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QUALITATIVE JUSTIFICATION OF STRATEGIC MANAGEMENT DECISIONS IN CHOOSING AGILE MANAGEMENT METHODOLOGIES

Abstract: *The study of the management system of modern companies indicates the need for a qualitative justification of managerial decisions related to the selection of methodological and instrumental approaches for their improving. It has been established that a qualitative choice of agile management methodologies is a prerequisite for the formation of universal algorithms for the automation of managerial processes and general optimization of the company strategic development processes. Agile management allows to quickly respond to processes of rapid change in the functioning environment of individual business entities and provides enterprise management with a sufficient number of managerial alternatives. The direct selection of agile management tools should be based on reliable methods, that is the basis of economic mathematical modeling. The article suggests using optimization models for choosing agile management tools based on the criterion of minimizing costs. It is proved that it is agile management with a reasonable choice of the necessary tools that can provide enterprise management with the opportunity to formulate high-quality management decisions in the context of the company strategic development.*

Keywords: *Agile management; Methodology; Management system; Mathematical modeling.*

1. Introduction

The development of economic science takes place in accordance with current problems and society needs. An urgent issue for economic science is the formation of such methods of interaction between business entities that could significantly expand the capabilities of enterprises and improve their management system. There is an objective need for an introduction and application of agile management considering the instability of the external environment and the dynamism of economic processes. However, the lack of experience of many business entities in the active use of agile management, and existing developments require adaptation, taking into account the specifics of the economy of this country should be noted. High-quality application of agile management methodologies in the enterprises practical activities is almost impossible today. This is due to the situation in the economy, which is changing and creates new challenges and threats. Thus, the rapid drop in oil prices and the negative reaction of global stock markets are not only indicators of macroeconomic instability and a possible global economic crisis. This is also a signal for most enterprises to form an appropriate protective reaction to

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possible negative consequences of these events. The constant struggle for the consumer and resource support of the activities of each enterprise, creates the need for changes and initiates transformations on different levels. Accordingly, it is important for enterprise managers to quickly respond to changes and make sound management decisions (Rudnichenko et al., 2020), which are based on a high-quality information base, which use agile management methodologies appropriate at that moment.

This situation creates the need not only for high-quality informational support of management decisions, but also for the gradual automation of these processes. Accordingly, complex mathematical tools that can predict scenarios, identify them and justify strategic decisionsare used more and more often in the study of economic systems (Havlovska N. et al., 2019; Rudnichenko et al., 2019; Zlotenko et al., 2019). In addition, mathematical tools make it possible to make a qualitative choice of agile management methodologies and is a prerequisite for the formation of universal automation algorithms for managerial processes, which is an extremely urgent task in the existing digital economy. Moreover, excessive complication of the proposed solutions is not an end in itself of management. The main criterion is the achievement of the target result using the minimum acceptable level of available resources. That is why, optimization problems have found wide application in applied problems of management and strategic development of modern enterprises.

2. Literature review

Agile management is an extremely important aspect of the development of a particular enterprise. It is modern research in the field of management that focuses on the flexibility and adaptability of systems. Most often, agile management is used in project management and software development. However, in our opinion, the use of agile management is also advisable for the purpose of managing the enterprise management system and its individual subsystems, which makes it possible to increase management efficiency and adjust strategic goals in accordance with the realities of the international and domestic market.

The methodologies used in the activities of enterprises for the purpose of agile management are divided into two groups: lean manufacturing methodologies and agile management methodologies.

There are a lot of lean manufacturing methodologies, and their initial stage of research in the scientific literature is associated with the use of the PDCA cycle (Plan-Do-Check-Act) (Niv, 2005). The PDSA cycle is one of the many elements that make up the Profound Knowledge system, to which creating W. Deming devoted the last years of his life. He believed that it is impossible to carry out effective transformations without mastering profound knowledge. The system of profound knowledge by W. Deming appears in the form of closely related four components, namely:
1) understanding of the system;
2) understanding of the theory of variability;
3) some knowledge in the field of psychology;
4) the basics of the theory of cognition.

One of the most famous methodologies in this area is Kanban. The Kanban methodology was founded by D.J. Anderson and A. Carmichael in 2007. This method used to determine, manage and improve services is the result of mental work, such as expert and creative services, as well as the development of physical or software products. It can be described as a «start with what you do now» method, as a catalyst for organizational change, aimed at reducing resistance to important organizational changes in accordance with the organization goals. Kanban system can help reduce waste by minimising the Work In Progress (WIP), unevenness in production and overloading for machines and operators (Oakland, 2014). Kanban is Japanese for signboard and a Kanban board is used to visualise and organise work items. Here WIP can be visualised and the progress of each task can be tracked (McLean & Canham, 2018). There are nine types of values (including respect) that briefly describe the reason for the existence of Kanban principles and practices (Anderson, 2016):

1) transparency - the belief that open exchange of information improves the flow of business value creation;
2) balance - understanding that in order to improve efficiency, it is necessary to strike a balance between different aspects, perspectives and opportunities;
3) collaboration - working together;
4) customer orientation - the endpoint of every kanban system - value creation, that is, getting a customer the right product or service;
5) flow - understanding the fact that work is a flow of value creation (continuous or episodic);
6) leadership - the ability to inspire others to act with your example, words and ideas;
7) understanding - mainly knowledge (both individual and organizational) about oneself for the purpose of further development;
8) coherence - the commitment to work together towards achieving goals, taking into account (and, if possible, settling) differences in opinion and in approaches;
9) respect - appreciation and understanding of others.

