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QUALITATIVE ASSESSMENT OF PRECISION DAIRY FARMING IMPACT ON FARM SUSTAINABILITY IN UKRAINE: THE FARMERS' PERSPECTIVE

Case Study

Keywords
Precision dairy farming;
Sustainability;
Ukraine;
Dairy farms;

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Q16

Abstract

The general objective of this research was to investigate one of the management approaches – precision dairy farming (PDF) and based on the example of Ukrainian dairy farms to assess its impact on environmental, economic and social pillars of sustainability. For conducting the study an inductive approach was used, which involved the development of a theory as a result of the observation of empirical data. Primary data was collected through semi-structured interviews and questionnaires via phone, with owners and managers of cow dairy farms of varied categories. In total, 17 dairy farmers took part in the study. Results showed that precision dairy farming technologies are being moderately used in Ukrainian farms. 41% of the participants (seven out of 17) are applying these tools in their farms. Most of the respondents indicated positive impact of PDF technologies on sustainability of farms. Particularly, financial performance of the farms has improved, health conditions of cattle got better and working conditions of the staff amended. Regarding environmental effects, it is hard to draw conclusions since none of the farms was measuring them.

INTRODUCTION

The current world population of 7.6 billion is expected to reach 9.8 billion in 2050 (United Nations, 2017). At least three billion people are expected to join the middle class by 2050 (Kharas, 2010), while the Food and Agriculture Organization of the United Nations (FAO) estimates that this will lead to a 60% increase in demand for high quality protein such as milk, meat and eggs (FAO, 2011). The supply of animal products can be increased by raising the number of animals. However, confronting the fact that in most regions land availability limits the expansion of livestock and the fact that humanity is already using 50 percent more resources than the Earth can provide (WWF, 2012), people have to meet the current and forecast demand in a sustainable way.

The need for the research arises from the latter report of FAO about the world livestock. It emphasizes that a major challenge will be to translate the role of livestock in the Sustainable Development Goals (SDGs) into national policies and strategies. Each country will have to decide how the role of livestock in the SDG should be incorporated into national planning processes, policies and strategies, and how to set national targets guided not only by the global level of ambition but considering national contexts (FAO, 2018).

The dairy sector faces a vast number of challenges, however, it has a great potential to solve them as well. For instance, it can play a key role in mitigating climate change through adoption of digital technology. It is also a powerful vehicle for achieving economic growth, as well as improving human well-being. Among the dairy farm management approaches, which widely use technology, is the precision dairy farming (PDF).

PDF is based on the precision livestock farming (PLF) approach, which was first coined as a term in 2004 by Berckmans (2004), while the first massive application of PLF technology, individual electronic milk meters for cows, happened years before – in the 1970s (Halachmi and Guarino, 2016). According to Berckmans (2014), PLF is a way of managing the farm, which involves the measurements, predictions and data-analyses of animal variable in a continuous and fully automatic way. The aim of PLF is to combine all the available hardware with intelligent software in order to extract information from a wide range of data. In the current research, definitions of precision dairy farming developed by Eastwood, Chapman, & Paine (2012) and Spilke, Buscher, Doluschitz, Fahr, & Lehner (2003) are being used. Eastwood et al. (2012) defined PDF as "the use of information and communication technologies for improved control of fine-scale animal and physical resource variability to optimize economic, social, and environmental dairy farm performance". According to Spilke et al. (2003) PDF conceptual approach aims for an ecologically and economically sustainable production of milk with secured quality, as well as a high degree of consumer and animal protection. It is a special interdisciplinary approach of different scientific disciplines (among informatics, biostatistics, ethology, economics, animal breeding, animal husbandry, animal nutrition and process engineering).

It is important to conduct studies for assessing the impact of PDF on the sustainable development of the dairy industry in order to cope with the challenges and to design appropriate and relevant governmental programs or interventions for supporting dairy farmers. The current research makes an attempt to analyze the effects of precision technology, based on the example of Ukrainian dairy farms, specifically through fulfilling the following objectives: (1) evaluating situation of dairy sector in Ukraine; (2) defining precision dairy farming technologies used by Ukrainian farmers; (3) assessing the impact of precision dairy farming technologies on sustainability of dairy farms in Ukraine.

