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Economic evaluation of cow-calf herds.
I. Calculation methods*

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Methodology for a comprehensive evaluation of production and economic variables for suckler herd production in Slovakia were developed using herd records from 2008 through 2012. Major characteristics of the production system were considered. Among other conclusions, the number of weaned calves as the only product of the system depended mostly on cow fertility and affected both revenues and costs. Herds were characterized by low labour requirements and capital investments. Feed costs were an important component in the calculation formula. Strict adherence to traditional seasonal winter calving (mainly in January-March) was critical for the investigated cow-calf system, because it facilitates effective grazing management and thus reduces costs of feed for cows and calves during the spring season. To rationally model the suckler cow production system and to properly allocate revenues and costs, the accounting period should be based on the production year (October-September). At no time over the period under investigation was the average herd profitable, even when direct subsidies were included in annual revenues. The most favourable economic outcome across years (-208 € per cow per year in 2008) was achieved primarily thanks to lower costs per feeding day (-48%) and higher average daily gain of calves till weaning (+18%) than in the other years.

KEY WORDS: economics / production / methodology / suckler herds

Beef cattle production is an important sector in agriculture, particularly in countries with substantial forage resources [Wolfová *et al*. 2004, Krupa *et al*. 2005, Doucha *et al.* 2012]. A specific challenge for cow-calf production systems is to efficiently meet

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the nutritional requirements of all categories of animals in the herd over the course of the production year [Daňo *et al*. 2001]. Producers should take into account the complexity of the beef-cattle operation and understand how individual components interact to ultimately affect farm profits [Miller *et al*. 2001]. Moreover, cow-calf farming is often a low-cost system, and the economic objective frequently is not to maximize production, but rather to optimize it under specific conditions [Lowman 1985, Taylor and Field 1995, Gajos and Dymnicki 2012, Krupová *et al*. 2014]. The review of literature revealed no formal studies concerning methods to calculate profit per cow per year (economic effectiveness) and to evaluate its main determinants in Slovak cow-calf herds.

Therefore, the aim of this study was to identify important production and economic variables in suckler herds and to develop an original and accurate methodology to comprehensively evaluate system profitability.

Material and methods

Data description

To evaluate the methodology for calculation of profit per cow per year (economic efficiency) in cow-calf herds in Slovakia, the main production and economic variables were first defined. Data from farmers and performance testing data from analysed herds (farms) published by the Breeding Services of the Slovak Republic [BS SK 2014] for the years 2008 to 2012 were used as input.

Commercial purebred and crossbred herds representing all most popular breeds in cow-calf production (Slovak Spotted, Slovak Pinzgau, Hereford, Limousine, Charolais, Blonde d'Aquitaine) and their commercial crosses farmed in the mountains and foothill regions of Slovakia were randomly sampled for analysis. Then the proportions of the target population by area were compared to the census report data to ensure that the distribution of herds in the sampling frame was representative, which this appeared to be the case. Analysed farms applied natural mating and traditional Central European pasture management practices, with winter calving and autumn weaning. Herds maintained a seasonal winter calving pattern and were on pasture from May 1 to October 30, with indoor feeding over the remainder of the year. Descriptive statistics of farm variables across years are shown in Table 1. Some cows remained in the herd in spite of failure to gestate. Culling rate was generally low (14-17%). Cows left the herd at an average age of 7 years. Average production of the sampled herds (Tab. 1) influenced the overall output, which lagged behind breeding standards for beef and dual purpose breeds (e.g. 90-95% for fertility coefficient and 365 days for calving interval). Moreover, in context of the basic statistics of evaluated variables it should be stated that the relatively high standard deviation in the variables may be influenced by the large variety of breed types and the diversity of production conditions for the herds.

Detailed analyses of the main production and economic variables of the herds are presented in an accompanying paper [Michaličková *et al*. 2015].

