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Gergő THALMEINER
PhD, assistant professor Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary
ORCID ID: 0000-0002-7224-1028
MTMT: 10068322

Sándor GÁSPÁR
PhD, assistant professor, Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary
ORCID ID: 0000-0002-6874-559X
MTMT: 10047571

Márk TÓTH
PhD, associate professor, Hungarian University of Agriculture and Life Sciences, Gödöllő, Hungary
MTMT: 10076936

LEAN PERFORMANCE EVALUATION OF DAIRY COW FARMING PROCESSES WITH MATHEMATICAL MODEL DEVELOPMENT

Анотація. *Науки управління, особливо контролінг, зазнають великих змін. Різноманітні математико-статистичні та IT-рішення допомагають організаціям розвивати свої системи та отримувати відповідну інформацію зі структур даних, таким чином підтримуючи ефективне прийняття рішень та організаційну діяльність. Сільське господарство – це особлива галузь, але і тут діють функції управління, а сучасні засоби та методи сприяють здійсненню ефективної діяльності. Молочне скотарство є особливо важливою галуззю сільського господарства, де системи контролю розробляються відповідно до особливих вимог. На контролінгову діяльність сфери суттєво впливає розвиток діджиталізації, що призвело до більш масштабніших та детальніших процесів моніторингу та оцінки ефективності управління. Бережливе управління також є важливим методом підвищення ефективності процесів та організаційної ефективності в аграрному секторі, що можна використовувати для оптимізації процесів, виявлення непотрібних дій і забезпечення належного контролю завдань. Таким чином, системи контролінгу повинні враховувати важливість ощадливого менеджменту та сприяти оцінці продуктивності організаційної ощадливості. У даному дослідженні представлено модель оцінки ефективності ощадливого виробництва за допомогою розширеного прикладу, який підходить для оцінки продуктивності ощадливого виробництва досліджуваної молочної ферми. Завдяки динамічно зростаючим і придатним для використання даних, модель здатна забезпечувати безперервний зворотний зв'язок щодо ефективної роботи організації та можливих точок розвитку та втручання.*
Ключові слова: *ощадливе управління, ощадливий контролінг, агробізнес, оцінка ефективності, нечітка логіка.*

JEL Classification: Q12

Absztrakt. *A menedzsment tudományok, különösen a controlling, széleskörű változásokon mennek keresztül. Különféle matematikai-statisztikai és informatikai megoldások segítik a szervezeteket abban, hogy fejlesszék rendszereiket és releváns információkat vonjanak ki az adatstruktúrákból, támogatva ezzel a hatékony döntéshozatalt és szervezeti működést. A mezőgazdaság speciális ágazat, ám a menedzsment funkciók itt is érvényesülnek, a modern eszközök és módszerek támogatják a hatékony működés megvalósítását. A tejelő tehenészet különösen fontos ágazat a mezőgazdaságban, ahol a controlling rendszerek a speciális követelményekre válaszolva fejlődnek. Az ágazat controlling tevékenységét a digitalizációs fejlődés jelentős mértékben befolyásolja, amely hatására a folyamatok nyomon követése és a szervezeti teljesítményértékelés monitoringozása kiterjedtebbé és részletesebbé vált. A folyamatok hatékonyságának és a szervezeti teljesítmény növelésére az agrár szektorban is kiváló módszer a lean menedzsment, amely alkalmazásával optimalizálhatók a folyamatok, azonosíthatók a felesleges tevékenységek és biztosítható a megfelelő feladatkontroll. Ezáltal a controlling rendszereknek figyelembe kell venniük a lean menedzsment jelentőségét és hozzá kell járulniuk a szervezeti lean teljesítményértékeléséhez. Tanulmányunkban egy kiterjesztett esettanulmányon keresztül fejlesztünk egy lean teljesítményértékelő modellt, amely alkalmas a vizsgált tejelő tehenészet lean teljesítményének értékelésére. Fuzzy háromszög függvényt alkalmaztunk a vállalkozások teljesítményének értékelésére, amely az adott paraméter értékét egy háromszög alakú eloszlással reprezentálja. A dinamikusan növekvő és felhasználható adatokkal a modell képes folyamatos visszajelzést adni a szervezeti lean működésről és a lehetséges beavatkozási pontokról.*
Kulcsszavak: *lean menedzsment, lean controlling, agrobusiness, teljesítményértékelés, fuzzy logic*