MATERIALS AND METHODS

For this research an inductive approach was used, which involved the development of a theory as a result of the observation of empirical data (Saunders, Lewis, & Thornhill., 2009) (Figure 1). A small sample of subjects was studied, by working with qualitative data for establishing the theory.

For answering research questions of the study primary and secondary data were used. Analyses of trends and tendencies of dairy sector in Ukraine was done based on the secondary data of State Statistics Service of Ukraine (UKRSTAT). UKRSTAT is a database, which is grounded in documents from Ukrainian statistical offices. The following data were obtained through the mentioned database: (1) milk yield, produced in the country and segregated by different regions; (2) number of dairy livestock; (3) international milk and dairy products trade (imports and exports indicators).

Primary data was collected through semi-structured interviews and questionnaires. Semi-structured interviews (also known as non-standardized) were conducted via phone, with owners and managers of cow dairy farms of varied categories, with the purpose of obtaining qualitative data. Contacts of 40 farms were retrieved through online company catalogue of Ukraine which consisted from 90 dairy farms (family farms, private enterprises, cooperatives) located throughout the country. After contacting the farm owners through the phone, 17

out of 40 agreed to take part at the interview. Besides this, an online questionnaire was created by using Google Docs. A link for the survey was sent to 80 dairy farmers via e-mail, as well as was published on two websites of Ukrainian agricultural portals and three online magazines. A response rate was very low and only three answers were obtained via online form.

Primary data was collected with the purpose for answering the following questions: "What is the impact of PDF approach on sustainability of Ukrainian dairy farms?", "What are the barriers for adopting PDF technologies by Ukrainian dairy farmers?", "What are the perspectives for development of dairy sector in Ukraine in the nearest five-ten years?". The methods of semi-structured interviews and questionnaires were used for answering the posed closed and open questions (available in Annex A).

A grounded theory approach (Strauss, & Corbin, 2008), involving the inductive building of theory, was adopted for primary data analysis. Within this strategy specific analysis procedures were used to build an explanation around the core theme that emerges from data. It is structured and systematic, with set procedures to follow at each stage of analysis. Figure 2 shows the data analysis process according to the grounded theory:

During the open coding process the data was disaggregated into conceptual units and provided with labels, the terms which emerged from the data. The same labels were given to similar units of data. The following units were differentiated: (1) type of farms: family farms, private enterprises, cooperatives; (2) location of farms: north, south, east, west of the country, central Ukraine; (3) size of herd: 1-24, 25-100, 101-500, 501-1000, >1001; (4) number of employees: 1-10, 11-50, 51-100, >101; (5) familiarity with PDF technologies: yes, no; (6) barriers for adopting PDF technologies: not familiar with the technologies that are available for the dairy sector, high cost of equipment, undesirable cost to benefit ration, not enough time to spend on learning technology, these devices are too difficult to use, lack of technical support/training, it is easier for me to carry out all the actions on the farm manually, fear of technology/computer illiteracy, I do not need to use these technologies; (7) impact on social aspect of sustainability: positive, negative; 8) impact on economic aspect of sustainability: positive, negative; (9) impact on environmental aspect of sustainability: positive, negative.

Axial coding refers to the process of looking for relationships between the categories of data that have emerged from open coding. It indicates a process of theoretical development. As relationships between categories are recognized, they are rearranged into a hierarchical form, with the emergence of subcategories. Upon recognizing relationship between the categories, testable propositions were developed. Negative examples, that do not conform the demonstrated relationships, were derived as well. In the "Results and discussion" section, an explanation why these negative cases occur is provided.

Selective coding is intended to identify a principal category, which becomes known as the central, in order to relate the other categories to this with the intention of integrating the research and developing a grounded theory.

Potential bias in this method can arise from the researcher's worldview, and influence on the case study farmers themselves. Pre-understanding can also bias the achievement of "pure" grounded theory (Gummesson, 2000). In this research some level of pre-understanding was acknowledged and minimized through reflection.

Qualitative data related to the barriers of PDF technologies adoption and impact of PDF on sustainability was also quantified and being presented as quantitative data. For the barriers of adoption particular reasons have been counted, and for the impact of PDF on sustainability of farms is being presented in relation to specific references to a phenomenon. These frequencies are displayed using tables and diagrams.

