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Milk Recording as a Factor Influencing the Performance of the Dairy Sector in Poland

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Abstract:

Purpose: *This study aimed to evaluate the economic situation of dairy farms enrolled in milk recording and determine the impact of milk recording on the Polish dairy sector's productivity.*
Design/Methodology/Approach: *The study involved agricultural holdings which specialized in dairy cattle farming in 2011-2013, kept continuous milk production records, conducted the required number of milk tests, were within the field of observation of the Polish Farm Accountancy Data Network (FADN), and kept continuous accounts during the investigated period.*
Findings: *The article analyzes the Polish milk market and the size and milk performance of the dairy cow population in Poland relative to selected EU countries. Milk recording was defined, and its objectives, the relevant laws, and methods were presented. The resources, organizational structure, output, financial performance, production value, sales, costs, and income of dairy farms enrolled in milk recording (listed in SYMLEK and FADN databases), and dairy farms listed in the FADN database only were compared. The costs associated with milk recording and the share of recording costs in the evaluated dairy farms' total costs were estimated.*
Practical implications: *The results will fill in the gap concerning factors influencing the dairy sector's performance in Poland.*
Originality/Value: *The new information about the potential effects of milk recording in the entire population of dairy cows in Poland in 2012-2017 was analyzed.*

Keywords: *milk recording, milk production, milk yield, financial performance of dairy farms, dairy sector.*

JEL codes: *Q11, Q12, Q16, Q18.*

Paper type: *Research article.*

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1. Introduction

The size of dairy cattle populations differs considerably across the European Union due to variations in farm organizational structure, production capacity, climate, livestock intensification, processing capabilities, modernization, and hygiene standards across European regions. Poland is one of the EU's leading producers of dairy cattle, and Polish herds accounted for 9.7% of the total population of dairy cows in the EU in 2018. The number of dairy cows was nearly twice higher in Germany (17.9%), whereas French herds accounted for more than 15% of the EU's dairy cow population. The number of dairy cows was similar in Italy and the United Kingdom at 8.5% and 8.2% of the EU population, respectively (Szajner, 2019).

Over the last decade, the Common Agricultural Policy has been the main driving force behind the Polish dairy sector's restructuring. As a result, the total number of dairy cows continued to decrease in successive years, but an increase in milk yield compensated for this drop. According to Bórawski and Kowalska (2017), the observed decrease in the Polish population of dairy cows can be largely attributed to the ongoing replacement of low-yielding animals with high-yielding cows in many farms.

Total milk production has continued to increase in the EU to reach 172.2 million tons in 2018 (Eurostat, 2020). The largest milk producer was Germany (33.1 million tons), whose output increased by 13.3% in the last decade. The Netherlands was also one of the European dairy market's key players, with 1.6 million dairy cows and 14.4 million tons of produced milk. In the last decade, the Dutch population of dairy cows decreased by 0.6%, whereas milk production increased by 20.4%. In 2018, Poland had 2.2 million dairy cows, and it produced 14.2 million tons of milk; milk production increased by more than 13.7%, and the size of the dairy cow population decreased by 14.4% in the last decade (Seremak-Bulge, 2010; Szajner, 2019). The progressing intensification of livestock production in large agricultural holdings improves efficiency. The two factors that play a key role in milk production are the size of the dairy cow population and cows' milk performance (Szajner, 2018). In Poland, milk yield increased by 34.4% in the last decade, reaching 6,446 kg/cow in 2018 (Szajner, 2019).

An analysis of milk yields in the EU countries in 2018 indicates that Poland still lags behind Europe's leading producers and that its milk yields are more than 800 kg/cow below the European average (7,280 kg/cow). Milk yields were highest in Denmark (9,851 kg/cow), Estonia (9,353 kg/cow) and Finland (9,095 kg/cow) (Cook, 2019). Milk yields are expected to grow in Poland in the coming years, but they will be largely determined by improvements in the production technology, breeding value, and an increase in the number of milk recording herds. In the EU, the average milk yield is expected to increase from 7,300 kg/cow in 2019 to 8,340 kg/cow in 2030. According to the European Commission, milk production growth will decrease from 1.9% p.a. in the previous decade to 1.2% p.a. in the coming decade, mainly due to the

introduction of modern dairy production systems (EC, 2019) because dairy intensification focused on profit maximization exerted adverse effects on the environment, animal welfare, socio-economic welfare and human health (Clay, Garnett and Lorimer, 2020). The anticipated increase in milk yields will reduce the size of the dairy cow population in the EU by 1.4 million head to 21.2 million head (6% below the 2019 level) (EC, 2019).

