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ALGORITHM FOR CALCULATING SIZE AND NUMBER OF DAIRY CATTLE FOR EARNING SMALL FAMILY FARM´S LIVING IN CONDITIONS OF THE SLOVAK REPUBLIC

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Abstract

Slovakia's agricultural policy is based on the Common Agricultural Policy ("CAP"). One of the objectives of the CAP reform in the dairy sector is to contribute to increasing its competitiveness and market orientation, especially in view of the increasing demand for milk and dairy products in the world market. The reform of the SPP in the milk and dairy products sector has focused production on market requirements and the aid is not linked to production but is geared to meeting food safety, animal welfare and environmental requirements.

The aim of the submitted paper was to calculate the minimum size and the minimum number of dairy cattle needed to cover the consumer expenditures of the family farm farming in mountain production conditions in the Slovak Republic. As a small family farm, we defined a 4-member family - 2 adults and 2 children, based on the assumption that the family will not process milk but will sell it. We also assume that the family will not employ other workers. The calculations show that to cover household consumption expenditures, which was amounted to 18,607 Euros in 2015, the area of the meadows is 40.85 ha and the area of the pastures is 28.83 ha, which together represents 69.68 ha of agricultural land. Regarding the structure of cattle, the farm will record 10 dairy cows, 5 calves, 9.39 heifers, 0.44 heavily pregnant cows and 6.37 fattening cattle. If a farm will record higher farmland sizes and higher animal numbers, it will only have a positive economic impact on family management.

Keywords: *farm size, agricultural land, dairy production, costs*

JEL classification: *Q12*

1 Introduction

Entrepreneurship on the agricultural land belongs among the oldest economic sectors of every country. Slovakia and its countryside was for many centuries a typical agrarian country. Despite the areal industrialization after 1950 agriculture remained its characteristic feature. Evidential sector organization of agricultural production was created as a result of manufacturing expansion. It was caused by industrialization process. It caused largely one-side orientation of rural regions towards the agricultural activities. In the current era of globalization, especially after the accession to the EU, the position of agriculture is changing especially in the trend of EU CAP reforms (Horská, Nagyová & Felixová, 2010; Kleinová &Neománi, 2010).

Obviously, the evolution of agriculture has important impacts on individual farmers. The rising size of a farm necessary to provide a reasonable level of farm income forces those with smaller holdings to expand beyond a single family operation, seek off-farm employment or exit from the agricultural sector altogether and thus constitutes a direct link between farm structure (structural change) and individual producer welfare. (Weiss C. R., 1998)

Agricultural entrepreneurs are indeed facing many challenges. Many of these have been identified by the Common Agricultural Policy as economic in nature, such as food security and globalization, a declining rate of productivity growth, price volatility, pressures on production costs due to high input prices and the deteriorating position of farmers in the food supply chain. Other challenges are environmental in nature, relating to resource efficiency, soil and water quality, and threats to habitats and biodiversity. Others still are territorial, especially where rural areas are faced with demographic, economic and social developments, including depopulation and relocation of businesses (European Commission, 2013).

There is considerable debate regarding what type or scale of agriculture should be promoted in order to most effectively achieve these goals (Larson, Otsuka, Matsumoto & Kilic, 2014).

Nagayets (2005) used agricultural census data from FAO to estimate that there are about 525 million farms of all sizes in the world. Several other sources maintain that worldwide there are about 500 million farms smaller than 2 ha (see for example Hazell et al., 2010; Wiggins et al., 2010; IFAD, 2011 and HLPE, 2013), many of them refer to Nagayets (2005).

There are many authors who are calculating with size of farm and economical results. Some results show that there is a negative relationship between farm size and productivity and positive relationship between credits and productivity. These results were statistically significant in all models at coefficient estimation

using the method of least squares and the fixed effect model. According to the reached results by authors Ladvenicová and Miklovičová (2015) can say that for Slovak farmers it would be better to operate on smaller size of farm than they do. Many studies estimated that in agriculture there are constant returns to scale. In our case we can follow decreasing returns to scale – each hectare of land leads to the decrease of production. Positive effect can be follow in credits. Access to credits can depend on farm size. If the amount of credits depends on collateral, then larger farms may have easier access to credits. They can use more inputs and it causes that productivity will depend positively on farm size.