Another well-known approach is the Lean Startup, which was proposed by E. Ries in 2009, and is an approach to continuous innovation. Lean Startup is a toolset for opportunity exploration (Bakker & Shepherd, 2017) that emphasizes iterative experimentation and early customer insight. It is based on five principles (Ries, 2011):

1) entrepreneurs are everywhere - an entrepreneur is anyone with a startup. A startup, in turn, is an «enterprise» whose goal is to develop new products and services in conditions of extreme uncertainty;
2) entrepreneurship is management. Startup needs a new type of management that will approach the conditions of extreme uncertainty;
3) confirmation by facts - the task of a startup is not only to produce goods and make money, but also continuous training using a scientific approach and testing hypotheses empirically;
4) «create-evaluate-learn» cycle - first you need to create a minimally working version of the product, evaluate the reaction of consumers, and then decide whether to follow the chosen path or change direction;
5) accounting for innovations is a system of criteria and indicators that help evaluate the success (or failure) of a startup actions.

Lean Startup is very popular. Hundreds of universities worldwide teach LS (LeanstartupCo, 2018), several large companies such as Intuit and Dropbox endorse it, and it is the foundation of a National Science Foundation program to turn scientists into entrepreneurs (Blank, 2013).

Agile management methodologies are divided into methodologies for the construction and operation of agile organizations and agile software development methodologies in the construction and operation of agile organizations.

As for the agile management methodologies, we will consider the most common ones used so far on the enterprise practice. And the first on our list is a methodology called «The New New Product Development Game», which was created in 1986 in connection with the publication of an article by H. Takeuchi and I. Nonaka, which proposed the application of a holistic method, like in rugby when the ball is passed inside the team, while the team moves across the field as a whole. The following six characteristics are inherent in this holistic approach (Takeuchi & Nonaka, 1986):

1) built-in instability - beginning the process of developing a new product, the top management of a company determines a strategic goal or strategic direction, and rarely determines a specific plan of action. The company's top management empowers the project team with greater authority;
2) self-organizing project teams - the project team starts with «zero information» and works as a start-up company. A team has the ability to self-organize if it has the following properties: autonomy, the ability to self-improvement and

mutual development of team members;
3) overlapping development phases - team members begin a project with different time horizons. However, at some point, the rhythm of each person and the rhythm of the group begins to unite, creating a new pulse, which is the driving force and pushes the team forward;
4) multilevel training - such training in practice is manifested in two dimensions: at different levels (individual, group and corporate) and for various functions;
5) Implicit control - management sets a sufficient number of control points to avoid chaos. At the same time, management avoids tight control, which reduces creativity and spontaneity;
6) transfer of knowledge within the organization - accumulation of knowledge at all levels and for all functions.

The methodology proposed by H. Takeuchi and I. Nonaka is based on the use of a team-oriented approach, which allows the introduction of more effective innovations by changing the design and development processes.

In 1993, D. Sutherland developed the Scrum methodology and formalized it in 1995 with K. Schwaber. This methodology has the highest percentage of implementation in the practical activities of enterprises, it remains the undisputed leader. Scrum is a set of basic elements and rules that provides a range of opportunities for productive and creative development of products with the highest possible value and solving non-trivial tasks in the process (Schwaber & Sutherland, 1991). The basis of Scrum is the theory of empirical control - empiricism. According to this theory, experience is the source of knowledge, and real data is the solution. In order to improve the predictability and effectiveness of risk management, Scrum uses an iterative and incremental approach. The empirical management process is based on the «three pillars» (Schwaber & Sutherland, 1991):
1) transparency - important elements of the process should be accessible to those who are responsible for its result;
2) inspections - participants in the process should regularly check the Scrum artifacts and progress towards the Sprint goal (this is the time period with a maximum duration of one month, during which the team creates a functioning and ready to work release of the Product Increment), which is necessary for the timely detection of unwanted deviations;
3) adaptation - if deviations from the permissible limits of one or more elements of a process or product are identified, appropriate changes should be made.

Scrum faces certain problems with the software development practices such as time and work management flow control, direct involvement of external stakeholders as critical leader, team size and their role (Bhavsar et al., 2020b). Scrumban can overcome several problems, such as workflow control, wire time management; continuous integration and delivery software product (Bhavsar et al., 2020a).

The Spotify model was developed internally by Spotify during 2011-2012 and is based on clear definitions of principles, roles and collaboration strategies. From an organizational point of view, Spotify replaced the generally accepted scrum commands with agile«squad» ones, which are free to define their own methods and practices and not held back by «only scrum» or «only kanban» methods imposed from above. At the next level of interaction, Spotify«squads» with a common or similar mission are combined into «tribe», which periodically gather to discuss and minimize the number of dependencies, as well as to make sure that the «squads» are working on the same mission. In addition, Spotify employs «chapter» and «guild» (Salameh & Bass, 2019).

