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Comparative analysis on effectiveness of AMS use on an example of three European countries

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Abstract. Automatic milking system (AMS) belongs to the increasingly significant solutions spread in modern dairy farm production in many countries. But among countries, agriculture and economic conditions can differ widely. As a result there are premises to put the thesis that conditions as well as effectiveness of the AMS use can differ between countries. In order to prove the thesis we have analysed data coming from three European countries. The methodological approach included comparison of data covering technical, biological, economic and technological potential in general and in the selected AMS farms, to propose new indices to express conditions of AMS implementation and their effectiveness in the countries. We would like to conclude that there are considerable differences in effectiveness of AMS use between countries and farms, so it is valuable to exchange experiences resulting from the presented analyses.

Key words: AMS, annual milk yield, effectiveness, European countries.

INTRODUCTION

Automatic milking system (AMS), named also by the acronyms VMS (voluntary milking system) and RMS (robotic milking system) constitutes one of the most important solutions demonstrating progress in the modern dairy farm production in the world.

The first automatic milking systems (AMS) were installed in the Netherlands in 1992. The main reason for investing in an AMS was possible labour savings. Many experiences resulting from AMS management over the last two decades show that there are premises to develop research studies covering technical, technological, health, quality, social, welfare and economic problems. Analyses covering benefits vs. risk as well as some conditions of AMS implementation constitute an important step to recognise additional ways leading to more effective use of automatic milking systems.

One of the factors referring to AMS effectiveness is the increased milk yield resulting from more frequent milking. When milking frequency increased from two times to three times per day an increase from 6 to 25% in complete lactations was

found (Erdman & Varner, 1995). However, French data indicate an average 3% and up to 9% increase in milk yield for farms that used the milking robots for more than two years (Veysset et al., 2001).

The AMS effectiveness aspects are expressed by reduction in labour demand, too. The labour savings can approximately equal 26–28% (Dijkhuizen et al., 1997). Other analyses show that robotic milking with human-controlled cow traffic during the whole year at milking frequency of three times a day results in physical labour savings for milking amounting to 37.5% (Sonck, 1996). According to Artmann & Bohlsen (2000), a robotic milking system with a suitably functioning facility and a high level of animal monitoring can give the possibility to save about 2/3 of the time needed in conventional milking methods.

The examples given above present problems of AMS effectiveness mainly on a dairy farm scale. But it is possible to bring a more global dimension to the discussion concerning effectiveness, where specific national conditions can be taken into account.

The main aim of our paper was to show differences in effectiveness of AMS use with the example of three European countries including biological and economic aspects of the analysis.

MATERIALS AND METHODS

There are certain premises for the thesis that conditions as well as effectiveness of AMS use can differ between countries.

In order to develop the thesis a set of statistical data was taken in the analysis, including the detailed data covering biological and economic potential of dairy production.

Dairy sector is characterised by many data, like the number of dairy cows, global domestic production, annual milk yield per cow, etc.. It means, that there are possibilities to select proper data to analyse some aspects of effectiveness in the dairy production sector.

The biological potential of dairy production was expressed by the mentioned annual milk yield per cow, while the economic potential of dairy production came down to use of raw milk prices paid to the farmers in each country.

The important stage in the undertaken analyses is selection or elaboration of proper indices, which allows for comparative analysis of the effectiveness of biological and economic potential use in comparison with the AMS technical potential.

The detailed investigations were carried out on the base of data coming from the dairy sector in Estonia, Latvia and Poland. Data concerning three European countries were taken into account to show differences between the regions, where dairy production constitutes an important part of the food economy sector.

There are many definitions and interpretations covering the word ‘effectiveness’. For the purpose of the undertaken analysis the “effectiveness” was developed in such a way to show some relationships between milk production and some technical equipment on a more global scale.

RESULTS AND DISCUSSION

Effective use of a one-stall milking robot, according to data given in some reports (Meskens et al., 2001) is achieved at the level of 500,000 litres (i.e. 515,000 kg) of milk per year. Including herd size of 69 cows (60 milking cows + 15% dry off cows) operated in a dairy farm equipped with a one-stall milking robot it is possible to calculate, that one cow in the barn with an automatic milking system should produce about 7,465 kg of milk per year.

