Process of Technological Innovation Management in a Manufacturing Company: Assessment and Improvement

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Abstract In the modern world, to ensure their competitiveness, organizations are forced to continuously improve their activities, especially through the implementation of innovative technological products and services. This paper presents an approach to assessing the innovation management process of a manufacturing company. It also formulates the areas for improving this process on the example of medium production enterprises in Russia. The TIPA process evaluation method is used as the basis of this approach. In analyzing and formulating recommendations for improving the process, the reference models, methods and frameworks are used: COBIT 2019, PCF APQC, Capability-Based Planning and TOGAF Standard, Agile—Stage-Gate method. Based on the experience of conducting this assessment at 3 Russian manufacturing enterprises, recommendations are formulated on the application of this approach. The main directions of improving the process of technological innovation management are also identified.

Keywords Innovation management · Process assessment · TIPA · COBIT · PCF APQC · Enterprise architecture · Agile–stage-gate

1 Introduction

The practice of implementing the innovation management processes and creating new products in manufacturing companies shows that those who have described and tuned this process are two to three times more likely to succeed [1]. Leading companies have a formalized process of managing a new product from idea to launch (new-product development projects from idea to launch). Various researchers notice that traditional development methods no longer work effectively, because they do not allow proactive responses to changing conditions and requirements. Leading-edge companies are switching to the Agile-Stage-Gate hybrid model, as it retains a stage system to support structure and control, while allowing for a flexible development

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E. Zaramenskikh and A. Fedorova (eds.), *Digital Transformation and New Challenges*,
Lecture Notes in Information Systems and Organisation 45,
https://doi.org/10.1007/978-3-030-71397-3_3

approach, providing the required high rate and productivity of implementation of innovative solutions [2].

The aim of this work is to determine the optimal approach to assess and improve the process of managing the technological innovations of a manufacturing enterprise. Therefore, two key questions are formulated:

1. What approach should be used to evaluate the innovation management process?
2. Which reference model is best suited for constructing the target state of the process of a given process?
3. Which improvement path is the most preferable for the innovation management process of an average manufacturing company?

In the main part of this article, in Sect. 1, we analyze scientific research and practical experience in the field of evaluating innovation management processes and developing a new product. It discusses modern standards in the field of process management and IT management, reference models and frameworks that contain recommendations for the study, evaluation and improvement of business processes and IT processes. Section 2 describes the proposed approach to process evaluation. Section 3, using the example of three medium Russian manufacturing and trading companies, shows how the above approach was applied and what results were obtained.

Approaches to the assessment and improvement of management processes.

Technological innovations represent the key tools for achieving strategic goals, capturing the best market positions or entering new markets for goods and services. For companies that adhere to the "Value Innovation" concept, innovation is necessary to create new markets and re-evaluate the existing ones [3]. The organization of innovative activities in the company has for a long time been an object of close attention. M. Hammer has developed a number of recommendations on the effective implementation of innovations, on procedures of auditing the processes [4–6].

Multiple approaches and methods for assessing and improving the business processes have been formulated to date. Different methods of improvement were proposed by Harmon [7], Madison [8]. However nowadays, when the conditions in the external and internal environment of the company change very fast, these approaches are not so efficient. Therefore a need has arisen for more flexible methods of evaluation and improvement.

Various approaches are used for these purposes in production companies. They are proposed in intersectoral and specialized frameworks and standards, for instance the ISO / IEC 33002 [9], the CMMI [10] family of models, COBIT PAM, COBIT 2019 [11], TIPA [12], Enterprise SPICE [13] and Automative SPICE [14]. Each of these standards has its own characteristics of application, and was originally developed for specific industries, but today they all have an intersectoral character.

For example, TIPA complies with the requirements of ISO/IEC 33002 in process assessment (standard scale and evaluation method, standard maturity scale, standard aggregation method) [15], and also with ITIL in terms of planning IT service management and improving IT processes [12]. When the processes related to technological innovation are concerned, such a two-fold compliance becomes an important

advantage in choosing the assessment method. The disadvantage of TIPA is the lack of coupling with the principles of Enterprise Architecture [16]. This makes it difficult to plan changes in accordance with the strategic goals of company and the key architectural factors. This deficiency can be compensated by using the concept of Capability-Based Planning and the ArchiMate Standard for coupling the Enterprise Architecture. This will allow to simulate the dependencies between the capabilities, which is very important when forming the roadmap of transformations [17].