The quantity of milk recorded dairy cows continues to increase in Poland. At the end of 2018, 816,345 cows were recorded, accounting for 36.9% of the total population (Radzio, 2019). Over the last decade, the number of recorded dairy cows increased by more than 234,000 heads, i.e., by 40.3% (Gandecka, 2010; Radzio, 2019). In Poland, the percentage of recorded dairy cows in the entire population is significantly below the values reported by other members of the International Committee for Animal Recording (ICAR). In 2018, 90% of cows were recorded in the Netherlands, 88% in Germany, and 66% in France (ICAR, 2019).

The milk performance of dairy cows is a vital determinant of milk production efficiency, and the main aim of milk recording is to improve milk yield. In the last decade, the average milk yield in Polish farms increased by 1,363 kg/cow (to 8,298/cow in 2018), i.e., by nearly 20%. Milk parameters that determine the price of milk were highly satisfactory (Jurczak, 2005), and in 2018, the average fat content of milk reached 4.03% and protein content – 3.39%. However, despite the continuous increase in recorded cows' milk performance, Poland still lags far behind other EU countries. In 2018, highly impressive results were reported in Portugal and Denmark, where the average milk yield reached 10,812 kg/cow and 10,263 kg/cow, respectively. Milk yields in excess of 9,700 kg/cow were reported in Belgium (9,941 kg/cow), the Netherlands (9,853 kg/cow), Sweden (9,827 kg/cow), Finland (9,795 kg/cow) and Estonia (9,785 kg/cow) (ICAR, 2019).

This study aimed to evaluate the economic situation of dairy farms enrolled in milk recording, compared with other farms specializing in milk production, and to determine the impact of milk recording on the Polish dairy sector's productivity.

2. Theoretical Background of Milk Recording in Poland

In Poland, animal products have a high share of agricultural production and total food production. Herd performance can be improved through genetic progress and breeding efforts, but milk recording also provides valuable information about dairy cows' nutrient requirements and rearing conditions (Ziętara, 2007). Milk recording enables farmers to optimize production costs, expand production, and manage the production of fodder crops more effectively. These internal factors positively affect milk production (Parzonko, 2004). Milk recording provides reliable information about a herd's performance, which can be used to plan changes in the production process, optimize milk yields (Gaworski and Wójcik, 2013), and improve milk's chemical

composition, and increase farm income. The results of milk recording are useful for optimizing agricultural inputs and direct costs. They enable farmers to meet the nutrient requirements of dairy cows, prevent diseases such as mastitis, select animals characterized by high reproductive performance and desirable physical characteristics that guarantee high levels of production for a long time, increase milk production and the protein and fat content of milk without substantially increasing production costs. Effective and modern agricultural holdings are built by farmers who plan their operations based on reliable data (Skarżyńska, 2011).

Herd recording contributes to an improvement in the performance traits of dairy cows. It provides information about the lineage of the evaluated cows, milk yield, milk composition (fat and protein content), dates of calving, insemination and drying off, diseases, date of birth, culling, and other parameters. Milk yield is the most important parameter in milk recording, and it is determined during milking on test days. The results are used to determine daily, seasonal, and annual milk yields, including milk yields during 100-day and 365-day lactation periods and throughout the lactation period (from calving to drying off). The average milk yield per cow, herd, or breed is calculated. The results of milk yield analyses can be used to assess the progress in milk production, heritability of milk production traits, desirable milk composition, milking ease, and other important performance traits. Milk recording provides information about every cow's nutrient requirements, which are determined by its body weight, physiological stage (pregnancy, drying off), and milk production. Individual feeding is a cost-effective solution that optimizes productivity and feed management.

In Poland, dairy cattle are recorded by the Polish Federation of Cattle Breeders and Dairy Farmers (PFCBDF) under the provisions of the Act of 29 June 2007 on livestock breeding and reproduction (Journal of Laws, 2017, item 2132) and the Regulation of the Minister of Agriculture and Rural Development of 19 June 2008 authorizing unions of livestock breeders and other organizations to record livestock (Journal of Laws, 2016, item 919). The scope of dairy and dual-purpose cattle, recording and the methodology applied by the PFCBDF have been approved by the Ministry of Agriculture and Rural Development. The recording methodology is consistent with Commission Decision of 20 June 2006 laying down performance monitoring methods and methods for assessing cattle's genetic value for pure-bred breeding animals of the bovine species (2006/427/EC; OJ L 169) and ICAR guidelines.