The mentioned minimum annual milk yield per cow constitutes important information about expected production potential of cows in farms equipped with AMS. On the other hand, it is possible to give data concerning current annual milk yield per cow. Basing on the mentioned parameters it is possible to propose a coefficient of AMS potential use. The coefficient can be calculated as a relationship between current milk yield per cow and the mentioned capacity of 7465 kg of milk per year.

The coefficient of AMS potential use was calculated for 2011 and data (milk yield per cow) coming from 27 EU countries (Fig. 1).

Comparison of the coefficient values show considerable polarisation in some regional conditions connected with implementation of technical advances in dairy farms. The highest values of the coefficient can be found for north-west European countries. It means that in the mentioned countries the highest level of biological progress was achieved, as one of the significant circumstances to implement effective ways for technical progress in dairy farms.

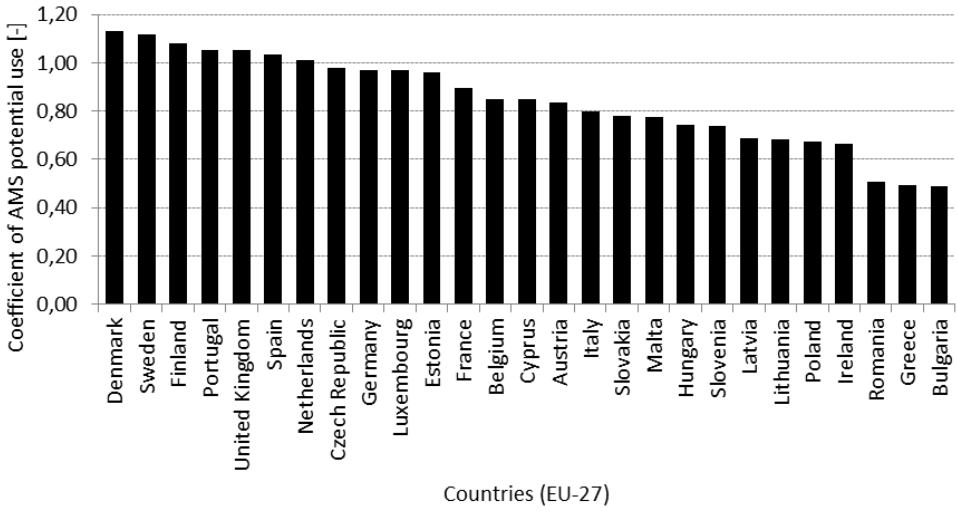

Figure 1. Coefficient of the AMS potential use for 27 EU countries in 2011 (Source: own calculations on the base of www.fao.org).

Detailed data concerning changes of annual milk yield per cow in the analysed three countries (Estonia, Latvia and Poland) are presented in Fig. 2.

The presented data (Fig. 2) show some differences in the annual milk yield per cow in the three European countries. Differences include data compared between the

countries and between the years. The analysed period covering two decades (1992–2011) was divided into two sub-periods, i.e. 1992–2001 and 2002–2011. For each period and country the increase in annual milk yield per cow was calculated and expressed by percentage value (Table 1).

