

Kolos I.

FORMATION OF THE KEY PERFORMANCE INDICATORS SYSTEM FOR LEAN MANAGEMENT OF ENTERPRISES

Об'єктом дослідження є елементи системи ключових показників ефективності (КПІ) у їх взаємодії для оцінювання результатів ощадливих змін з орієнтацією на стимулювання ощадливих перетворень. За результатами здійснення моделювання, критичного аналізу, логічного узагальнення обґрунтовано доцільність використання методів ощадливого виробництва в процесі формування цілісної системи КПІ і подальшого її практичного супроводу.

За результатами застосування 5 W, методів критичного аналізу і наукового інформаційного пошуку запропоновано застосування критеріїв відбору показників до системи КПІ:

- каузативність і каузальність між індикаторами і цілями розвитку в поточному періоді і на перспективу;
- іманентність часового лагу індикатора до операційних покращень і покращення фінансового результату;
- стимулююче спрямування індикатора до ощадливої трансформації і значущість;
- виключення індикаторів з мультиколінеарними зв'язками;
- виключення індикаторів, що створюють конфлікт інтересів.

Доведено, що поєднання 5 S+5 W+Jidoka+Kaizen посилить обґрунтованість в ході якісного відбору і включення конкретного аналітичного показника до системи КПІ. Комбінування SOP+VSM+Visual Management+Kanban забезпечить об'єктивність під час розроблення внутрішніх стандартів з оцінювання/аналізування результатів і динаміки ощадливих змін. SMED сприятиме коректності отримання результатів в процесі практичної реалізації сформованої системи КПІ в системі ощадливого управління підприємством.

За результатами системного і критичного аналізу, логічного узагальнення доведено важливість і доцільність розроблення внутрішніх стандартів підприємства з оцінювання/аналізування результатів і динаміки ощадливих змін:

- положення про організацію оцінювання/аналізування результатів і динаміки ощадливих змін;
- методика оцінювання/аналізування конкретного показника;
- альбом уніфікованих форм управлінської звітності;
- положення про автоматизацію оцінювання/аналізування в інформаційній системі.

Запропоновано їх анований зміст. Це забезпечить однозначність розуміння системи КПІ всіма зацікавленими сторонами, зменшення часу на генерування необхідного масиву даних та виконання розрахунків. Як результат, цілеспрямованість розроблення альтернатив для ухвалення виважених управлінських рішень з орієнтацією на підтримання прийнятного рівня ощадливих трансформацій і ефективності подальшого розвитку на засадах ощадливості.

Ключові слова: ключові показники ефективності, внутрішні стандарти підприємства, методи ощадливого виробництва.

1. Introduction

Before enterprises, they are actively introducing the concept of lean production, as a rule, there is a problem of correctly analyzing the achievement of goals and operating results on a continuous basis. Measurement becomes the primary task of management [1]. The question of selecting key indicators for the rational establishment and tracking of the dynamics and level of efficiency of lean changes within the enterprise, the value stream, specific employees are important and need to be addressed. The urgency of the problem is enhanced by the timely establishment of lean transformations and their assessment with a focus on minimizing waste (overhead) in all aspects of the activity and functions of enterprise management. In this regard, there is a need to develop methodological approaches to the formation of an effective system of key performance indicators (KPI), which provides for the introduction of internal evaluation standards.

2. The object of research and its technological audit

The object of research is the elements of the KPI system in their interaction to evaluate the results of lean changes with a focus on stimulating lean transformations.

It should be noted that the correctness of the assessment of the results of changes and the efficiency of the enterprise on the lean basis depends on:

- selection of a list of specific analytical indicators;
- consideration of causativeness and causality between indicators and development goals in the current period and in the future;
- consistency and orderliness in the form of an integral KPI system through causal relationships.

The formation of a KPI system has a significant impact in the system of lean enterprise management, with a focus on continuous minor improvements. Important and difficult is the justification of the selection criteria and the

number of indicators for assessing the budget changes, the frequency of their revision, as well as the development of internal standards. At the same time, it is advisable to find out the subordination and focus of each action in order to make informed lean management decisions. The introduction of the existing system of the KPI is a defining element of the system of functional enterprise management on the lean basis. The hypothesis of the study is the assumption that the procedure for the formation of a KPI system can be universal in the system of lean enterprise management, and the specifics of the economic sector are decisive for selecting indicators for the KPI system.