Abstract. *Management sciences, especially controlling, are undergoing extensive changes. Various mathematical-statistical and IT solutions help organizations develop their systems and extract relevant information from data structures, thereby supporting effective decision-making and organizational operations. Agriculture is a special sector, but management functions apply here too, and modern tools and methods support the implementation of efficient operations. Dairy farming is a particularly important sector in agriculture, where controlling systems are developed in response to special requirements. The controlling activity of the sector is significantly influenced by the development of digitalization, which has resulted in the monitoring of processes and organizational performance evaluation becoming more extensive and detailed. Lean management is also an excellent method for increasing the efficiency of processes and organizational performance in the agricultural sector, which can be used to optimize processes, identify unnecessary activities and ensure appropriate task control. In this way, controlling systems must take into account the importance of lean management and contribute to the performance evaluation of organizational lean. In our study, we develop a lean performance evaluation model through an extended case study, which is suitable for evaluating the lean performance of the examined dairy farm. We used a fuzzy triangular function to evaluate the performance of enterprises, which represents the value of the given parameter with a triangular distribution. With dynamically growing and usable data, the model is able to provide continuous feedback on organizational lean operation and possible intervention points.*
Keywords: *lean management, lean controlling, agribusiness, performance evaluation, fuzzy logic*

Problem statement. Controlling, as one of the key elements of management disciplines, is currently undergoing a significant and comprehensive change. Various mathematical and IT tools allow organizations to be able to extend their systems holistically. The extraction of relevant information from the data collected by information systems - along different structures - is essential to support management's decision-making, which can thus contribute to a more productive and efficient organizational operation [8]. The primary sector can be considered a special sector due to many factors, but at the same time, the various management functions can be

effectively applied in this sector as well. The use of strategic and operative management methods clearly increases the efficiency of the sector. One of the most significant sectors in the primary sector is the dairy sector. In the dairy farming sector, the different controlling systems must provide solutions to specific challenges, therefore the development of the controlling systems used in the sector is carried out according to individual aspects. Well-functioning information systems developed for organizations operating in the field of dairy farming help to monitor processes and increase the efficiency of processes. The use of lean management can be considered an effective management method for optimizing the processes typical of the sector. The primary goal of lean management is to make processes more efficient, identify unnecessary activities and ensure the necessary task control. Due to the fact that the application and importance of lean management is becoming more and more widespread in the industry, the controlling systems must also develop. Controlling systems must no longer only cover the measurement and analysis of economic performance and the support of strategic and operational decisions, but the information provided by the controlling systems must also contribute to the evaluation of organizational lean performance, and thereby the processes and to improve the efficiency of the entire organizational operation.

In our research, we present a case study and model development, during which we use the controlling system of a dairy farm to develop a performance evaluation model using given key performance indicators (KPIs). The developed performance evaluation model is suitable for evaluating the organization's lean performance, which provides management with information about the efficiency of the processes. With the dynamic growth and usability of the data that can be collected about the processes, the model is able to provide continuous and accurate feedback on both the organizational operation and the need for the possible improvement of the efficiency of the processes.

Literature review. Controlling is an activity and function that does not belong to value-creating processes. Instead, it represents a specific set of activities, which are formed based on the specific operational characteristics of the given organization. The main purpose of controlling is to reveal the problems that arise in the organization in different areas and with responsible managers. It provides solutions to problems so that the efficiency, productivity and competitiveness of the organization can be improved. By dealing with these problems, controlling contributes to the organization's greater performance and success. Controlling is a function dealing with financial planning, accounting, and decision support, the purpose of which is to help organizations make appropriate decisions, optimize resource use, and ensure the achievement of organization goals [1]. At the same time, controlling nowadays has to use not only financial data, but also various non-financial data. As a result, in addition to reports based on financial data, the inclusion of non-financial reports in decision support has become significant [3].

