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Sándor Gáspár

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DEVELOPMENT OF MANAGEMENT ORGANIZATIONAL PROCESSES, INTEGRATION OF LEAN METHODS INTO THE CONTROLLING SYSTEM

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Sándor Gáspár

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Doctoral school

Name:	Doctoral School of Economic and Regional Sciences
Discipline:	Management and Business Administration Studies
Head:	**Prof. Dr. Zoltán Lakner** Professor, Correspondent member of the MTA Hungarian University of Agriculture and Life Sciences Institute of Economics
Supervisor(s):	**Prof. Dr. Zoltán Zéman** Professor, PhD Hungarian University of Agriculture and Life Sciences Institute of Economics

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Approval of Head of Department	Approval of Supervisor

Content

1. ANTECEDENTS AND OBJECTIVES OF THE WORK

1.1. Introduction

The intensified global competition in the 21st century is forcing organizations to make the best possible use of different sources of competitive advantage. Increasing the efficiency of organizational processes can serve as one of the most significant sources of competitive advantage. A few decades ago, the lean concept emerged as a kind of universal success concept in this area, but the COVID-19 crisis in 2019 also highlighted the disadvantages of the lean concept. The most significant of these disadvantages is the inventory minimization and pull system due to “lean”. As a result of the crisis, global supply and logistic chains have been disrupted, making the purchase of raw materials and semi-finished products at extra cost and, in some cases, impossible. After the crisis, this situation was exacerbated by growing global demand. This growth and scarcity of raw materials has also led to the cessation of global production in many industries (McMASTER et al. 2020). The lean concept, like other management organizational and management concepts and philosophies, has many advantages and disadvantages. In order for an organization to gain a long-term competitive advantage, it is necessary to apply the tools, methods, different concepts and philosophies in a way of island-like. However, a combination of these tools and methods can only lead to a long-term competitive advantage if they are properly adapted to changes in macroeconomic conditions.

Monitoring the island-like operation of lean management requires controlling methods and a system that can provide feedback in an aggregated way integrated into modern corporate governance systems. In recent years, databases and information opportunities have been made available to organizations through the use of IT and business IT innovation, mainly Big Data and digitalisation, which fundamentally change the controlling systems used so far (HAZEN et al. 2014). . The data mining methods and various mathematical-statistical models developed for the analysis of huge and extensive data sets make it possible to transform these data into relevant information and to extract the relevant information (TABESH et al. 2019). Controlling systems must form a kind of bridge between the strategic and the resulting operative, functional goals and the mathematical-statistical, data mining methods already mentioned (OTLEY 1999). Properly defining and structuring the Key Performance Indicator (KPI) between strategic goals and data sets can be an effective solution (FANNING 2016). Proper definition and structuring of lean KPIs is the basis of a modern lean controlling system, because lean operations and lean processes are island-like in the management and organization processes of organizations. Because of these, it is a challenge to measure the effectiveness of organizations ’lean management tools (kaizen, JIT, KANBAN, VSM, etc.). Innovative methods in business informatics and lean controlling models derived from the proper definition of lean KPIs, in turn, allow the evaluation of the effectiveness of island-like lean processes and the efficient detection of a lean index.

1.2. Objectives

The actuality of the topic, based on my personal practical experience and what I have learned in the literature, was provided by the shortcomings and problems arising from the evaluation of lean processes. Organizations operating in different industries need to create a lean controlling model that meets the basic goals of controlling, implements modern controlling methods (e.g., Big Data Analysis, KPI) and can be integrated into different corporate governance systems. The lean controlling model should provide management with information content that can be used to effectively develop and optimize lean processes. The developed model should be able to evaluate lean performance as a function of target variables. These target variables are primarily value streams and a set of different lean tools and methods. In addition, the model must be able to integrate different enterprise units, divisions, and enterprise-wide lean performance as target variables. The output of the model should be an evaluation that is not only an index but also a decision supporting information whoch is interpreted as a function of context.

The objective of my research is to explore and model the lean controlling methods and systems used in the literature and corporate practice, and to create a general conceptual lean controlling model based on the synergies between the literature and my empirical research. My goal is to create a multidisciplinary, industry independent conceptual model that structures and evaluates KPIs based on causality relationship.

2.MATERIAL AND METHODS

Based on qualitative interviews, I built my research through a case study methodology. In the case of organizational research, this case study methodology is most often used in qualitative research (BRYMAN 1992), but this does not mean that this methodology can be considered fixed or even called a unified approach. Some researchers, such as EISENHARDT (1989) and YIN (1994), consider theory building as the main goal of the case study methodology. In his research, BRYMAN (1992) stated that the aim of case studies used in organizational research should be to thoroughly explore and understand the local context. STAKE (1994), distinguishing between qualitative and non-qualitative case studies, stated that the aim of a qualitative case study is to understand a given case as thoroughly as possible, focusing on "What can we learn from a single case?" Based on these, it can be said that the author does not have an explicit goal of generalization, but if it is still necessary, he still considers the in-depth analysis of one case and the generalization based on it to be more reliable than the based on many cases. In case study based research, the unit of the case can also be defined by defining the case as a concept (BABBIE 2012). Sampling as a concept means the selection between possible test units and the definition of different aspects. Since in my research I do not research the lean controlling methodology in a specific organization, the case appears as a concept, as each case represents the lean controlling system of a given organization, and the totality and structure of the related methodologies. In qualitative case studies, sample selection is not statistical but fundamentally theoretical (MILES - HUBERMAN 1994).