Many authors are solving problem relationships between farm size and sustainability. Large-scale dairy farms had a higher labor productivity and NFI than other dairy farms, without compromising on phosphorus surplus, energy use or ghg emission. Higher profits were accompanied by a lower solvency ratio on large-scale farms. Pesticides use, however, was higher on large-scale dairy farms due to a lower share of grassland. Large-scale farms had a shorter cow lifetime and applied less grazing compared to other dairy farms.(Meulen, Dolman, Jager & Venema, 2014).

In the USA larger farms are more likely to be profitable than small farms (those with GCFI of less than $350,000), reflecting economies of size in farming. Smaller farms in the critical zone typically do not earn enough from the sale of farm commodities and ancillary services to cover expenses: cash expenses exceed cash receipts for the 70 percent of the farms with GCFI below $100,000 that are in the critical zone. The share of farms in the critical zone is especially high for retirement, off-farm occupation, and low-sales small farms—which together account for 98 percent of farms with GCFI less than $100,000—but tapers off rapidly for larger farms. (Hoppe, 2014)

The aim of submitted paper is to determine the minimum size of agricultural land and number of dairy cows of a small family farm focused on dairy production in the economic and production conditions of the Slovak Republic. Under the term farm family, we mean family with 2 adults and 2 children. In the paper we analyze the dairy cow farm and its breeding (calves, heifers, cattle fattening - closed turnover of the herd). The paper deals with the possibilities of family farms in mountain areas, where less meadows and pastures are used.

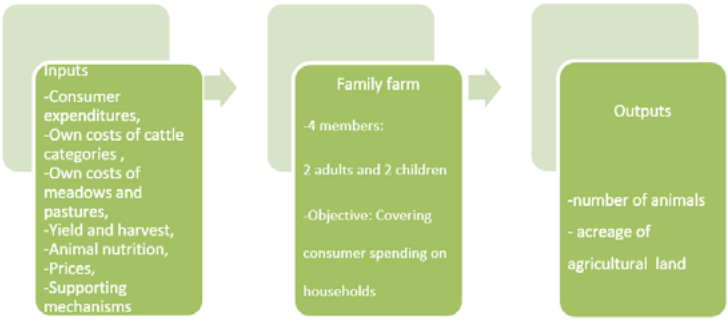
2 Data and Methods

For determination of the farm size value and the number of livestock in the cattle category of a small family farm, we can determine the following algorithm.

Each step of the algorithm must be unambiguously and precisely defined; in each situation, it must be fully clear what and how to do and how will the algorithm continue.

Algorithm usually works with some inputs, quantities that are available before or during the activity. Inputs have defined sets of values they can acquire. The algorithm has at least one output, quantity that is in the desired relation to the inputs, thus forming the answer to the problem that the algorithm solves. In general, we require that the algorithm has to be effective, in the sense that we require each operation required by the algorithm is simple enough to be at least in principle converted at the end time only by the use of pencil and paper. The algorithm does not solve one specific problem (e.g., "how to calculate 3 × 7"), but solves a general class of similar problems (e.g., "how to calculate the product of two integers").

Figure 1 **Scheme of Algorithm for Calculation of Acreage and Number of Animals**



Source: Own processing.

The algorithms for determining the size of a family farm focused on dairy farming of beef-cattle in the mountain production area in the economic and production conditions of the Slovak Republic were given the following inputs:

1. Annual consumer expenditures of the average four-member family,
2. Own costs of cattle categories,
3. Own costs of meadows and pastures,
4. Producers prices for milk and meat,
5. Support mechanisms in mountain areas in beef-cattle farming and in meadows and pastures,
6. The average annual yield of the different categories of livestock (beef-cattle),
7. Average annual yields of meadows and pastures,

8. Nutrient and Nuclear Feed Needs and Purchase of Other Mineral Ingredients, etc.

The outputs of the presented algorithm will be the following variables:
1. Acreage of meadows and pastures required for beef-cattle breeding,
2. The numbers of animals by individual accounting categories,

Mentioned cost calculations were drawn from the publication "Costs and Income of Agricultural Products in the Slovak Republic" by Research Institute of Agricultureand Food Economics. The publication contains the results of the selected set of agricultural holdings for the year 2015 in the breakdown by production area. The publication provides data on the actual costs of selected crop and animal products and other economic data to assess the efficiency of production.