Along with the methodologies for the construction and functioning of agile organizations presented in a «classical» form, methodologies of agile software development during the construction and functioning of agile organizations are distinguished, namely: the Crystal family of methodologies - was developed in 1992; Dynamic Systems

Development Method, DSDM - in 1994; Design Patterns - in 1994; Feature driven development, FDD - in 1997; Adaptive Software Development, ASD - in 1999; eXtreme Programming, XP - in 1999. All of these methodologies are based on interactive development, in which requirements and solutions evolve through collaboration between multi-functional teams capable of self-organization (Johnson et al., 2005). These methodologies aimed at minimizing the risks and threats caused by the unpredictability of the functioning environment of organizations. All agile software development methodologies for building and operating agile organizations are based on the agile development manifesto, adopted by 17 developers who called themselves «organizational anarchists» on February 11–13, 2001 at The Lodge at Snowbird Ski Resort in the Utah Mountains.

Practitioners and consultants offer frameworks for large-scale agile approaches in software development, such as the Scaled Agile Framework (SAFe) (Scaled Agile, 2017), Large Scale Scrum (Vodde & Larman, 2014) and Disciplined Agile Delivery (Ambler & Lines, 2012). Olteanu C. presented a case study on the knowledge management problem and transformation process for IT agile adaptation as the organization changes (Olteanu, 2018). Fuchs and Hess conceptualized the process of agile transformation in large organizations, conducted two in-depth case studies, and provided guidance for managers (Fuchs & Hess, 2018). Hekkala et al. examine an information systems (IS) development team that transitioned to agile methods, revealing, amongst others, the challenges of misunderstanding agile practices and unsuitable organizational structures for agile principles and values being in place (Hekkala et al., 2017).

At the moment, agile management methodologies are being developed, especially agile software development methodologies; this is due to the rapid development of digital technologies (Beck & Andres, 2004).

3. Methodology

The introduction of agile management in the activities of organizations is based on the application of certain methodologies that require description and explanation. And given that the basis of the vast majority of the proposed methodologies is the effective practical experience of their use, it is necessary to consider which methodologies were applied by enterprises during 2013-2018 (Fig. 1).

Agile management is increasingly being introduced into practical activities, and this is due to positive changes in organizations after its implementation. According to the 13th report (based on the results of 2018) on agile management published by Collab Net Version One, respondents consider the following to be the main reasons for implementing agile management (13th State of Agile, 2019): accelerate software delivery (74%); enhance ability to manage changing priorities (62%); increase productivity (51%); improve business/IT alignment (50%); enhance software quality (43%); enhance delivery predictability (43%); improve project visibility (42%); reduce project cost (41%); improve team morale (34%); reduce project risk (28%); improve engineering discipline (23%); increase software maintainability (21%), better manage distributed teams (19%).

As the data in figure 1 shows, the Scrum methodology is used most often in the practical activities of enterprises when introducing agile management, from 55% to 58%, depending on the years of research.

Such a high percentage of Scrum in practice is explained by its advantages, namely (Liubokhynets et al., 2020):

1) transparency and cooperation;
2) team autonomy and high level of interaction between its members;
3) motivation by result and readiness for changes;
4) minimization of market risks;
5) minimization of financial risks.

To support the feasibility of introducing agile management in the practical activities of enterprises, we present the data from a report conducted by McKinsey (Ahlbäck et al., 2017). The online survey involved 2546 respondents representing a full range of regions, industries, companies (of different sizes), functional specialties and officials. 207 of respondents work in non-profit organizations and government agencies or departments.

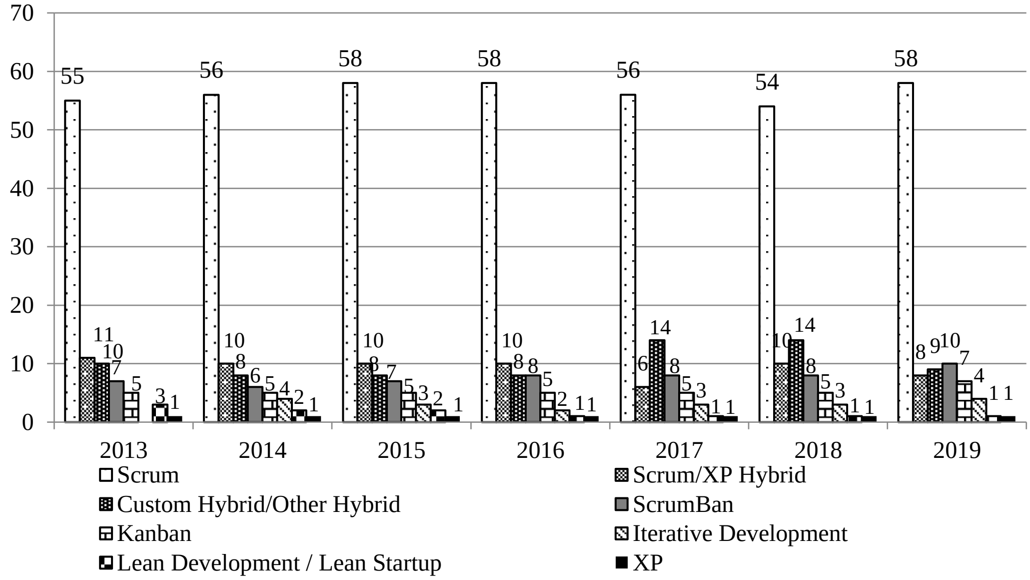


Figure 1. Agile management methodologies applied by enterprises during 2013-2018, %(8thState of Agile, 2014; 9thState of Agile, 2015; 10thState of Agile, 2016; 11thState of Agile, 2017; 12th State of Agile, 2018; 13th State of Agile, 2019; 14th StateofAgile, 2020)

According to respondents, the beginning of agile management in the activities of their companies was associated with instability and rapid changes. Also, it should be noted that in the practical activities of the vast majority of companies, agile management is at the implementation stage.