The recording methodology applied in Poland is consistent with ICAR guidelines (group A), which implies that test milking is carried out. An authorized representative makes entries in the recording organization's farm records and that cows are milked by a person indicated by the authorized representative. All dairy and dual-purpose cows in the herd are recorded, and identical procedures are applied to the entire population. In farms equipped with milking robots, the recording method's choice is

determined by the applied milking system. To ensure the reliability and comparability of the collected data, milk measuring equipment must be compatible with the International System of Units (SI), permanently or periodically approved by the ICAR, and regularly inspected or calibrated. The quantity of sampled milk is measured with weighing scales, mechanical milk meters, automatic milk meters, and electronic data capture.

The data collected in the recording process are accumulated, processed, and made available by the SYMLEK information system. The recording process is being increasingly automated each year. The results are presented to farmers in the form of reports generated by the system. The reports support daily farm operations, and they enable breeders to detect infections and other health problems and adequately meet the nutrient requirements of cattle (Słoniewski, 2010). Breeders can also access the relevant data via the Stado OnLine (SOL) application. The program is a rich source of information that can be effectively used to plan farming operations and manage cattle herds. Herd events can also be recorded in the system.

3. Materials and Methods

The analyzed agricultural holdings specialized in dairy cattle farming in 2011-2013, kept continuous milk production records, conducted the required number of milk tests, were within the field of observation of the Polish Farm Accountancy Data Network (FADN) kept continuous accounts during the investigated period. The results were used to compare the analyzed farms' organizational structure, facilities, output, and financial performance.

Dairy farms for the study were selected by targeted sampling. All milk producers registered in SYMLEK and FADN databases in the analyzed period were divided into two groups, A and B. Group A comprised farms registered in both systems. Group B was the reference group, and it was composed of milk producers registered in the FADN database only. The size of both groups differed in each year of the study because the number of agricultural holdings that fulfilled the definition of a dairy farm (milk production has to account for more than 60% of the farm's total production) changed the investigated period. The production profile of agricultural holdings was evaluated according to FADN criteria based on standard output (SO). Only farms registered in SYMLEK and/or FADN databases in all three years of the study were included in the analysis.

The changes in the evaluated parameters during the three-year study were analyzed based on the average rate of changes described by the following formula:

$$\left(\sqrt[n-1]{\frac{y_n}{y_1}} - 1 \right) \cdot 100\%$$

where: y_1 – value of the analyzed parameter in the first year of the study (2011);
y_n – value of the analyzed parameter in the last year of the study (2013).

The real cost of milk recording was estimated based on SYMLEK and FADN data. The classification of cows in each recording method was taken into consideration. Therefore, milk recording costs were calculated as the sum of the products of unit costs in each recording method and the number of cows recorded using a given method. The developed linear regression model was characterized by an extremely high goodness of fit to empirical data ($R^2 = 0.916$).

The hypothetical costs of milk recording in the entire population of dairy cows were calculated as the total number of dairy cows in Poland and the average recording cost per cow. Seven milk recording methods (A4, AT4, A8, AR4, AR8, AZ4, and AZ8) were used in 2012-2017; therefore, the number of cows recorded using a given method has used a weight to calculate the weighted arithmetic mean. The developed linear regression model was characterized by satisfactory goodness of fit to empirical data. ($R^2 = 0.829$).

4. A Comparison of the Organizational Structure and Facilities in the Evaluated Farms

Environmental and economic factors determine farm production capacity. According to Ziętara (1998), agricultural holdings can maximize their output by adapting the farm's organizational structure to local conditions. The rapid advances in dairy technology, in particular solutions that facilitate cow rearing and milking, enable farmers to optimize production processes and improve their financial performance (Wójcik, 2013). Bojarszczuk and Księżak (2011) observed that milk production is correlated with effective management of land for the cultivation of fodder crops, and they noted that the organization of production processes should be further optimized in dairy farms.

Selected parameters of dairy farms where cows were and were not milk recorded are compared in Table 1. The average area of agricultural land per cow was 12.8% higher in group B, indicating that farmland was used more effectively in group A holdings. The area of permanent grasslands per cow was higher in group B farms where animal diets were highly abundant in grass herbage. Herbage-based diets decrease production costs, but they do not always adequately meet cows' nutrient requirements and, consequently, prevent farms from achieving high milk yields (Chabuz, Litwińczuk, Teter, Stanek and Brodziak, 2012). In group A holdings, more arable land was dedicated to fodder crop production, which indicates that animal diets were more abundant in fodder that better met the high energy and protein requirements of dairy cattle. Labor expenditure was lower by 14 hours per cow on average in group A farms, which suggests that these holdings were better organized and equipped, and that milk recording contributed to productivity.