RESULTS AND DISCUSSION

Current trends and tendencies of dairy sector in Ukraine

In Ukraine cow milk constitutes 98 percent of all milk produced, with the remaining two percent coming from goats and sheep. Milk production has experienced a decline since the country's independence in 1991. The total milk production in 2017 amounted to 10.5 million tons, corresponding to 55% of 1992 levels (Figure 3).

Cattle population in Ukraine, opposed to the world tendencies, is also decreasing and scaled back to 2 million in 2018 from 8.5 million in 1990 (Figure 4). If in 1991 per 100 hectares there were 20.3 heads of cattle at farmlands, and 16 heads at farm enterprises, in 2017 these indicators accounted to six and less than two respectively. According to the data provided by FAO (2016) in the EU countries in the year 2015 at farmlands per 100 hectares on the average there were 13.2 cattle, in particular 37.5 – in Belgium, 20.9 – in Denmark, 74 – in the Netherlands, 12.6 – in France (Tyvonchuk, Tyvonchuk, & Pavlocjka, 2017).

Moreover, nowadays in Ukraine only about 4% of agricultural enterprises have a population of more than 500 animals, which roughly corresponds to a fifth of the total population. The main volumes of milk production (in particular, in 2004-2007 – 82%) and its harvesting (about 65%) are concentrated in private households, almost 90% of

which hold one-two cows. This situation prevents implementation of the latest technologies concerning keeping and feeding animals, as well as the veterinary service, and therefore, in the end, technologically does not allow to ensure the receipt of high-quality dairy products (Shubravska & Sokolska, 2008).

In 2017 Ukraine entered top 10 milk producing countries with the volume of 10.3 million metric tons, amounting to 1.2% of the global production (FAOSTAT, 2019). The biggest volume of milk was produced in Vinnytsya and Poltava (central Ukraine), followed by Khmelnytskiy region (west of the country). Together these oblasts contributed 21% to the total production of the country. The output indicators were the lowest in Luhansk and Donetsk (east part), as well as in Zaporizhzhya (south-eastern Ukraine) (Figure 5).

According to the official statistics, in 2017 Ukraine had 2826 agricultural enterprises, involved into milk production. However, these enterprises produced only 27% of national raw milk volume (2.77 million tons), while family farms constituted 73% of the total output, which is equal to 7.5 million tons of milk (UKRSTAT, 2019). All the while, rural households in Ukraine continue to be the main producers of milk, the structure of fluid milk purchases by processors has shifted in recent years towards milk produced by commercial farms, which accounted for 58-60% of all milk processed in 2013 as compared to 37% in 2006. The share of commercially produced milk in total processing will likely continue to increase at the expense of milk produced by the household sector in the future (FAO, 2013).

Export volume of dairy products in Ukraine has been unstable. Main trends in the export of dairy products have showed that the exporting volume dropped by an average of 7% annually, and in 2016 a decrease reached 28% comparing to the year of 2010 (Figure 6). As analysts say, on the export of raw materials in natural terms Ukraine shifted from 28th place in 2014 to 42nd in 2016 in the ranking of world milk export countries (Tyvonchuk et al., 2017). At the end of July 2014, one of the largest markets (Russian Federation) became completely closed for cheeses from Ukraine, which led to reduction of production and export volumes respectively. Moreover, quality of processed dairy products in Ukraine needs improvement, what nowadays limits distribution of the products mainly to Former Soviet Union countries.

The profile of dairy farms, which participated in the study

Farms of the following types were investigated: family farms, private enterprises, and cooperatives. According to the law of Ukraine "On Amendments to Laws of Ukraine on Promoting the Establishment and Activities of Family Farms" (2016), family farm is an economy, formed without the status of a legal entity by individual entrepreneur or jointly with members of his family on the basis of a contract for the establishment of a family farm. Private enterprise is a legal entity acting on the basis of the private property of one or several citizens, foreigners or stateless persons and their labor or with the use of hired labor (Article 113 of the Commercial Code of Ukraine, 2004). Cooperative is a legal entity formed by natural and/or legal persons who voluntarily united based on membership for conducting joint economic and other activities in order to meet their economic, social and other needs on the basis of self-government (Law of Ukraine "On Cooperation", 2003).