Table 1 Means and standard deviations (SD) of basic production variables of cow-calf herds in 2008-2012

Variable[1] (unit)		Year 2008 (n^2=5)	2009 (n=5)	2010 (n=5)	2011 (n=7)	2012 (n=7)	Total (n=29)
Number of cows in herd	mean	82	99	100	72	78	86
	SD	54	54	61	55	80	13
Fertility coefficient[3] (%)	mean	78	79	75	78	78	78
	SD	7	8	21	16	1	2
Death loss of cows (%)	mean	1.2	1	2.6	3.9	10.1	3.8
	SD	2.03	0.9	1.7	4.9	3	3.7
Death loss of calves till weaning (%)	mean	3.2	4.3	7.1	7.1	11	6.5
	SD	3.1	6.5	8.5	4.1	13	3
Calving interval (day)	mean	438	440	418	421	436	431
	SD	196	243	230	207	30	10
Age at first calving (day)	mean	1138	1048	1051	1015	955	1041
	SD	509	577	578	503	120	66
Number of calving per cow lifetime	mean	3.2	3.4	3.6	2.7	2.7	3.1
	SD	1.4	1.9	1.8	1.4	0.6	0.4
Sold calves coefficient[4] (%)	mean	60	55	63	53	52	57
	SD	5	13	18	24	21	16

Source: BS SK [2014], the authors' calculations of data from evaluated farms.
n – the number of individuals.
[1]Values are expressed as means and standard deviations.
[2]Number of herds evaluated.
[3]Percentage of calves born alive.
[4]Percentage of calves sold.

Economic evaluation

Profit of the cow-calf operation (P) expressed on the per cow per year basis was calculated as the difference between total revenue (TR) and total costs (TC) using the standard formula:

$$P = TR - TC \tag{1}$$

To calculate the total annual revenue (TR) per cow, the following variables were taken into account:

$$TR = W \times R_{calf} P_s + R_{cow} + S \tag{2}$$

where:

W – live weight of calf at sale (kg);

R_{calf} – revenue per kg of sold calf (€ per kg);

P_s – the proportion of calves sold per cow per year;

R_{cow} – revenue from culled cows per year (expressed as culling rate per 100 cows multiplied by revenue per one culled cow);

S – subsidies per livestock unit (€ per cow and per year).

Total costs (TC) expressed per cow per year were calculated as follows:

$$TC = C_{cow} + (LBC + A \times C_{calf}) \times P_s \times (1 + M_{calf} / 100) \tag{3}$$

where:

C_{cow} – total costs per cow (€ per year);

LBC – the value of a live born calf (€) explained below;

A – age at the time of sale of the calf (days);

C_{calf} – costs per feeding day per calf based on accounting (€);

P_s – the proportion of calves sold per cow and per year;

M_{calf} – mortality rate of calves from birth to weaning (%).

The methodology for calculating total revenues and total costs in cow-calf herds, partially outlined by Daňo *et al*. [2001], was applied here with some modifications. The first difference is in the calculation of revenue and costs. In this analysis, calf age at time of sale was highly variable, ranging from160 to 240 days of age. Therefore, we "standardised" this variable to 180 of days of age when calculating revenue and costs. Moreover, to more objectively define revenue and costs connected to calves, the proportion of calves sold per cow (P_s) and calf mortality rate (M_{calf}) were also considered.

The next modification of the methodology proposed by Daňo *et al*. [2001] was to account for the by-product value (manure and live born calf, in this study). In this case, principles of the countdown calculation method were applied in computing costs per cow (C_{cow}), i. e. costs per feeding day of cow were calculated when the by-product value was eliminated from the total costs. The price of manure was based on the average market price of nutrients contained in manure [3.65 € per t of manure; Krupová *et al*. 2012, Michaličková *et al*. 2014]. Appreciation of live born calves as the second by-product of the cow herd was estimated on the basis of the energy consumption (i.e. 60% total feed costs) needed for fetal growth in the last five months (152 days) of pregnancy [Burian 1981]. The average birth weight of 35 kg per calf and an average price of 1.66 € per kg of live weight were used in the present methodology. Similarly, the countdown calculation method was applied when quantifying the costs per sold calf (C_{calf}), with manure as the only by-product in this category.

The UNIVARIATE procedures as implemented in the SAS® statistical package [SAS Institute Inc., 2009] were used to compute descriptive statistics.

Results and discussion

Calculation methods

The primary objective of the present study was to estimate annual cow costs and revenues in suckler herds, properly taking into account variation among herds in biological traits such as fertility, culling rate of cows and calf mortality till weaning and thus to evaluate the economics of the system more comprehensively. Basic assumptions of the methodology were outlined in the Materials and methods section. Therefore, only some aspects will be highlighted in the following text.