Basically, controlling considers five different goals as primary, which are as follows:

1. Goal orientation: This is one of the basic pillars of controlling activity, which determines the performance of organizations and their various performance

measurements and evaluations. Organizations must formulate strategic and operational goals and constantly monitor their relevance in accordance with environmental changes. Continuous monitoring of the realization and fulfillment of the goals is therefore a particularly important task. Controlling supports management in defining, following and evaluating goals so that the organization can achieve the planned results [9].

2. Bottleneck: A bottleneck indicates weak points that can cause problems in organizations if they are overloaded. These problems can be related to both production and management. The bottleneck mostly refers to the company's capacity, i.e. the factors that can partially or completely hinder production and development (for example, human resources, capital, inventories, sales, etc.). The orientation of the bottleneck means that these weak points must be identified. Planning and action programs must be developed to reduce problems and increase efficiency and performance. The identification and management of the bottleneck is crucial for the effectiveness and sustainability of the organization. As a result, controlling helps the organization to identify bottlenecks where problems or challenges may occur and provides an opportunity for more efficient and effective operation [12].

3. Future orientation: An important element of controlling that focuses attention on the future. Controlling deals with the analysis and evaluation of data and knowledge acquired in the previous period, as these past experiences can influence and predict the future. Future orientation means that controlling supports the work of management in focusing on the future and taking appropriate measures to respond to future challenges and opportunities. Based on the previous data and knowledge, controlling helps in strategic planning and decision-making, and also promotes the long-term successful operation of the company as a goal [16].

4. Cost-orientation: One of the outstanding goals of controlling, as one of the most important tasks for organizations is to optimize costs. From the point of view of effectiveness, reducing costs became the most important task. Cost orientation therefore means that the focus of controlling is the analysis and optimization of costs so that the organization can manage its resources efficiently and effectively. Cost-oriented controlling helps the organization identify opportunities to reduce costs, introduce more efficient processes, and thereby increase the organization's competitiveness and effectiveness [1].

5. Decision orientation: One of the basic goals of controlling is to provide support to the management in evaluating the current situation of the organization and in making appropriate decisions. The methods of controlling help to compare the plan and fact states and represent the current situation for decision makers. This enables them to effectively evaluate the organization's performance and results. Based on information and analyses, decision-oriented controlling helps decision-makers to make the best decisions for the achievement of the organization's goals and for its effectiveness. The properly built controlling system supports the organization's decision-makers in making well-founded decisions by using the extensive data sets collected about the organization's operation. Based on the available information and analyses, decision-makers can make the best decisions [12].

Controlling in the primary sector

The primary sector is constantly developing with the development of technology, for example through precision agricultural technologies, biotechnological innovations, sustainable farming practices and digital agricultural technologies [13]. The controlling systems must also respond to this continuous development. With the development of controlling systems, the monitoring of processes in the primary sector, especially in dairy farming, can become more effective and efficient. Its production in dairy farming presents many challenges for farmers. Controlling must be able to solve these challenges, which can be answered primarily by developing cost control, monitoring performance indicators, analyzing health data, and planning and optimizing production processes [6].

The application of lean management is not widespread in the dairy sector, but at the same time, indirect application of lean management can be observed. The application of lean management can be clearly observed through the continuous development of the sector's processes and the optimization of costs. At the same time, nowadays, organizations must not only apply lean management methods, but must also place a strong emphasis on lean management performance evaluation [5]. It can be observed in the international literature that value-producing processes are primarily evaluated during lean performance evaluation. The efficiency of the processes is judged on the basis of the amount of losses. Losses are caused, among other things, by product quality defects, unnecessary work and waiting times. When evaluating the efficiency of the processes, they take into account how much value is created from the available resources [10]. It is important to implement a culture of continuous improvement in the organization, which plays an important role in the development of processes [11]. By taking this culture into account, managers can better understand which areas are most in need of change and improvement. The development of applied controlling systems can also be considered a significant task in the primary sector. As a result of the development, the direct application of lean management can be encouraged and by expanding the applied performance evaluation systems, more detailed information can be collected about organizational operations.

Research aim and objectives. The purpose of our study is to explore the controlling system of a dairy farm operating in the primary sector, during which we focus primarily on lean processes and performance evaluation. During the analysis of the controlling system, the indicators considered as the basis of the performance evaluation are explained. The purpose of this study is to explain that by developing the organizational controlling system, the performance evaluation can be made closer to reality through a more extensive analysis of the processes, thereby supporting management decision-making with more detailed and accurate information.