3 Results and Discussion

Livestock production is the second most important sector of agricultural production. It is part of a closed farming system and an important co-founder of the environment. It plays an important role in the closed chain consisted of soil-plant-animal-soil. Animal products provide 48% of protein consumption in Slovakia and more than 40% of agricultural production revenues.

An important fact for the agricultural enterprise is fact that livestock sales are distributed and regular throughout the year. The importance of livestock production in enterprises operating in worse climatic conditions is increasing. This means that businesses in mountain and under-mountain conditions cannot manage without it.

In the European multifunctional farming, the beef-cattle breeding performs more important tasks. They can be simply defined as tasks of a productive and non-productive nature. The production mission of livestock is the production of the main commodities - milk and meat, which have a significant role in human nutrition and contribute significantly to the revenues of agricultural subjects (on average in the Slovak Republic these account for about one quarter of agricultural production revenues and more than half of livestock production revenues). In addition, milk production ensures a continuous supply of cash. Production of high quality livestock manure can also be included in production functions. The most important non-productive livestock functions are important contributions to maintaining the cultural landscape and the social function resulting from the existence of employment opportunities in this sector. (Brestenský, 2015)

Grazing as the cheapest and the most natural form of cattle nutrition has and always will have a special meaning. Different habitats, production, economic and other conditions determine the intensity of management and corresponding grazing systems. The primary aim of the grazing system is to adapt the quantity and quality of the grass to be delivered during the season to the needs of grazing animals.

Grazing of dairy cows positively affects their health. The feed of milk- cows uses the principle of ad libitum feeding. It is a feeding technique when animals can receive as much feeds as desired. The feeding is sufficient to cover milk production on 8-14 kg of milk per dairy cow per day. The causes of a decrease or increase in milk production depend on the vegetation stage of the skewed grassland.

This means that if the skewed grassland is over seasoned, milk production decreases. If the grassland is younger at the beginning of grass- blade creation, the milk production of milk- cows grows. This dependence is given by the concentration of energy in the grassland which gradually decreases with aging.

In the submitted calculations, the authors predict the average production of milk from grassland at the level of 10 kg per 1 feeding day, which represents 3,050 kg of milk per milk- cow. When reaching such a level of nutrition, we can regulate the feeding of concentrated feeding stuff depending on the overall performance of the dairy cows. Production feed mixtures are given to dairy cows for each kilogram of milked milk excessing the basic production from the bulk feed (grass and hay).

The amount of feed required for each kilogram of milked milk depends on the nutritive content in 1 kg of the compound feed. In our calculations is calculated that dairy cow produces 2 kg of milk from 1 kg of compound feed.

During life, the beef-cattle go through different stages of development, which is economically evaluated by calculating as direct costs spent on calculated output, which in the shortest term expresses - the production costs.

In beef-cattle breeding aimed at milk production, we measure the following calculation breeding categories:

- calves (from birth to 6 months),
- rearing of young cattle (heifers from 6 months to 7 months),
- heavily pregnant cow (in 8th and 9th month of gestation),
- cattle fattening (bulls from the age of 6 months to carcass maturity);
- cows (from 1st harvesting to disposal).

Herd turnover expresses quantitative relationships between categories and groups of livestock. The herd turnover is based on the number of born calves, the growth intensity and the breeding rate in the offspring. Therefore, detailed age categorization needs to be made, in line with biological change and housing options. From the herd turnover it is possible to determine the length of stay and the

number of animals in each breeding category. For the herd turnover calculation, it is also crucial to assume the reproductive and utility parameters of the animals. In our paper we assume that each dairy cows are fed once a year and half of the born calves will be heifers and the other half will be the bulls. From the herd turnover was calculated the expected status of breeding bulls and heifers in individual breeding categories. The calculation is based on the residence time of the animals in the given category and the number of animals assigned and eliminated.