When evaluating production variables and subsequently economic impacts in cow-calf herds, seasonal variation within a production year should be considered, similarly as it was also concluded by Bilik *et al*. [2009] and Andric *et al*. [2011] from the economic evaluation of cow-calf herds in European countries. In Slovakia the traditional production year covers October 1 to September 30 [BS SK 2014]. However, in order to accommodate accounting schedules of farms, major production and economic variables are generally recorded from January 1 to December 31. In consequence, all of the production and economic data presented in this paper are relevant to the calendar year time interval. In the cases, when revenues and costs are available for the production year, they were applied in our computations.

In regard to revenue from government subsidy payments, only direct payments per livestock unit were considered in the present study, as data on single area payments for agricultural land and additional EU financial support for less favoured areas within farms were not available. Due to payment regulations, subsidies provided to Slovakian cow-calf farms are not based upon animal performance or levels of economic input of the farm. However, when economic efficiency of the total farm is being evaluated, subsidies paid per unit of land area should be accounted to compensate the lower yield and/or higher costs for feed used in animal nutrition [Doucha *et al*. 2012]. This finding may be applicable in Slovakian cow-calf systems, in which semi-extensive and extensive farming methods are used for multipurpose cattle breeds. However, agricultural cooperatives used a wide range of production activities (dairy, beef, sheep, crop production etc.) within an individual farm to diversify business risk. For that reason, direct allocation of agricultural payments to individual animal categories is sometimes problematic. In the present case, subsidies paid per livestock unit may be considered only for the quantification and interpretation of economic results in cow-calf herds. Additionally, it can be said that our approach is useful when the direct impact of production and economic variables on profits in the cow-calf system is evaluated. With some modifications, our methodology may be applied to other cow-calf production systems.

Revenue gained from cows sold from the herd could be excluded from the calculation, for example, due to its variability in cow-calf herds and its low share in total revenue. Looking at the structure of revenue in cow-calf herds in our study (Fig. 1), the proportion of revenue from sale of culled cows (14%) was influenced mainly by the low culling rate (14-17%) and low market price (0.89 € per kg of live weight). As another example, revenue and costs associated with young breeding animals could be incorporated into the formulas when heifers and bulls are sold outside the herd (which was not the case in the current study).

Some specifics of cost structure

As shown in Figure 2, labour accounted for only 5% and property depreciation – only 3% of total costs for the analysed herds, in agreement with the reports by Daňo *et al*. [2001] and Gajos and Dymnicki [2012] that cow-calf farming systems

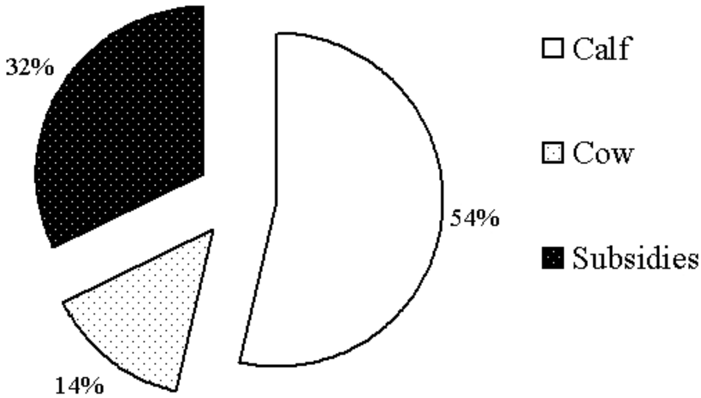

Fig. 1. Average structure of revenue in cow-calf herds in 2008-2012.

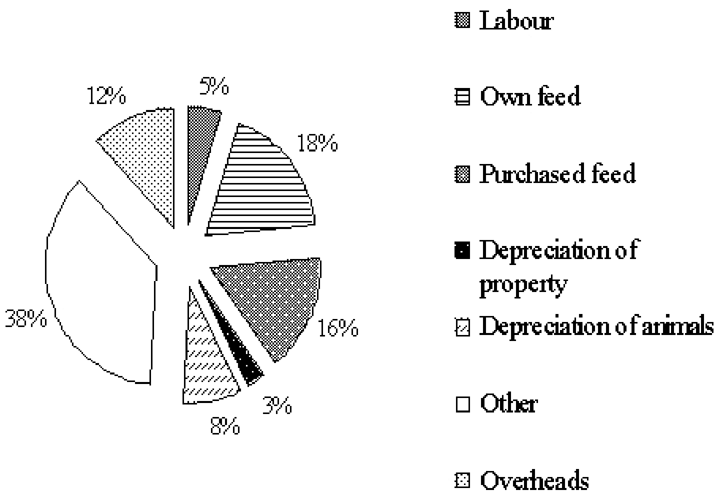

Fig. 2. Average structure of costs in cow-calf herds in 2008-2012.

