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WHEN TO SELL THE COW?

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ABSTRACT
In Hungary hundreds of thousands of cows produce milk for us. A common disease of them is mastitis that influences their productivity and profitability substantially. The usual practice is to decide on a rule of thumb basis whether the ill cow should be kept or sold. E.g. they are kept till the fifth mastitis case occurs. The present study investigates this problem from a mathematical modelling point of view. The relative amount of the possible lost profit is in the order of magnitude of 10s of percentages, which is quite large, especially regarding the profitability outlooks of the dairy branch.
The problem lies in the personal relationship of the farmers to the cows, and in the complexity of the estimation of the uncertain future scenarios. We present a model that is based on collected historical data on the distribution of several model parameters such as the length of the illness, the amount of medicine needed, the number of inseminations required to get into the next lactation cycle etc. The applied methodology is microsimulation (i.e. we simulate all possible events one-by-one) and stochastic optimization. Our typical result is a suggested decision on the basis of the expected value of the profit/loss for the given animal.
We report on the first results that confirm our research expectations in terms of improvement of the business decision. The ongoing research will focus on a recommendation system type data mining technology that can utilize the local specialties of the actual dairy farm in question, and to validate the additional advantage involved in it.

Keywords: milk production, mastitis, profitability, stochastic optimization, microsimulation

INTRODUCTION

Milk production is a sensitive branch of economy, being on the limit of profitability. To compete in a global economy, with anticipated milk price volatility, production systems need to be efficient regardless of the level of scale (DILLON ET AL., 2008). Several studies show that as milk price drops in a volatile milk price environment the benefits associated with cost control increase (MARCH ET AL., 2017). In the present study we investigate the possibility of effective economic modelling of an important decision: when to sell the cow after a diagnosed new mastitis illness. The folklore rule of thumb is to sell the cow when it is in a very bad shape. According to the RUSSEL AND BEWLEY's (2013) survey in which 229 producers in Kentucky State were asked the producers with large herds (≥200 cows) relied more heavily on information from consultants, nutritionists, veterinarians, and on employee input than did producers with small herds (1 to 49 cows). Based on our experiences in microsimulation (BLÁZSIK AND CSENDES, 2010, ALMÁSI AND PALATINUS, 2010), we have elaborated a simple but hopefully detailed enough model of the decision situation.
As we understand the present situation, if a cow gets ill with mastitis, then the most probable action is to treat it accordingly with proper medicine, and keep the animal – if it is not in a very bad shape. We expect that by careful investigation of the probable future life of that cow we can estimate the probable profit to be achieved by keeping or selling the animal.
We are in an early phase of the planned research, first we wanted to prove the concept

based on realistic data, and show its limitations. Later we plan to extend the system to a data mining and recommendation system based sophisticated method. We shall also complete our model to incorporate the related connecting economic subsystems such as the animal food production and milk processing.

MATERIAL AND METHOD

Material. To collect the data for our study, we have visited dairy farms and used other open sources. We have built a simple but hopefully detailed enough model that is capable to provide the most important factors that influence the economic model. We think the following assumptions are realistic. The settings were meant just for the present investigations, and are subject to be fitted to the actual historic data of the dairy farm where the model will be used to support the decision on the ill cow. Although the milk production of a cow follows a specific curve, the dairy cycle curve, according to our computational tests, to optimise the purchasing decision, we can assume that the milk production is constant within the dairy cycle. At the same time we are also aware of the marginal economic weight of conception rate of cows and longevity, somatic cell counts and mastitis incidence proved to be dependent on the milk yield (FEKETE ET AL., 2012).

We assume that the actual mastitis requires 5 days of healing with a probability of 70%, and 10 days with probability 30%. An additional interval of 15 days is needed to first profit from the milk production. To get ill, we have a daily probability of just 0.05% if it will be the first mastitis of the given cow, 0.1% for the second, 0.2% for the third, and 0.4% probability for all the later illnesses. We have determined these probabilities to fit the measured average number of ill cows around 15 out of 1000 on a farm.