Our calculations show that for one dairy cow is the structure of other breeding categories based on the following coefficients (Table 1):

Table 1 **Indicators of the Conversion of Other Accounting Categories per 1 Structured Dairy Cow**

Calves 0-6 months	0.50
Rearing of young heifers	0.94
Cattle fattening (bulls)	0.64
Heavily pregnant cows	0.04

Source: Own calculations.

The above coefficients indicate that in average on one cow is 0.50 calves at the age of 0-6 months, 0.94 heifers, 0.64 fattening bulls weighing 550 kg and 0.04 heavily pregnant cows (cows in the 8t^{h} and 9th months of pregnancy).

The herd turnover serves us to calculate the length of stay in feed days for each category, and on the basis of feed days, we calculate the feed balance. From the feed balance we calculate the required acreage of meadows and pastures in hectares for all categories of livestock.

The utility parameters of dairy cows and breeding categories were taken from the Research Institute of Agricultural and Food Economics from NAFC. The publication "Own costs and farm performance of agricultural holdings in the Slovak Republic" also shows growth increments by individual breeding categories per 1 feed day and yields of dairy cows for 1 year.

The following cost items have been included in the own cost of breeding:
- medication and disinfecting material,
- other direct material (consumption of cleaning and minor maintenance material for the maintenance of single-purpose buildings and structures for animal production and consumption of low – value tangible property),
- repairs and maintenance,
- depreciation of tangible investment property
- depreciation of animals,

- breeding and veterinary services,
- other direct materials and services (consumption of electricity and other energy in stables, consumption of other non-storable supplies such as water for animals and for technological purposes, costs of deratization and disinfection, other services related to a particular holding, e.g. rent for stables and other single-purpose machines and equipment, real estate tax, i.e. from stables and other structures used in individual holdings, other operating costs, insurance against damages in animal production, or interest, if they relate directly to a particular breed, etc.)
- costs of auxiliary activities (freight transport, tractors, coatings for the import of feed and animal bedding, manure removal and other intra-plant work for certain livestock breeding, which will be included in the aliquot amount in the individual costs of each breed.)

The paper aims at determining the minimum number of animals and the minimum size of agricultural land in hectares needed by small family farms to cover average consumer expenditure. As a small family farm in the described algorithm is a family with 4 members.

The algorithm is based on the assumption that besides the cows of a basic herd, we also have to calculate the following accounting categories of animals: calves 0-6 months, rearing of young heifers, bulls fattening and heavily pregnant cow. Another assumption in the calculations is the fact that in our paper, the proposed algorithm is applied in the mountainous production and economic conditions of the Slovak Republic. It means that from the above mentioned, the farm will have only meadows and pastures and no arable land. The compound feeds will have to be secured from the external sources and the meadows and pastures will be used for grazing respectively the hay production for the winter fodder season.

The algorithm for calculating the size and number of livestock is based on the average yield of dairy cows in mountain production conditions and on the price of milk per 1 liter according to NPPC. In addition, the production and reproduction indicators are included in the calculations for individual animal categories:

- Braking of dairy cows 25%, Elimination from breeding is referred as braking and is expressed in %. In case of 25% braking, the basic herd is changed every 4 years.
- Price of braking meat is 1.5 Euro per 1 kg of live mass.
- Average slaughter weight of braking dairy cows is 500 kg.
- % of natality 100%, i.e. we plan to breed one calf per dairy cow a year on the basis of the assumption that half of the born calves will be bulls and the second half will be heifers.

The fertility of meadows and pastures together with the costs were taken from NPPC as a mountain production area. The yield of meadows in green matter is 9.75 t.ha-1 and the yield of pastures is 6.91t.ha-1 in the production and economic conditions of the mountain regions of the Slovak Republic. For pastures, we plan to consume 55 kg of green matter per 1 feed day and 1 dairy cow during the summer period of 185 feed days. In the winter, we plan to feed the hay that we produce on the meadows where we plan with 11 kg of hay for 1 feed day and 1 cow. The grassland stockpile on trampled pastures is scheduled to be 30%. The loss of hay is 10%. Reserve of the whole food balance is 15%, which is recommended by Slovak researchers for the stability of the production of bulk feeding stuffs.