The difference in the sampling principles of qualitative research is justified by different research goals: the generalization cannot be related to a predefined population, but to a specific observed phenomenon, context or a theoretical-conceptual framework (BOKOR 1999). In most cases, the theoretical aspects indicate only the initial case and the second case, but the further progress is focused on the research goals and the first results of the analysis are formulated (GELEI 2002). When defining or choosing a sample, based on KVALE (1996) interpretive and qualitative criteria, the researcher has the opportunity to rely on his intuitions, implicit knowledge and personal expertise. In studies based on a qualitative case study, data collection is done iteratively. The circular system of data collection lasts until the occurrence of the theoretical saturation (GLASER - STRAUSS 1967), until the point when further data and cases no longer have a significant effect on comprehension.

I used an interview sketch for the semi-structured interviews. This interview sketch had a loose structure. During the interview, my goal was to allow the interviewee to talk about the topic in a very wide area, as this facilitated my researcher's understanding of the particular controlling system. My main interviewees were top and middle managers, senior controllers, value stream controllers, junior controllers and lean managers. The selection of interviewees by position was mainly justified by the suggestion that employees in this position have the most accurate and comprehensive information on the operation of organizational controlling systems. In the course of their work, they use and develop these systems on a daily basis. Because the interview sketch had a loose structure, the following topic areas were for guidance only. (Presentation of the business organization processes and methods operating in the organization. Introduction of the strategic controlling system. Presentation of the applied lean methods and tools. What lean controlling methods are used? How the lean processes are monitored? Does the company plan to the developement of the lean methods? Personally, what ideas do you have for improving lean methods?

In the second round of interviews, I sought an accurate understanding of the different processes and methods, so I sought targeted questions. In order to gain a deeper understanding, I examined the management organization processes and the controlling systems at different levels during these second interviews. Furthermore, I tried to find correlations between lean processes and controlling systems.

The following sources also provided additional sources of information. Corporate governance and controlling systems and parameterization procedures. Other company documents such as BSC operating lists. KPI definitions, information system descriptions and documents.

3.RESULTS AND DISCUSSION

1. **Case Study:** Evaluation of Lean Performance by Lean KPIs in a case of a Vehicle Manufacturing Organization.

Through the case study of the domestic subsidiary of a vehicle manufacturing multinational organization, the research presents a lean controlling system applied in practice and the aggregation possibilities facilitating the reporting activities derived from this system. The lean controlling system of the examined organization is based on KPI indicators, which can be aggregated in different forms and structures, based on lean principles and different value streams. Using the system, it is possible to prepare reports in a few indicators and the information content is not lost. The lean controlling system works effectively in the organization, but the monitoring of the different lean principles is not completely accurate because, for example, the indicators or measurement points belonging to the 6S principle are not integrated into the controlling system. In order for the final aggregation option, the lean index to provide relevant information to management, it would be necessary to monitor and aggregate all principles and all lean processes and other soft factors, support activities (administration, finance department, etc.). The disadvantage of this method is the distortion of the data from the averaging method. The corporate governance system and data warehouse capacity would allow the supply chain and customers to be monitored and the results of these indicators to be incorporated into the calculation of the lean index. In the case of aggregation options, aggregation would also be possible based on different mathematical-statistical methods. In such cases, in addition to assigning some goal-independent variable, the use of multivariate analyzes could provide an excellent complex and aggregate lean reporting option for controlling.

2. **Case Study:** Further development of the BSC model using the KPI-tree method presented through a case study of a dairy farm