had low labour requirements and capital investment. Important cost components in our calculation formula included: other direct primary external services and social costs (e.g. payments from wage); other direct secondary costs such as operation of tractors, own harvesting machines for fodder crops, transport and repair work in workshops; repairs and services, material costs), which together accounted for 38% of the total costs in cow-calf herds. The second most important cost component, representing 34% of total costs, was feed. Compared to milking herds, herds raised for meat production have a higher proportion of feed produced on the farm and a lower proportion of purchased feed. In the presented case, however, lower feed costs due to the grazing system played a main role, because the unit price of pasture did not exceed 1 € per tonne on most of the analysed farms. Based upon reports of Miller *et al*. [2001] and Cabral *et al*. [2014], however, it is possible to decrease feed costs using forage programs, in which cows graze for more days per year and the harvested forage is fed for a shorter duration.

Most of the components in the total cost were considered as direct (labour, feed, depreciation of property and of animals, other material costs, external repairs and services, other direct primary (external services) and direct secondary costs (on-farm services). Only overhead costs for management of the farm were considered as indirect. A similar structure was defined for cost of calves till 180 days of age (excluding only the costs for depreciation of animals), based on the accounting practices of the evaluated farms. This could account for the relatively higher cost in the calf category, compared to that of cows (given in Tab. 2).

Economic results

Total costs, total revenue and annual profit per cow, calculated for the 2008-2012 period, are presented in Table 2. An average enterprise was not profitable in any year of the analysed time period, which is in agreement with findings of Daňo *et al*. [2001] and Doucha *et al*. [2012]. This is partially attributable to the economic depression of the global economy, which started in 2008 and had an important influence on the cattle sector. International demand for dairy products declined in late 2008, which had a dramatic impact on milk product prices during the first half of 2009 [Doucha *et al*. 2012]. Some dairy farmers in Slovakia reacted by shifting to the cow-calf beef

Table 2 Means and standard deviations (SD) of basic economic variables of cow-calf herds in 2008-2012

Variable[1,2] (in € per cow per year)		Year 2008 (n[3]=5)	2009 (n=5)	2010 (n=5)	2011 (n=7)	2012 (n=7)	Total (n=29)
Revenue from calf[4]	mean	324.65	234.79	228.39	202.7	239.17	245.93
	SD	58.35	87.93	113.31	94.41	100.96	46.21
Revenue from culled cows	mean	68.94	67.52	66.5	51.26	73.89	65.62
	SD	9.94	11.81	29.74	29.37	23.66	8.51
Subsidies per livestock unit (LU)[5]	mean	167.09	177.6	171.6	180	42.96	147.85
Costs per cow	mean	711.75	766.5	886.95	1065.8	1324.95	951.19
	SD	116.8	193.45	350.4	529.25	737.3	249.19
Costs per calf[4]	mean	57.11	60.33	87.73	129.08	96.65	86.18
	SD	10.49	28.10	27.28	94.79	38.44	29.43
Profit[6]	mean	-208.19	-346.931	-508.193	-760.92	-1065.58	-577.96
	SD	83.78	48.34	41.99	569	785.88	341.4

Source: Krupová *et al*. [2014], MA SR [2014], the authors' calculations of data from evaluated farms.
[1]Values are expressed as means and standard deviations. The average exchange rate of 30.126 Slovak Crowns per € was used in 2008 (Law No. 659/2007 on the introduction of the euro in Slovakia).
[2]For detailed description of variables and methodology of calculation see section Materials and methods.
[3]Number of evaluated herds.
[4]Calf sold at 180 days of age.
[5]Calf to 6 months of age = 0.2 LU; suckler cow = 1 LU.
[6]Including subsidies.

production system [Krupová *et al*. 2014], as portrayed for years 2008 through 2012 in Figure 3. The number of dairy cows in Slovakia declined from 170,000 in 2008 to 151,000 in 2012 (-11%). Although the number of suckler cows increased by 23% during the evaluated period (from the total number of 41,000 to 51,000 animals), the number of suckler cows per herd fluctuated between 87 and 135 cows in the evaluated period. This transformation was influenced by the fact that cow-calf systems seemed to be well prepared for economic sustainability particularly in marginal regions [Daňo *et al*. 2001, Krupová *et al*. 2014]. However, in the newly emerging cow-calf herds, breed composition was not always well adapted to extensive and semi-extensive conditions, leading to lower fertility, longer calving interval and poorer economic outcomes. Therefore, achieving sustainable economic returns of cattle farms in mountainous and foothill areas became more dependent on subsidies paid as less favoured area payments (LFA) and single area payments (SAPS). An overview of the support and values of national direct and EU supports paid in Slovakia in that period may be found in Krupová *et al.* [2014].

