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AN INVESTIGATION INTO THE PROBLEMS OF ESTIMATING ACTIVITY DURATIONS IN PROJECTS

BADANIE PROBLEMÓW I ROZWIĄZAŃ SZACOWANIA CZASU TRWANIA DZIAŁAŃ W PROJEKTACH

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Summary: The article presents a theoretical and empirical investigation into the problems of estimating activity durations in projects. Uncertainty, the uniqueness of projects as well as their complexity make the process of estimation particularly difficult, but still crucial for successful project planning and implementation. As part of the literature analysis, the main techniques for project tasks estimating were presented. Classification was carried out and possible ways of their use were shown. The purpose of the research was to explore the actual use of the estimation methods and practices, to analyze their effectiveness and to identify obstacles in the process of activity time estimation. A survey was conducted on 40 project management specialists. The group of respondents was diverse in terms of company size, type and profile of implemented projects, importance of projects for the organization's activities, as well as knowledge and experience in project management.

Keywords: project management, project, project time management, estimation techniques, project planning.

Streszczenie: Artykuł przedstawia teoretyczne podstawy szacowania czasu trwania zadań w projektach. Zagadnienie to charakteryzuje duża niepewność związana z dynamiką współczesnych procesów biznesowych i z niepowtarzalnością przedsięwzięć projektowych. W ramach analizy literaturowej przedstawiono główne techniki szacowania czasu trwania zadań w projektach. Przeprowadzono ich klasyfikację, a także zaprezentowano sposoby ich wykorzystania. Cele artykułu stanowiły poznanie najczęściej stosowanych sposobów i praktyk

estymacji czasu trwania zadań w projektach, analiza ich skuteczności, a także wskazanie przeszkód utrudniających rzetelne szacowanie. Przeprowadzono badanie ankietowe na 80 respondentach. Grupa respondentów była zróżnicowana pod względem wielkości firmy, rodzaju i profilu realizowanych projektów, znaczenia projektów dla działalności organizacji, a także wiedzy i doświadczenia w zarządzaniu projektami.

Słowa kluczowe: zarządzanie projektami, projekt, zarządzanie czasem projektu, techniki szacowania, planowanie projektu.

1. Introduction

Project management is one of the most rapidly developing disciplines nowadays. The phenomenon of the increasing spread of projects as a way of operation of modern organizations has become so significant for economies that it has started to be treated as a separate trend, called 'projectification' [Midler 1995; Schoper et al. 2017; Nieto-Rodriguez 2012; Wald et al. 2015].

Uncertainty, the uniqueness of projects as well as their complexity make the process of project planning particularly difficult, but still crucial for successful project implementation [PMI 2017; ISO 2012; Axelos 2018; IPMA 2015; Wyrozębski, Spałek 2014]. The theory and practice of project management provide with numerous planning methods and techniques [Trocki, Wyrozębski 2017]. However their use and value of their outputs still depends on the quality of data entered into the particular algorithm employed by the particular technique. Whether CPM, PERT, CCPM or any other technique is used, the black box principle remains valid, in which the quality of the results obtained depends on the quality of the input data [Wyrozębski 2014].

Therefore the issues related to the planning phase and project estimation in particular continue to be of the utmost importance. In the article, the authors investigate the current picture of the estimation of project activity duration in selected Polish firms, and find out how and to what extent estimation techniques are applied and what influences the estimation-related processes. Therefore, the main goal of the article is to study the key factors influencing the project activity estimation by different industries and various types of projects. This paper introduces a valid empirical study, exploring project management estimation practices in a range of industries. Based on the literature review, the authors formulated the research questions, then described the research and discussed its results, leading to the final conclusions.