The daily profit of a cow producing milk is composed of 1500 HUF revenues for the milk, minus 1000 HUF for the keeping costs. That gives 500 HUF per day. If a cow is in dry period, that means 0 revenue for the milk, and 700 HUF for the keeping, i.e. 700 HUF loss for each such days. The medicine against mastitis costs around 200 HUF per day. The average lactation cycle length is 305 days, then a rest of 115 days is assumed.

The selling price of a cow is estimated by a simple expression in our model (in thousands of HUF): 400 - 25 times the age of the cow in years - 37.5 times the number of illnesses suffered. We understand that in reality, the selling price is better decided on the classification of in how bad shape the cow is, and also based on its weight.

With these assumed data a cow producing milk for a month gives 15 thousand HUF profit, while the loss for a dry cow is 20 tHUF per month, and a new illness causes 27 tHUF direct loss, plus 38 tHUF loss in the selling price. In this way, an optimal 420 cycle provides a profit of 57 tHUF.

We underline that these data and model settings are not fixed, they serve just for the present study, and are subject to be fitted to the historical data of the given dairy farm in real life situation. We expect more additional profit due to our decision support method once the specialities of the given case are accounted for.

Method. With our microsimulation model we investigate the possible best way to decide when to sell the ill cow. The basis of our technique is to simulate the life of a cow on daily basis. In other words, we start with a cow of a given age, number of already suffered mastitis illness, and in a given phase of the dairy cycle. For each day we draw a pseudo random number to decide whether we consider the animal ill. Once having mastitis, we start with a cure. The length of the cure is also decided randomly, following the simple model we gave in the materials subsection. After a proper dry period, the milk production will resume. The cycle of that cow ends by its selling. The date of the purchase is

determined by our simple rule of thumb: we sell the cow if it reaches either the 6th mastitis, or its 10th year of living. The selling price is calculated by the formula given in before: 400 – 25 times the age in years – 37.5 times the number of illnesses.
Having a model for the financial description for a cow, we simulate 100 times the possible outcome to have an approximate stochastic description of the distribution function of the profit. Then we can determine an optimal decision on the expected achievable profit. This microsimulation approach is similar to that used to investigate whether a time based ticket system is better than the existing trip based on in public transportation in Szeged (BLÁZSIK AND CSENDES, 2010, ALMÁSI AND PALATINUS, 2010). The coding was made in Java language, and the simulation programs were run on a blade server.

RESULTS

The distribution of the cumulated profit is depicted on *Figure 1.* We started with a three years old cow entering the first illness in the 161th day of the dairy cycle. The 100 independent simulations provide a stochastic description of the possibilities. On *Figure 1* we can see the least and the most profitable cases together with the average and two more quartile curves. The increasing segments indicate milk production, the decreasing segments illness or resting phases. Also, the repeated cures can be noticed.