The procedure of evaluating the process can be conventionally divided into two kind of work [13]. One work consists in comparing the current process with reference models, recommendations from industry and government regulatory organizations, and best practices. The second work is identification of areas for improvement of process under investigation using maturity assessment models or opportunity assessment models.

The following models and classifications can be considered as reference basis: ISO / IEC 15504-2; intersectoral or specialized process classifiers, such as PCF APQC; industry reference models, such as: COBIT for IT processes, SCOR for supply chains.

In the course of analyzing the organization of the process under investigation, it is necessary to study the principles and methods of management, and evaluate how they correspond to the goals and objectives of the company and how they will assure the required level of productivity and effectiveness.

In the field of technological innovation management and creation of IT products and services, the key requirements for the processes of development and implementation are the speed and the compliance of result with consumer expectations. To ensure the agreement with these requirements, companies are forced to use flexible multi-iterative methods of managing the products and services. Such concepts and methods include Len Startup [18], Agile [19, 20]. In manufacturing companies, the management of technological product development is also increasingly shifting to flexible techniques. For instance, the use of Agile–Stage-Gate hybrid method allows increasing the rate of development of innovative solutions and providing the required number of iterations to achieve the customer satisfaction with a found solution [2].

2 Development of an Approach to Assessing the Process of Innovation Management

An approach to assess the process of innovation management was developed for medium-sized manufacturing companies whose main activity is not related to providing the IT services. In order to remain competitive, they are developing new sources of value. Among them are automation of customer interaction, marketing and consumer processes [21], as well as improvement of production management processes using IT.

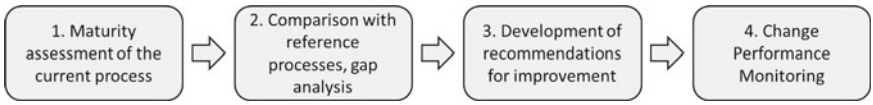

Fig. 1 Key stages of the adapted TIPA method (Class 2)

In this paper, we are talking about medium-sized manufacturing enterprises, to which we conventionally classify companies with revenues of 1–2 billion roubles a year and a staff of 250–1000 people. Most of these enterprises have already the partially or fully described business processes. However, they are not prepared to incur significant expenses for the use of CMMI or other large-scale and paid tools of analysis and evaluation. Therefore, a more accessible methodology, like TIPA, may be the most suitable option.

Of the 3 TIPA classes, the class 2 was chosen, since it is designed to assess the maturity of individual processes and is focused on evaluating and improving processes to achieve the company's internal goals [22, 23], which represents the scope of this paper.

As part of the adaptation of this method to assess the innovation management process of an average company, some simplification was introduced in the procedure. Thus, the proposed approach presents 4 key stages, which are shown in Fig. 1.

Stage 1. Maturity assessment of the current process. In order to determine to what extent is the process formalized and implemented, the proposed model of assessing the possibilities COBIT 2019 can be used. It is based on one of the most common approaches to assessing the capabilities and capabilities of CMMI. At the same time, COBIT 2019 is an open framework that includes, in addition to the reference process model for IT, the recommendations on assessing the maturity and possibilities [24]. These recommendations are developed not only for processes but also for other components of practices. This allows a more detailed assessment of the studied area of activity.

Step 2. Comparison with reference processes, gap analysis. Consumer Products Process Classification Framework APQC (v.7.2.1.) proposes to systematize processes and activities by kinds of activity in the organization [25]. So, as part of the Define and manage technology innovation process, it provides 7 activities:

«Establish selection criteria for research initiatives,
«Analyze emerging technology concepts,
«Identify technology concepts and capabilities»,
«Execute IT research projects»,
«Evaluate IT research project outcomes»,
«Identify and promote viable concepts»,
«Develop and plan IT investment projects».

COBIT 2019 recommends implementing 6 practices as part of innovation management [11]:

«Create an environment conducive to innovation»,

«Maintain an understanding of the enterprise environment»,
«Monitor and scan the technology environment»,
«Assess the potential of emerging technologies and innovative ideas»,
«Recommend appropriate further initiatives»,
«Monitor the implementation and use of innovation».