Table 2 **Indicators of Dairy Cows Breeding**

Indicator	unit	value
DAIRY COWS	pcs	10
UTILITY	l	5,370
PRICE FOR 1 LITER OF MILK	EUR	0.3
BORN CALVES	pcs	10
REVENUES FROM BRAKING	EUR	1,875
REVENUES FROM MILK	EUR	16,108
REVENUES FROM DAIRY COWS	EUR	17,983
REPRODUCTION OF CALVES IN PIECES		
BORN CALVES TOTAL	pcs	10
-of which heifers	pcs	5
-of witch bulls	pcs	5
THE YIELD OF MEADOWS IN GREEN MATTER	T	9.75
THE YIELD OF PASTURES IN GREEN MATTER	T	6.91
-CONSUMPTION IN GREEN MATTER PER FEED DAY	KG	55
PASTURES – AREA	HA	14.32
MEADOWS – AREA	HA	10.43
MILK PRODUCTION FROM 1KG OF COMPOUND FEED	LIT	2
MILK PRODUCTION FROM GRAIN FEED	LIT	2,319
REQUIREMENT FOR COMPOUND FEED FOR 1 DAIRY-COW PER YEAR	KG	1,159
PRICE FOR 1 KG OF COMPOUND FEED	EUR	0.27
OWN COSTS OF COMPOUND FEED FOR DAIRY COWS (ALL) PER YEAR	EUR	3,131
COSTS OF 1HA OF MEADOWS	EUR	96.33

Indicator	unit	value
COSTS OF 1HA OF PASTURES	EUR	63.29
LOSSES OF TRAMPLED PASTURES	%	30
AREA OF PASTURES + FEED STOCKPILE	%	15
AREA OF PASTURES + FEED STOCKPILE + HARVESTING LOSSES	HA	13.20
AREA OF PASTURES + FEED STOCKPILE +LOSSES OF TRAMPLED PASTURES	HA	21.41
OWN COSTS MEADOWS + PASTURES + COMPOUND FEED	EUR	5,758
DIFFERENCE = REVENUES /MEAT + MILK/ - OWN COSTS OF FEED	EUR	12,225
COSTS FOR 100 FEED DAYS	EUR	229.11
OWN COSTS OF 10 PCS OF DAIRY COWS PER YEAR	EUR	8,362
OWN COSTS TOTAL (CROP AND LIVESTOCK PRODUCTION)	EUR	14,121

Source: Own calculations.

In the calculations, we expect milk to be produced at a volume of 10 liters and the remaining will be produced by cows from the bought grain feed. Production efficiency of 1 kg of grain feed is 2 liters of milk (i.e., from 1 kg of grain feed, the dairy cow produces 2 liters of milk). From the above calculations, the proposed farm produces 3,051 liters of milk from bulk feed and 2,319 liters of milk from grain feed per dairy cow for a single accounting year. On the basis of these nutrition adjustments for dairy cows it is necessary to buy 1,160 kg of the production compound feed for one dairy cow. The price of compound feed is 0.27 Euro per 1 kg.

Table 3 **Overview of Calculated Basic Indicators in Dairy Cattle Breeding**

Indicator	Unit	Dairy-Cows	Calves 0 – 6 Months.	HEIFERS From 6th To7th Month Of Pregnancy	HEAVILY PREGNANT COWS	FATTENING CATTLE	TOTAL
Number of animals	pcs	10.00	5.00	9.39	0.44	6.37	10.00
Area of meadows required for breeding	ha	13.20	2.96	13.34	1.24	10.10	40.85