Figure 7 illustrates participants of the study, segregated by the farm type and the country region. Most of the respondents had dairy farms registered as private enterprises. Their share constituted 53%, nine entities respectively. The second biggest group were family farms, which accounted to seven participants. Cooperatives constituted the smallest part, with only one respondent.

The business characteristics, as defined in this study include information on labor needed for operating dairy farms and herd size, are presented in Table 1. On the farms with 501-1000 cattle, the biggest number of animals per worker is observed in the west of Ukraine, and is accounted to 15.0 cows/person, while the lowest number is in the north – 4.4 cows/person. These interviewed dairy farms come under the category of private enterprises. Family farms in all regions have up to 10 cattle, with the highest number in the south – three cows/person and the lowest in the central Ukraine – one cow/person. There is as well a significant difference between the number of cows per worker at private enterprises and family farms, indicating that one worker at a private farm is able to take care of five times as many cows as a worker at a family farm.

Applied PDF technologies and barriers for adoption

Figure 8 shows the number of dairy farmers familiar with the term precision dairy farming. Among the respondents eight out of 17 know the meaning of the approach, what is equal to 47%. In the north of Ukraine none of the questioned farmers heard about it. The illustration also highlights the number of dairy farms, using PDF technologies, which accounts to seven or 41% respectively. An interesting fact is that two participants of the study were using PDF technologies, however, were not aware about the PDF concept. Disaggregated data by farm type shows that PDF technologies are being used only at private enterprises, and not adopted by any of the family farms and the cooperative, participating at the current study.

Overview of the applied PDF technologies by Ukrainian dairy farmers is presented in Table 2. Among the participants, seven producers, using PDF approach, were able to mention more than a single technology during the interview. Responses of participants indicated that the most commonly used technologies are sensors for fertility monitoring (43%), sensors for monitoring cow health (43%).

As the study shows, different sensors are being applied by dairy farms, however only two are using the herd management software. Nevertheless, there is a need for adopting the software, which can collect, process and utilize the information, since raw data on its own is of limited value.

Dairy farmers, with applied PDF technologies (seven out of 17), were asked an open question: "Why have you decided to use these technologies?". Many producer answers indicated similar thoughts: (1) "For effective and profitable work"; (2) "To increase productivity of the farm"; (3) "To increase milk yield";

(4) "For easier management and better control". Results indicate that most of the farms wanted to increase the profitability with the application of PDF technologies, as well as to facilitate the management.

Among the 17 respondents, 10 dairy farmers were not using PDF technologies for performing operations at the farms. They were asked a list question, containing the barriers for adopting. Their answers are presented in Table 3.

Impact of PDF technologies on sustainability of Ukrainian dairy farms, prospects of sector development

For analyzing the impact of PDF technologies on sustainability, were used measurement indices, proposed by Oudshoorn and de Boer (2005):

(1) environmental: the use of natural resources, eutrophication (nitrogen and phosphorus), global warming, acidification, and biodiversity;
(2) economic: the financial situation of the farm and the sector as a whole;
(3) social: animal health and welfare, landscape, farmers' attitudes, consumers' attitudes, product quality, work quality.

Dairy farmers, applying PDF technologies, were asked the following questions:

1) Does the use of PDF technologies have impact on your working hours?
2) What impact does technology have on the economic situation of your farm? For example, have you increased milk yield?
3) In your opinion, what impact do precision dairy technologies have on the environment?

Most of the respondents indicated positive impact of PDF technologies on sustainability of farms in general. A summary, segregated by the sustainability pillows, is presented below:

- Environmental effects: rational utilization of natural resources; improved waste management;
- Economic effects: increased milk yield; improved financial performance of the farm;
- Social effects: improved quality of milk; better reproduction and fertilization of cattle; improved health conditions of herd (e.g., lower risk of getting mastitis; improved animal welfare; better working conditions for staff; more free time for employees.

Thanks to sensors for monitoring feed intake, farmers are able to utilize the natural resources in a rational way. However, none of the participants of the study were keeping records about environmental effects, such as air pollution, utilized land area, etc. Thereby, it is not easy to make an assumption on environmental impact. A deeper quantitative research is required in this area.