3. The aim and objectives of research

The aim of research is creation of a system of key performance indicators in the system for lean management of the enterprise.

Achieving this goal necessitated the following scientific objectives:

1. To bring the feasibility of a combination of lean production methods for the consistent formation of a KPI system for analyzing the results of lean transformations in the system of lean enterprise management.

2. To substantiate the composition and the main content of the internal standards of the enterprise for assessing/analyzing the results and the dynamics of lean changes.

4. Research of existing solutions of the problem

Question of analysis of the effectiveness of economic entities, which introduced the concept of lean production or its elements, are considered by scientists and practitioners for more than one year. For the first time, a KPI system was proposed [1] for estimating lean success. Emphasis is placed on the importance of determining the significance of each indicator, consistency with the goals of good governance and the avoidance of contradiction between indicators and targets.

In the published works of research results reasonably:

- the need to understand the order and algorithm of calculation, the role and value of a specific KPI in evaluating the processes and results of the operation of the enterprise [2]. That is why for inclusion in the KPI system it was proposed [3, 4] to test each individual analytical indicator;
- the expediency of a significant amount of contextual information to ensure the usefulness of each KPI and causativeness with management functions (planning, organizing, controlling, looking, regulating) [5];
- the feasibility of visualizing the KPI results [2]. In [6], it was established that it is appropriate to combine actual state graphs with trend graphs, which will allow the most profitable identify deviations and track the gap. At the same time, it was noted that trend charts are the best way to control the unstable deviation of the actual values of the KPI from target/planned.

The position [2] on the complexity of the task of forming a common KPI system for business entities of various sectors of the economy deserves support. Correct is the conclusion [7] about the feasibility of developing a unique KPI system by adapting the indicators recommended in ISO 22400 [8, 9] with the needs of a particular enter-

prise. At the same time, there is no single position on a rational quantitative and qualitative composition of KPIs in the system of lean enterprise management.

Some researchers [1, 3, 4] determine how necessary a sufficient number of 10 to 20 indicators are included in the KPI system. Other researchers in [10] argue about an individual approach to determining an acceptable number of KPI, depends on:

- size of the enterprise;
- the complexity of business processes;
- the number of targets and their priority.

There is no unity in the views of researchers regarding the allocation in the KPI system of lean management of subsets/groups of indicators:

- strategic indicators, value stream indicators, process indicators [1];
- indicators of the quality of the production, indicators of the amount produced, indicators of the cost of production, indicators of the duration of production [10];
- process indicators and organizational indicators [11].

Indisputable is the focus of the KPI system on the promotion of lean transformations and the achievement of a target basis for the development of an enterprise (mission and set of objectives).

Interesting position [6] on the feasibility of the formation of KPI regulations as a guide for assessment based on consistency. This will contribute to the regulation, planning and organization of the activities of the enterprise on the priority of goal-setting.

Recognizing the importance of the developments, it should be noted that the methods of lean manufacturing for developing a system of key performance indicators in the context of enterprise management on the lean basis have not been adequately justified. This determines the prospects of this problem and the need for this study.

5. Methods of research

The methodological basis of research for obtaining specific scientific results is general scientific and special methods of scientific knowledge:

- critical analysis, scientific information search – to establish the requirements for the selection of indicators for the formation of a KPI system;
- modeling, critical analysis, logical generalization – to justify the sequence of formation of the KPI system in the context of lean management of the enterprise;
- system and critical analysis, logical generalization – to establish the types and content of internal evaluation standards in the system of lean management of the enterprise;
- synthesis, induction, deduction – to justify the feasibility of using methods of lean production in the formation of a KPI system.

6. Research results

Undoubtedly, the activities of top management are not limited to the issues of assessment/analysis, which have to be solved when justifying and preparing alternative management solutions for their adoption. The volume and complexity depends on where, when, by what methods and means to carry out calculations, to establish the level of accomplishment of the tasks set and the achievement

of goals. Management's ability to skillfully select data, process it quickly, and generate correct conclusions is a key. The result is timely and high-quality execution of the tasks on the basis of an analysis of the actual state/level of functioning. That is why it is important to justify a rational system of KPI, its coordination with the target basis of lean management of the enterprise and maintaining in working condition on a continuous basis. The author proposes to use the following lean production methods for the formation of the KPI system as part of the study:

- 5 W (Five Whys);
- 5 S;
- Jidoka;
- Kaizen;
- Standard Operating Procedure (SOP);
- Value Stream Mapping (VSM);
- Visual Management;
- Kanban;
- Single Minute Exchange of Dies (SMED).

