

Edyta Gajos\*, Sylwia Małażewska\*\*

*\*Institute of Agricultural and Food Economics – National Research Institute, Poland,*

*\*\*Warsaw University of Life Sciences – SGGW, Poland*

## EXTERNALITIES IN LIVESTOCK PRODUCTION ON THE EXAMPLE OF ANIMAL WELFARE

### *EFEKTY ZEWNĘTRZE W PRODUKCJI ZWIERZĘCEJ NA PRZYKŁADZIE DOBROSTANU ZWIERZĄT*

**Key words: external effects, animal welfare, economic valuation, milk production**

*Słowa kluczowe: efekty zewnętrzne, dobrostan zwierząt, wycena ekonomiczna, produkcja mleka*

*JEL codes: Q12, Q19*

**Abstract.** Externalities occur when the decisions of production and consumption made by one market participant are directly affected by the decisions and actions of others, whilst this impact is not fully reflected in market prices. In case of livestock production, the examples are: agricultural landscape, biodiversity, carbon dioxide and methane emission, unpleasant odour and animal welfare, all called environmental externalities. The aim of the paper is to estimate the potential costs and benefits of possible changes in requirements associated with public goods and externalities generated by agriculture on the example of upgraded animal welfare standards in milk production. It was found, that implementing higher animal welfare standards may lead to a labourious increase in milk production. It may result in a farming scale decrease, an increase in labour costs (and production costs) and consequently lead to the deterioration of financial conditions. Revenues per cow increased in the analysed scenario in the case of the small and medium scale farms and remained stable in the case of the large scale farm. However, farm income decreased in the case of all farms. This is mainly due to employment, depreciation and an increase in financial costs.

### Introduction

Externalities occur when the decisions of production and consumption made by one market participant are directly affected by the decisions and actions of others, whilst this impact is not fully reflected in market prices. In case of agriculture there are many external effects that influence a large part of the population, e.g. in the case of livestock production: the agricultural landscape (e.g. cattle herds on pastures), biodiversity (e.g. maintaining rare national farm animal breeds or the protection of natural habitats like meadows and pastures), carbon dioxide and methane emissions (especially by ruminants), unpleasant odours and animal welfare, all called environmental externalities.

Animal welfare has been under researchers' attentions for a long time. This interest was mainly focused on the influence of various environmental conditions on animal health and behaviour. However, in the 1990s, when the European Union implemented the first animal welfare requirements within a legal directive, political and economic interest gained ground focusing not only on animal husbandry issues, but also economic ones. An important element of the discussion is the recognition of animal welfare as an external effect. It is an important topic because of the progressive process, called "greening" of the Common Agricultural Policy, and the fact that direct support in agriculture is gradually moving away from production to non-production aspects, such as environmental public goods and externalities.

Support for environmental public goods and the emergence of positive externalities providing farmers with the same level of direct payments as currently practiced, only under conditions of fulfilling specific environmentally-friendly requirements, will result in additional costs and benefits at a production level. Changes in norms and standards may result in significant consequences for

the farming economy. For instance, in the case of animal welfare, a higher level can contribute to an increase in production costs by 5-30% [Blandford 2006, Bennett 1997 by Mitchell 2000]. On the other hand, healthy animals achieve better production results, and therefore provide a higher welfare level contributing to revenue growth [Kołacz 2006]. It was found that an approximate 20-30% difference in milk yield between different dairy herds was related to the level of fear animals felt towards humans [Słoniewski 2005a, Breuer et al. 2000]. What is more, well treated cows produced approximately 500 liters of milk per year more (an increase of 13%) than animals treated more brutally (experimental research) [Słoniewski 2005b].

The aim of the paper is to estimate the potential costs and benefits of possible changes in requirements associated with public goods and externalities generated by agriculture on the example of upgraded animal welfare standards in milk production<sup>1</sup>.

### Material and methods

Data was collected using an interview questionnaire in 2011 in the Mazovian Province. 150 farmers were interviewed, after which three farms were selected deliberately to conduct a case study. Selected farms fulfilled all present welfare requirements and represented three scales of milk production.

Based on the obtained data, optimized models (one for each studied farm) with a non-linear cost function were constructed using the Positive Mathematical Programming (PMP) method. Net farm income was the objective function and production parameters, such as the number of cows or land use, were variables. Models were solved for two scenarios:

- base – model for basic conditions,
- welfare – model for conditions assuming upgraded welfare standards.