During the research, it was possible to gain a deeper insight into the lean processes of a large multinational company and their monitoring through the models and analyzes applied in the controlling system. There are several indicators in the illustrated VSC controlling model that are not related to lean processes. Only KPIs that have an impact on lean or cost implications have been illustrated in the research. Using the model, it is also possible to explore intervention points and filter out more nuanced errors that may need further fine-tuning. Thus, it can often be the case that there are more serious shortcomings in the evaluation of the KPIs chosen, which may lead to a change in strategy. In the light of the above, this type of analytical method plays a particularly important role in informing the value stream and factory management, and can help to make more rational decisions. Furthermore, in addition to increasing the efficiency of lean processes, it is also important in relation to the optimal allocation of resources. It is important to note that the KPIs and procedures currently used may also need to be fine-tuned, but the fundamentals and context of the model should not fundamentally change as a result of these changes. Changes can be understood as even more precisely defined mathematical relationships and the improvement of the shortcomings of the used corporate information system, as well as the more detailed monitoring of certain specially highlighted areas. Such a separate priority area could be, for example, the declaration of the context of the use of stocks and, at the same time, the satisfaction of customer needs, which was a key status at the time of the research. The ultimate goal is to keep inventories to a minimum, but always in a way that keeps customer inquiries and deliveries in line with orders. At the same time, a key cost factor, the cost of capital for inventories, would be reduced. To monitor this priority area, a number of other indicators and measurement points could be built into the model. The disadvantage of the model is that it contains only financial data, which greatly distorts the results of the lean performance evaluation. Establishing an extensive lean controlling model and mapping the different correlations and interactions would require a multiple of a much more complex KPI in the current model. Currently, this model has only been compiled from lean KPIs related to the manufacturing processes used in the study organization. Thus, in order to create a specialized model for measuring and monitoring lean processes, individually developed aggregate indicators and benchmarking tools must be used in all functional areas. In addition, the illustrated theoretical model of lean controlling raises another issue, which is the lack of soft, ie non-measurable factors. These factors cannot be measured with exact values and cost factors cannot necessarily be associated with them. However, it has a major influence on the success of lean processes.

3. **Case Study:** Appearance and examining of Lean KPIs in a controlling system of a manufacturing organization

Through the operational processes and the conroll system of the examined dairy farm, I point out that the hierarchical aggregation based on the possible causal relationships made by the KPI-tree method is an effective tool for evaluating the lean performance of the enterprise, based on past data. It is clear from the analysis of my case study that although agriculture is a special sector, different controlling models can be applied in this industry as well. The presented method is used to describe reality, therefore profitability as an aggregate peak KPI can be replaced by other aggregate peak indicators, but the logical structure of the method is not affected.

The further developed method is based on the analysis of different KPIs of the BSC. With the help of the KPI-tree containing plan-fact analyzes, the controlling system becomes able to generate more relevant information in an aggregated form. The advantage of this method is that it provides a wider and more comprehensive information content. Aggregation based on causality can be used to provide relevant information about a firm's performance in terms of a peak.

Examining the indicators at the lower levels of the peak indicator provides more detailed information and points of intervention can be identified.

One of the biggest shortcomings of the model is that the method does not express the degree of influence of the causally related indicators at different hierarchical levels, nor does it define only three hierarchical levels. Another shortcoming of the method is that the result scales need to be standardized because it is a basic condition for methods with weighting and mathematical correlations. The impact of each KPI on the indicators at the above levels can be determined using different expert opinions. With the knowledge of expert opinions and the standardization of result scales, it is possible to determine the extent of the impact of the indicators influencing the performance of KPIs at each level. Another suitable method for examining changes and correlations may be the use of different mathematical-statistical methods and different algorithms. These can provide even more accurate information content to management through the system.

4. **Case Study:** Application of KPI-tree as a controlling method for the analysis of management organizational processes.

The advantage of this method is that it can clearly show immediate results. Performance evaluation of individual and specialized areas that cannot be detected in the information system will be possible. Using the method, intervention points and areas can be clearly defined at all hierarchical levels, thus creating an island-like controlling system. Another advantage of this method is that the results of the reports can be traced back to the data from the VSM for lean organizations. The method is able to evaluate ideas and suggestions formulated at different hierarchical levels. It may be easier to determine the value of a given idea, as the method also makes it possible to show the effect on the peak indicator. The disadvantage of the model is that in addition to the exploration of the intervention points, the method is not suitable for determining the causal relations. These causal relationships could be explored using different algorithms and mathematical-statistical methods to extend the method. A disadvantage is the high risk of error factors resulting from human work. Due to the aggregation, this error can have high information bias in reporting and decision making. The aggregation method used by the organization may also distort reporting activity. A shortcoming of the system is the untraceability of analyzes resulting from changes in value streams during the year. If the processes of the examined valuestreams change, then the method may not be able to handle this, and the analyzes may be significantly distorted by this deficiency. The lack of prediction is also a significant disadvantage of the method, as the interim performance evaluation does not provide feedback on the fulfillment of the pre-defined plan value for the given period. Too wide a range of classification limits for KPI and value stream plan-fact analysis ratios will result in a significant change in performance for category change. This can distort KPI or value stream performance judgments. The KPI-tree as a lean controlling method does not cover the evaluation of the lean performance of a company's suppliers. In addition, the lean controlling system of the company does not cover the lean evaluation of the support and administration processes. The KPI-tree methodology is an excellent tool for structuring a complex process system and serving as a basis for various analyzes. The method is already used in many cases by various industry organizations, but developments require increasingly in-depth analysis and organizational knowledge. The KPI-tree methodology is an effective tool for lean controlling, which has also been proven in the case of the examined organization. Using this method, it is possible to structure the data in the information system in such a way that they can illustrate the results of the performance of lean processes and lean goals.