The issue of harmonization of criteria for the selection of indicators to a holistically-ordered system of KPI of enterprise operation on the lean basis is discussed. Thus, 5 W allows to study the causal laws and clearly establish the correct criteria. According to the results of the joint use of the 5 W, methods of critical analysis and scientific information retrieval [1, 4, 12] in the framework of research, it is proposed to apply the following selection criteria when forming the KPI system:

- causativeness and causality between indicators and development goals in the current period and in the future;
- immanence of the indicator time lag to operational improvements and improved financial results;
- stimulating the direction of the indicator to lean transformation and significance;
- elimination of indicators with multi-collinear links;
- exclusion of indicators, create a conflict of interest.

The implementation of 5 S is aimed at sorting and streamlining the totality of the proposed analytical indicators, followed by selection and systematization as a whole-ordered set of KPI. For correctness of selection and constant revision/updating of specific indicators, it is appropriate to use simultaneously:

- 5 W and verification tests [3] and establish cause-effect relationships between indicators;
- Jidoka will prevent the inclusion of indicators without focusing on the target basis of lean management;
- Kaizen promote continuous improvement and the formation of proposals for the change of certain indicators.

So, the combination of 5S+5W+Jidoka+Kaizen is aimed at active involvement of specialists in the selection of analytical indicators for the KPI system, the submission of proposals for revision and improvement on a continuous basis. It is worth noting that the effectiveness of the KPI system has a significant impact on goal setting when choosing specific indicators. To assess the state, dynamics and efficiency of lean changes and transformations, it is important to create an original KPI system with a focus on the built-in quality of indicators and making calculations taking into account:

- specifics of the type of activity and volume of business;
- organizational and legal form of management;
- management structure and production structure;
- priority development areas;
- the level of maturity and readiness to implement lean management.

For the unification of the primary KPI system in the context of lean production, ISO 22400 has been developed. Thus, ISO 22400-2: 2014 is recommended to use 34 KPIs to assess the effectiveness. Each indicator is described according to the following scheme [9]:

- name/title of indicator;
- identifier;
- description;
- application;
- timing;
- formula;
- unit/dimension;
- rating;
- analysis/drill down;
- user group;
- effect model;
- manufacturing type.

It is important to note that the use of ISO 22400 is aimed at facilitating the selection and implementation of the most important and acceptable KPI for analyzing the state of readiness and the level of lean management with the subsequent coordination of the planned activities and actions.

It is advisable for an enterprise to form a system of internal standards for evaluating/analyzing the results and dynamics of lean changes. The law of Ukraine fixes the standard period as «... a normative document based on consensus, adopted by a recognized body that establishes for general and repeated use of rules, instructions or characteristics about an activity or its results, and aims to achieve an optimal degree of orderliness in a particular area...» [13]. The proposed integrated use of SOP+VSM+Visual Management+Kanban, which ensures the development, adoption and implementation of a system of internal standards, covers the following groups:

1. *Organizational standards* governing the organizational aspects of the analytical work of the enterprise as a whole, a functional unit or a dedicated management entity, a separate workplace. The establishment of correct relationships within the enterprise is aimed at the management's awareness of the security of a timely response to the identified changes through the justification and adoption of effective, lean management decisions.

2. *Methodological standards*, standardized describe the method of calculating each indicator for a single format. As a basis, it is advisable to choose a format structure that is recommended by ISO 22400. This will help to unambiguously understand the essence of the KPI and minimize the time spent on data retrieval and calculation. At the same time, the objectivity and reliability of the evaluation results will be enhanced, as well as the comparability of the consolidated results for top management. This approach focuses on a motivated improvement in the level of achievement of target results by each employee.

3. *Technical standards*, representing in visual format the options for visualization of the KPI results: a graph of the actual state, a graph of the desired state, a graph of the ideal state, as well as their combination. This is the best way to control the unsustainable deviation of the actual values of the KPI from target/planned.

The author has developed a package of internal enterprise standards for evaluating/analyzing the results and dynamics of lean changes, the annotated characteristics of which are presented in Table 1.