In PCF APQC, innovation management activity is implemented in the framework of environmental assessment, as well as in the process of identifying and evaluating strategic options for achieving the organization's goals. This is partly in line with the recommendations of COBIT 2019. However, this kind of activity is splitted into different categories of processes: strategic management and IT management. COBIT identifies a separate group of practices which are proposed for implementation to solve the problem of innovation management (APO04). However, this framework is designed specifically for the governance and management of IT in the company. For the type of organization under consideration, the management of technological innovation is of broader importance, as it is demonstrated in PCF APQC. Therefore, we propose to use a reference model that is built on the basis of two frameworks described above. Figure 2 presents the sequence of processes of the developed reference model.

Table 1 describes the activities in the framework of these processes.

Stage 3. Development of recommendations for improvement. As one of the key recommendations for improving the process under study, we propose to switch to the Agile hybrid management method—Stage-Gate. In a traditional Stage-Gate structure, the Agile method can be embedded in different ways [2]. For medium manufacturing companies we recommend to implement the innovation management process according to the Stage-Gate model [1, 2, 26, 27], and to use Agile at the stage of product development and testing. A complete transition to Agile, or its application at the first stage of implementation of the studied process is impractical. This is due to the fact that the instability that accompanies the Agile approach, the lack of necessary competencies inside the company and skills to work in this mode will not allow to bring the project to the development stage, or they will significantly

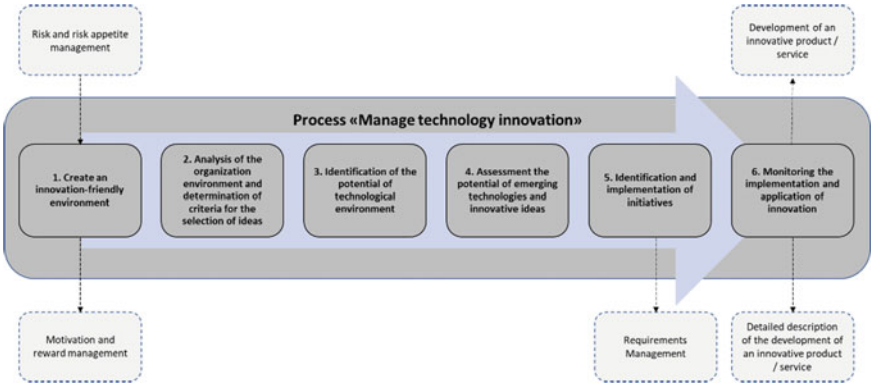

Fig. 2 Model of process «Manage technology innovation»

Table 1 Activities of process «Manage technology innovation»

No.	Subprocess	Activity
1	Create an innovation-friendly environment	Create an innovation plan Provide infrastructure for innovation Encourage innovation ideas from staff, customers, suppliers and business partners and move ideas forward
2	Analysis of the organization environment and determination of criteria for the selection of ideas	Analysis of the driving forces and challenges of the industry and a specific organization Analysis of the advantages and disadvantages, bottlenecks and advantages of the current activities of the organization Defining selection criteria for innovative ideas and suggestions
3	Identification of the potential of technological environment	Identification of key elements that ensure the competitive advantage of the company (potential value) Determining the organization's needs for innovations and the opportunities to implement them Organization of the collection of ideas and suggestions of employees of the organization and external stakeholders
4	Assessment the potential of emerging technologies and innovative ideas	Select ideas that are consistent with the goals and objectives of the organization for detailed consideration Evaluate identified technologies Identification of problems that need to be solved before the start of the implementation of the innovation project Determining the necessary resources for the implementation of the initiative Organize a preliminary review of the viability and effectiveness of the proposed ideas
5	Identification and implementation of initiatives	Documenting the results of testing ideas and suggestions Analysis and generalization of the causes of deviations Preparation for launching the implementation of accepted initiatives
6	Monitoring the implementation and application of innovation	Verification of the compliance of innovations with the organization's goals Assessment of development opportunities Analysis of the applicability and effectiveness of the implemented innovation

increase the implementation time of this process. With the current implementation model the better results can not be achieved either. A hybrid method allows reducing the implementation time of an initiative from an idea to a finished product by 20–30% [2].