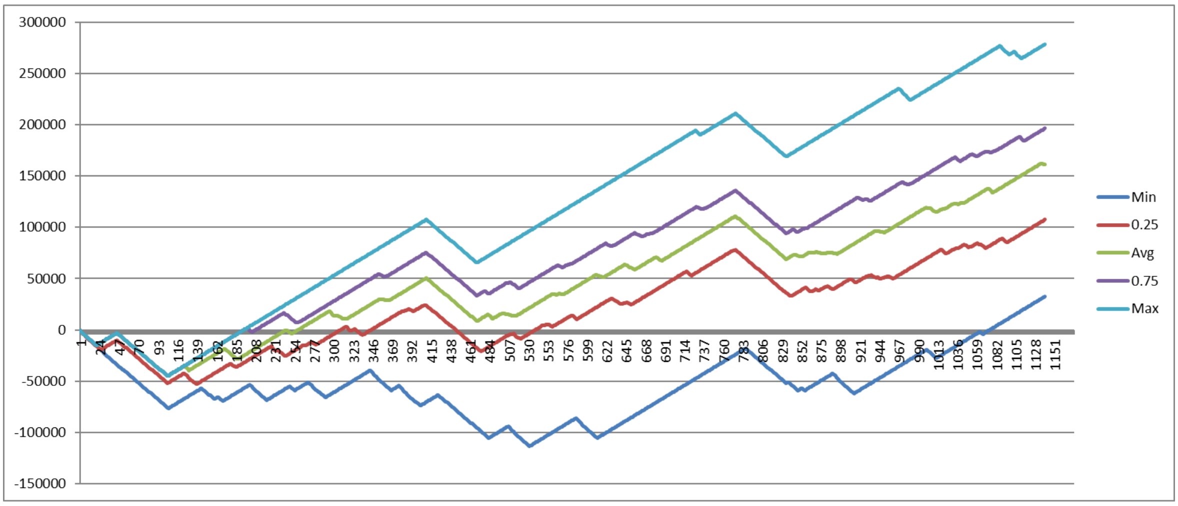

Figure 1. Cumulated profit of a cow in HUF according to the days spent in the farm. The minimal, maximal, average and 2 further quartiles curves of the distribution are depicted. These results were obtained based on 100 independent simulations of the probabilistic events in the model.

Table 1. The expected profit in HUF as the function of the age of the cow, the day of the dairy cycle in which mastitis is detected, and whether the decision is to sell or hold.

Age	3 years		4 years		5 years	
day of the cycle	sell in HUF	hold in HUF	sell in HUF	hold in HUF	sell in HUF	hold in HUF
150.	225,000	244,045	212,500	243,320	200,000	211,730
250.	225,000	219,090	212,500	223,955	200,000	178,665
270.	225,000	236,275	212,500	189,765	200,000	195,025
300.	225,000	212,510	212,500	190,380	200,000	185,515

As a next test, we analysed how the dairy cycle phase and the age of the cow influence the difference between the rule of thumb and microsimulation based decisions. *Table 1* summarizes the results. The green colour indicates cases when it is better to hold the cow for further production, and red signs cases when it is better to sell her right now. Note that here the rule of thumb was to sell when the 4th disease or the 6th year was reached.

Table 2. The expected profit as the function of the serial number of the illness and the age of the cow, and whether the decision is to sell or hold.

illness	3 years, in HUF		4 years, in HUF		5 years, in HUF		6 years, in HUF	
1	287,500	594,540	262,500	517,660	237,500	421,115	212,500	381,645
2	250,000	515,710	225,000	443,640	200,000	352,835	175,000	330,700
3	212,500	392,740	187,500	359,130	162,500	269,240	137,500	250,245
4	175,000	246,885	150,000	191,855	125,000	148,265	100,000	129,375
5	137,500	72,250	112,500	45,350	87,500	18,800	62,500	-3,005

Another aspect was studied in *Table 2* for cows in the 261th day of the dairy cycle. With based on fixed dairy cycle phase, and the rule of thumb to sell the ill cow when it is either the sixth time ill, or it is already 10 years old, we can register profit differences on the magnitude of 60-70,000 HUF.

The simple program that is capable to solve such problems with straightforward input data is available for smart phones and tablets (having Android 6.0 or newer operating systems) at

www.inf.u-szeged.hu/~banhelyi/Buu

We shall update it regularly, and we also plan to implement the application in such a way that also earlier versions of Android should run it.

CONCLUSIONS

We report the first results obtained by our microsimulation model that confirm our research expectations in terms of improvement of the business decision. On realistic data and setting, the suggested new methodology can achieve 60,000 to 70,000 HUF more profit per cow – compared to folklore rule of thumb decisions. The ongoing research will focus on a recommendation system type data mining technology that can utilize the local specialties of the actual dairy farm in question, and to validate the additional advantage involved in it. The future research will also consider the stochastic optimization (CSENDES ET AL., 2008) of the rule of thumb parameters.

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