

Lean management as the innovative technology of an enterprise

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Abstract. The paper is devoted to the problem of management of innovative activity of an enterprise on the basis of Lean technology. The study shows that there are no generally accepted theoretical models for understanding this relationship and its unambiguous assessment. The paper discusses a pilot study of the relationship of Lean management factors and innovative activity for large Russian enterprises taking into account their life cycle and type of innovation. The results of the study demonstrate the correlation between lean production and innovative activity of the enterprise. The conclusions on the impact of the type of enterprise (business), the stage of its life cycle and the type of innovation on this relationship are innovative and important. The study is aimed at testing the methodology of future research, the purpose of which is to build a mathematical model of such a relationship.

1 Introduction

The main trend of modern management is to increase the innovative activity of the enterprise. The development of globalization, digitalization of production and customer orientation require innovative activity that increases the competitiveness and sustainability of the enterprise. Innovation is the introduction of a new product or service to the market, the introduction of a new production process, the development of a new business model, and the creation of new markets [1]. There are generally seven types of innovation [2]: technological innovation, process innovation, product innovation, innovation products, works, services, marketing innovation, organizational innovation, environmental innovation. Innovative development is carried out within the framework of the innovation process through the implementation of certain stages and business processes [3], and involves an extensive range of scientific, technological, organizational, financial, marketing, commercial activities and is only possible with the appropriate level of innovative activity of the enterprise.

Currently, there are many approaches to increase the innovation activity. One approach to increase the innovation activity of the company is the concept of "lean production". Lean management implies the identification and elimination of all types of losses and processes that do not generate value for the consumer [4]. The studies show that lean production methods lead to a reduction in the time of orders, rapid creation of new standards of work; optimization of orders leads to increased production "margin" [5, 6]. Lean production tends to be aimed at innovation in the improvement of production, but more recently, there is concern regarding

the fact that it may contribute to the innovative development of the enterprise as a whole and increase its innovative activity.

Nevertheless, innovation experts are quite ambiguous in assessing the relationship between the methods of "lean production" and the innovative development of the company. On the one hand, lean production methods may be part of product and technological innovations, or through organizational and cultural changes at the enterprise lead to the formation of an innovative culture in the company. On the other hand, according to their purpose, lean production methods are aimed at optimizing the existing technologies. Therefore, according to a number of researchers, they "conserve" the current state of affairs and "slow down" the innovative development of the enterprise. This means that at the moment the problem is the relationship between the innovative development of companies and the methods of lean production: how does lean production affect the innovative development of the company?

Our hypothesis is that the use of lean production tools contributes to the innovative activity of the enterprise. At the same time, it is necessary to take into account the size of the enterprise, the stage of its life cycle, the type of innovations (horizontal and vertical), since different tools of lean production are required at different stages of the enterprise life cycle for different purposes.

The purpose of this paper is to analyze approaches to the interaction of lean production and innovative activity, as well as to test the tool of empirical study of the relationship between lean production factors and indicators of innovative activity. The purpose of this pilot study is to test the methodology based on the life

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cycle of the enterprise and the type of innovation to verify our hypothesis during a further large-scale research project.

The objectives of this project are as follows: first, the analysis of the relationship between lean management and the innovative development of the enterprise, second, the analysis of the relationship between the factors of lean production and the factors of innovative activity, third, the consideration of the features of the use of lean production tools in order to increase the innovative activity of the company taking into account the life cycle and type of innovation. The solution of these problems will not only confirm the initial hypothesis of the study, but will also make it possible to formulate a mathematical model of the relationship between the factors of lean production and indicators of innovative activity, which will become the basis for managing innovative activity through the use of lean production tools.

2 Methods and Materials

2.1. Theoretical description

A fairly large number of studies are devoted to the relationship between innovative development and lean production. All of them may be divided into two groups.

The first group includes studies in which the relationship and mutual influence are evaluated quite positively. As a rule, these works emphasize the study of the influence of lean management on individual sides of the innovation process.