Indicator	Unit	Dairy-Cows	Calves 0 – 6 Months.	HEIFERS From 6th To7th Month Of Pregnancy	HEAVILY PREGNANT COWS	FATTENING CATTLE	TOTAL
Area of pastures required for breeding	ha	21.42		7.41			28.83
Area of the whole crop + livestock production	ha	34.62	2.96	20.75	1.24	10.10	69.68
Own costs total (crop+ livestock production)	EUR	14,121.36	1,785.08	3,231.28	296.94	3,042.84	22,477.50
Revenues	EUR	17,983.98	0.00	0.00	0.00	4,381.06	22,365.04
Subsidies for crop production (meadows and a pastures)	EUR	8,655.09	739.94	5,187.85	310.95	2,525.74	17,419.58
Subsidies for livestock production	EUR	1,300.00	0.00	0.00	0.00	0.00	1,300.00
Revenues +Subsidies (crop+ livestock production)	EUR	27,939.08	739.94	5,187.85	310.95	6,906.80	41,084.62
(REVENUES +SUBSIDIES FOR FARM) – OWN COSTS	EUR	13,817.72	-1045.14	1,956.58	14.01	3,863.95	18,607.12

Source: Own calculations .

Table 3 shows the calculated basic indicators for the area of meadows and pastures for the feeding of 10 dairy cows, their costs, revenues and subsidies.

Revenues from dairy cows consists of revenues from sold milk / 16,108 EUR / and revenues from braking meat of dairy cows / 1,875 EUR /. Based on the model farm model calculations, the total sales of dairy farms reached 17,983 EUR.

The costs of dairy cows in the present model calculation consists of the cost of the total area of meadows and pastures, which includes the harvesting losses, losses of trampled pastures grazing pastures and the feed stockpile. The cost per 1 hectare of meadows reaches a cost of 96.33 EUR and a pasture 63.29 EUR. According to our calculations, the area of meadows for feeding the dairy cows is 13.2 ha and area of pastures is 21.4 ha. The total cost of the bulk feed was 2,626.5 EUR. The cost of dairy farming is also the bought feed, whose value reached 3,131 EUR. The cost of medications, depreciation and other costs related to livestock described in the methodology are amounting to 229,11 EUR for 100 feed days and for whole breeding is total 8,362 EUR for 10 dairy cows and 1 year. From the above calculations results that the total cost of dairy cow breeding, including feed, compound feed and livestock costs, is EUR 14,121.36.

Subsidies for the model farm consist of subsidies for area of meadows and pastures amounting to 8,655.09 EUR and subsidies for diary-cows breeding worth 1,300 EUR. The total subsidies for dairy cow breeding / crop + livestock / are 9,955.09 EUR.

In Table 3, indicators are also calculated not only for the category of dairy cows, but also for the other breeding categories: calves, heifers, heavily pregnant cows and fattening cattle.

The calculations show that household consumption expenditure, which in 2015 was 18,607 Euro (for a 4-member family), requires the meadows area of 40.85 ha and pastures area of 28.83 ha, which together represents 69.68 ha of agricultural land. Regarding the structure of cattle, the farm will record 10 dairy cows, 5 calves, 9.39 heifers, 0.44 heavily pregnant cows and 6.37 fattening cattle. If a farm will record higher area of agriculture land and higher animal numbers, it will only have a positive economic impact on family management.

The aim of agricultural policy in the dairy sector in Slovakia is to produce and process milk to ensure its domestic consumption. It is particularly important to increase consumption, as we belong to the countries with the lowest milk consumption in the EU. Therefore, it is necessary to focus on the following:

- to stabilize the numbers of cattle and dairy cows and preferentially increase their reproductive and utility properties
- to inform and educate consumers about the importance of nutrition, to increase the promotion of milk and dairy products
- to increase the competitiveness of agricultural and food products (raw cow's milk and products)

- to create the conditions for the sale of domestic products through direct sales from the yard and support the sale of domestic products
- to use the new scientific knowledge to innovate products and innovative technologies that meet good manufacturing and hygiene practices that do not have a negative impact on the environment
- to support the training of primary producers of milk in the area of management and marketing of enterprises.

4 Conclusion

Slovakia's agricultural policy is based on the Common Agricultural Policy ("CAP"). One of the objectives of the CAP reform in the dairy sector is to contribute to increasing its competitiveness and market orientation, especially in view of the increasing demand for milk and dairy products in the world market. The reform of the SPP in the milk and dairy products sector has focused production on market requirements and the aid is not linked to production but is geared to meeting food safety, animal welfare and environmental requirements.

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