Stages provide a capability of monitoring and managing the processes of identification, selection and implementation of innovative projects. Gates represent the decision-making points to determine ideas for implementation, timing, resources, analyze the progress of implementation. However, the formulated results, assessments, and metrics have rather general character, are not detailed, that provides the possibility to maneuver and brings flexibility in implementation and adjustment.

Step 4. Change Performance Monitoring. For permanent improvement in technological innovation, it is important to ensure that the procedure of process assessment is cyclical in accordance with the TIPA method. It is necessary to monitor with a certain frequency the effectiveness of changes, to assess the achievement of specified indicators, and based of the data obtained, take a decision on further actions at a new cycle of process improvement.

3 Application of the Developed Approach in Russian Manufacturing Enterprises

This approach has been tested in three manufacturing companies: the production of office furniture; production and sale of equipment for cash processing and storage of valuables; and production, implementation and maintenance of transport systems. All studied companies are approximately equal in scale and turnover. In addition, each of them is a niche leader. However, they all experience difficulties in developing their innovative component. The results of the assessment are broadly similar. There are discrepancies only in the details of the implementation of subprocesses and operations. Therefore, we will consider the features of the proposed approach by the example of a manufacturing and trading company that produces and sells the office furniture.

The company's management formulated the task to improve the innovation management process to create conditions for the continuous development of the portfolio of products and services, through the introduction of new IT solutions. The proposed approach to assessing and developing directions for improving the change management process has been successfully applied in this situation.

A study of the current innovation management process showed that the process achieves its original goal by performing a predefined set of actions. This corresponds to the 2nd level of possibilities [24]. The maturity also corresponds to the 2nd level, given the presence of process control operations, interest in improvement, process performance monitoring, but the latter procedure is not standardized. Thus, the next step is to improve the process through organizational changes.

As a result of the assessment in accordance with class 2 according to the TIPA method, the following artifacts were developed: a list of detailed conclusions for the process under study and its subprocesses; model of the current and target processes; recommendations for improving the process and the main results that should be achieved as a result of the implementation of the proposed changes.

Create an innovation-friendly environment. Activities to create an environment in the organization that will contribute to the development and implementation of innovations should be guided by the risk appetite of the company's management. Therefore, it is important that the results of the risk assessment of the company and possible ways of its development [11] be considered.

In addition, creating an innovative and supportive environment in a company is difficult without appropriate motivational support. Various tools should be used to reward and encourage innovative activity of employees, putting forward the ideas and proposals for improving business processes, developing new products and services.

To support this activity, the production holding company under consideration introduced an information system that allows it to collect and manage the ideas and initiatives of the company employees. In addition, this solution provides a classification of ideas according to the goals and areas of the organization, managing the status of proposals and tracking their implementation. It also provides the ability to manage incentives and rewards for innovative activity.

Analysis of the organization environment and determination of criteria for the selection of ideas. Innovation activities shall comply with the company's strategy and its limitations with a clear understanding of environmental trends: competitors, customers, regulatory agencies and the social atmosphere. At this stage «Establish selection criteria for research initiatives» [25] should be defined. The formulated recommendations can also be implemented through an IT solution that supports the collection and management of innovative proposals in the company.

Identification of the potential of technological environment. As part of the analysis of the possibilities and potential of the proposed innovative technologies, it is important to use the knowledge and opinions of stakeholders in the field of current IT infrastructure and possible directions for its improvement. It is necessary to determine: the business potential of the proposed IT solution, development and implementation time, risks and the possibility of ensuring compliance with regulatory requirements, possible ways to incorporate into the enterprise architecture (problems and necessary changes).

The proposed Agile-Stage-Gate hybrid model requires a new take on the process. The formed plan and schedule for the implementation of the initiative will have a rather high-level description that will allow maneuvering with time, while making it possible to estimate the costs of the project. This estimate is very rough, which entails some uncertainty. But if the task is to quickly introduce innovation, then it is necessary to take the appropriate risks.

Assessment the potential of emerging technologies and innovative ideas. It is important to determine the prospects of these IT solutions, the possibility of development, scaling, building functionality, etc. In addition, it is important to consider the effectiveness of the application in a particular organization. Performing this process

will allow generating data for the development of a high-level description of the proposed solution and its inclusion in the organization's architecture, as well as for determining the necessary requirements for the implementation of this innovative proposal.