5. **Case Study:** Examining a lean controlling system and lean KPIs in the operation of a multinational service company

In my research, I illustrate the lean controlling system operated in practice through a case study of a subsidiary of a multinational organization in the telecommunications sector. The lean controlling system of the examined organization is based on KPI indicators and KPI report tables. For most KPIs, target cost is defined and evaluated in plan-fact analyzes. Target cost is a lean method that is calculated using a predefined method. The research highlights the possible application of lean management and target cost in the service sector. In the case of the examined organization, in addition to the tools of lean management, non-lean tools and methods appear to support the fulfillment of lean goals. Consequently, the lean controlling system should cover not only the measurement of lean assets, but also indirect measures such as the extent of digitization at the company level. In evaluating different lean KPIs, predictive extrapolation can be constrained in many cases. This is because many lean KPIs assume ad hoc nature. The solution to this problem is the specialization of the lean controlling system and the development of an island-like lean monitoring system. The lack of exploration of causal relationships can be described as a problem, as lean KPIs are very complex and diversified by functional area. As a result, in many cases, exploring the intervention point only provides an answer to the cause. The lean controlling system is not necessarily suitable for determining the cause, so the research of the cause is not fulfilled. Another disadvantage of the applied lean controlling model is the lack of aggregation. Aggregation could be possible along different groupings, allowing not only areas and human resource groups, but also lean principles to be aggregated.értékelni.

6. **Case Study:** Mapping the application of lean controlling methods in a case of a vehicle manufacturing organization

During the research, an island-like lean controlling system was mapped, which can serve as a solution to deal with the subjectivity arising from the evaluation of lean management. The questionnaire survey and the parallel, island-like lean controlling system are able to provide strategic and operational feedback for lean management and lean goals. The system does not use a predictive evaluation method. However, with the help of the corporate governance system and the questionnaire, it dynamically and regularly monitors the fulfillment of lean goals. The company uses a number of lean management tools and methods, but in the controlling system there are no clear and specific indicators related to them, only in the lean questionnaire. Using lean KPIs, the organization primarily measures lean goals. The organization uses special production cell system and cost allocation based on them, which is similar to the VSC method, but process-related KPIs and costs are handled separately by the system. Another research opportunity is the analysis of the correlations and differences between the results of the lean questionnaire and the results of the lean KPI tables. This would make it possible to coordinate the two island-like systems and get a more accurate picture of the effectiveness of lean management.

Lean controlling conceptual model

Based on the analysis of the correlation of the methodological elements used in the case studies, I formulate a generally applicable lean controlling model. The model seeks to synergistically integrate the advantages of the methods explored in the literature and in the case studies, while avoiding the disadvantages. The model corresponds to the five basic controlling goals formulated in the literature (goal-orientation, bottleneck, future-orientation, cost-orientation, decision-orientation) (ZÉMAN - TÓTH 2017). Using the model, it is possible to evaluate lean performance, 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 results from the conceptual definition of lean and the subjectivity of the definition of lean goals. Fuzzy logic does not define exact values , blurs the values of indicators. This makes it possible to assess the subjectivity of inferential processes. The conceptual model of lean controlling I have created consists of the following steps:

1. step: From all KPIs of the organizational controlling system, the indicators influencing lean effectiveness and lean goals must be defined and formulated.

2. step: Organize the enterprise lean KPIs into a KPI-tree structure at three hierarchical levels.

3. step: The fact values of the KPI should be extrapolated to the date corresponding to the planned values

4. step: Determining predictive ratios based on plan-fact analysis

5. step: Evaluation of predictive ratio numbers derived from plan-fact analysis at different hierarchical levels

<u>5.1. step:</u> Classification in the organizational controlling - planning system along predefined limits (1st ST, 2nd ST)

<u>5.2. step:</u> Contribution to the average performance (3rd ST)

Steps of the model

<u>1. step:</u> From all KPIs of the organizational controlling system, the indicators influencing lean effectiveness and lean goals must be defined and formulated. The weighting of the indicators is mandatory in all cases. Weight values can be determined subjectively, using a questionnaire involving various relevant operational and strategic managers and semi-structured in-depth interview methods. These indicators should be used for further analysis.

2. step: Organize the enterprise lean KPIs into a KPI-tree structure at three hierarchical levels. During structuring, it is necessary to define the aggregation method to create the indicators at the higher levels. In the model, the aggregation method is a weighted average calculation. In the model, weights need to be assigned only to the non-aggregated KPI. Indicators formulated at aggregation levels can be linked to value streams, production cells, lean principles, lean tools and methods, and functional areas (support, administration processes). The value of a KPI can also be used to calculate multiple higher level aggregates.