First, the use of lean management tools leads to increased customer orientation, the introduction of new services, and the formation of innovative leadership. These factors of lean production become the factors of increased innovative activity of the company. Thus, the study [7] shows that in companies, which business is based on the provision of traditional services, the use of lean production tools contributes to the development of customer-oriented business, the introduction of innovative ways of customer service. The work of Iranian researchers [8] raises the issues of how the innovative behavior of the company's employees is formed. The results show that there is a positive relationship between employee participation in lean thinking and the innovative behavior of employees, and that the introduction of lean production methods generally contributes to the formation of an innovative climate in the enterprise.

Second, lean production methods are seen directly as tools for managing innovation, more precisely, tools for the fastest commercialization of innovation. In the work [9], the authors of the study conclude that with the use of lean production tools, the original innovations in the new business may be introduced more efficiently. This is confirmed by the study [10], in which lean management methods are considered as tools for generating additional added value for product innovations.

Third, there are some works that consider the specific use of lean management in supply chain operations and

improving methods aimed not at further waste reduction, but at achieving environmental effect. This concerns operating companies. Thus, the study [11] shows how sustainable lean production programs have contributed to improved performance.

Fourth, these are studies of the impact of lean production methods on the efficiency of innovative processes in production organizations. The research is very important here [12]. Researchers A.K. Moldner, J.A. Garza-Reyes, V. Kumar state that "little is known about such an influence"; therefore, in their study, three hypotheses were put forward about the negative, neutral and positive effect of lean production on the effectiveness of innovative processes. These large-scale surveys made it possible to formulate a refutation of the misconception of scientists and leaders that lean management and innovation are difficult to coexist. The conclusion is that the practice of lean production has a generally positive effect – from moderate to strong – on the introduction of additional and radical technological innovations in production organizations. Innovations, in turn, improve the operating performance of companies. Besides, the authors of the study proposed an integrative structural model, which is considered as a system of interconnected internal and external processes that together increase the innovation of the company. This model is open to additions, and different types of external and internal processes may be easily integrated into it. The general conclusion of this study is important – the integrative approach implies that lean innovation management stimulates the overall innovation of companies.

Adjacent to this are Lean-Startup efficacy studies [13; 14; 15; 16]. These studies are less optimistic because they note that Lean-Startup methodologies emerged precisely to reduce uncertainty of project-based innovation. The key point in applying these tools is to reduce the uncertainty of the innovation process, increase the soundness of decisions when introducing innovations and reduce the share of "dying" startups. However, in general, Lean-Startup management also proceeds from the direct positive impact of lean production on the innovative development of the company.

Finally, fifth, there are works considering the synergistic effect of lean production and innovative development. This concerns the difference in the goals of these management methods: innovation is aimed at the development of the enterprise, while lean production – at its sustainability. Therefore, a number of authors prefer to say that "lean processes may positively and negatively affect the company's sustainable performance depending on the state of its innovation capacity" [17]. A synergistic approach is also considered in another study based on the analysis of small and medium-sized enterprises [18]. Here, lean and sustainable innovations are considered as input criteria, and the economic, operational, environmental and social aspects of the enterprise are considered as output criteria for assessing its innovativeness. The main conclusion is that the combination of lean production and innovations helps to achieve sustainability of the supply chain.

Nevertheless, it cannot be argued that there is unambiguous evidence of the positive impact of lean production on the innovative development of companies. There are quite a few skeptics who consider this relationship not so unambiguously. Therefore, in the literature there is a second group of studies where this assessment is quite negative. Here, the main argument is that lean production is aimed more at stabilization and sustainability than at development.

At the same time, it is usually indicated that in modern management there is no clear idea of indicators of innovation and indicators related to lean production. This makes it impossible to clearly divide between these indicators and establish a correlation between them. Thus, according to [19], there are 4 groups of indicators, one of which is innovation, among the indicators of lean production. Other sources [for example, 12], on the contrary, consider the indicators of lean production factors as the indicators of innovative development. Besides, in all such studies, the original theoretical models themselves are different, and therefore the understanding of the relationship between lean production and innovative activity is different. This results in research findings being limited or even incompatible with other studies.

Moreover, the studies are often associated with different types of innovation, and this is an important success factor. For example, in the study [20], continuous improvement programs are associated with incremental innovations and process innovations. Lean production is more associated with gradual innovations than with radical ones [21]. Other studies consider product innovations. There is also little research on the relationship between the continuous improvement programs of Lean, Six Sigma and Lean Six Sigma, and the effectiveness of innovation.