2. Estimation techniques for project activity duration

The literature related to project management presents a number of techniques for estimating the duration of tasks in a project. Based on the available information, they can be divided into 'soft' and 'hard'. 'Soft' techniques are those based on one's

Table 1. Project activity duration techniques

Techniques	Strengths	Weaknesses	Estimation error	Costs of implementation
Expert judgement	Used where other techniques are not applicable	Determined by expert knowledge. Susceptibility to the influence of various factors, intuition and other psychological elements	Possibly big (determined by expert knowledge)	Expert employment costs
Group decision-making techniques	A comprehensive (interdisciplinary) approach. Building an atmosphere of creative cooperation in the design team	Susceptibility to decision biases, coalitions, dominance of individuals or groups	Moderate (depends on the organization of the team's work and the experience of its members)	The costs of organizing group meetings. The costs of employing external experts
Analogous estimating	Universal use. Speed and simplicity	Use in repetitive projects with a high degree of similarity	Moderate	Information collection costs (small - simple documentation of previous projects)
Parametric estimating	Flexibility (a wide selection of tools adequate for various applications)	Vulnerability to ‚information ageing'	Moderate or small (depending on the quality of the information and the tools used)	The cost of collecting and analyzing data (collecting data in a structured and systematic way)
Three-point estimating	Interval estimation with risk management support	Good knowledge of statistics and probability theory is needed. Requires the use of software	Small	The cost of collecting and analyzing data (collecting data in a structured and systematic way). Software costs
Reserve analysis	Supports risk management even in areas difficult to predict	Vulnerability to Parkinson's law. The need to constantly monitor reserves during the project	Depends on the quality of information	Possible delaying of tasks – Parkinson's law

Source: own study based on [PMI 2013].

judgment, experience and assessments. 'Hard' ones in which statistics play an important role, are characterized by the high demand for information. Being more accurate, their use requires having very reliable, comprehensive and systematic historical data and the careful selection of statistical tools. The issues to be considered in this process include: project type, work efficiency, marginal resource efficiency and safety margins.

The PMBoK Guide [PMI 2013, p. 170], the well-established, global project management standard distinguishes six basic techniques for estimating the duration of tasks in a project: expert judgement, analogous estimating, parametric estimating, three-point estimating, group decision-making techniques and reserve analysis.

The main decision criterion in the selection and applicability of the appropriate estimation technique is the availability of information [Newell, Grashina 2004]. The borders between techniques are conventional, due to the subjectivity of the assessment of the quality of the information possessed. A good knowledge of the techniques presented below, as well as an awareness of their limitations, areas of application as well as their implementation costs allows the accurate assessment of the estimating conditions, the correct selection of their set and its proper application.

The description of each technique, its strengths and weaknesses, implementation costs and estimation error are presented in Table 1.

3. Own study results

The following part presents the results of research carried out by the authors on the estimation of the tasks duration in projects.

Based on the literature review, and building on the similarities from the research in the other project management domains, the authors formulated the following major research questions:

RQ1: How are the project activity durations estimated in the practice of project managers?

RQ2: What are the impediments of the activities estimation process?

RQ3: Does a typical set of variables such as type, cost, duration, repeatability or innovation of the organization's portfolio of projects' differentiating influence the course of the estimation process and its conditions?

3.1. Research method

In the research, the authors applied a questionnaire-based method. The research consisted in conducting standardized paper and pencil surveys (PAPI) in relation to the methods for estimating the duration of tasks in the projects. Based on the literature analysis and main project management methodologies, the authors formulated eight research questions (six closed single and multiple choice and two open ones) and

metrics (five closed single choice questions). The record sheet included such data as: the type and profile of implemented projects, the size of the organization, the importance of projects in the organizations, as well as the respondents' current state of knowledge and experience in project management.

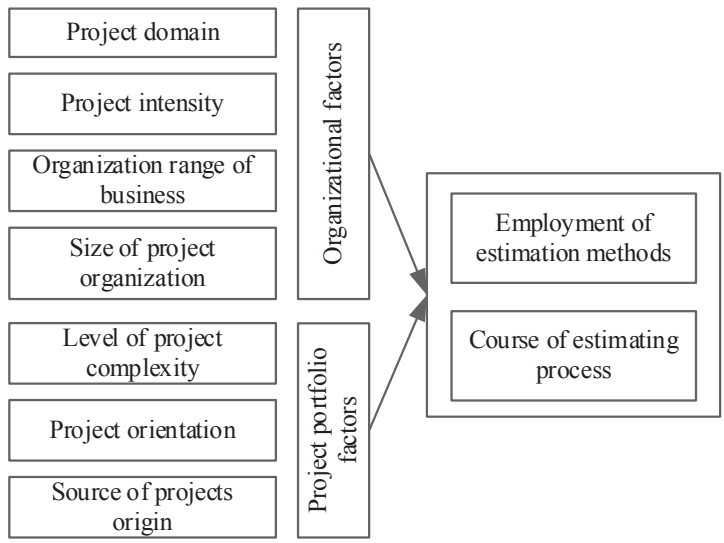

Fig. 1. Research model

Source: own study.