Material and methods.

During our research, we conducted an extended case study [2]. The subject of the case study was a small and medium-sized dairy cow enterprise operating in the Central Hungary region. The organization currently employs 12 people, which includes the management. We chose the methodology of extended case study analysis because we could further develop the controlling system applied in practice with theoretical

knowledge. The controlling system was developed by building a model, during which the performance evaluation process became more extensive and closer to reality. The controlling model we have developed enables the evaluation of lean performance, and also helps the effective implementation of goals and the targeted planning of interventions. The applied fuzzy logic can handle the subjectivity of the definition and measurability of lean. Fuzzy logic does not define the values of the indicators with exact values, but with intervals [8]. This approach allows us to evaluate the organization's lean performance.

We conducted our research with semi-structured in-depth interviews, the subjects of which were employees in the organization's leading positions. The semi-structured in-depth interview methodology was used in order to explore the areas that the interviewees would like to shed light on in relation to the research area. We set ourselves the goal of mapping the indicators used in the organizational controlling system and analyzing the evaluation process of the processes. After analyzing the controlling system, our goal is to develop a model that, integrated into the controlling system, is suitable for lean performance evaluation.

Results and discussions. We created a company-specific lean controlling model based on the analysis of the relationship between the methodological elements and indicators used in the revealed case study. The model strives to synergistically integrate the advantages of the methods revealed in the literature and during the case study, while avoiding the disadvantages already stated. The model corresponds to the five basic controlling objectives formulated in the literature. By applying the model, it becomes possible to perform lean performance evaluation, to achieve goals more effectively and to define intervention points more precisely. The applied fuzzy logic creates an opportunity to deal with the subjectivity that arises from the conceptual definition of lean and the subjectivity of defining lean goals. Fuzzy logic does not define exact values, but vaguely formulates the values of the indicators. This makes it possible to evaluate the subjectivity of inferential processes.

Model conditions

The meaning of fuzzy is vague, as a result, the classification into a given set in these systems is determined by membership functions. These functions illustrate the value of a given linguistic terms [15]. The lean fuzzy concept is based on the fact that lean is an indicator that does not have sharp boundaries that can be used to create generic categories. "The lean level of the enterprise is better than the lean level of enterprise B" or "The lean level of enterprise C is excellent" and "This enterprise is acceptable from a lean point of view" [4]. Based on the previous example, membership in a given set can be determined with the help of a function, this is fuzzification [8]. The next step in model development is the creation of the rule system, which performs operations and conclusions with the help of individual language variables. As a result of this process, an aggregate consisting of member functions can be created, which is a basic element of defuzzification. During defuzzification, a fact value can be created, and this can be considered the end result of fuzzy analysis [8] [14].

In our study, the classification of the lean index is defined as a fuzzy subset. To formulate a fuzzy logic model, it is mandatory to define the universe (U), the elements

(xi) U, where U={x1+x2+...xn}, and the fuzzy subset A, which is included in the set U, where

$$A = \left\{ \frac{x}{\mu_A(x) | x \in U} \right\} \quad (1)$$

In most cases, the membership function of the fuzzy subset A is expressed by the following:

μA: U → [0,1], which assigns to each element of x ∈ U the degree of membership of x μx in A: μA (x) = μx.

The most commonly used fuzzy logic operations are intersection, union and complement:

- Section of two fuzzy subsets A and B: μA∩μB = minimum {μA (x), μB (x)}
- Union of two fuzzy subsets A and B: μA∪μB = maximum {μA (x), μB (x)}
- Complementary: μ_A '(x) = 1 - μ_A (x) [4] [14].

The lean KPIs used in the model and their aggregates can be interpreted as subjective expert opinions. The reason for this is that there is no generally accepted indicator system for lean performance evaluation, so the use of lean KPIs is subjective and organization-specific. As a result, the significance of lean KPIs' contribution to achieving lean performance can also be determined subjectively, but this was not done within the framework of the current research. As a result, all KPIs are included in the model with the same weight value. However, this problem resulting from the lack of prioritization can be handled and counterbalanced by the evaluation along the intervals applied by fuzzy logic. But only if the distance between the intervals belonging to the classes is large.