Another aspect of the negative assessment of the impact of lean production on innovations is indicated in the work already reviewed [17]. The authors believe that different tools of lean production may act differently depending on the level of innovative development of the company. Therefore, it is quite possible, using different tools of lean production at different stages of the innovation process, to contribute to the growth of innovative activity by streamlining at initial stages and freeing up time and resources. From the point of view of the authors of this study, the most important issue is the determination of the balance and the point of view of using lean production tools in the company's innovation process.

Finally, there are works that deny the positive impact of lean production on innovative development associated with modern digitalization of production. Digitalization and lean production often contradict each other. Therefore, it is necessary to consider open process innovations. This does not mean the rejection of lean production methods at all, but, firstly, it indicates their subordination to digital technologies in the production process of the enterprise, and, secondly, the introduction of approaches to lean production in digitalization and transformation processes to accelerate them.

Based on the analysis of these works, it may be generally concluded that the negative assessment of lean production regarding innovation does not concern so much the lean production itself as a management technology, but its correct use in working with open and constant innovations. These questions are considered in the study of J. Craig, G. Pairaudeau, J. Pettersson [22], in the study [23]. The positive relationship between improvement programs and incremental innovations in products and processes shows that such improvements may lead to increased innovation opportunities.

However, the following should be noted. First, there are not enough empirical studies that clearly record the positive impact of lean production on innovative development. Second, there is no clear distinction between indicators of innovative development and factors of lean production. Hence the difference in the methodology of such studies is that their results are clearly verified on a certain empirical basis, but cannot be transferred and tested on other empirical material. Third, only some studies are devoted to large enterprises. And, fourth, there is no research that takes into account the life-cycle stages of the organization when establishing the relationship between lean technologies and innovation activities.

This is what determines the author's approach to the study of the influence of lean production tools on the innovative activity of the company.

2.2. Research methodology

Our hypothesis is that lean production positively affects the innovative activity of the enterprise. This hypothesis is based on the following studies [24, 18, 20] and our own study [25, 26].

The purpose of our study is to analyze the impact of lean management on the innovative development of companies, taking into account the type of innovation, on the one hand, and the life cycle of the company, on the other. Therefore, with the general methodology of the study based on the works [27, 20] other meaningful changes have been made to it. First, the list and content of judgments based on the preliminary classification of lean production factors and external and internal factors of innovative activity have been changed. Second, the difference is the testing of the research methodology at large industrial enterprises of the Russian Federation. Unlike small and medium-sized enterprises, for which innovative activity is not always the primary factor, for these enterprises innovative activity is the main factor of sustainability. Besides, only innovative enterprises participated in the study. This is fundamentally important for the development of Russian business, for which large enterprises are the driver of the innovative development of the national economy in general. Finally, the third distinguishing feature of our study is the recognition of the difference between horizontal and vertical innovations.

At the same time, we took into account the following limitations of this study. The innovative activity of the enterprise is an integral indicator determined by various

factors. Meanwhile, we adhere, firstly, to taking into account only a limited list of factors of innovative activity (the presence of completed vertical innovations, the presence of completed horizontal innovations, the share of innovation costs, the speed of implementation of new ideas, the coefficient of introduction of new products, the competitiveness index of goods, the presence of the R&D department, the level of qualification and competence of personnel involved in the development of innovations, the resource potential of innovative activity. In this study, we do not define an integral indicator of innovative activity. This is explained by the subsequent task of our research project – provided that a quantitative model is obtained of the influence of a certain list of factors of lean production on indicators of innovative activity – the creation of a system for managing the increase of innovative activity by managing these factors. At the same time, this is a primary validation test of the conceptual model itself. It is important to understand the fundamental correctness of the model aimed at confirming our hypothesis.

The main purpose of the study is to determine the existence of a relationship between the level of innovative activity and the degree of use of lean production tools.