The data gathered included the declaration of methods used in practice to estimate the duration of tasks in the project and the level of satisfaction with the obtained estimates in relation to the projects carried out by the survey participants. The survey also included questions concerning the level of engagement in the estimation process, the conditions affecting the quality of the results, the reasons for delays in project implementation, and the approach to gathering and disseminating lessons learned from the planning activities.

3.2. Research sample

The respondents represented the selected companies located in Poland, from different types of industries. The questionnaire was addressed to the sample of selected 70 project management specialists (project managers, members of project teams and steering committees, project advisors) and the final response rate was 58%. Such a high response rate was obtained because the questionnaires were given to the participants at the beginning of a meeting that had been previously scheduled and had a generally different

purpose. Moreover, the construction of the questionnaire limited the time needed to fill it in to 15 minutes, which enabled it to be coupled with the general meeting concept. As a result, the data from 41 companies was gathered and analyzed.

The following research model was employed in order to answer the research questions. The significance level for hypothesis testing was set at $p < 0.05$. Due to the limitations of the study, the sample is unrepresentative. The study authors are aware that the test results cannot be applied to the entire population, however it gives a valuable insight into the practicalities of estimating process.

3.3. Descriptive statistics of the sample

The sample included the major areas traditionally pursuing their activities in the form of projects. The most numerous were: construction projects, information technology followed by research projects, marketing and production/technology (Table 2).

Table 2. Areas of project activities of the survey participants

Areas of project activities	Responses	
	N	%
Construction	9	22.0
IT	9	22.0
Research	5	12.2
Marketing	4	9.8
Production / technology	4	9.8
Legal	3	7.3
New product development	2	4.9
Non-Governmental Organizations (NGO)	2	4.9
Education/training	1	2.4
Infrastructure	1	2.4
Organizational	1	2.4
Total	41	100.0

Source: own study.

Almost half of the survey participants (41%) described their project intensity as high, and their organizations as project-oriented with all the business activity oriented towards project implementation. One third (34%) stated that their companies carry out many projects that are essential for their strategy implementation. Organizations with few and occasional projects amounted to mere 2% of the sample.

Detailed characteristics of the research sample, including its project portfolio description, are shown in Table 3.

Table 3. Descriptive statistics of sample*

Source of projects origin – internal/external					
internal		external			
54%		46%			
Type of projects orientation – process oriented ('soft')/product oriented ('hard')					
'hard' – product oriented		'soft' – process oriented			
78%		22%			
Level of projects complexity					
Low		moderate		high	very high
7%		17%		48%	28%
Organization range of business					
local		nationwide		international	global
12%		32%		37%	19%
Size of project organization (number of employees engaged in projects)					
01-09	10-49	50-249	250-499	500-1999	over 2000
17%	41%	20%	5%	10%	7%
The importance of projects for the organization					
low		moderate	High	very high	
2%		22%	34%	41%	
The level of previous knowledge and experience in the field of project management					
beginner		Intermediate		expert	
34%		61%		5%	

* As a percent of valid responses.

Source: own study.

Question 1. How do you assess the level of commitment put into estimating the duration of tasks in projects in your organization?

In over 40% of cases, the respondents assessed the level of involvement in the estimation of task duration as medium, 27% of the respondents as large, and every tenth respondent as very large, while almost every fourth one declared that in their organization the level of involvement put into the implementation this activity is very small.

According to the authors, such results testify to the awareness of how important the element of planning is in estimating the duration of tasks, as well as the benefits of minimizing the estimation error. The differences in indications may reflect the different nature of the implemented projects and their importance for the organization. In projects where the level of task complexity is very high, and a properly constructed

