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Economic evaluation of cow-calf herds. II. Analysis of the main determinants*

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Effects of basic production and economic variables on the economic outcome of cow-calf herds in Slovakia for the period 2008 to 2012 were quantified using a linear regression model. Total costs per cow per year, costs per calf sold and average daily gain of calf from birth to selling were identified as the major determinants (P<0.05) of variation in economic results among analysed herds. Annual profit per cow declined by 1.09 € and 0.80 €, respectively, per 1 € increase in the annual cost per cow and per sold calf, respectively. Among individual cost components, farm feed, depreciation of animals, other direct costs and overhead costs significantly impacted profits. A 1 g increase in average daily calf gain was associated with an increase in annual profit of 0.59 € per cow. This is related to the specific character of the cow-calf production system, in which economic outcomes are predominantly dependent upon calf production. Major determinants increasing profitability included higher weight of sold calves, lower costs per sold calf and lower costs of producing replacement heifers. Regular calculation and analysis of costs are necessary to maximise utilization of inputs and evaluate farm efficiency as objectively as possible.

KEY WORDS: economics / determinants / regression model / suckler herds

Economic success of a nation's cattle sector is in general determined by environmental and climatic conditions, marketing strategy, production variables,

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human labour participation and effective utilisation of inputs [Daňo et al. 2001, Miller *et al*. 2001, Látečková *et al.* 2009, Krupová *et al*. 2012, Wolfová *et al*. 2004].

Beef production in Slovakia decreased by 51% during the years 2008-2012, while the decline in EU27 was much smaller at 6% (Fig. 1). Annual per capita consumption of beef also decreased, again at a higher rate in Slovakia than in EU27. It averaged 4.2 kg per capita in Slovakia from 2008 to 2012 (Fig. 2). In 2012, the annual beef consumption in Slovakia averaged 3.6 kg per capita, which was only 24% of average consumption in the EU27 countries amounting to 15.3 kg per capita. Other authors confirmed decreased beef production and consumption in the same time interval [Andric *et al*. 2011, Salevid and Kumm 2012, Wang *et al*. 2013]. This reduction, in spite of an increased number of suckler cows, indicates decreased production per cow, which is contrary to the expectation that economic success of a cow-calf system is generally based on minimising inputs (costs) while maximising the value of calf produced per cow [Rogers *et al*. 1985, Daňo *et al*. 2001].

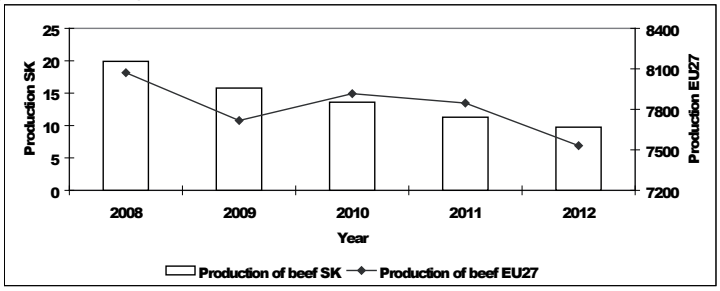

Fig. 1. Beef production in Slovakia (SK) and EU27 in 2008-2012 (thousand kg). Source: RIAFE [2014], SLOVSTAT [2014].

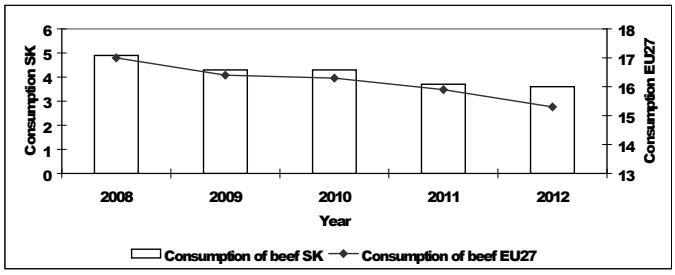

Fig. 2. Beef consumption in Slovakia (SK) and EU27 in 2008-2012 (kg per capita per year). Source: RIAFE [2014], SLOVSTAT [2014].