Table 1. *Selected parameters of the analyzed dairy farms in 2013 per cow*

No.	Parameter	Unit	Values in farms		Difference relative to group A
			A	B	
1.	Area of agricultural land	ha	1.33	1.50	+
2.	Area of arable land	ha	0.87	0.82	+
3.	Area of permanent grasslands	ha	0.46	0.68	+
4.	Labor	hours	176	190	+
5.	Fixed assets	PLN ‘000	23.2	17.1	+
6.	Value of buildings and structures	PLN ‘000	10.4	7.2	+
7.	Value of vehicles, machines and equipment	PLN ‘000	9.3	6.7	+

Source: *Own elaboration based on FADN and SYMLEK data.*

The value of fixed assets was higher in group A holdings. Fixed assets increase costs, but they also increase labor and production efficiency when optimally used (Manteuffel, 1984). The value of buildings, structures, vehicles, machines, and equipment was also higher in farms enrolled in milk recording, which indicates that these farms were more likely to rely on advanced technology and modern dairy cattle management systems (milking parlors, free stall systems, robots, etc.).

5. A Comparison of the Output and Financial Performance of the Analyzed Dairy Farms

Agricultural holdings have to derive profits in order to survive in a highly competitive market. Selected production and financial performance indicators in the analyzed dairy farms are compared in Table 2.

Table 2. *Selected production and financial performance indicators in the analyzed dairy farms in 2013 per cow*

No.	Indicator	Unit	Values in farms		Difference relative to group A
			A	B	
1.	Economic size	ESU	0.97	0.86	+
2.	Production value	PLN ‘000	8.75	5.30	+
3.	Milk yield	kg	7424.2	5206.7	+
4.	Sales	PLN ‘000	7.4	4.1	+
5.	Direct costs of livestock production	PLN	2224.65	1360.25	–
6.	Direct feed costs	PLN	1880.14	1204.99	–
7.	Direct service costs	PLN	210.24	84.73	–
8.	Farm income	PLN ‘000	4.35	2.42	+

Source: *Own elaboration based on FADN and SYMLEK data*.

An agricultural farm's economic size denotes the total farm revenue derived from different types of activities (Wasąg, 2009; Goraj, 2006). According to Goraj (2006), farms with a larger economic size have a greater competitive advantage on the market in the long term. In comparison with group B farms, group A holdings were

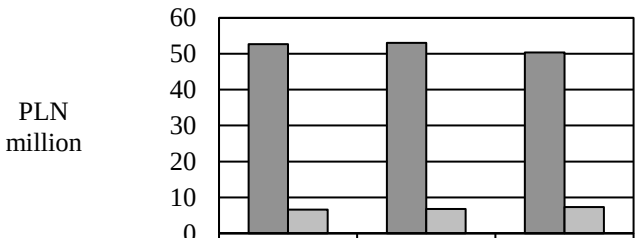
characterized by a higher standard gross margin (SGM), which is a measure of their overall economic size. Similar differences between groups were noted in production, including milk yield (which was higher by 2,217.5 kg/cow in group A), which, according to Runowski (1990), exerts a positive effect on cattle's final production and milk. Sales were 44.6% lower in group B holdings. These findings suggest that farms enrolled in milk recording are more effective and that milk recording contributes positively to their economic situation and financial performance.

According to Skarżyńska and Jabłoński (2013), production volume influences sales and costs. These factors determine the financial performance of agricultural holdings (Żmija, 2019), and they should be optimized to increase profitability. Group A farms were characterized by higher direct costs associated with livestock production (by 38.9%), feed production (by 35.9%), and services (by 40.3%), but they also derived higher income per cow (by 44.4%) than group B enterprises. The above findings indicate that agricultural intensity was higher in farms enrolled in milk recording, which improved their financial performance. In these enterprises, production costs have not yet reached a critical level, which implies that agricultural inputs can be further intensified to increase profits (Klepacki, 1998).