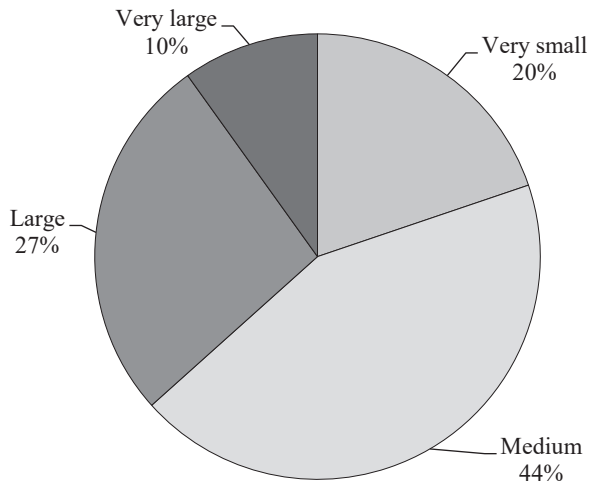

Fig. 2. The level of commitment put in the process of estimating the duration of tasks in projects

Source: own study.

schedule is crucial for the success of the project, i.e. implementation in the assumed time, budget and quality, the level of involvement in estimating the duration of tasks should be correspondingly higher than in uncomplicated projects, those repetitive or of little importance to the organization.

The analysis of the correlation between the answers to the following questions and the describing variables included in the study showed the existence of two statistically significant correlations between the data.

The first one shows that the level of involvement put into estimating the duration of tasks in the project was positively correlated with the level of satisfaction with the estimates of the duration of tasks in the projects. The strength of correlation and level of significance is shown in the following table.

As shown above, the obtained calculations seem to support the claim that the greater the awareness and effort put into the estimation process, the better the quality of the estimates obtained.

Table 4. Results of correlation analysis: level of satisfaction with the estimates of the duration of tasks in projects vs the level of involvement put into estimating the duration of tasks in the project

Correlation analysis	Value	Asymptotic standard error	Approximate *T*	Approximate significance (alfa)
Pearson's *R*	0.439	0.144	3.055	.004
Spearman Correlation	0.433	0.148	2.997	.005
N valid responses	41	-	-	-

Source: own study.

The second one shows that level of the involvement put into estimating the duration of tasks in the project was positively correlated with the importance of the projects in the organization. The strength of correlation and level of significance is shown in Table 5.

Table 5. Results of correlation analysis: the importance of projects for organization vs the level of involvement put into estimating the duration of tasks in the project

Correlation analysis	Value	Asymptotic standard error	Approximate *T*	Approximate significance (alfa)
Pearson's *R*	0.438	0.123	3.045	.004
Spearman Correlation	0.410	0.137	2.806	.008
N valid responses	41	-	-	-

Source: own study.

Organizations which strongly rely on projects in which the projects' implementation is their core business, tend to make scientifically bigger effort in getting right the estimates on which further business cases, project plans, etc. are based on.

None of the further analysis of the correlations between the variables included in the study showed statistically significant correlations.

Question 2. What is the most frequently employed method of estimating the duration of tasks in a projects in your organization?

By far the most commonly used technique in respondent organizations is estimation by analogy (78%). Every second respondent indicated that the determination of the duration of tasks is based on intuition, and more than 40% determine the duration of tasks together with the project team. Expert analysis and questions to contractors amounted to 32%, respectively. Almost one in four respondents indicated an analysis of historical data.

Table 6. The most frequently employed method of estimating the duration of tasks in a projects

Estimating methods	Responses	
	N	%
Analogous estimating	32	26.9
Intuitively	21	17.6
Team estimation	17	14.3
Expert analysis	13	10.9
Inquiries to contractors	13	10.9
Analysis of historical data	11	9.2
Experimental methods	5	4.2
Standards and industry statistics	3	2.5
Other	2	1.7
Parametric estimating	2	1.7
Total	119	100.0

Source: own study.

According to the authors, such results indicate that the organizations in which the projects are implemented, the respondents use very different techniques for estimating the duration of tasks, depending on their specificity or currently available information. A very high percentage of indications for the technique of estimating by analogy confirms the popularity of this technique, and may mean that a large proportion of projects implemented by the respondents are based on similar tasks, as this is the basis for using this method.

Question 3. How do you determine the level of satisfaction with the estimates of the duration of tasks in the project?

Almost half of the respondents described the level of satisfaction with their estimates as good (46%), every fifth respondent as rather satisfactory, and only 2% of respondents said that they are definitely satisfactory. The rest of the respondents (31%) were dissatisfied with the results obtained.

