Masovian and Podlaskie voivodeships, the prevalence of lower-quality soils has led to a significant proportion of grassland within the total agricultural area. Grasslands account for over 30% of agricultural land, facilitating the availability of inexpensive, good-quality cattle feed (Adamski, 2014). According to Brodzińska (2016), such feed is 2.5 times cheaper than feed obtained from arable land. Kelly *et al.* (2012) argue that soil quality is one of the key variables affecting the technical and economic efficiency of dairy farms.

The issue of soil quality and its impact on production specialization is addressed far less frequently in the literature than topics related to production scale and farm size. Numerous studies (Wojewodzic, 2017; Bórawski *et al.,* 2020; Parzonko *et al.,* 2023) demonstrate that the development of small farms is both organizationally and economically challenging. Limited farmland resources often restrict plant production to maize cultivation for silage frequently in monoculture which, unfortunately, has a detrimental effect on soil health (Czarnocki, Paluszkiewicz and Rowicki, 2013).

According to Datta, Haider and Ghosh (2019), empirical studies confirm a positive, statistically significant relationship between farm size, milk yield, and gross margin. Research conducted in mountainous areas of South Tyrol demonstrated that dairy farms with low production investments, small-scale operations, and extensive production methods achieved lower profits per farm and per hectare of agricultural area compared to farms that relied on intensive production and high investment levels (Kühl, Flasch and Gauly, 2020).

Studies by Wysokiński and Klepacki (2013), MacDonald and Newton (2014), and Sass (2024) further emphasize the importance of production scale. Farms with larger-scale dairy operations generated higher incomes, with income growth being more than proportional to the increase in herd size.

This suggests that the concentration of milk production leads to greater profitability in specialized farms, with income rising at a faster rate than the number of cows in the productive herd. However, research by Wysokiński and Klepacki (2013) also indicates that a focus on dairy production entails a high level of income risk. Despite, milk producers must expand their operations in response to market pressures, including declining prices and the impact of inflation on farm income (Evink and Endres, 2017).

The paper presents quantitative findings, with a particularly valuable insight being that farms specializing in milk production can achieve better economic outcomes than other farms, even when operating on lower-quality land. This suggests that engaging in milk production can, to some extent, offset the disadvantages of poorer soil quality and positively influence farm profitability.

5. Conclusions

This paper examines the economic performance of farms specializing in dairy cow farming and milk production. The study is based on empirical data from 1,688 commercial farms which conducted agricultural accounting within the Polish FADN system.

The research revealed that milk farms achieved higher farm income and greater potential remuneration for their own labour compared to other farms. This finding is particularly significant given that milk farms more often operated under conditions of poor-quality soils.

The results led to the positive verification of the research hypothesis, Despite operating on relatively poorer-quality land, farms specializing in milk production achieved higher gross value added, greater agricultural income, and higher remuneration rates for their own labour than the other analysed farms. This economic pattern supports the continued concentration of milk production in areas with lower soil quality.

Soil quality is one of the key factors influencing a farm's economic performance. However, by aligning production with local environmental and economic conditions, farms can significantly mitigate the impact of soil quality on their financial outcomes. Farms specializing in milk production, in particular, require a higher input of human labour and a sufficient supply of roughage.

Low soil quality does not necessarily hinder the development of milk production, provided the farm has adequate labour, capital, and land resources. In contrast, for other types of agricultural production, lower-quality land typically results in significantly poorer economic performance compared to dairy farms.

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