To develop strategies that increase economic sustainability of cow-calf farms, it is important to identify which variables influence the cow-calf system and how they affect profits. A review of literature review showed a very limited number of articles [Taylor and Field 1995, Lowman 1985, Daňo *et al*. 2001] particularly devoted to analysis of profitability in cow-calf farms.

The aim of the present study is to comprehensively define and analyse the main variables (determinants) of annual profit per cow in cow-calf farms in Slovakia.

Material and methods

Detailed analyses of the main variables determining annual profit per cow in cow-calf farms were carried out using data from a total of 29 cattle farms in Slovakia for the period 2008 to 2012. Each herd-year represented one observation, and farms supplying data for more than 1 year provided a distinct "observation" for each occurrence. Performance test data provided by the Breeding Services of the Slovak Republic [BS SK, 2014] also were accessed. A detailed description of the methodology and of the main production and economic variables of analysed suckler herds was given by Michaličková *et al*. [2015]. Differences between the current and previous report are that in this study revenue from sold calves was considered to be the only source of revenue, and revenue from culled cows and subsidies was not included in the total revenue calculations. This strategy was adopted in order to define the direct impact of changes in production and economic variables on profit in the analysed systems without impact from external subsidies. The main reasons were: 1) the subsidies provided to the Slovakian cow-calf farmers are not dependent on animal performance or level of economic inputs, and 2) the proportion of culled cows in the production system is typically small and has a low impact on the total farm revenue. Our methodology is in agreement with many principles (e.g. cost structures) described by Gajos and Dymnicki [2012].

Variables presented in this study were relevant for the time period from January 1 to December 31 of each year, which is in accordance with the business accounting period of the analysed farms. The average exchange rate of 30.126 Slovak Crowns per 1 € was used (Law No. 659/2007 on the introduction of the euro in Slovakia) for economic data in the year 2008.

Statistical analysis

The influence of the production level and cost variables on the annual economic output per cow was quantified by a multivariate linear regression model [Miller *et al.* 2001]. The forward selection procedure was applied to identify the optimal model for input dataset [Rogers *et al*. 1985, Miller *et al*. 2001].

The following regression equation was used to examine relationships between the variables and the economic productivity of suckler herds:

$$P_j = \beta_0 + \beta_1 x_{j1} + \beta_2 x_{j2} + \beta_3 x_{j3} + \beta_4 x_{j4} + \beta_5 x_{j5} + \beta_6 x_{j6} + \varepsilon_j \quad (1)$$

where:

P_j – the value of profit or loss (in € per cow per year) of j-th farm;

β_0 – the intercept;

β_1 to β_6 – regression coefficients for individual independent variables;

x_{j1} – costs per cow (€ per year);

x_{j2} – costs per sold calf (at 180 days of age in €);

x_{j3} – average daily gain of sold calves (from birth to selling in g);

x_{j4} – the fertility coefficient of cows (proportion of calves born alive per 100 cows per year);

x_{j5} – average calving interval (days);

x_{j6} – age at first calving (days);

ε_j – residual.

Characteristics of individual variables applied in the regression model (eq. 1) are shown in Table 1.

Relationships between individual cost components (variables) and the economic result per cow and per year were evaluated as follows:

$$C_j = \beta_0 + \beta_1 x_{j1} + \beta_2 x_{j2} + \beta_3 x_{j3} + \beta_4 x_{j4} + \beta_5 x_{j5} + \beta_6 x_{j6} + \beta_7 x_{j7} + \varepsilon_j \quad (2)$$

where:

C_j – the value of profit or loss (in € per cow per year) of j-th farm;

β_0 – intercept;

β_1 to β_7 – regression coefficients for individual independent variables (in € per cow per year);

x_{j1} – labour costs;

x_{j2} – farm feed costs;

x_{j3} – costs for purchased feed;

x_{j4} – depreciation of property;

x_{j5} – depreciation of animals;

x_{j6} – other direct costs i.e. material costs, repair and services, other direct primary (breeding and veterinary care, energy, social costs (payments from wage) and other external services) and secondary costs (own-account trucking and other own-account services);

x_{j7} – overheads i.e. indirect costs for managing and operating of the production process and in administration of the farm;

ε_j – residual.