Four out of ten respondents claim that their companies use agile ways of working in processes related to operations, strategies and technologies, while about a third say they do this in the field of supply chain and talent management (Ahlbäck et al., 2017).

Despite the advisability of introducing agile management, many companies are reluctant to take this approach, and not every company that decides to implement them achieves success. The main obstacles to the implementation of this methodology include (Rigbyet al., 2016):

1. Inability or unwillingness to apply the methodology: 44% of respondents say that they are not familiar with agile management; about 35% of respondents report a lack of qualified personnel; 33% report team reluctance to follow agile management practices.
2. Lack of management support: 38% of respondents report a lack of management support; 22% - refer to management concerns about a possible loss of control.
3. Agile principles contradict the operating model of the company: more than 40% of respondents say that agile management methods contradict the company's philosophy; 71% - notes tensions between teams and the rest of the organization.

The use of agile management in the practical activities of enterprises allows to quickly develop and make management decisions. When implementing agile management, the company's management must realistically evaluate both the company's activity at the moment and its development prospects. This is due to the fact that not every management function can and should be implemented by agile teams. And, in addition, when several teams operate within the same enterprise, their work should be based on the principles of cooperation and focus on achieving a strategic goal (for example: increasing the profitability of the enterprise, increasing its market value, etc.), otherwise conflicts may occur. In addition, the application of agile management methodologies in practice requires the selection of optimal tools within the specified methodologies, as well as additional costs for their implementation. That is why the choice of agile management tools and their implementation requires taking into account efficiency based on a minimum of costs.

In modern research, the tools of economic and mathematical modeling are used as an effective tool for solving many applied problems. However, their application in management requires considerable preparatory work and the proper organization of the modeling process itself. First of all, the task of modeling is to determine the optimal tools for agile management and to find out the possibility of using all or some of tools within the framework of the chosen common instrumental approach to enterprise management with forecasting the result of their application.

One of the important stages in organizing the modeling process is the choice of modeling tools. Traditionally used modeling tools in building models of economic phenomena and processes are (Illiashenko et al, 2020; Rudnichenko et al., 2019b): simulation modeling, mathematical modeling, descriptive models, prescriptive models, game theory and more. In our opinion, it is advisable to use mathematical modeling, namely the method of discrete multiple-criteria optimization, since it is precisely the search for optimal management decisions based on certain information and available agile management methodologies, which gives the necessary result for enterprise management.

The multiple-criteria analysis problems can be divided into three types: problems of multiple-criteria choice, problems of multiple-criteria ranking and problems of multiple-criteria sorting (Belton, 1993; Ananda & Herath, 1993; Kelley et al., 2002; Mustajoki, 2003; Srdjevic et al., 2004).

The multiple-criteria optimization problems are only problems of multiple-criteria choice. Many reallife problems in planning, control and industrial production may be formulated as problems of multiple-criteria choice (Ehrgott & Ryan, 2002; Hamalainen et al., 2003; Kaleta et al., 2003; Thibault et al., 2002; Vera et al., 2003).

The implementation of the discrete multiple-criteria optimization method requires the development and use of an appropriate model, the formation of which should be preceded by the determination of the necessary requirements for it (Rudnichenko et al., 2019a). Such requirements can be divided into three large groups: requirements for the result of the model, requirements for the model itself as an integrated complete ready-to-use tool, and requirements for the process of using the model.

The proposed requirements for the result of the model for choosing optimal agile management tools are presented in Fig. 2.

In disclosing the content of the proposed requirements more fully, it should be noted that the results should be clearly perceived by the entities and clearly reflect possible options for the implementation of certain management decisions. Also, obtaining the result should not be associated with large expenditures of resources, but should promptly and in a chronological sequence provide the necessary information to the subjects of modeling to adjust their behavior depending on changes in model parameters.

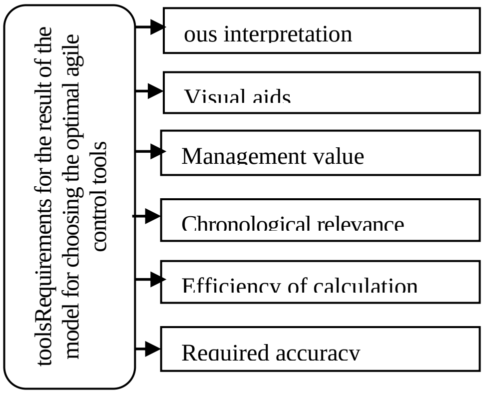


Figure 2. Requirements for the result of the model for choosing the optimal agile control tools

The proposed model result requirements can only be provided if certain model requirements are met, which execution allows for a complete, reliable, unambiguously interpreted result. The requirements for the model for choosing the optimal agile management tools are in Fig. 3.