In the model we have created, we use data from the past period as a standardized norm to classify the performance evaluation of lean. The standardized norm used in the model can be used to illustrate how lean performance has progressed compared to the past. It is important to emphasize that in the case of models from a controlling point of view, the plan values would be more appropriate, but the examined organization does not currently have exact plan values that we could use effectively.

Steps of the model

The lean controlling conceptual model we developed is built from the following steps:

Step 1: Among all the KPIs of the organizational controlling system, the indicators that have an influence on lean effectiveness must be defined and formulated.

Step 2: Determining the historical data of the organization's lean KPI indicators and placing the indicators in a structure.

Step 3: Determination of ratios based on the plan-fact analysis.

Step 4: Evaluation of ratios from plan-fact analysis.

Application of model steps:

Step 1: Among all the KPIs of the organizational controlling system, the indicators influencing lean effectiveness and lean goals must be defined and

formulated. These indicators should be used during the further analysis. Table 1 shows the lean KPIs that influence lean effectiveness, which were used by the organization examined in our case study. These can serve as recommendations, but in addition to them, many company-industry-lean specific indicators can be defined.

Table 1.

Lean performance evaluation KPIs

No.	KPI Name	Calculation form
1.	Profitability	income (HUF) / expenditure (HUF)
2.	Better health status	replacement rate (%)
3.	Improve milk yield	milk yield (kg) / cow (pcs)
4.	Improve utilization of feed	feed units / cow (pcs)
5.	Higher yield	feed units / hectare (ha)
6.	Less storage loss	used quantity / stored quantity
7.	Better performance of milk quota	gross margin (HUF) / quota (kg)
8.	Less labour uses	hours / milking cow (pcs)
9.	Foot diseases	foot disease / cow
10.	Mastitis	mastitis / cow
11.	Feed consumption	feed (kg) / sold milk (kg)
12.	Average daily milk production	average milk (kg) / cow daily milk production a lactation period 305 by correcting it for the day

Source: own editing

Step 2: Organizing the organizatiom's lean KPI indicators into a structure, at hierarchical levels. During the arrangement in the structure, it is necessary to define the aggregation method for creating the indicators at higher levels. The aggregation method in the model is the average calculation. In our model, we define only one peak indicator, but regardless of this, any number of intermediate aggregates can be defined when applying the model.

Step 3: Determination of ratios based on the plan (past)-fact analysis. By applying the plan (past)-fact analysis, it is possible to standardize the various indicators in the form of percentages. The plan value in the model means the past value. So the purpose of the model is to illustrate the development compared to the past in a standard form. If the indicator expresses a cost, then the additive inverse of the value of the ratio must be classified on the evaluation scale.

Step 4: Evaluation of ratios from plan-fact analysis

The standardized norm (ST 1) is based on the subjective evaluation of deviations compared to specific past data. According to the threshold values set by the organization, the ratios can be classified into five classes. The threshold values of the classification are based on a subjective choice and can therefore be interpreted as fuzzy logic. The following fuzzy triangle membership function was determined based on the results of the semi-structured in-depth interviews. The function used for classification is structured as follows:

$$\sigma_j = \frac{\sum \frac{A_{ji}}{N_j} \times \xi_i}{K} \quad (2)$$

where,
a: fact value,
n: past period value (ST 1),
ji: sequence number of the examined element,
K: KPI/Aggregate indicator examined element number,
ξi: derived value of weight.