Value of the cost component j is expressed as a cumulative variable as follows:

$$CC_j = C_{j_{cow}} + C_{j_{calf}} \times P_s \times (1 + M_{calf}/100) \quad (3)$$

where:

CC_j – cumulative value of the cost component j (in € per cow per year);

C_{jcow} – value of the total cost component j per cow (€ per year);

C_{jcalf} – value of the total cost component j per sold calf (at 180 day of age in €);

P_s – proportion of calves sold per cow per year;

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

Descriptive statistics for the cumulative values of individual cost components in the regression model are summarised in Table 2.

The UNIVARIATE and REG procedures in the statistical package SAS® [SAS Institute Inc., 2009] were applied for the descriptive statistics and regression analyses. The coefficient of determination (R^2) was calculated to indicate how the analysed data were fitted by the statistical model. The adjusted coefficient of determination (Adj R^2) was calculated to take into account penalizations for points that do not fit the linear regression models.

Results and discussion

Production and economic determinants

Impacts of the production and economic variables (determinants) on economic outcomes in the evaluated cow-calf herds over the period 2008 to 2012 are shown in Table 3. Variables included in the model accounted for 99.02% of the variation in profit among suckler herds. Annual costs per cow, costs per sold calf and average daily gain of sold calves (from birth to selling) were the three most significant determinants of economic outcomes ($P<0.05$). In contrast, the fertility coefficient, calving interval and age of cow at first calving had negligible impacts on annual profit per cow. This is in agreement with a study by Taylor and Field [1995], in which costs and weight of the final product (weaned calf) were identified as important variables affecting profitability in a cow-calf production system.

Negative impacts of costs, both per cow and per sold calf, and positive impacts of calf growth rate on profitability in our investigations are summarized in Table 3. The value of annual profits in the herds declined by 1.09 € as the annual cost per cow increased by 1 €. A similar situation was found for cost per sold calf. An increase of these costs by 1 € resulted in the 0.80 € decline in profits per cow per year. Miller *et al*. [2001] and Bruce *et al.* [1999] used a different methodology, in which costs attributable to cows were not included in the regression analysis. Miller *et al.* [2001], however, did provide a subsequent evaluation indicating that costs per cow are an important variable influencing profits in cow-calf herds.

In our study, an increase in average daily calf gain (from birth to selling) of 1 g per day was associated with increased profits by a statistically significant 0.59 € per cow per year. This relationship is consistent with the business model of cow-calf farming, in which the calf is the primary product, and revenues depend on the weight of sold calves [Lowman 1985, Taylor and Field 1995]. From this point of view it is encouraging that the average daily gain of calves increased (+13%) during the last three years of our evaluated period. Costs per feeding day and average daily gain of calves from birth to selling were also found to be important positive determinants

Table 1. Means and standard deviations (in parenthesis) of basic characteristics of production and economic variables in cow-calf herds used in the regression model

Variable (unit)[1]	Year					Total
	2008 (n[2]=5)	2009 (n=5)	2010 (n=5)	2011 (n=7)	2012 (n=7)	
Profit per cow per year[3] (€)	-435.61 (87.64)	-592.05 (141.16)	-746.29 (326.83)	-992.18 (560)	-1182.43 (786.46)	-789.71 (300.65)
Cost per cow per year (€)	711.75 (116.8)	766.5 (193.45)	886.95 (350.4)	1065.8 (529.25)	1324.95 (737.3)	951.19 (249.19)
Cost per sold calf[4] (€)	57.11 (10.49)	60.33 (28.10)	87.73 (27.28)	129.08 (94.79)	96.65 (38.44)	86.18 (29.43)
Average daily gain of calves[5] (g)	886 (87)	781 (120)	688 (151)	740 (172)	783 (67)	776 (73)
Fertility coefficient[6] (%)	78 (7)	79 (8)	75 (21)	78 (16)	78 (13)	78 (2)
Calving interval (days)	438 (196)	440 (243)	418 (230)	421 (207)	436 (30)	431 (10)
Age at first calving (days)	1138 (509)	1048 (577)	1051 (578)	1015 (503)	955 (120)	1041 (66)

Source: BS SK [2014], the authors' calculations of data from evaluated farms; n – the number of individuals.
[1]Values are expressed as means (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]Number of evaluated herds.
[3]Excluding subsidies and revenues from culled cows.
[4]180 days of age.
[5]From birth to selling.
[6]Proportion of calves born alive per 100 cows.