As a **pilot study tool**, an expert survey form was developed containing 20 statements based on the Likert scale (Likert scale – a starting point for the development of the tool was research [23, 18, 20, 26] – however, the shape of the tool was significantly refined): six statements characterizing the overall level of development and sustainability of the organization, nine reflecting innovative activities, and five statements on lean production tools. Besides, four questions were included in the questionnaire to identify the type of the enterprise: number of employees, industry, scope of activity, position of the respondent. Previously, the tool was validated ensuring the sustainability of judgments (the starting point for this was 80 negative and positive judgments). The indicators of innovative activity are taken from existing methods [28, 29, 30, 31]. As part of the pilot study, the experts were offered judgments that belong to three groups of factors influencing the company’s sustainable competitive development, namely:

- fundamental factors, including conditions for sustainable management of the production system;
- factors determining the availability of lean production principles and tools in the company’s production system;
- factors determining the presence of innovative processes and prerequisites for innovative development of the company.

Research method – an expert survey, which is optimal for collecting the necessary data (respondents must be professionals in the management and innovation of a particular enterprise).

Research object – innovative large industrial enterprises in various industries of Perm and Perm Territory.

Research subjects – factors of innovative activity, lean technologies.

Sampling description and calculation.

The representatives of Perm and Perm Territory enterprises took part in the survey: heads of enterprises, development directors, and employees engaged in innovation and production. The pilot sampling included 21 enterprises (optimal sampling for the study).

The sampling is available: the study involved organizations that were ready to disclose information (including commercial), as well as experts who had time to answer the questions in the questionnaire (in several stages). The sampling is quota-based: innovation and lean technologies at enterprises should have a decisive role; innovation is carried out at enterprises (any types of innovation, not only product innovations). The market in which experts work does not belong to the oligopoly or to the monopoly. The sampling included production enterprises from different industries.

Place and time of contact with respondents. The survey of experts was conducted in their offices, as well as through communication by e-mail and on social networks.

3 Results and Discussions

The results of the study show the development of innovative activity of the enterprise due to the implementation of lean production tools. Let us formulate key conclusions of the analysis.

1) The relationship between the factors of innovative activity of the company and lean production was revealed. It is established that it is positive, which is confirmed by the indicators of the variation coefficient $\gamma \leq 33\%$ specified in Table 1. Calculations were performed using the Integrated Analysis Methodology, which includes the collection of expert estimates and their statistical processing [32].

Table 1. Results of a comprehensive factor analysis of the relationship between sustainable management of the production system, innovation activity and lean production

Group of factor	Variation coefficient (γ), %	Upper quartile indicator and factors
Fundamental factors that include conditions for sustainable management of the production system	10.96	- Company’s position at the “Growth” and/or “Stability” stage - Involvement of employees in the process of developing new products, ideas, processes
Factors determining the availability of lean production principles and tools in the company’s production system	29.9	- Application of the set of lean production tools (flow mapping, visual control, 5S, etc.) - Leadership interest in the results of lean production in the company’s production system
Factors		- Development and

determining the presence of innovative processes and prerequisites for innovative development of the company	24.8	implementation of vertical and horizontal innovations - Development of R&D Institute - Highly qualified staff involved in innovation development
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The calculation was made according to the following formulas:

Mean-square deviation of estimates:

$$\sigma = \sqrt{\frac{\sum_{i=1}^n (X_i - \bar{X})^2}{n}} \quad (1)$$

where, n – number of experts; X_i – value of i expert.

Coefficient of variation:

$$\gamma = \frac{\sigma}{\bar{X}} \times 100, \% \quad (2)$$

2) The factor analysis suggests that fundamental factors ($\gamma=10.96\%$) demonstrate the greatest convergence and significance in the relationship of the three groups of factors. The most important factors for ensuring the relationship between “Sustainable Management – Innovation Activity – Lean Production” are the following:

- in the group “**sustainable management of the production system**”: position of the company at the “Growth” and/or “Stability” stage and the involvement of employees in the process of developing new products, ideas, processes;

- in the group “**factors determining the availability of lean production principles and tools in the company’s production system**”: use of a set of lean production tools; leadership interest in the results of lean production in the company’s production system;

- in the group “**factors determining the presence of innovative processes and prerequisites for the innovative development of the company**”: development and implementation of vertical and horizontal innovations; development of R&D; highly qualified staff involved in innovation development.

3) Fundamental factors affecting the level of innovation activity are the stage of the company’s life cycle and the company’s mainly horizontal (process) or vertical (revolutionary) innovations.