Ukrainian farmers were able to provide wide range of opinions, regarding the impact of PDF approach on social pillar. This is the only category, where the answers vary and indicate positive, as well as negative effects. Concerns are related to animal health conditions and working hours of employees. Indeed, thanks to sensors a farmer is able to react on changes in cattle health faster, human factor in monitoring is excluded and possibility of making a mistake is also lower. However, with PDF technologies, cows are used more intensively, which might be considered as a negative aspect. In general, application of technologies has decreased the working hours of farm employees. In spite of this, some respondents indicated that they spend more time on fixing technologies. Similar results were observed by Schewe & Stuart (2015), mentioning that new tasks emerged for dairy farmer as a result of the introduction of robots and the digitalization of farms, namely the maintenance of the new tools and the analysis of the data generated by these machines.

In addition, the study explored prospects for Ukrainian dairy sector development from the dairy farmers' perspective. Those, who operate farms under the category of private enterprises, are quite optimistic about the future of the sector. According to their opinion, new market possibilities will emerge thanks to the European Union integration process of Ukraine. In addition, the profitability of farms will increase owing to PDF technologies. Meanwhile, small dairy farmers fear that they will not be able to survive and to compete at the market. Some of the respondents, operating family farms, even plan to close their farms in recent time.

If the government wants to maintain a structure in which both small and large farms exist, it has to become more proactive and assist small-scale farmers to overcome the current challenges of the sector. Trends of the dairy industry show that private enterprises, with herd over 500 cattle, will strengthen their position and occupy the biggest

share of the market. Taking into consideration the results of this research, government needs to support the introduction of PDF technologies on dairy farms in order to increase profitability and competitiveness of dairy households.

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Table 1
Average number of workers and cows at participating farms

	South	East	Central Ukraine	West	North	All
Average number of workers	26	176	26	15	99	68
Average number of cows	373	2501	254	202	525	771

Table 2
Overview of PDF technologies, used at Ukrainian dairy farms

PDF technology	Number of respondents	Percentage
Sensors for fertility monitoring	3	43%
Sensors for monitoring cow health	3	43%
Sensors for monitoring feed intake	2	29%
Herd management software	2	29%

Table 3
Barriers for applying PDF technologies

Factor	Number of respondents	Percentage
It is easier for me to carry out all the actions on the farm manually	6	60%
High cost of equipment	6	60%
Not familiar with the technologies that are available for the dairy sector	5	50%
Fear of technology/computer illiteracy	2	20%
I do not need to use these technologies	2	20%
Not enough time to spend on learning technology	1	10%
These devices are too difficult to use	1	10%
Lack of technical support / training	1	10%

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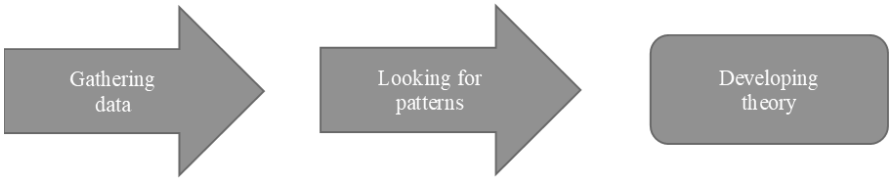

Figure 1
Main steps in the inductive approach
Source: Own elaboration based on Saunders et al. (2009)

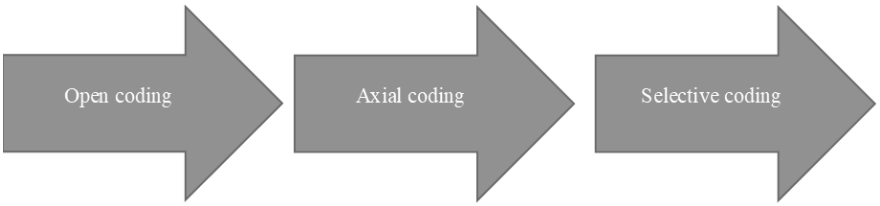

Figure 2
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Source: Own elaboration based on STRAUSS and CORBIN (2008)