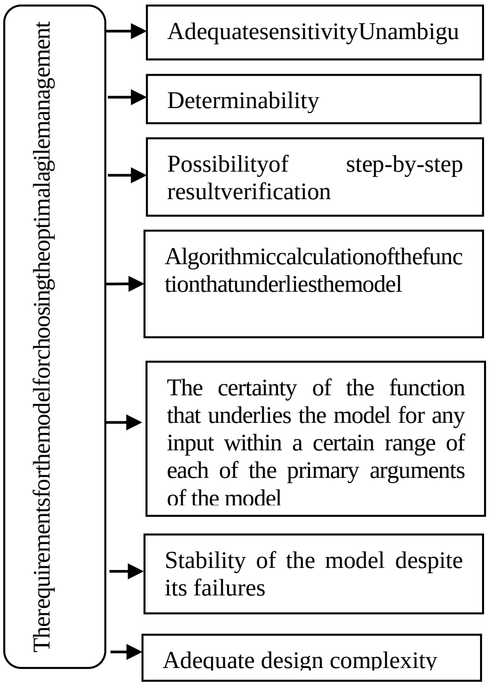


Figure 3. The requirements for the model for choosing the optimal agile management tools

Note that Fig. 3 presents only specialized requirements for such a model, since a significant part of the unreviewed requirements (completeness, readiness for practical use, possibility of algorithmization, etc.) are trivial and do not need to be clarified.

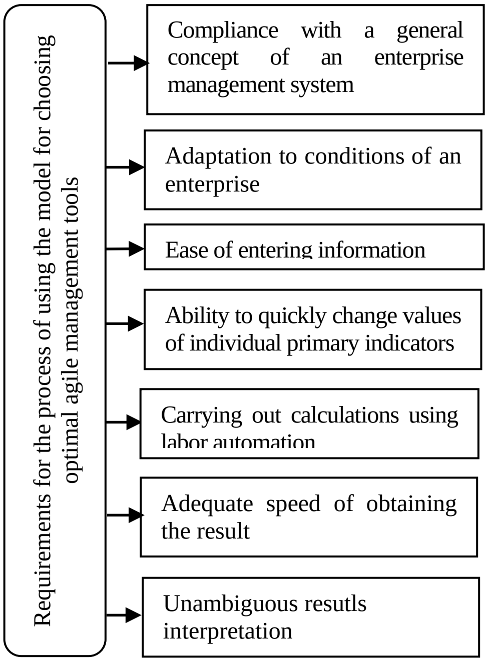
Commenting on the proposed requirements for the model, it is worth noting that special attention should be paid to the sensitivity of the model, since it must correspond to the tasks that are being solved, and promptly and correctly display the desired result without excessive detail and redundant information, but with proper accuracy and reliability at each stage of calculation.

The function that underlies the model must be algorithmically resolved and clearly defined for any input within a certain range of each of the primary arguments of the model. The model must be stable to failures and adequately calculated without undue complications and costs. Now briefly reveal the content of the requirements for the process of using the model. Such requirements are presented in Fig. 4.

Revealing the content of the proposed requirements, we note that its usefulness and practical value will be fully realized only if the model conforms to the general concept of the enterprise management system.

The model should be adapted to the conditions of the enterprise, which takes into account the specifics of its activity and features of interaction with the external environment. Requirements for the operational processes of using the model, such as ease of entering information, the ability to quickly change the values of individual primary indicators, carrying out calculations using labor automation will easily integrate the model into the enterprise management system.

The productive characteristics of the model - the speed of obtaining results and the unambiguity of their interpretation - will become an argument for making appropriate management decisions and using the results in strategic and tactical planning.



F**igure 4.** Requirements for the process of using the model for choosing optimal agile management tools

The process of improving the enterprise management system *(MS)* is based on the flow of internal and external information on the formation of costs. From a formal point of view, the enterprise management system is optimized. With insignificant simplifications in practice, such optimization means the efficiency of making managerial decisions with a sufficient level of reliability when choosing the optimal agile management tools with a minimum of costs. Therefore, the basis for building the optimality criterion in the corresponding optimization model are the following two minimization problems:

$$x^* \in \arg\min_{x \in S} S_{MS}(x) \quad (1)$$

$$y^* \in \arg\min_{y \in T} \theta_{MS}(y) \quad (2)$$

in which$S_{MS}(x)$ – a function whose value corresponds to (is equal) normalized (standardized) costs;

$\theta_{MS}(y)$ – a function whose value characterizes the efficiency of managerial decision-making with a sufficient level of reliability;

x – a set of parameters or factors that indirectly or directly affect the resulting costs;

y – a set of parameters or factors that indirectly or directly affect the efficiency of management decisions with a sufficient level of reliability;

s – a set of all possible (permissible) factors of influence on the resulting costs;

T - aset of all possible (admissible) parameters of the MS management system related to the efficiency of making managerial decisions.

4. Results

The introduction of agile management tools requires their list. Therefore, first of all, we will consider the agile management tools used in the world practice (table 1) (14th State of Agile, 2020).