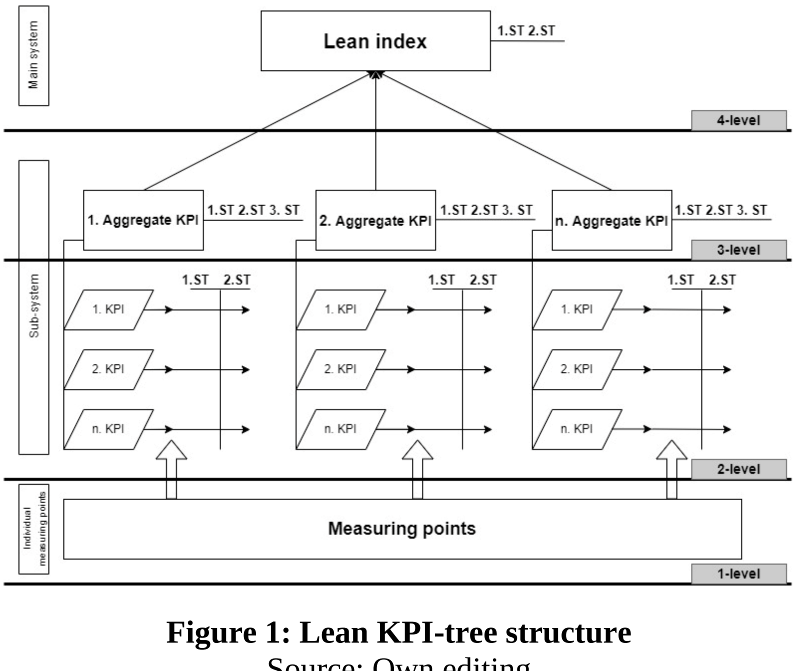

Figure 1: Lean KPI-tree structure
Source: Own editing

The evaluation of the indicators at different levels is possible with the standardized norms, functions and limits described below. The peak index, the lean index, is classified along the same logic.

3. step: This step serves to ensure that the analysis is not actual but expected, predictive. To achieve this, the actual values of the KPI must be extrapolated to the target date. Actual value is the cumulative value of a given KPI in the current period. Based on the cumulative values of lean KPIs and aggregates, extrapolation is made to the plan value at the time point. The factual value can be determined taking into account the trend as follows:

$$Z_{pred}=t-\lambda a$$

$$\lambda=\frac{\sum(a-\bar{a})(t-\bar{t})}{\sum(a-\bar{a})^2}$$

4. step: Determining predictive ratios based on plan-fact analysis. Using plan-fact analysis, it is possible to standardize the various indicators in percentage form. The plan value can be determined by calculating the target cost or target value. In most cases, this plan value can be determined based on the company's past period, capacity, internal organizational data, and industry forecasts. In the case where the indicator expresses a cost, the additive inverse of the value of the ratio should be classified on the evaluation scale.

5. step: Evaluation of predictive ratios derived from plan-fact analysis.

5.1. step: Classification in the organizational controlling - planning system along predefined limits (1st ST, 2nd ST)

The first and second standardized norms (1st ST, 2nd ST) are based on a subjective assessment of defined plan deviations. According to the limits set by the organization, the ratios can be divided into five classes. The limits of classification are based on subjective choice and can therefore be interpreted as fuzzy logic. The function used for classification is structured as follows:

$$\sigma_j=\frac{\sum\frac{A_{ji}}{N_j}\times\xi_i}{K}$$

where, a: predictive actual value, n: projected plan value (1st ST); value of the past period (ST 2), ji: Serial number of the examined element, K: KPI / Aggregated indicator examined number of elements (pcs), ξi: derived value of weight

The organization has the following five classes to evaluate the effectiveness of the indicators.

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

The function acts as a calculation methodology for evaluating and classifying different KPIs, aggregates, and lean index values. Classification is based on linguistics terms. When applying the conceptual definitions of classes, it is not the value on the scale that is determined, but the limit values and standardized norms.

5.2. step: Contribution to the average performance (3rd ST)

For the third standardized norm, it is not a predefined plan value that is determined, but classification based on the contribution to average performance. At the level of KPIs, the application of a standardized norm can only be interpreted if the plan-fact ratios of the KPIs belonging to a given aggregate KPI are multiplied by their respective weighting. The other level is the level of aggregated KPIs within the subsystem. At this level, I illustrate the calculation methodology at the level of aggregated KPIs by defining KPIs for the following five different aggregation indicators. This calculation method is needed because aggregated KPIs do not have separate weights, but are based on the weights and weighted averages of the lower-level KPIs. The average of the items in the sets can be calculated as follows:

$$\frac{A_1,\ A_2, \ldots.\ A_n}{n} \in A'$$

$$\frac{B_1,\ B_2, \ldots.\ B_n}{n} \in B'$$

$$\frac{C_1,\ C_2, \ldots.\ C_n}{n} \in C'$$

$$\frac{D_1,\ D_2, \ldots.\ D_n}{n} \in D'$$

$$\frac{E_1,\ E_2, \ldots.\ E_n}{n} \in E'$$

where, A, B, C, D, E: KPI which are related to an aggregate KPI at a given higher hierarchical level A ', B', C ', D', E ': aggregate KPI