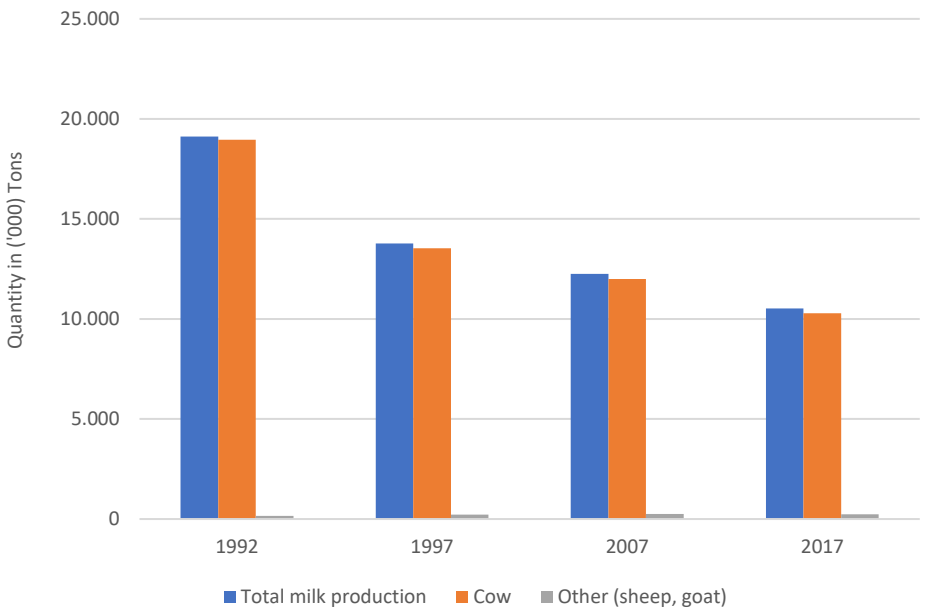

Figure 3
Milk production in 1992-2017 in Ukraine
Source: Author's work based on UKRSTAT (2019)

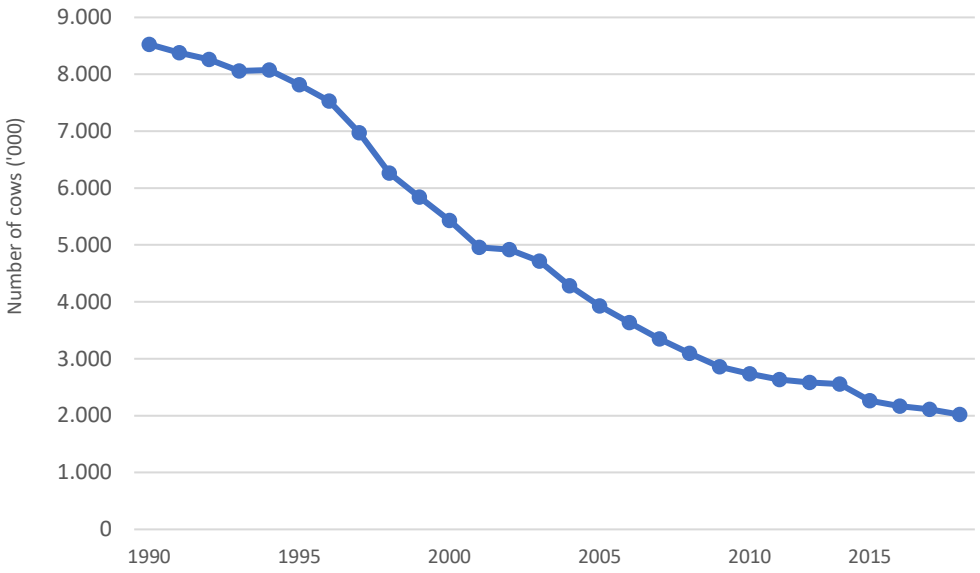

Figure 4
Number of cows in 1990-2018 in Ukraine
Source: Author's work based on UKRSTAT