Given the significant number of tools, it is proposed to implement not all tools, but those that are most often used in world practice from 50% or more. For many enterprises, the set of choices is sufficient because analyzing all the methods presented and calculating the effect of their implementation in today's turbulent changes is unacceptable option.

Experience in the practical implementation of the tools presented in the study indicates that companies choose a specific methodology and useful tools within 1-3 approaches, or their combinations. So, this list will include the first 11 tools presented in Table 1 (highlighted in gray), which are most actively used by companies in the world.

Since the management system of state-owned companies is the most inert due to its «institutional memory» and a penchant for traditionalism, the proposed methodological approaches were tested at the state-owned enterprise «Krasylyvsky Aggregate Plant».

It should be noted that in the practice of «Krasylyvsky Aggregate Plant» during 2013-2019, flexible management tools were not implemented, but lean production tools were used in fragments, which allowed to reduce resource losses, product quality costs and ensure transparency of management processes. The main tools of lean production used at the enterprise were Bottle neck analysis and Heijunka. Bottle neck analysisis based on finding production "bottlenecks" and allows to increase productivity. Heijunka is a planning of orders in a special way, which help to reduce the likelihood of a production process disruption risks at different stages and to avoid disruptions in a transfer of finished products to a customer.

It should be noted that there is a management's desire to optimize the management system and implement innovative approaches in practice and all areas of the enterprise. According to the presented requirements, the most realistic is the implementation of the first 11 tools from Table 1.

According to the table 1, we number the first 11 elements of the set U from 1 to 11. That is$z_1 \in U$respondsKanban board, $z_2 \in U$ responds Taskboard, etc. Therefore, the list of methods in table 1 is the subset $\{z_j\}_{j=1}^{11} \subset U$.

So, the set of all MS configurations is $U = \{z_j\}_{j=1}^{M}$, where the number is:

$$M \le \sum_{m=1}^{11} \frac{11!}{m! \cdot (11-m)!} = 2047$$

The maximum number of combined methods is 2047 – 11 = 2036. Of course, the case where all 2036 combinations of original agile management tools are used is unlikely.

A variable set of agile management tools of the State Enterprise «Krasylivsky Aggregate Plant» in the context of increasing the efficiency of making management decisions and minimal costs is given in Table 2.

Table 1. List of agile management tools for 2019

№	Tool name	% of application
1	Kanban board	76%
2	Taskboard	66%
3	Bug tracker	63%
4	Spreadsheet	64%
5	Agile project management tool	65%
6	Wiki	60%
7	Automated build tool	55%
8	Unit test tool	54%
9	Continuous integration tool	54%
10	Wireframes	50%
11	Product Roadmapping	51%
12	Traditional project management tool	44%
13	Requirements management tool	46%
14	Release/deployment automation tool	45%
15	Automated acceptance tool	37%
16	Static Analysis	38%
17	Project & portfolio management (PPM) tool	39%
18	Story mapping tool	30%
19	Timecards	30%
20	Index cards	26%
21	Refactoring tool	26%
22	Customer idea management tool	19%

Table 2. Anagile set of agile management tools of the State Enterprise «Krasylivsky Aggregate Plant» in the context of increasing the efficiency of managerial decision-making and minimal costs

Variant	Method	
1	Kanban board	
2	Product Road mapping	
3	Wireframes	
4	Taskboard	Agile project management tool
5	Spreadsheet	Continuous integration tool
6	Agile project management tool	Wireframes
7	Unit test tool	Product Roadmapping
8	Bug tracker	Agile project management tool

The characteristics of the selected instruments for «Krasylyvsky Aggregate Plant» (Table 2) are given in more detail in Table 3.

Evaluation of the appropriateness of applying a particular method is carried out with the assistance of experts. For expert evaluation we attract 30 experts with approximately the same working experience.

After expert matrices $\left\{\mathbf{S}_i = \left[s_{mn}^{(i)}\right]_{M_0\times M_0}\right\}_{i=1}^{30}$ and $\left\{\mathbf{\Theta}_i = \left[\theta_{mn}^{(i)}\right]_{M_0\times M_0}\right\}_{i=1}^{30}$ are formed, in which $M_0=8$ for SE «Krasylivsky Aggregate Plant», using formulas (3) and (4) we determine the averaged matrices of pairwise comparisons.

$$\mathbf{S} = \left[s_{mn}\right]_{M_0\times M_0} \in \arg\left\{\min_{\substack{\mathbf{A}_q\in\bar{B}_9(M_0)\subset B(M_0)\\ q=\overline{1,Q}}} \rho\left(\mathbf{A}_q, \left\{\mathbf{S}_i\right\}_{i=1}^{N}\right)\right\} \quad (3)$$

$$\mathbf{\Theta} = \left[\theta_{mn}\right]_{M_0\times M_0} \in \arg\left\{\min_{\substack{\mathbf{A}_q\in\bar{B}_9(M_0)\subset B(M_0)\\ q=\overline{1,Q}}} \rho\left(\mathbf{A}_q, \left\{\mathbf{\Theta}_i\right\}_{i=1}^{N}\right)\right\} \quad (4)$$