To determine the relative eigenvalue of aggregated KPIs, it is necessary to determine the value of the lean index. The value of the lean index can be determined as follows:

$$\frac{A' + B' + C' + D' + E'}{n} = L$$

The relative eigenvalues of aggregated KPIs can be determined as follows. These values also determine the positions on the scale.

$$\frac{A'}{L} = X_{A'} \mid X \in [0, \infty)$$

$$\frac{B'}{L} = X_{B'} \mid X \in [0, \infty)$$

$$\frac{C'}{L} = X_{C'} \mid X \in [0, \infty)$$

$$\frac{D'}{L} = X_{D'} \mid X \in [0, \infty)$$

$$\frac{E'}{L} = X_{E'} \mid X \in [0, \infty)$$

where, L: is the lean index

The eigenvalue may be different for the different sets examined. Thus, the position of aggregated KPIs relative to average performance can be determined. By placing aggregate KPIs on a linear scale, you can see how group members are positioned relative to average performance. The five classification categories are defined below.

$$\mu_{critic}(\omega_i)=\max\left(\min\left(\frac{1\frac{1}{3}-\omega_i}{\frac{2}{3}},1\right),0\right)$$

$$\mu_{not\ acceptable}(\omega_i)=\max\left(\min\left(\frac{\omega_i-\frac{2}{3}}{\frac{2}{3}},\frac{2-\omega_i}{\frac{2}{3}}\right),0\right)$$

$$\mu_{acceptable}(\omega_i)=\max\left(\min\left(\frac{\omega_i-1\frac{1}{3}}{\frac{2}{3}},\frac{2\frac{2}{3}-\omega_i}{\frac{2}{3}}\right),0\right)$$

$$\mu_{good}(\omega_i)=\max\left(\min\left(\frac{\omega_i-2}{\frac{2}{3}},\frac{3\frac{1}{3}-\omega_i}{\frac{2}{3}}\right),0\right)$$

$$\mu_{excellent}(\omega_i)=\max\left(\min\left(\frac{\omega_i-2\frac{2}{3}}{\frac{2}{3}},1\right),0\right)$$

4. CONCLUSIONS AND SUGGESTIONS

1. Island-like lean controlling system.

According to the theory of Hines et al. (2004), the island-like introduction of lean principles is not possible because the application of some tools also necessitates the use of other tools in order to implement them effectively. Thus, in the long run, businesses that use lean tools need to become lean organizations. However, there are a number of case studies in the literature in which lean tools and methods and the lean concept itself operate in an island-like manner in the operation of the analyzed companies. In the case that the island-like operation of lean management in the operation of the examined enterprises is only a temporary state, it is still necessary for the controlling system of the enterprises to monitor and evaluate the lean processes and methods. Furthermore, it is necessary to monitor and evaluate lean processes and methods for organizations that do not aim to become a lean organization and only use lean tools and methods in an island-like manner.

The aim of my research is not to prove or disprove the theory of Hines et al. (2004), but regardless of this theory, controlling systems must monitor and evaluate the effectiveness of island-like lean processes and methods. Regardless of which of the former two versions applies to the enterprises examined in the literature, island-like operation exists and controlling systems and methods must respond to this. For lean organizations, “lean accounting” methods may be suitable for monitoring lean processes, but the effectiveness of these methods in island-like lean operations is unclear.

2. Lean methods and tools used in corporate practice.

In my research, I came to the conclusion through five different qualitative case studies that in addition to the “lean accounting” methods used to measure the effectiveness of lean processes, controlling methods that do not belong to the “lean accounting” toolbox can also be used. Based on the case studies, it can be said that lean processes are monitored and evaluated by controlling systems either in an island-like form or in an integrated system. There is also a lean controlling system that, although operating as an integrated system, evaluates lean processes and the achievement of lean goals in an island-like form. The most commonly used “lean accounting” method for most of the organizations I examined was the target cost calculation and the VSC method. These methods were applied by the companies in an organization-specific manner and integrated into their controlling system. All of the companies in the case studies used lean KPIs. Organizations have defined identical or very similar lean KPIs in many cases independently to evaluate and monitor similar lean processes. The KPI management methodology also provided an opportunity for the organizations to evaluate the lean processes operating in an island-like manner. Due to the subjectivity and organization-specific nature of the definition of KPIs, the controlling system of a given enterprise can adapt the measurement methods to its own processes and operations. This can form the basis of a general lean controlling model, as it is also possible to define and extensively evaluate lean KPIs for island-like lean management and lean organizations. Thus, KPIs can be a kind of general lean controlling method regardless of industry, organization, and lean organizational extent. The basis for measuring island-like is lean KPIs, the definition of which must always be adapted to the processes of the given enterprise. This makes it possible to monitor and further evaluate lean processes.