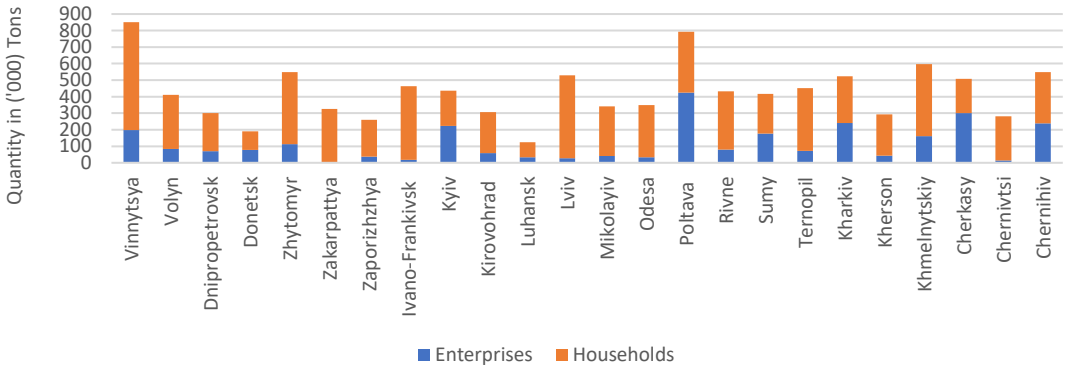

Figure 5
Milk production in 2017 in Ukraine, by oblasts
Source: Author's work based on UKRSTAT data (2019)

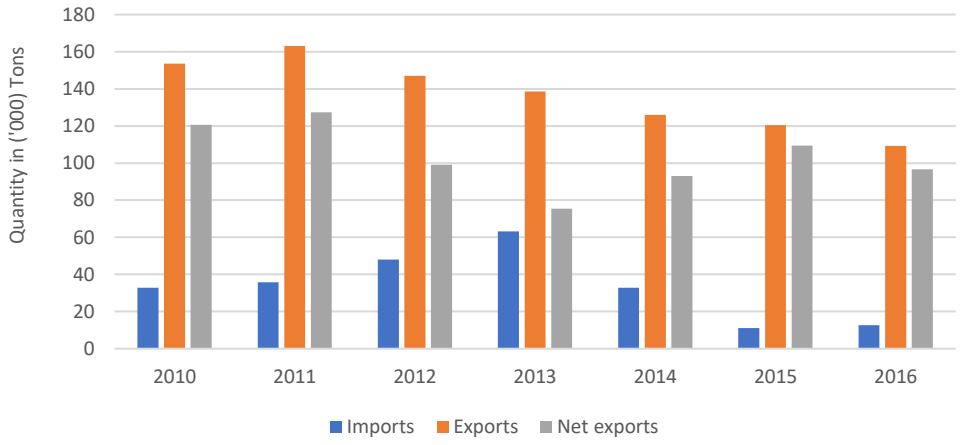

Figure 6
International trade of Ukrainian dairy products, in 2010-2016

Source: Author's work based on UKRSTAT data (2019)