Welfare models were solved for the same point in time as base models and assumed the following changes in welfare standard in relation to current regulations: a minimum 60% of roughage in the daily feed ration, calves fed with natural milk for at least 5 days after birth, avoidance of horn removal without anesthesia, bedding material in the lying area, avoidance of slotted floors, avoidance of tethering: loose housing system or tied system with daily access to an open run, minimum space in a cowshed per one adult cow – 5 m<sup>2</sup>, green fodder feeding in the summer period: access to pasture or feeding with green fodder on an open run (combination of both methods allowed).

Parameters adopted in the models, such as yield, farm resources, herd structure, production parameters, input, as well as parameters related to a welfare standard upgrade were estimated basing on data received from interviews, results of the EconWelfare Project<sup>2</sup>, expert opinions and literature review. The parameters were individually adapted to each farm model.

### Results and discussion

Basic characteristics of studied farms are shown in table 1. All data are based on model results. The number of cows decreased in the analysed scenario in the case of the medium scale farm by two (8%). It is a result of higher labour input. There was no possibility of increasing family labour input, therefore there was a necessity to use hired labour. In the case of small and large scale farms no changes in the number of cows were found. However, while there were no labour input changes in the case of the small scale farm, it increased significantly (by 14.4 %) in the case of the large scale farm. This was due to a higher workload caused by the need to provide animals with access to pasture/open run as well as the need to feed with green fodder in the summer period.

<sup>1</sup> Paper founded: Multiannual Programme 2015-2019, research study “Economic valuation of external effects and common goods in agriculture.” Program Wieloletni 2015-2019, zadanie badawcze “Ekonomiczna wycena efektów zewnętrznych i dóbr wspólnych w rolnictwie”.

<sup>2</sup> Econ Welfare – good animal welfare in a socio-economic context: project to promote insight on the impact of upgrading welfare standards on the animal, the production chain and society.

Some investments are required on all farms: barn modernization (small scale farm) and open runway building (medium and large scale farms). In addition to this, there is also a necessity to change young calf feeding system – natural milk instead of milk replacers during the first 5 days after birth in the case of the large scale farm and to change summer cow feeding – introducing green fodder feeding in the case of the medium and large scale farm. It can be said that, in general, similar investments would be necessary on the majority of farms when it comes to implementing higher animal welfare standards.

Based on the obtained results, it can be noted that implementing higher animal welfare standards would lead to a labourious increase in milk production. It may result in a decrease of farming scale, an increase in labour costs (and production costs) and consequently the deterioration of

Table 1. Basic characteristics of studied farms (models results)

*Tabela 1. Podstawowe charakterystyki badanych gospodarstw (wyniki badań modelowych)*

Specification/ <i>Wyszczególnienie</i>	Small scale farm/ <i>Małe gospodarstwo</i>		Medium scale farm/ <i>Średnie gospodarstwo</i>		Large scale farm/ <i>Duże gospodarstwo</i>	
	base/ <i>baza</i>	welfare/ <i>dobrostan</i>	base/ <i>baza</i>	welfare/ <i>dobrostan</i>	base/ <i>baza</i>	welfare/ <i>dobrostan</i>
Number of cows/ <i>Liczba krów</i>	12	12	25	23	85	85
Land use area/ <i>Powierzchnia użytkowanych gruntów [ha]</i>	14.5	14.5	19.5	21.5	65	65
Cowshed type/ <i>Rodzaj obory</i>	tied system/ <i>uwieżiowa</i>	tied system/ <i>uwieżiowa</i>	tied system/ <i>uwieżiowa</i>	tied system/ <i>uwieżiowa</i>	loose housing/ <i>wolno-stanowiskowa</i>	loose housing/ <i>wolno-stanowiskowa</i>
Open run/ <i>Wybieg</i>	yes/ <i>tak</i>	yes/ <i>tak</i>	no/ <i>nie</i>	yes/ <i>tak</i>	no/ <i>nie</i>	yes/ <i>tak</i>
Pasture/ <i>Pastwisko</i>	yes/ <i>tak</i>	yes/ <i>tak</i>	no/ <i>nie</i>	yes/ <i>tak</i>	no/ <i>nie</i>	no – feeding with green fodder on open run / <i>nie – dowóz zielonki</i>
Family labour input [godz./rok]/ <i>Nakłady pracy rodzinnej [h/year]</i>	2 205	2 205	3 512	3 512	1 978	2 156
Hired labour inputs [godz./rok]/ <i>Nakłady pracy najemnej [h/year]</i>	0	0	0	489	2 942	3 474
Milk replacers used in calf feeding during first 5 days after birth/ <i>Stosowanie preparatów mlekozastępczych w wychowie cieląt przez 5 dni po ocieleniu</i>	no/ <i>nie</i>	no/ <i>nie</i>	no/ <i>nie</i>	no/ <i>nie</i>	yes/ <i>tak</i>	no/ <i>nie</i>
Investment type/ <i>Rodzaj inwestycji</i>	-	cowshed modernization/ <i>modernizacja obory</i>	-	open run building/ <i>budowa wybiegu</i>	-	open run building/ <i>budowa wybiegu</i>