My results highlight that not only lean processes and goals can be monitored and evaluated, but also that lean principles and methods can be evaluated together through a system. From this, it can be concluded that the values of the same lean KPIs can be evaluated from several perspectives. The structure of hierarchical indicators was an effective tool in the evaluation of lean KPIs. In the case studies examined, this hierarchical structure appeared in several ways (value streams, KPI-tree method, lean principles). Indicators at hierarchical levels are created using aggregation methods. The values of the KPI and the aggregated KPI indicators can be defined as a plan-fact analysis ratio for each examined enterprise. Based on this, it can be concluded that the evaluation of lean processes was in each case compared to some predefined plan-target value. It follows that it was not the absolute value of the lean KPIs that was assessed by the controlling system, but the value of the ratio from the plan-fact analysis in each case. The evaluation of the ratios for the examined companies is carried out according to different thresholds and methods. Thresholds and evaluative classifications differed in all cases, but the evaluation of lean KPIs did not differ from the evaluation of non-lean KPIs in either case. In my research, I have come to the conclusion that it is not possible to formulate objective and precise limits. Each threshold is organization-specific and subjective, so each can be considered a subjective expert opinion of equal value.

3. Conceptual model

In order for a general lean controlling system to be able to effectively monitor the various lean processes, it is necessary to map the operation of lean management. The level of lean management integrity and lean goals should determine the set of KPIs used in a general lean controlling model. Due to the subjectivity resulting from the measurement of lean processes and the relative nature of organization-specific lean KPIs and evaluation thresholds, there is no general lean KPI toolkit or evaluation threshold. Taking these factors into account and in the literature, it can be concluded that the most commonly used method based on fuzzy logic for calculating the lean index can be effective for a general lean controlling model as well. The model should also take into account and evaluate the effectiveness of aggregate indicators formulated at different hierarchical levels. Fuzzy logic makes this possible by evaluating results at different levels along the same membership functions and standardized norms. The model should be able to define intervention points at different levels and to incorporate general plan objectives and use them as a benchmark. The ratios derived from the plan-fact analysis form the basis of the integrated and island-like controlling systems that can be observed for all the enterprises I examined.

Considering the above conditions, the model I have created is a generally applicable lean controlling model. Using fuzzy logic, it is possible to incorporate and manage subjectivity in the model. The conceptual model is based on lean KPIs. By defining these KPIs, it is possible to monitor the lean management operating in an island-like manner, and in the case of lean organizations, to monitor the performance of the entire organization. In the case of lean performance evaluation models formulated in the literature, it is important to highlight that the best in the industry, competitors, and other industry players serve as a standardized norm. Thus, in the case of a model using such a benchmark, it is important to use a standard indicator system and a uniform structure for all the organizations examined. This, in turn, makes it difficult to monitor and evaluate the operation of island-based lean management at multiple internal levels, and in many cases makes it impossible in the absence of appropriate standard indicators. In many cases, financial accounting indicators are used as standard indicators in the literature. The use of these indicators does not make it possible to explore effective intervention points, the efficiency of operational processes, the evaluation of island-like lean processes, or the monitoring of results related to strategic lean goals. The conceptual model I have created solves these problems by formulating several standardized norms and only internal benchmarks, thus defining and evaluating the effectiveness of lean processes in each case in relation to the company's goals and its own results. As a standard indicator, it defines predictive ratios derived from plan-fact analysis, which allow the evaluation and comparison of expected results from different areas. The internal standard norms and the plan-fact analysis ratios make it possible to implement this model in various integrated corporate governance systems.

The conceptual model, using the KPI-tree, provides an opportunity to monitor lean KPIs across multilevel, aggregated, and specialized areas. Regardless of the number of horizontal and vertical levels created in the KPI-tree structure, the model provides feedback at each level and evaluates lean performance. The model is suitable for handling any number of hierarchical levels and aggregated KPIs. For aggregated indicators, the plan value is the sum of the plan values of the associated KPIs. During this evaluation, a grouped evaluation of the different areas is carried out.

The hierarchical structure can be used to create a peak KPI, which in each case is the lean index. The lean index expresses how a company meets the goals of lean, that is, it expresses the expected lean performance in an indicator. At the same time, the model provides feedback on the expected value of cumulative performance over a period of time, not only in an indicator, but at all vertical and horizontal levels, depending on the different contexts. This will make it possible to identify critical areas along the intervention points along which the set lean goals are not expected to be met. For many extreme classifications, however, a change in objectives is required, leading to an examination of the planning mechanism.

With the created model, not only the lean performance of the entire company can be evaluated and compared, but also the evaluation and monitoring of the lean performance of different factory units, value streams, production lines, production cells, lean devices and methods, and workforce too.

4. Model development suggestions

The conceptual model created in my research is not suitable for using the results of external, ie industry competitors, best industry players or other organizations as standardized norms or benchmarks. The model projects lean management only in the organization's processes and not on the basis of the lean performance of supply chain actors. In order for such an in-depth analysis to take place, it would be necessary to involve all actors in the supply chain in the analysis. The extension requires the use of structured analysis methods and, similarly, the examination and aggregation of internal processes. In order for the model to be suitable for this, three conditions must be met.