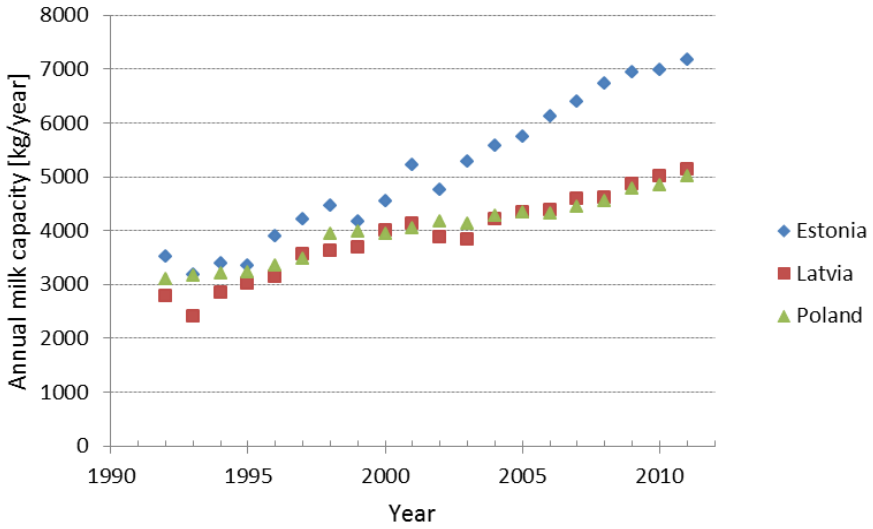

Figure2. The annual milk yield per cow in three European countries, including the 1992–2011 period (Source: www.fao.org).

Table 1. Increase in annual milk yield per cow (in %) for two periods (1992–2001 and 2002–2011) in three European countries

Country	Period	
	1992–2001	2002–2011
Estonia	47.74	51.00
Latvia	48.89	32.17
Poland	30.16	20.55

Source: own calculations on the base of www.fao.org

The data given in Table 1 show differences in the increase in annual milk yield per cow including particular periods.

Results of the calculations (Table 1) can be an inspiration to propose coefficient of biological (milking) potential increase. The coefficient (λ_{bp}) can be calculated by the following equation:

$$\lambda_{bp} = A_{mc} \cdot i_a \quad (1)$$

where λ_{bp} – coefficient of biological (milking) potential increase [kg year^{-1}]; A_{mc} – current annual milk capacity [kg year^{-1}]; i_a – index of changes [–].

The index of changes (i_a) can be calculated on the base of value covering the unit increase in annual milk yield per cow. The unit increase includes a one-year increase in annual milk yield per cow, as a result of data (given in Table 1) divided by investigated period (10 years) and expressed in absolute value.

The coefficient (λ_{bp}) can be used to show the current state of biological potential of dairy production, important from the view-point of some comparisons with AMS technical potential use.

We have calculated coefficient of biological (milking) potential change (λ_{bp}) for three countries. The coefficient can be calculated for the selected year. For 2011 value of the coefficient is as following – Table 2.

Table 2. Coefficient of biological (milking) potential increase (λbp) in 2011

Country	λ_{bp} [kg year^{-1}]
Estonia	365.91
Latvia	165.00
Poland	103.14

Source: own calculations

Analysis of data given in Table 2 indicates considerable differences between the countries in the field of biological (milking) potential increase. It means, that there are some specific conditions to develop dairy production and as a result use of automatic milking systems (AMS).

Including values given in Table 2 it can be possible to find the period, which is necessary to reach the annual milk yield level of 7,465 kg year^{-1} (explained at the beginning of the chapter). Results of the calculations were given in Table 3.

Table 3. Time necessary to reach annual milk yield per cow amounted to 7,465 kg year^{-1}

Country	Time [years]
Estonia	0.79
Latvia	14.16
Poland	23.71

Source: own calculations

Such results are a little pessimistic, especially for Poland and Latvia, where it is necessary to wait for a longer time to improve the dairy cow herd to reach the annual milk yield per cow required from the view-point of AMS effective use. On the other hand, it is important to indicate that not all cows on the national scale will be covered by automatic milking systems (AMS) in the future, so there are premises to develop other areas of discussion.

The discussion covers the problem of a proper approach to some aspects concerning the annual milk yield per cow. The mentioned yield, according to data used for detailed analyses can be presented on the base of general (national) population of dairy cows as well as a group of cows under a system of dairy recording. The dairy recording system is developed in many countries. For example, dairy cows in some Polish farms are covered by a recording system managed by the Polish Federation of Cattle Breeders and Dairy Farmers. According to data edited by the Federation statistical office, the annual milk yield per cow under the recording system in Poland

amounted to 7,135 kg year^{-1} in 2011. It is about 42% more than average annual milk yield per cow (5,019 kg year^{-1}), i.e. data given by Polish Statistical Office in 2011. Moreover, according to the Estonian Animal Recording Centre report (www.jkkeskus.ee) the annual milk yield per cow under the recording system in Estonia amounted to 7,756 kg year^{-1} in 2011. It means that the recorded yield per cow was about 8% higher than the average yield per cow in Estonia in the examined period.