Source: own study

*Źródło: opracowanie własne*

financial conditions. Besides, some investments that may increase the potential scale of financial condition deterioration would be required. On the other hand, providing animals with access to pasture or open run would lead to an improved animal health status as a result of a limitation in negative effects of year-round housing (e.g. predisposition to various diseases, behavioral changes, increased stress levels) [Sossidou 2007, Lewandowski 2008] and consequently would help achieve better production results (e.g. lower milk loss as a consequence of mastitis [Miciński 2015]) contributing to revenue growth [Kończak 2006]. The final effect of these changes is hard to determine. Presented research is an attempt at estimating that final effect.

Revenues, costs and incomes in studied farms are shown in table 2. All data were based on model results. The values of economic parameters presented are better the larger the production scale. This is a typical example of a scale economy – as production scale increases so does effectiveness. However, at the same time, in the case of farms characterized by a larger production scale, a negative impact of higher animal welfare is more visible. In general, in the case of large scale farms, the impact of requirements connected with access to pasture or open run and green fodder feeding on laboriousness and production profitability is significant. In small farms, the usage of pasture in summer feeding is popular, so fulfilling this requirement does not have such an impact on laboriousness. On the contrary, in large farms pasture is much less popular, which results in a significant laboriousness increase in the analysed scenario. It is logistically more dif-

Table 2. Revenues, costs and incomes in studied farms (models results)

Tabela 2. Przychody, koszty i dochody w badanych gospodarstwach (wyniki badań modelowych)

Specification/ <i>Wyszczególnienie</i>	Small scale farm/ <i>Małe gospodarstwo</i>		Medium scale farm/ <i>Średnie gospodarstwo</i>		Large scale farm/ <i>Duże gospodarstwo</i>	
	base/ <i>baza</i>	welfare/ <i>dobrostan</i>	base/ <i>baza</i>	welfare/ <i>dobrostan</i>	base/ <i>baza</i>	welfare/ <i>dobrostan</i>
Milk yield [l/cow]/ <i>Wydajność mleczna [l/krowa]</i>	3 223.9	3 395.2	8 291.1	8 878.4	7 074.6	7 074.6
General revenues [PLN/cow]/ <i>Przychody ogółem [zł/krowa]</i>	5 914	6 119	13 401	14 511	12 478	12 478
Direct costs [PLN/cow]/ <i>Koszty bezpośrednie [zł/krowa]</i>	2 000.5	1 969.5	4 252.1	4 497.3	3 103.1	3 277.0
Direct cost of production of 1 liter of milk [PLN]/ <i>Koszt bezpośredni produkcji 1 litra mleka [zł]</i>	0.68	0.63	0.53	0.52	0.44	0.46
Labourious milk production of 100 liters of milk[godz.]/ <i>Pracochłonność produkcji 100 litrów mleka [h]</i>	6.3	6.3	1.73	2.03	0.83	0.9
Gross margin per farm [PLN]/ <i>Nadwyżka bezpośrednia w przeliczeniu na gospodarstwo [zł]</i>	46 962	49 800	228 711	230 312	796 851	782 067
Gross margin per cow [PLN]/ <i>Nadwyżka bezpośrednia w przeliczeniu na jedną krowę [zł]</i>	3 913.5	4 150.0	9 148.4	10 013.6	9 374.7	9 200.8
Farm income per farm [PLN]/ <i>Dochód rolniczy w przeliczeniu na gospodarstwo [zł]</i>	16 542	14 880	55 187	52 634	455 237	438 953
Farm income per cow [PLN]/ <i>Dochód rolniczy w przeliczeniu na jedną krowę [zł]</i>	1 378.5	1 240.0	2 207.5	2 288.4	5 355.7	5 164.2

Source: own study

Źródło: opracowanie własne

ficult and more labour intensive to provide animals with a sufficient amount of movement and green fodder when it comes to big herds. It is especially visible when feeding with green fodder, whereby large scale farms, in this particular study, had no possibility of providing all animals with access to pasture and, instead, green fodder was delivered to an open run. This conclusion would be true for the majority of large scale farms in general.