Table 2. Descriptive statistics for cumulative values of individual cost components used in the regression model

Variable (€ per cow and per year)[1]	Year					Row mean (n=29)
	2008 (n[2]=5)	2009 (n=5)	2010 (n=5)	2011 (n=7)	2012 (n=7)	
Labour costs	43.22 (20.78)	61.32 (56.63)	79.87 (42.77)	71.65 (22.35)	80.41 (50.80)	68.49 (40.32)
Farm feed	378.95 (76.95)	361.69 (106.45)	378.62 (176.24)	124.57 (76.45)	92.84 (46.17)	245.46 (163.86)
Purchased feed	40.29 (29.54)	34.23 (22.38)	21.63 (14.56)	403.81 (263.53)	431.78 (234.2)	218.27 (255.88)
Depreciation of property	50.98 (49.25)	59.15 (49.44)	37.31 (28.41)	4.83 (3.32)	19.5 (29.99)	35.22 (40.28)
Depreciation of animals	138.29 (58.02)	115.58 (56.24)	112.92 (96.77)	113.42 (159.07)	72.51 (50.39)	110.43 (83.64)
Other direct costs[3]	152.42 (60.65)	176.93 (103.29)	218.89 (129.49)	745.85 (362.54)	898.94 (413.96)	491.55 (422.46)
Overhead costs[4]	23.03 (19.09)	90.25 (61.96)	83.8 (44)	251.59 (197.04)	289.98 (309.71)	164.71 (203.23)

Source: the authors' calculations.
[1]Express cumulative value, per cow and per year, of the individual cost component of cows and of calves; values are expressed as means (standard deviation).
[2]Number of evaluated herds.
[3]Detailed description of the costs is given in Material and methods section.
[4]Indirect costs for managing and operating of the production process and in administration of the farm.

Table 3. Production and economic determinants of profit in cow-calf herds[1]

Variable (unit)	Parameter	Regression coefficient	p-value
Intercept	β_0	713.08	0.2208
Cost per cow and per year (€)	β_1	-1.09	<0.0001
Cost per sold calf (€)[2]	β_2	-0.8028	0.0487
Average daily gain of calves (g)[3]	β_3	0.5917	0.0233
Fertility coefficient[4] (%)	β_4	0.6311	0.7438
Calving interval (day)	β_5	-1.5174	0.1377
Age at first calving (day)	β_6	-0.2386	0.3216

[1]$R^2 = 0.990$, Adj $R^2 = 0.9853$ (definition of these parameters is given in Material and methods section).
[2]180 days of age.
[3]From birth to selling.
[4]Number of calves born alive per 100 cows.

for economic outcomes obtained in 2008 compared to the rest of analysed period, as reported by Michaličková *et al.* [2015] in our companion paper.

Although age at first calving did not significantly impact profits in analysed herds, it should be mentioned that its average value decreased (i. e. improved) by 16% over the five-year period examined. Surprisingly, the effect of the fertility coefficient on profits per cow per year was not statistically significant, in contrast to the results of Lowman [1985] and Daňo *et al.* [2001]. The difference in results may be due to differences in methodology, i.e. whether profit is expressed per cow per year as in this study or per sold calf as in the other investigations. Moreover, the relatively low number of calves born alive in analysed herds (see Tab. 1) negatively impacted economic results over the whole period. Low fertility coefficients of cows may be associated with the fact that some non-pregnant cows were retained and that culling rates were low (14 to 17%) in the analysed herds. This interpretation is consistent with the findings of Lowman *et al.* [1985].

Although the market price of weaned calves is an important determinant of profitability in studies of Bruce *et al*. [1999] and Hughes [1991], it was not taken into account in these regression analyses. This was based on the decision that impacts of direct production variables of the cattle herd along with utilization of inputs (rational spending of financial sources through an appropriate volume of inputs for a given production level) should be focused on in the analyses. Moreover, although farmers to a certain degree may control costs, they have a limited ability to influence market prices, determined primarily by international and national market forces and the interaction of supply and demand.