6. Milk Recording as a Factor Influencing the Performance of the Dairy Sector in Poland

Milk recording costs (Figure 1) and their share of total costs (Figure 2) were determined in the examined agricultural holdings. In 2011-2013, the average annual total costs in the evaluated dairy farms reached PLN 52.3 million, and they decreased by 2.2% in each year of the study. In the same period, annual recording costs were determined at PLN 6.9 million on average, and they increased by 4.9% each year. Therefore, recording costs accounted for more than 13.1% of total costs in the analyzed farms.

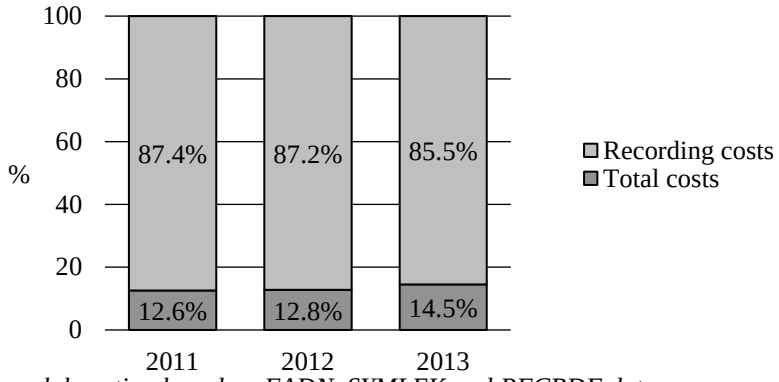
Figure 1. *Total costs and recording costs in the analyzed dairy farms in 2011-2013*



	2011	2012	2013
Total costs	52,7	53,1	50,4
Recording costs	6,6	6,8	7,3

Source: *Own elaboration based on FADN, SYMLEK and PFCBDF data.*

Figure 2. *Share of recording costs in total costs in the analyzed dairy farms in 2011-2013*



Source: *Own elaboration based on FADN, SYMLEK and PFCBDF data.*

The potential costs associated with milk recording in the entire population of dairy cows were evaluated in the next step. Comparing the real costs of milk recording in 2012-2020 with the potential costs of implementing the milk recording scheme in the entire population of dairy cows revealed a significant difference between the two values (Table 3).

Table 3: *Estimated costs of milk recording in the analyzed population and the entire population of dairy cows in 2012-2020*

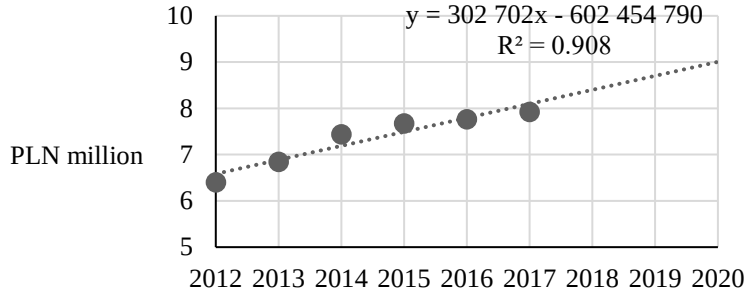
Year	Milk recording costs in the analyzed population (PLN) [1]	Potential milk recording costs in the entire population (PLN) [2]	Share (%) of [1] in [2]
2012	6 403 468	23 462 257	27.3
2013	6 840 586	23 472 589	29.1
2014	7 441 174	23 128 058	32.2
2015	7 671 642	22 461 771	34.2
2016	7 761 952	21 587 094	36.0
2017	7 923 476	21 862 581	36.2
2018	8 399 844*	21 230 276	39.6
2019	8 702 547**	20 821 101	41.8
2020	9 005 249**	20 411 925	44.1

Note: ** estimate, ** forecast*

Source: *Own elaboration based on FADN, SYMLEK and Statistics Poland data.*

Real recording costs accounted for only 32.6% of potential costs on average in the analyzed period. Powerful linear trends were observed for the increase in real costs (Fig. 3) and the decrease in potential costs over time (coefficient of determination R2 = 0.908 for real costs and R2 = 0.875 for potential costs). The average annual increase in real costs reached 4.35%, and the average annual decrease in potential costs was determined by 1.4%.