Table 3. Characteristics of agile management tools

Tool name	Characteristics
Kanban board	is visually depict work at various stages of a process using cards to represent work items and columns to represent each stage of the process.
Product Roadmapping	is a shared source of truth that outlines the vision, direction, priorities, and progress of a product over time. It's a plan of action that aligns the organization around short- and long-term goals for the product or project, and how they will be achieved.
Wireframes	are simple block diagrams that show the placement of elements in a user interface and demonstrate the intended layout and functionality of a solution.
Taskboard	are a type of visual management tool that help busy people keep track of their work.
Agile project management tool	a software product created specifically to manage projects (For example: Atlassian JIRA, VersionOne, Atlassian JIRA Align and other).
Spreadsheet	is a computer application for organization, analysis and storage of data in tabular form.
Continuous integration tool	every change to the code is added to the project soon after its written, and then immediately tested for defects. There is a largevarietyofContinuousIntegration tools (Forexample: Jenkins, TeamCityMicrosoft'sTeamFoundation Server and other).
Unit test tool	a Software Testing practice which follows Agile Software Development Principles. Testers in the Agile project may be using different testing tools to test various functionalities within the application (Forexample: Worksoft, PractiTest, JunoOne and other).
Bug tracker	is a software application that keeps track of reported software bugs in software development projects. Most Popular Bug Tracking Software are Airbrake.io, Backlog, ReQtest and other.

For SE «Krasylivsky Aggregate Plant» we get:

$$\mathbf{S} = \left[s_{mn}\right]_{8\times 8} = \begin{bmatrix} 1 & 2 & 1/7 & 1/2 & 1/6 & 1/4 & 1/4 & 1/3 \\ 1/2 & 1 & 1/8 & 1/3 & 1/7 & 1/5 & 1/5 & 1/4 \\ 7 & 8 & 1 & 6 & 2 & 4 & 4 & 5 \\ 2 & 3 & 1/6 & 1 & 1/5 & 1/3 & 1/3 & 1/2 \\ 6 & 7 & 1/2 & 5 & 1 & 3 & 3 & 4 \\ 4 & 5 & 1/4 & 3 & 1/3 & 1 & 1 & 2 \\ 4 & 5 & 1/4 & 3 & 1/3 & 1 & 1 & 2 \\ 3 & 4 & 1/5 & 2 & 1/4 & 1/2 & 1/2 & 1 \end{bmatrix}$$

$$\mathbf{\Theta} = \left[\theta_{mn}\right]_{8\times8} =$$

$$= \begin{bmatrix} 1 & 1/4 & 1/5 & 1 & 1/2 & 1/2 & 2 & 4 \\ 4 & 1 & 1/2 & 4 & 3 & 3 & 5 & 7 \\ 5 & 2 & 1 & 5 & 4 & 4 & 6 & 8 \\ 1 & 1/4 & 1/5 & 1 & 1/2 & 1/2 & 2 & 4 \\ 2 & 1/3 & 1/4 & 2 & 1 & 1 & 3 & 5 \\ 2 & 1/3 & 1/4 & 2 & 1 & 1 & 3 & 5 \\ 1/2 & 1/5 & 1/6 & 1/2 & 1/3 & 1/3 & 1 & 3 \\ 1/4 & 1/7 & 1/8 & 1/4 & 1/5 & 1/5 & 1/3 & 1 \end{bmatrix}$$

For SE «Krasylivsky Aggregate Plant» matched matrices are:

$$I_{cons}\left(\mathbf{S}\right) = \frac{8.3-8}{8-1} = 0.0429,$$

$$I_{cons}\left(\mathbf{\Theta}\right) = \frac{8.25-8}{8-1} = 0.0357,$$

$$r_{cons}\left(\mathbf{S}\right) = \frac{0.0429}{1.41} = 0.0304,$$

$$r_{cons}\left(\mathbf{\Theta}\right) = \frac{0.0357}{1.41} = 0.0253.$$

We evaluate functions $s_{MS}\left(z\right)$ and $\theta_{MS}\left(z\right)$ by ratios (5) and (6).

$$s_{MS}\left(z_{j_m}\right) = p_m\left(\mathrm{S}\right)\ \forall m = \overline{1, M}_0 \qquad (5)$$

$$\theta_{MS}\left(z_{j_m}\right) = p_m\left(\Theta\right)\ \forall m = \overline{1, M}_0 \qquad (6)$$

Then we perform the rationing (7) – (10).

$$\tilde{s}_{MS}(z) = \frac{s_{MS}(z)}{\max\left\{\max\limits_{h\in U_0\subset U=\{z_j\}_{j=1}^{M}} s_{MS}(h), \max\limits_{h\in U_0\subset U=\{z_j\}_{j=1}^{M}} \theta_{MS}(h)\right\}}, z \in U_0 \subset U \qquad (7)$$

$$\tilde{\theta}_{MS}(z) = \frac{\theta_{MS}(z)}{\max\left\{\max\limits_{h\in U_0\subset U=\{z_j\}_{j=1}^{M}} s_{MS}(h), \max\limits_{h\in U_0\subset U=\{z_j\}_{j=1}^{M}} \theta_{MS}(h)\right\}}, z \in U_0 \subset U \qquad (8)$$

$$\tilde{s}_{MS}(z) = \frac{s_{MS}(z)}{\max\left\{\max\limits_{h\in\{U\setminus U_0\}\subset U} s_{MS}(h), \max\limits_{h\in\{U\setminus U_0\}\subset U} \theta_{MS}(h)\right\}}, z \in \{U\setminus U_0\} \subset U \qquad (9)$$

$$\tilde{\theta}_{MS}(z) = \frac{\theta_{MS}(z)}{\max\left\{\max\limits_{h\in\{U\setminus U_0\}\subset U} s_{MS}(h), \max\limits_{h\in\{U\setminus U_0\}\subset U} \theta_{MS}(h)\right\}}, z \in \{U\setminus U_0\} \subset U \qquad (10)$$