Cost components

Descriptive statistics of the cumulative values of individual cost components per cow per year over the period 2008-2012 used in the regression model (eq. 2) are

shown in Table 2. Regression coefficients of profits of the cow-calf operation on the cost components, along with their statistical significance, are presented in Table 4. Independent variables representing cumulative costs, that were included in the model, accounted for 93.42% of the variation in herd profits. The impact of expenditure on farm feed, depreciation of animals, other direct costs and overheads was statistically significant, all sharing a negative relationship to profits (Tab. 4). This is in agreement with the results of Miller *et al*. [2001] and Bruce *et al*. [1999], who reported that the largest effects were those associated with feed cost, not only for the annual profit per cow, but also for indicator „return to unpaid labour and management per cow". In our study, a 1 € increase in farm feed costs was associated with a 1.33 € decrease in profits per cow per year. The prominent importance of feed costs is probably determined by the high proportion that it contributes to total costs in a suckler-cow herd, as it was reported in our accompanying study [34%; Michaličková *et al*. 2015] and from 50% to 60% in other investigations [Lowman 1985, Rogers *et al*. 1985, Taylor and Field 1995, Miller *et al.* 2001].

Table 4. Detailed economic determinants (individual cost components) of profits in cow-calf herds[1]

Variable (€ per cow and per year)[2]	Parameter	Regression coefficient	p-value
Intercept	β_0	-469.72	0.0049
Labour	β_1	-1.7742	0.0677
Farm feed	β_2	-1.3259	0.0004
Purchased feed	β_3	-0.3431	0.1554
Depreciation of property	β_4	0.5717	0.4737
Depreciation of animals	β_5	-1.5386	0.0007
Other direct costs[3]	β_6	-0.7254	0.0003
Overheads	β_7	-2.1774	0.0037

[1]R^2 = 0.934, Adj R^2 = 0.896 (definition of these parameters is given in Material and methods section).
[2]Cumulative per cow and per year value of individual cost components of cows and calve.
[3]Detailed description of the costs is given in Material and methods section.

Depreciation of animals and other direct costs also significantly affected suckler herd profits (i. e. profit per cow per year). As depreciation of animals and as the other direct cost categories increased by 1 €, profits dropped by 1.54 € and 0.73 € per cow per year, respectively. (Tab. 4). This is in agreement with the findings reported by Miller *et al*. [2001], showing that other direct costs (expressed as operating costs) and depreciation were important economic determinants of profits per cow and year.

Overhead costs were also a statistically significant determinant of profits per cow per year. An increase in overhead of 1 € was associated with a decrease in profits of 2.18 € per cow per year (Tab. 4). The negative relation of overhead costs to the profit may be an outcome of accounting practices, in which allocation of indirect costs (overheads) is based primarily on the magnitude of direct costs. However, according

to our best knowledge, the allocation coefficient (for conversion of the number of feeding days to livestock unit of the individual animal category) should be taken into account when allocation of overheads costs is provided in the farm. In economic analyses of Miller *et al.* [2001] and Taylor and Field [1995], overhead costs were not taken into account. However, in Slovakia these costs represent at least 10% of direct costs of cow-calf farms, as reported in this study and in those of Daňo *et al*. [2001] and Krupová *et al*. [2012]. Moreover, from an accounting perspective, it is important to define overhead costs per production unit objective, i.e. excluding subsidies, as was the case in an investigation concerning dairy cattle [Michaličková *et al*. 2014].

Cow-calf farms in Slovakia frequently pursue economic success by minimising inputs and maximising the value of calf production. According to our analysis, annual costs per cow, average daily gain of calf (from birth to selling) and annual costs per calf sold are the main determinants of success for Slovakian cow-calf farms. To maintain economic solvency, their production levels should be improved and inputs should be utilized more efficiently. The main determinants influencing profitability were higher weight of sold calves, lower costs per sold calf and lower costs to produce replacement heifers. In addition, variation among herds in many of the cost components and production variables indicates that recommendations for improvement should be customised to circumstances of each individual farm. Moreover, collection of appropriate data and regular accounting of costs are necessary to identify sub-optimal utilisation of inputs and to evaluate the farm from an economic point of view. The methodology presented in this study facilitates proper accounting of biological (production traits) and economic variables on suckler farms. It could be used, after necessary adjustments, to evaluate determinants in other cow-calf production systems.

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