Figure 3. *Estimated real and potential costs of milk recording*



Source: *Own elaboration based on FADN, SYMLEK and PFCBDF data.*

A simulation was performed with the use of the following data:

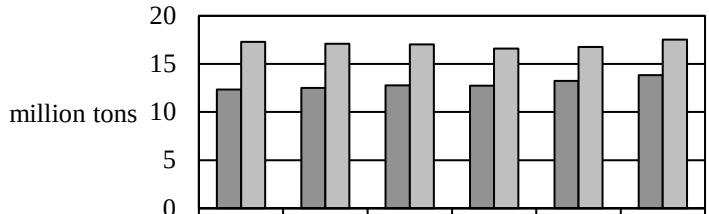
- the number of recorded cows and their average milk yield based on SYMLEK data,
- the number of the remaining cows expressed by the difference between the total number of dairy cows in Poland in the Statistics Poland database and the number of recorded cows,
- the average milk yield of the remaining cows in the Statistics Poland database expressed as the average milk yield of all dairy cows in Poland.

The real milk yield of all dairy cows in Poland was calculated by summing up the above variables' products.

A hypothetical scenario assuming that all dairy cows in Poland are milk recorded was then adopted. The milk yield of all dairy cows was expressed by the average milk yield of recorded cows. Hypothetical milk production in Poland was calculated as the total number of recorded and non-recorded cows and the average milk yield of recorded cows. The increase in milk yield in the hypothetical scenario (if the entire population of dairy cows in Poland was recorded) was determined as the difference between the hypothetical milk yield and the real milk yield of all dairy cows in Poland.

All calculations were performed for each year in 2012-2017. The forecasted increase in milk production in the hypothetical scenario was calculated as the difference between the hypothetical milk yield and the milk yield of the entire cow population divided by real milk yield, and the results were expressed in percentage terms. The decrease in the size of the dairy cow population resulting from the implementation of the milk recording scheme in all dairy farms was then calculated as the quotient of the difference between the real and hypothetical number of cows in Poland (if the entire population of dairy cows was recorded) divided by the real number of dairy cows, and the results were expressed in percentage terms. If all dairy cows in Poland were recorded in 2012-2017, milk production would increase by 26.9% in 2017 (Figure 4).

Figure 4*. Real and potential total milk production*

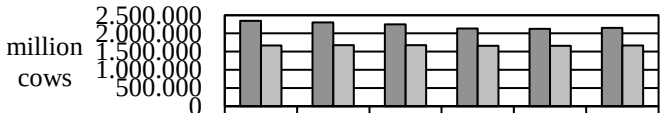


	2012	2013	2014	2015	2016	2017
Real	12,33	12,52	12,77	12,73	13,24	13,83
Simulated	17,29	17,11	17,04	16,58	16,75	17,55

Source*: Own elaboration based on FADN, SYMLEK and Statistics Poland data*.

According to Gaworski, Leola, and Priekulis (2013), milk recording should be introduced in the largest possible number of dairy herds because it enables breeders to monitor changes in cow productivity, contributes to the implementation of modern technological solutions in agricultural holdings, and enhances the biological potential of dairy production in Poland. The simulation revealed that if all dairy cows were milk recorded, the domestic population of dairy cows could be reduced to 1.7 million head (by 24.7%) without decreasing milk production (Figure 5).

Figure 5*. Size of the dairy cow population at the current level of total milk production and the simulated population size if all cows were recorded*



	2012	2013	2014	2015	2016	2017
Real	2.346	2.299	2.247	2.134	2.129	2.152
Simulated	1.671	1.675	1.678	1.663	1.658	1.666

Source*: Own elaboration based on FADN, SYMLEK and Statistics Poland data*.

The simulation results indicate that the size of the dairy cow population in Poland could be reduced by 25% without compromising current milk production if the milk recording scheme were introduced in all dairy farms.

7. Conclusions

Polish farms enrolled in milk recording were analyzed. The agricultural holdings selected for the study were in the field of observation of the Polish FADN; they recorded dairy cows and specialized in milk production. Therefore, the obtained results cannot be generalized to all dairy farms. However, the solutions deployed by farms enrolled in milk recording can increase total milk production in Poland.

Agricultural holdings that specialized in milk production and participated in milk recording achieved higher financial performance than dairy farms where cows were not recorded. This observation suggests that milk recording could improve the productive capacity and economic situation of dairy farms, thus strengthening the Polish dairy sector's competitive advantage.

The simulation conducted based on data for 2012-2017 revealed that the number of dairy cows could be reduced by 25% without compromising current milk production if the entire population of dairy cows in Poland was recorded. The milk recording scheme's implementation in all dairy farms would force milk producers to search for new export markets where surplus dairy products could be sold. Additional jobs would have to be created in the dairy industry, and around 25% of the existing farms would have to modify their production profile.

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