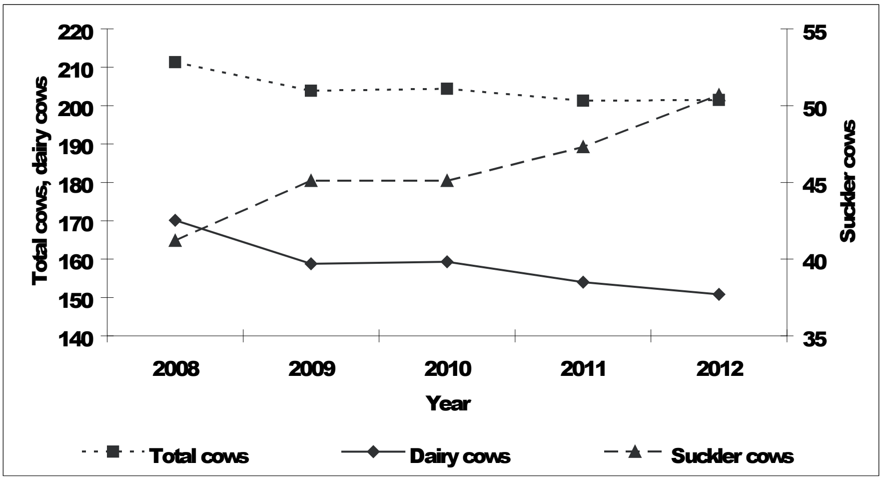

Fig. 3. Cattle population in Slovakia for 2008-2012 (in thousands of animals). Source: BS SK [2014], RIAFE [2014].

The least unfavourable economic outcome of -208 € per cow per year was recorded for 2008, which had 48% lower costs per cow per year and 18% higher sale revenue from calves when compared to the rest of the analysed period (Tab. 1). When comparing absolute values of economic results in cow-calf systems in Slovakia and in the literature, differences in the adopted methodology and the time period being analysed should be taken into account. For example, Miller *et al.* [2001] reported very low negative financial (-32.07 €) and economic returns (-129.98 €) per cow per year for the average cow-calf enterprise in the United States. Compared to our results a low value for annual financial loss (230.89 € per cow per year) was also observed by Taylor and Field [1995]. In contrast, the much higher loss presented in our paper (an average of -577.96 € per cow per year) resulted mainly from differences in the cost definitions. In the study of Miller *et al*. [2001], costs included only the cash-flow, debt services and labour costs (financial variables) and charges for invested capital and value of family labour (economic variables). Differences between our report and those of Taylor and Field [1995] were due to a low cost per cow per year (370.40 €). Moreover, in both of the abovementioned papers, not all of the cost components were taken into account (e.g. material costs, repairs and services, other direct primary and secondary costs and overheads). On the other hand, similarities with our study were found in the manner, in which the two compared studies computed revenue. Income from sold calves and from culled cows and price per kg of live weight per sold calf were comparable with our methodology. A difference among the studies was that the weight of sold calf was 47% higher in Miller *et al.* [2001] and 33% higher in Taylor and Field [1995] than our result (175 kg of live weight).

The calculation methodology used in our study provides, for the first time for the Slovak situation, a comprehensive evaluation of biological (production variables) and economic aspects of the cow-calf system. This approach could be used, after necessary adjustments, for cow-calf systems having other technical and economic characteristics. Generally it may be stated that for cow-calf herds managed under conditions similar to those in our analyses, strict adherence to winter calving, implying a January and February calving season, may be recommended, as it would allow more effective utilisation of forage resources and thus cheaper farm-grown feed for cows and calves in the spring season. Furthermore, increasing age at weaning from six to eight months would generally have a positive impact on the utilisation of milk per live weight gain of calves. With respect to seasonality in suckler herds and the definition of the production year (from October to September), the calving interval should be shortened to increase turnover in one year. Harmonisation of these variables may minimise the disjunction between economic results per accounting period versus per production year and enable more rational analyses of revenues and costs.

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