- The first condition is the uniform definition of lean interpretation, the unification of the meaning of lean at the industry level.
- The second condition is to map the industry and the supply chain related to the given industry, and to estimate the actual and expected performance. This estimate should cover the industry and each industry player. If possible, this analysis should be performed at a deeper level, the level of value streams.
- The third condition is to collect and systematize the data needed for the analysis and to define standardized norms of general application to the industry.

The “ambiguity” inaccuracy resulting from fuzzy logic is a disadvantage of the model that has a major impact on the final result. The model is not suitable for determining the exact organizational lean effectiveness, but can only formulate it with an approximate value. It may be appropriate to use the Mamdani membership function to refine the approximate value. Accuracy can be enhanced by extending the model to a nerular network, which, together with the Mamdani membership function, could represent an efficient evaluative neurofuzzy model. In addition, it could be used to select the most appropriate standardization norm. This neurofuzzy model may also be a suitable method for determining the weights of KPIs and aggregated KPIs. One of the disadvantages of this proposed model is the high data requirements.

Although the model uses prediction and defines each result as an expected value, it would be possible to extend the model with regression analysis and neural network-based extrapolation to increase the accuracy of the extrapolation. Another model development opportunity is to develop the goal of model cost orientation controlling. Thus the different indicators and the lean index could also be characterized by cost and financial indicators.

The developed conceptual controlling model can be applied to a number of problems and areas that meet the following criteria:

- Subjective expert opinions are of almost equal value in evaluations.
- There is a high degree of subjectivity in the classification of results. Evaluation is a function of context. (Many standardized norms are applicable, and in most cases different categories are caused by the evaluation of the same result.)
- The thresholds that can be used for evaluation and classification are subjective, and it is not possible or will not be possible to formulate objective evaluation thresholds in the near future.
- A hierarchical structure can be created for the evaluation, in which it is possible to arrange the used indicators vertically and horizontally.

Based on the above criteria, it can be stated that the model can be excellently applied to the evaluation of investment portfolios, where the goal is to judge the achieved returns. Another area is the sustainability evaluation of companies and geographical regions, where the goal is to evaluate the results that have already been achieved or are related to the goals to be achieved in relation to the goals. The model may be suitable for evaluating different human resource performance and evaluating employee well-being. The model can also be an effective method for assessing the level of agility, where the goal is to assess corporate flexibility and adaptation. In addition to these, it can be applied in many other scientific fields of society and nature.

5. NEW SCIENTIFIC RESULTS

1. **If the island-like operation of lean management in the operation of organizations appears only as a transitional state, it is still necessary to monitor and evaluate lean processes and methods. It is also necessary to monitor and evaluate lean processes and methods for organizations that do not aim to become a lean organization and only use lean tools and methods in an island-like manner. According HINES et al. (2004), controlling systems need to monitor and evaluate the effectiveness of island-like lean processes and methods. Controlling systems and methods must also respond to island-like lean operation. For lean organizations, "lean accounting" methods may be suitable for monitoring lean processes, but the effectiveness of these methods in island-like lean operations is unclear.**

2. **In my research, I created a conceptual lean controlling model, which can be used to evaluate the effectiveness of lean processes and the various tools and methods used in lean management. The KPI management methodology I use provides an opportunity for the analyzed companies to evaluate the island-like lean processes. Thus, my model makes it possible to evaluate the performance of island-like lean processes at different hierarchical levels.**

3. **Extrapolating the results at different levels provides an opportunity to provide an expected estimate of lean performance for a pre-defined time point, taking into account trends. This expected value will be used as a plan-fact analysis ratio in the model. These ratio numbers form the basis of the evaluation.**

4. **At the company level, a lean index can be defined that illustrates performance relative to the expected average lean goals, regardless of level. From the subjectivity of these lean goals, the model classifies lean performance along three different standardized norms. There is a high degree of subjectivity in the classification of results, so the evaluation of lean processes is a function of context. Therefore, in my model, lean performance is classified according to three standardized norms. Different standardized norms may result in different categories when evaluating the same performance. In this way, intervention points can be defined taking into account several contexts (1st ST, 2nd ST, 3rd ST). By mapping and reviewing them, they can help meet lean goals. The information from the results of the model provides more detailed, accurate information content for business decision-makers to make more effective decisions.**

5. **The conceptual lean controlling model can be applied to a number of problems and disciplines in which the application conditions of the model are given. As a result of the development of digitization, the application conditions of the model can be effectively fulfilled, as the data sets required for the analysis are available. If the conditions are met, the model provides an opportunity to illustrate in an indicator the expected extent of the achievement of the goals associated with the given area, taking into account the trends. The application of the model allows the application of a wide range of controlling and lean methods, but within specified limits and conditions.**

6. SCIENTIFIC PUBLICATIONS RELATED TO THE TOPIC OF THE

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