We would also like to emphasise the importance of economic effectiveness of automatic milking system (AMS) use in the three European countries. There are many studies, where economic aspects are developed to show relationship between annual milk yield per cow and other factors, like salary of a barn worker (Priekulis, 2010) and additional ones. In our study the problem of economic effectiveness can be developed on the base of a proposed index of potential loss of economic benefits (ε_b). The index ε_b can be calculated as following:

$$\varepsilon_b = (y_{\min} - y_c) \cdot p_m \tag{2}$$

where ε_b – potential loss of economic benefits [euro year^{-1}·cow^{-1}]; y_{min} – the needed (from view-point of AMS) annual milk yield per cow (7,465 kg·year^{-1}·cow^{-1}) [kg·year^{-1}·cow^{-1}]; y_c – current annual milk yield per cow [kg·year^{-1}·cow^{-1}]; p_m – price of milk [euro·kg^{-1}].

Of course, when $y_c \geq y_{min}$ it means that the potential loss of economic benefits doesn't appear.

The proposed potential loss of economic benefits was calculated for data covering value of the currently produced milk by one recorded cow per year (y_c) in Estonia, Latvia and Poland in 2011 (Table 4).

Table 4. Potential loss of economic benefits (εb) per one cow in three European countries including annual milk yield per recorded cow (yc) and price of milk (pm) in 2011

Country	y_c [kg·year^{-1}·cow^{-1}]	p_m [euro·100 kg^{-1}]	ε_b [euro year^{-1}·cow^{-1}]
Estonia	7756	32.0	0.0
Latvia	6128	29.7	397.1
Poland	7135	28.3	93.4

Source: own calculations on the base of www.icar.org and DG-AGRI – Milk Market Situation, Brussels, 15 December 2011

The results (Table 4) show some differences between potential loss of economic benefits per one cow in three European countries. The hypothetical loss of economic benefits found on the farms should be investigated with respect to the size of dairy cow herd. When the unit losses (per cow) are higher it means that higher total losses on the farm are generated.

The problem of lost economic benefits concerns not only automatic milking systems but also other milking installations, especially when seasonality of milk production is observed (Gaworski & Dumas, 2012). So it is important to recognise in detail the large number of factors deciding the economics of milking robot applications

(Cooper & Parsons, 1999) to create favourable conditions of AMS effective use and implement progress in dairy production (Gaworski, 2006). Such favourable conditions of AMS effective use can be observed in the countries of high annual milk yield per cow. In practice, this thesis is confirmed by comparison of AMS implementation dynamic in the investigated countries (Estonia, Latvia and Poland). The Estonian dairy farms, characterised by highest (against the background of Latvia and Poland) annual milk yield per cow are equipped with the highest number of automatic milking systems (2 AMS in 2006 vs. 136 AMS in 2012). For example, in Latvia 7 and 8 new automatic miliking systems were installed in 2008 and 2009, respectively.

The presented data shows some differences between the countries in the field of modern milking solutions implementation. But the current experiences resulting from AMS use should constitue valuable inspiration for further development of automatic milking system ideas among the dairy farms. The mentioned development is possible to recognise in many European farms equipped with AMS, where milk production amounted to 800,000–850,000 litres per one-stall AMS per year is indicated, e.g. in Denmark. Such results of dairy production are confirmed by many Estonian farms, where AMS annual milk capacity amounts to about 600,000–870,000 litres per one-stall AMS.

CONCLUSIONS

Implementation of dairy farms with modern technical equipment for milking needs simultaneous improvement of dairy cow herds and other factors expressing biological progress.

The carried out analyses showed the important role of proper data included for comparison, especially when we talk about annual milk yield per cow.

The included indices in the analyses show a general approach to the important problem of effectiveness of technical milking systems use. At the same time, the indices can be one of the propositions to conduct deeper analyses concerning factors affecting development and assessment of milking systems and their technical potential against a background of biological potential of dairy cow herds.

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