When developing innovative solutions using the Agile-Stage-Gate approach, the focus is on the result and productivity of the developed technological solution. Therefore, to evaluate the improvements made, appropriate metrics should be formulated. These metrics can further be used for assessment of the effects of innovation.

Identification and implementation of initiatives. This stage is highly desirable to ensure continuous ongoing innovative development of the organization. Evaluation of the results of initiatives gives an idea of the best practices within the organization, the effectiveness of the application of certain IT solutions. This allows you to develop sound recommendations for adjusting the directions of innovative development, evaluation criteria and the selection of ideas for implementation. It will also improve the quality of decision-making at the beginning of the process of technological innovation management.

Monitoring the implementation and application of innovation. User experience, the rapid development of technology and IT services forces organizations to constantly improve IT services and products. This leads to the fact that it is already becoming impractical to use the traditional life cycle, such as a "waterfall", for developing innovations, and it's time to switch to the more flexible methods. They allow to manage and improve the product continuously. Therefore, it is recommended that the classic requirement of deep preliminary design be replaced by the development of a Minimum Viable Architecture (MVA). It defines the minimum set of architectural solutions and infrastructure capabilities that determine the beginning of the first (or next) flexible iteration [28].

To provide a link between the recommendations obtained by evaluating the process using the TIPA method and the principles of organization architecture (principles of Enterprise Architecture), a model was developed that demonstrates the relationship between the strategy and the plan of changes in the enterprise architecture based on improvement opportunities (Fig. 3).

A similar model, implemented in ArchiMate notation, allows to schematically present proposals for improving the process, the necessary resources and goals that this improvement will achieve. Thus, by means of Capability-Based Planning [17] and the TOGAF Standard method [29], it is possible to ensure the desired coordination of projects to change the company's activities and IT within the framework of architectural design.

4 Conclusion

The innovative activity of manufacturing companies today is the key to their competitiveness. Therefore, it is important to create the conditions for effective innovation management. For this purpose it is necessary to ensure the identification of the best

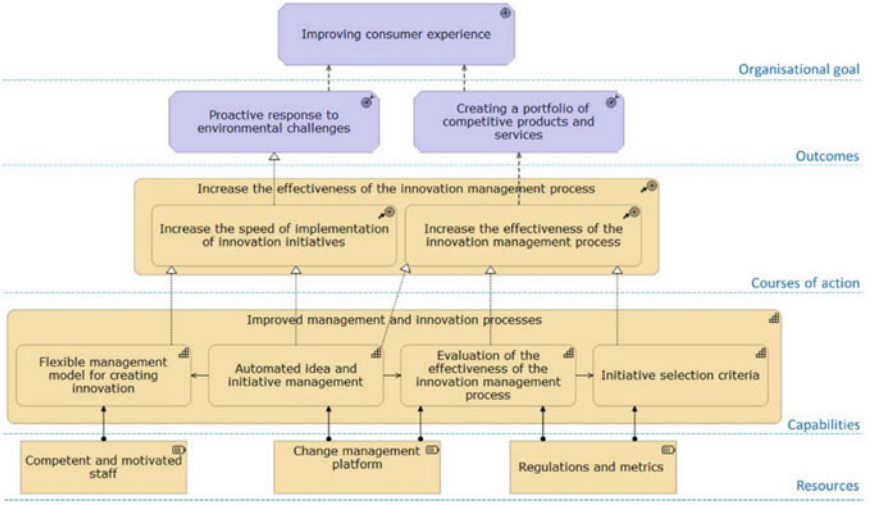

Fig. 3 Goals and opportunities for improving the process of innovation management

innovative ideas which, following the implementation, will achieve the strategic goals of the company; and rapid development and implementation of new technological products and services. To evaluate the current process and identify areas for improvement, it is recommended to use a combination of assessment and analysis methods for the current innovation management process adapted to the specifics of medium production enterprises. To identify key assessment steps, the TIPA method is proposed for use. To analyze the compliance of the process with best practices, a reference process model based on PCF APQC and COBIT 2019 has been developed. It is recommended to use the Capability-Based Planning method to coordinate the recommendations formulated for improving the process with the existing Enterprise Architecture.

This approach provides the opportunity for continuous improvement of the process, which is extremely important for the stable and confident development of an average production company.

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