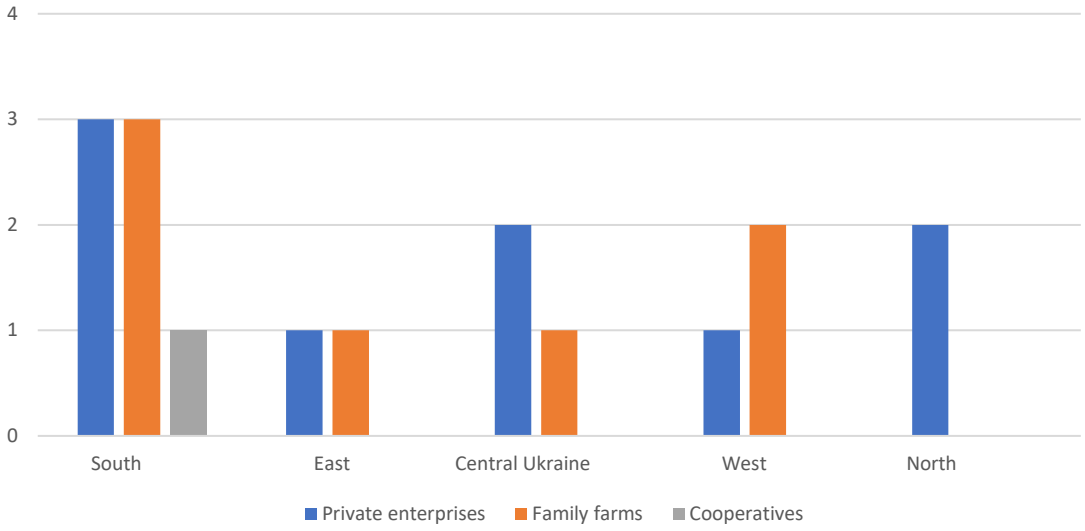

Figure 7
Types of dairy farms, segregated by country region

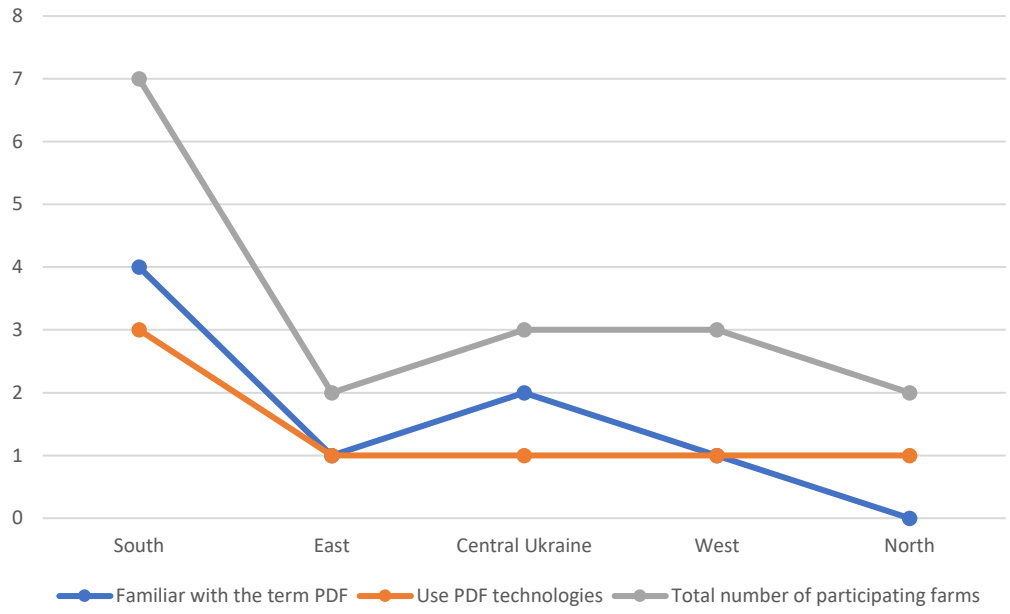

Figure 8
Number of dairy farmers familiar with PDF term, as well as farms using PDF technologies

APPENDIX A

INTERVIEW QUESTIONS

1. What is the type of your dairy farm: family farm, private enterprise, cooperative, other?
2. Where is the dairy farm located? Please, specify the name of the settlement and the region.
3. What is the size of the herd?
4. How many employees work at the farm, including you?
5. Are you familiar with the term "precision livestock farming" (PDF)?
6. Do you use PDF technologies at your farm?
7. In case you are not using PDF technologies, please, select the barriers for adopting them (multiple answers are possible): a) not familiar with the technologies that are available for the dairy sector; b) high cost of equipment; c) undesirable cost to benefit ration; d) technologies provide too much information and I don't know what to do with it; e) not enough time to spend on learning technology; f) these devices are too difficult to use; g) lack of technical support/training; h) it's easier for me to carry out all the actions on the farm manually; i) fear of technology/computer illiteracy; j) I do not need to use these technologies.
8. What PDF technologies do you use on your farm?
9. Why did you decide to use these technologies?
10. List the advantages of using these technologies.
11. What are the disadvantages, risks and uncertainties associated with precision livestock technology?
12. Based on your experience, where do you see the greatest advantage for your animals when using these technologies?
13. Does the use of PDF technologies have impact on your working hours?
14. What impact does technology have on the economic situation of your farm? For example, have you increased milk yield?
15. In your opinion, what impact do precision dairy technologies have on the environment?
16. How do you see the development of the dairy sector in Ukraine in the next 5-10 years?