For SE «Krasylivsky Aggregate Plant» we get:

$$\left\{s_{MS}\left(z_{jm}\right)\right\}_{m=1}^{8} = \left\{\begin{matrix}0.0337, 0.0237, 0.3406, 0.0497, 0.2444,\\ 0.1164, 0.1164, 0.0751\end{matrix}\right\},$$

$$\left\{\theta_{MS}\left(z_{jm}\right)\right\}_{m=1}^{8} = \left\{\begin{matrix}0.0677, 0.2403, 0.3378, 0.0677, 0.1104,\\ 0.1104, 0.0433, 0.0225\end{matrix}\right\},$$

$$\left\{\tilde{s}_{MS}\left(z_{jm}\right)\right\}_{m=1}^{8} = \left\{\begin{matrix}0.0990, 0.0696, 1.0000, 0.1460, 0.7176,\\ 0.3417, 0.3417, 0.2205\end{matrix}\right\},$$

$$\left\{\tilde{\theta}_{MS}\left(z_{jm}\right)\right\}_{m=1}^{8} = \left\{\begin{matrix}0.1988, 0.7056, 0.9917, 0.1988, 0.3241,\\ 0.3241, 0.1270, 0.0661\end{matrix}\right\}.$$

Matrices $\left\{\mathbf{W}_i = \left[s_{mn}^{(i)}\right]_{2\times2}\right\}_{i=1}^{30}$ for SE «Krasylivsky Aggregate Plant» were evaluated separately. Here in the matrix (11):

$$\mathbf{W} = \left[w_{mn}\right]_{2\times2} \in \arg\left\{\min_{\substack{\mathbf{A}_q\in\overline{B}_9(2)\subset B(2)\\ q=\overline{1,Q}}} \rho\left(\mathbf{A}_q, \left\{\mathbf{W}_i\right\}_{i=1}^{N}\right)\right\} \qquad (11)$$

We have w_{12}=1 again, and the task has this solution:

$$z^* \in \arg\min_{z\in U=\{z_j\}_{j=1}^{S}} \left\{w_{12}\cdot\tilde{s}_{MS}(z) + \tilde{\theta}_{MS}(z)\right\} = \arg\min_{z\in U=\{z_j\}_{j=1}^{S}} \left\{\begin{matrix}0.2978, 0.7752, 1.9917,\\ 0.3448, 1.0417, 0.6659,\\ 0.4687, 0.2865\end{matrix}\right\} = \{z_8\}$$

which corresponds to the fact that the combination of the Bug tracker and the Agile project management tool is optimal for MS at the «Krasylivsky Aggregate Plant». And it allows to improve management processes in the enterprise under study, taking into account certain optimality criteria.

5. Conclusions

Research and accounting of the overwhelming majority of decision-making features in the field of implementing agile management tools using economic-mathematical modeling, allows to specify the process of improving the enterprise management system by implementing the most appropriate agile management tools in compliance with minimizing costs.So, as a result, the optimal agile management tool (or several tools for specific purposes) is selected using the economic-mathematical model and the potential ability to minimize implementation costs is evaluated, which provides enterprise management with the ability to «maneuver» when making management decisions. Provided that the expected effect by the enterprise management is ensured, the optimization is completed for a certain period of time and the corresponding model operates in the normal mode, and if the operation of the enterprise is not provided or is significantly changed, the input parameters are corrected and the model is «restarted».

In the process of developing the model, it was taken into account that, from a formal point of view, the enterprise management system is optimized, and this involves increasing the efficiency of managerial decision-making with a sufficient level of reliability. Accordingly, in order to construct an optimality criterion, two minimization problems are solved in the corresponding optimization model, which allow reducing management costs and choosing agile management tools appropriate to the conditions of the enterprise's functioning. The detailed description of agile management methodologies and related tools presented in the study allows to conclude that there is a significant number of possible reactions of the management system to changes in the operating conditions of enterprises. It is empirically proven that the model can also be used in enterprises with a rigid system of distribution of managerial powers, which mainly include state-owned enterprises, however, this requires the management's will to implement the changes. The behavior of key individuals (owners, top management, functional managers) will determine the speed of implementation of the studied tools and agile management methodology as in general. The resistance to change and the deliberate ignoring of the expediency of change is one of the major management problems of most of large companies. This leads to transformation of approaches of managerial influence on processes of strategic development and better qualification of perspective directions of development. It is the quality of management decisions, based not only on the personal perception of the expected changes by interested parties, but also the economic and mathematical justification of managerial choice that is a sufficient result of the implementation of the developed model. However, there is a promising field of further research in the presented area, since the implementation of the above methodologies must take into account regional and sectoral aspects and conditions for their practical implementation.

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