The following five classes can be defined for evaluating the effectiveness of the organization's indicators.

$$T_j \begin{cases} \text{Critical} & \text{if } \sigma_j < -\alpha \\ \text{Not acceptable} & \text{if } \sigma_j \in [-\alpha; 1) \\ \text{Acceptable} & \text{if } \sigma_j \in (1; \alpha) \\ \text{Good} & \text{if } \sigma_j \in (\alpha; \beta] \\ \text{Excellent} & \text{if } \sigma_j > \beta \end{cases} \quad (3)$$

$$T_j \begin{cases} \text{Critical} & \text{if } \sigma_j < 0{,}95 \\ \text{Not acceptable} & \text{if } \sigma_j \in [0{,}95; 1{,}0) \\ \text{Acceptable} & \text{if } \sigma_j \in (1{,}0; 1{,}05) \\ \text{Good} & \text{if } \sigma_j \in (1{,}05; 1{,}1] \\ \text{Excellent} & \text{if } \sigma_j > 1{,}1 \end{cases}$$

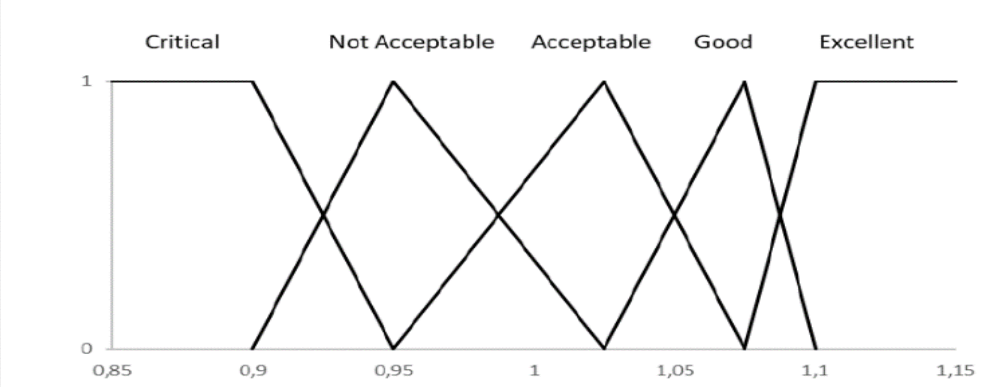

Figure 1: Membership function (1ST)

Source: Own editing

The function works as a calculation methodology that can be used to evaluate and classify different KPIs, aggregate indicators and lean index values. Classification is based on conceptual definitions (linguistics terms). When applying the conceptual definitions of the classes, it is not the value recorded on the scale, but the threshold values and the standardized norm that are decisive. The threshold values of the

function were determined based on the results of the case study, but these are only approximate values. In order to define the threshold values more precisely, it is necessary to take into account company specifications and the subjective and unique opinions of decision-makers on a wider and deeper level.

Conclusions and prospects for further research. Lean management is an area in agriculture that can have a big impact on the organization's performance. The reason for this is that while the application of lean is already a competitive criterion in the secondary and tertiary sectors, it can be a competitive advantage in the primary sector. In our research, we created a model using an extended case study methodology, which can serve as a general model for monitoring the lean performance of dairy cow farms. The model is based on fuzzy logic, along which subjectivity becomes manageable, and creates fuzzy numbers for human decision-makers that are easy to interpret and appropriate decisions can be made based on the information. The purpose of the model is to evaluate development in a standardized way. One of the main advantages of this is that lean goals are not precisely defined for organizations in the applying industry, so instead of pre-defined plan data, they can use already existing past data to judge progress and lean performance.

However, one of the main disadvantages of the model is that the model cannot handle different extreme values effectively. Its extreme values distort the effectiveness of the membership functions, thereby reducing the accuracy of the model. Another disadvantage is that only fuzzy numbers are defined in the model, and as a result, it only serves as an approximation for the objective evaluation of exact values. This corresponds to the criticism of Giangiacomo (2017) [7], according to which the method does not give an accurate enough answer in terms of the formalization of inferential processes. Another disadvantage of the model is that it only partially meets cost orientation as a basic controlling goal.

We defined the following as further research opportunities:

- The exact determination of the weight values of the model can be a bottleneck task, especially in the case that the threshold values of fuzzy categories are not wide. The fuzzy AHP model can be an excellent methodology for determining weight values.
- Expanding the model with other classification methods and standardized norms. Among these, the dynamic comparison to mean values created by mathematical methods can be an excellent tool.
- Extension of the model with additional indirect lean KPI indicators.
- Clear disclosure of cost impacts for each KPI.

In addition to lean performance evaluation, the model can be used in many other areas. Such areas include the evaluation of investment portfolios, projects and various human resource performance evaluation systems.

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