Table 1

Internal standards of the company for evaluating/analyzing the results and dynamics of lean changes

Standard	Annotated characteristic
1. Organizational standard	
Regulations on the organization of assessment/analysis of the results and dynamics of lean changes	<ol style="list-style-type: none"> 1. The actions of specialists in assessment/analysis of the results and dynamics of lean changes are fixed. 2. Established responsible specialists with a list of job responsibilities for assessment/analysis the results and dynamics of lean changes. 3. A list of types of liability is defined in the context of the content of the violation, indicating specific measures of influence to violators. 4. The procedure for delegation of authority and responsibility for the activities and results is defined. 5. Types and control procedures are established. 6. A motivation system is established, taking into account material and moral incentives/disincentives
2. Methodical standards	
Method of assessment/analysis of a specific indicator	<ol style="list-style-type: none"> 1. KPI feasibility is determined. 2. The description of the procedure for KPI calculation is fixed. 3. Alternative management decisions are identified that can be made based on the result of the KPI calculation. 4. The order of viewing/replacing the KPI and its range is established. 5. Consolidation with the system of motivation to achieve an acceptable KPI level is fixed
Album of unified forms of management reporting	The essence set out in [14]
3. Technical standard	
Regulation on automation of assessment/analysis in the information system	<ol style="list-style-type: none"> 1. The information assessment/analysis system with a description of its main technical characteristics is fixed. 2. The order of administration and support of software with the distribution of rights and control access to user information is established

SMED acquires strategic importance if it is necessary to quickly reconfigure technical means for carrying out calculations or data exchange between information systems within the shortest possible time. This will avoid downtime and errors during the practical maintenance of the developed and implemented KPI system.

As a result of the implementation of the system standardization of assessment/analysis of lean transformations and the practical implementation of the provisions of the developed internal standards, it will be possible to:

- unification of the system of analytical indicators for assessing/analyzing the results and dynamics of lean changes in a business entity;
- reducing the influence of the level of professional competence and subjectivity of professional judgment on the establishment of an algorithm for determining a specific analytical indicator;
- reducing the complexity of the procedures for generating/selecting the necessary data and calculating values;
- prevention of possible variation of the algorithm for calculating a specific analytical indicator;
- consistency and compliance with the recommendations of ISO 22400.

7. SWOT analysis of research results

Strengths. The strength of research is the further development of the internal standardization of an integrated system of key performance indicators in the system of lean

enterprise management. This will ensure an unambiguous interpretation of the goal and the procedure for determining a specific indicator by all interested parties, reducing the time to generate the necessary data set. As a result, the purposefulness of the development of alternative management solutions with a focus on maintaining an acceptable level of lean changes and transformations, as well as the effectiveness of further development on the basis of lean.

Weaknesses. The weak side is the choice of criteria for the selection of indicators in the formation of a system of key performance indicators in the system of lean enterprise management. The obtained results are subjective and may be incomplete, so it is necessary to carefully carry out a scientific search in this area of research.

Opportunities. The opportunities of further theoretical and applied research consist in the formation of a KPI hierarchical model in the management of an enterprise on the basis of lean production. At the same time, it is advisable to carry out experimental confirmations by testing the proposed methodological guidelines for the formation of a KPI system for evaluating the results of lean changes in the activities of an enterprise.

Threats. Threats for further research are the difficulty of correctly developing a KPI system and proper implementation of a system of internal standards for assessing/analyzing results and the dynamics of lean changes. This is due to the leadership's willingness to track lean transformations and the development of lean thinking of the staff.

8. Conclusions

1. Application of lean production methods is received a further development (5W, 5S, Jidoka, Kaizen, SOP, VSM, Visual Management, Kanban, SMED). This will ensure objectivity, strengthen the soundness and correctness of the system of key performance indicators at different stages of its development and maintenance:

- 5W when establishing and justifying the criteria for the selection of indicators to the KPI system;
- combination of 5S+5W+Jidoka+Kaizen during the qualitative selection and the inclusion of a specific analytical indicator in the KPI system;
- combination of SOP+VSM+Visual Management+Kanban in the development of internal standards for assessment/analyzing the results and dynamics of lean changes;
- SMED in the process of practical implementation of the existing KPI system in the system of lean enterprise management.