4) A possible confirmation of our hypotheses is the opinion of experts who note the potential of opportunities due to the application of lean management principles and tools, which stands in the position of rational distribution of all the resources available to the company. At the same time, the type of innovation is an important factor. The role of lean production tools is maximized when it comes to process and organizational, horizontal innovations. Besides, their role is minimal

(but the use of tools is necessary) for the introduction of vertical, breakthrough innovations.

5) Life cycle and relationship of lean production and innovation activity. According to most experts, the streamlining and systematization of all processes, as a result of the use of lean production tools, allows freeing up temporary, information and material resources aimed at building the innovative potential of the company. This is also confirmed by the relationship between the major group factors and the second and third group factors, and there is a convergence in understanding the need to involve all staff in innovation processes and to introduce lean production philosophy and tools; to ensure leadership transparency; to welcome new ideas and projects (vertical and horizontal innovations).

6) Types of innovation activity and the relationship between innovation activity and lean production. The closest link between the indicators of innovative activity and lean production is observed at the “Stability” stage. Regarding the stages of the life cycle “Decline” and “Launch”, the answers of experts are quite close in their values, i.e. they poorly demonstrate the relationship of the studied factors. At the same time, at the “Decline” stage, companies use vertical innovations to a minimum degree, compared to other stages. At all other stages, experts noted the same importance for both types of innovations (Figure 1).

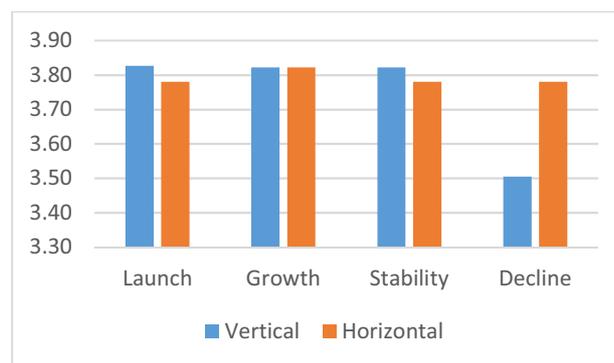


Fig. 1. Relationship between the life cycle phase and company innovation activities

7) The stage of development of the organization and innovative activity. It is important to take into account the development stage of the organization and the stages of the innovation process, since the goals and objectives of using lean production tools may differ depending on the level of development and level of innovation of the organization. Thus, at the “Launch” stage, the role of lean production tools may be minimal, while at the “Growth” and “Stability” stages it is necessary to organize processes to release resources.

4 Conclusions

The results of the study are largely determined by the research methodology and experts involved in assessments. The problem with such a study is that innovation experts may generally agree with the parameters for estimating innovativeness in the study,

but as respondents they may disagree with the specific estimates (results) of the study. As the managers of a company, they may see a negative correlation between the actual commercialization of innovations and the obtained estimates. This does not question the correctness of the model, but raises the question of its applied significance.

Within the framework of the study it was important to understand the fundamental correctness of the model aimed at confirming our hypothesis. The results obtained in such a limited study (in case of positive validity of the conceptual model) make it possible to raise the question of the system of management of lean production indicators as tools for innovative development of the company. However, full confirmation of the hypothesis should be carried out in a larger sampling of industrial enterprises, and this goes beyond the scope of the present study. Based on this, it is possible to build a mathematical model of this relationship (DEA). Therefore, as part of further research it is necessary to expand the sampling, determine its size on the basis of statistical calculations taking into account such restrictions as industrial enterprises, size – large (300 or more employees), the presence of innovative activity, the introduction of vertical and horizontal innovations, the life cycle of the company. Sampling should be performed in the context of the life cycle stages of the organization, since the goals and motives for using lean production tools to increase the innovative activity of the enterprise at different stages of the life cycle may be different. Thus, the construction of a mathematical model of the relationship between lean production factors and indicators of innovative activity is the task of a future large study, the testing of which is covered in this paper.

In case of empirical confirmation of the initial conceptual model (mathematical dependence of lean production factors and indicators of innovative activity), the question may be raised about the system of management of lean production indicators as a tool of innovative development of the company. The management of this model may influence the choice of innovative development strategy. This is the next task of our research project.

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