Revenue per cow increased in the analysed scenario in the case of small and medium scale farms and stayed at the same level in the case of the large scale farm. This is a result of factors such as improved milk yield and calf death reduction due to the improvement of animal welfare [Kołac, Dobrzański 2006, Flower, Weary 2001, Weary, Chua 2000].

Direct costs per cow and the direct cost of production of 1 liter of milk decreased in the case of the small scale farm and increased in the case of the large scale farm in model “welfare” solutions. In the case of the medium scale farm, there was an increase of direct costs per cow, while the direct cost of production of 1 liter of milk decreased as a result of the increase in milk yield. In two out of three analysed farms, there was a positive impact on production unit costs due to an increase in the welfare level. In the case of the medium scale farm, despite the increase in direct costs, there was a decrease in the direct cost of production of 1 liter of milk due to higher milk yield. In the case of the small scale farm, there was also a decrease in direct costs in addition to decreased production unit costs, resulting from savings in e.g. veterinary costs. Milk yield increased on these two farms. This is the effect of better cow health as a result of improved cowshed conditions in the case of the small scale farm and the introduction of access to pastures and open run in the case of the medium scale farm. Both analysed parameters increased in the case of the large scale farm, as a result of lower benefits from the introduction of higher welfare norms (there already is a loose housing system and an open run in the base scenario) and a significant increase in labour costs.

The gross margin decreased by 2% in the case of the large scale farm, whilst it increased by 5-10% in the case of the small and medium scale farms. That shows, that implementing higher animal welfare standards is not solely a production limitation, but has some advantages. However, the farm income decreased in the case of all farms. It is determined by an increase in employment and depreciation costs. And, in addition to that, by financial costs associated with the necessary investment increases in the case of the small and medium scale farms.

## Summary

Implementing additional environmentally-friendly requirements in order to support the generation of environmental public goods and positive externalities in agriculture may result in significant consequences for the farming economy. This was analysed by implementing higher animal welfare standards in milk production. It was found that this would lead to significant changes both in organization and economic output. In the analysed model scenario, there was a need to change the feeding and maintaining system as well as production scale. It was found that economic consequences are both positive and negative at the production level. The final effect of these changes on farm income is hard to estimate. In this research, it was mostly negative – farm income decreased in the case of all farms in the analysed scenario.

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### Streszczenie

*Celem artykułu jest oszacowanie potencjalnych korzyści i kosztów wynikających z ewentualnych zmian wymogów związanych z generowaniem dóbr publicznych i efektów zewnętrznych przez rolnictwo na przykładzie podwyższenia standardów dobrostanu zwierząt w produkcji mleka. Zewnętrzne efekty występują wtedy, gdy decyzje o produkcji i konsumpcji dokonywane przez jednego uczestnika rynku mają bezpośredni wpływ na decyzje i działania innych, a wpływ ten nie jest w pełni odzwierciedlony przez ceny rynkowe. W przypadku produkcji zwierzęcej przykładami są: krajobraz rolniczy, bioróżnorodność, emisja dwutlenku węgla i metanu, nieprzyjemny zapach oraz dobrostanu zwierząt (nazywane środowiskowymi efektami zewnętrznymi). Stwierdzono, że wdrożenie wyższych standardów dobrostanu zwierząt może prowadzić do zwiększenia pracochłonności produkcji, co może prowadzić do zmniejszenia skali produkcji, wzrostu kosztów pracy (i tym samym kosztów produkcji), a w konsekwencji do pogorszenia warunków finansowych gospodarstw. W analizowanym scenariuszu przychody na jedną krowę wzrastają w przypadku gospodarstw o małej i średniej skali chowu oraz pozostają na tym samym poziomie w gospodarstwach o dużej skali chowu. Jednak dochód rolniczy małał w przypadku wszystkich gospodarstw. Było to przede wszystkim efektem wzrostu kosztów pracy, amortyzacji i kosztów finansowych.*

Correspondence address

Dr Edyta Gajos  
Institute of Agricultural and Food Economics – National Research Institute  
General Economics Department  
Świętokrzyska 20, 00-002 Warsaw, Poland  
email: edyta.gajos@ierigz.waw.pl

Mgr Sylwia Małazewska  
Warsaw University of Life Sciences – SGGW  
Faculty of Economic Sciences  
Nowoursynowska 166, 02-787 Warsaw, Poland  
email: sylwia\_malazewska@sggw.pl