2. A feasibility of developing internal standards for assessing/analyzing the results and the dynamics of lean changes is proved. The system of such standards is the basis for a rational justification of lean management decision through the correct selection of analytical indicators, an understandable algorithm for calculating them, and recognizing an acceptable range of recommended values. The main content of the package of internal standards in the context of groups is determined:

- organizational standard – Regulation on the organization of assessment/analysis of the results and dynamics of lean changes;
- methodical standards – Methods for assessing/analyzing a specific indicator; Album of unified forms of management reporting;
- technical standard – Regulation on automation of assessment/analysis in the information system.

References

1. Maskell B., Baggali B. Praktika berezhlivogo ucheta: upravlencheskiy, finansovyy uchet i sistema otchetnosti na berezhlivykh predpriyatiyakh. Moscow: Institut kompleksnykh strategicheskikh issledovaniy, 2013. 384 p.
2. Implementing and Visualizing ISO 22400 Key Performance Indicators for Monitoring Discrete Manufacturing Systems / Ramis Ferrer B. et. al. // *Machines*. 2018. Vol. 6, Issue 3. P. 39. doi: <http://doi.org/10.3390/machines6030039>
3. Neely A., Adams C., Kennerley M. The Performance Prism: The Scorecard for Measuring and Managing Business Success. Prentice Hall, 2002. 417 p.
4. Felps B. Umnye biznes-pokazateli: Sistema izmereniy effektivnosti kak vazhnyy element menedzhmenta. Dnepropetrovsk: Balans-Klub, 2004. 312 p.
5. Brandl D. L., Brandl D. KPI Exchanges in Smart Manufacturing using KPI-ML // *IFAC-PapersOnLine*. 2018. Vol. 51, Issue 11. P. 31–35. doi: <http://doi.org/10.1016/j.ifacol.2018.08.230>
6. Richard J. Schonberger. Lean performance management (metrics don't add up). 2008. URL: [http://leanaccountingsummit.com/images/Schonberger %20Article.pdf](http://leanaccountingsummit.com/images/Schonberger%20Article.pdf)
7. Diego Fernando M. D., Rivera Cadavid L. Lean manufacturing measurement: the relationship between lean activities and lean metrics // *Estudios Gerenciales*. 2007. Vol. 23, Issue 105. P. 69–83. doi: [http://doi.org/10.1016/s0123-5923\(07\)70026-8](http://doi.org/10.1016/s0123-5923(07)70026-8)
8. ISO 22400-1: 2014. Automation systems and integration – Key Performance indicators (KPIs) for manufacturing operations management – Part 1: Overview, concepts and terminology. URL: <https://www.iso.org/standard/56847.html>
9. ISO 22400-2: 2014. Automation systems and integration – Key performance indicators (KPIs) for manufacturing operations management – Part 2: Definitions and descriptions. URL: <https://www.iso.org/standard/54497.html>
10. Borsos G., Iacob C. C., Calefariu G. The use KPI's to determine the waste in production process // 20th Innovative Manufacturing Engineering and Energy Conference (IManEE 2016) IOP Conf. Series: Materials Science and Engineering. 2016. Vol. 161. P. 012102. doi: <http://doi.org/10.1088/1757-899x/161/1/012102>
11. Lean Government Metrics Guide. URL: https://www.epa.gov/sites/production/files/2014-04/documents/metrics_guide.pdf
12. DeWayne L. Searcy. Developing a Lean Performance Score // *STRATEGIC FINANCE*. 2009. P. 34–39. URL: <https://sfmagazine.com/wp-content/uploads/sfarchive/2009/09/Developing-a-Lean-Performance-Score.pdf>
13. Pro standartyzatsiiu: Zakon Ukrainy No. 1315-VII. 05.06.2014 (zi zminamy). URL: <http://zakon3.rada.gov.ua/laws/show/1315-18>
14. Kolos I. V. Pokaznyky zvitnosti pidpriemstva v systemi oshchadlyvoho upravlinnia // *Oblik, Ekonomika, Menedzhment: naukovy notatky / Mizhnarodnyi zbirnyk naukovykh prats*. 2015. Issue 1 (5 (2)). P. 163–171.

Kolos Iryna, PhD, Associate Professor, Department of Accounting and Auditing, National University of Food Technologies, Kyiv, Ukraine, e-mail: iryinakolos2016@gmail.com, kolos_i@meta.ua, ORCID: <http://orcid.org/0000-0001-7134-1441>