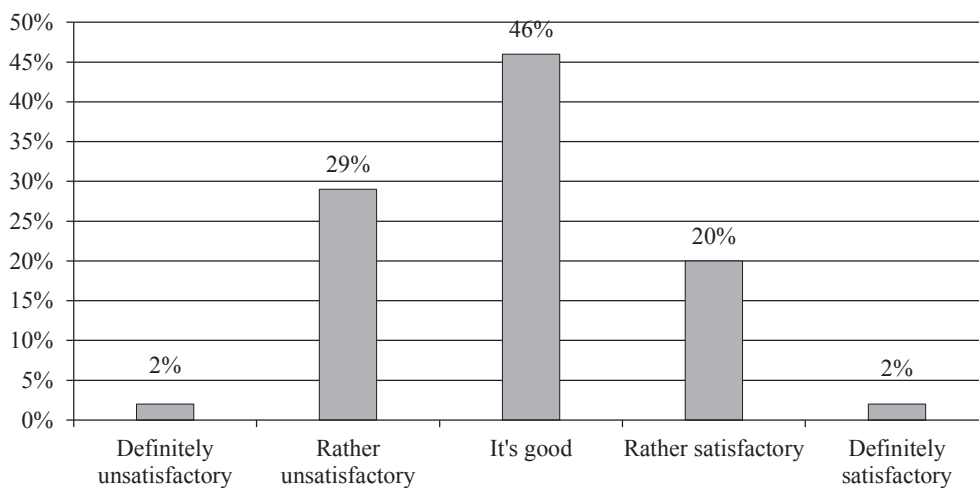

Fig. 3. Level of satisfaction with the estimates of the duration of tasks in the project

Source: own study.

Further analysis allowed to indicate that the average level of satisfaction stays close to "good" with the mean sample score of 2.90. According to the respondents, the most effective methods are: industry norms and statistics (mean score of 3.67), parametric estimating (mean score of 3.5), experimental methods (mean score of 3.2) and analysis of historical data (mean score of 3.18). The least effective methods were: intuitive (mean score 2.57/48% dissatisfied) and team estimation (mean score of 2.94/294% dissatisfied).

Table 7. Methods employed vs level of satisfaction with the estimates of the duration of tasks in the project

Estimating methods	Level of satisfaction with the estimates of the duration of tasks in the project					Total
	definitely unsatisfactory (1)	rather unsatisfactory (2)	good (3)	rather satisfactory (4)	definitely satisfactory (5)	
Standards and industry statistics	0	0	2	0	1	3
Parametric estimating	0	0	1	1	0	2
Experimental methods	0	2	1	1	1	5
Analysis of historical data	0	2	5	4	0	11
Inquiries to contractors	0	1	10	2	0	13
Expert analysis	0	4	5	4	0	13
Analogous estimating	0	9	15	7	1	32
Other	0	0	2	0	0	2
Team estimation	0	5	8	4	0	17
Intuitively	1	10	7	3	0	21
Total	**1**	**12**	19	8	1	41

Source: own study.

According to the authors, the results should not be surprising. Techniques based on collected data and experience on implemented tasks, i.e. those from the 'hard' group, are more effective because they are characterized by a significantly lower level of uncertainty, and are also not burdened with a psychological aspect that may cause large deviations, and thus the estimates obtained in this way they will be far from reality. However it should be remembered that external factors, which are not directly taken into account in the methods and techniques for estimating the duration of tasks, may have a significant impact on the implementation of tasks in the assumed time, therefore awareness and early risk verification is an important element of project planning. A helpful tool is the reserve analysis proposed by PMI, which assumes the addition of appropriate time buffers for tasks at risk of unforeseen events, thereby minimizing the risk of delays in the event of their occurrence.

Question 4. What are the conditions for the accurate assessment of the duration of tasks in the project?

The respondents considered industry experience (23%), having the full scope of project information (23%), analysis of previously completed projects (19%) and an experienced project team (16%) as the most important conditions for the accurate assessment of the duration of tasks in a project. According to the respondents, the lack of excessive pressure from the project sponsor (6%) and the participation of people performing tasks in the planning process (6%) were the least significant.

What is worth emphasizing is that despite the fact that all the conditions indicated by the respondents reduce the level of uncertainty and thus increase the effectiveness of estimates, every tenth respondent indicated good communication in the team and the right amount of planning time as conditions conducive to the accurate assessment of the duration of tasks in projects.

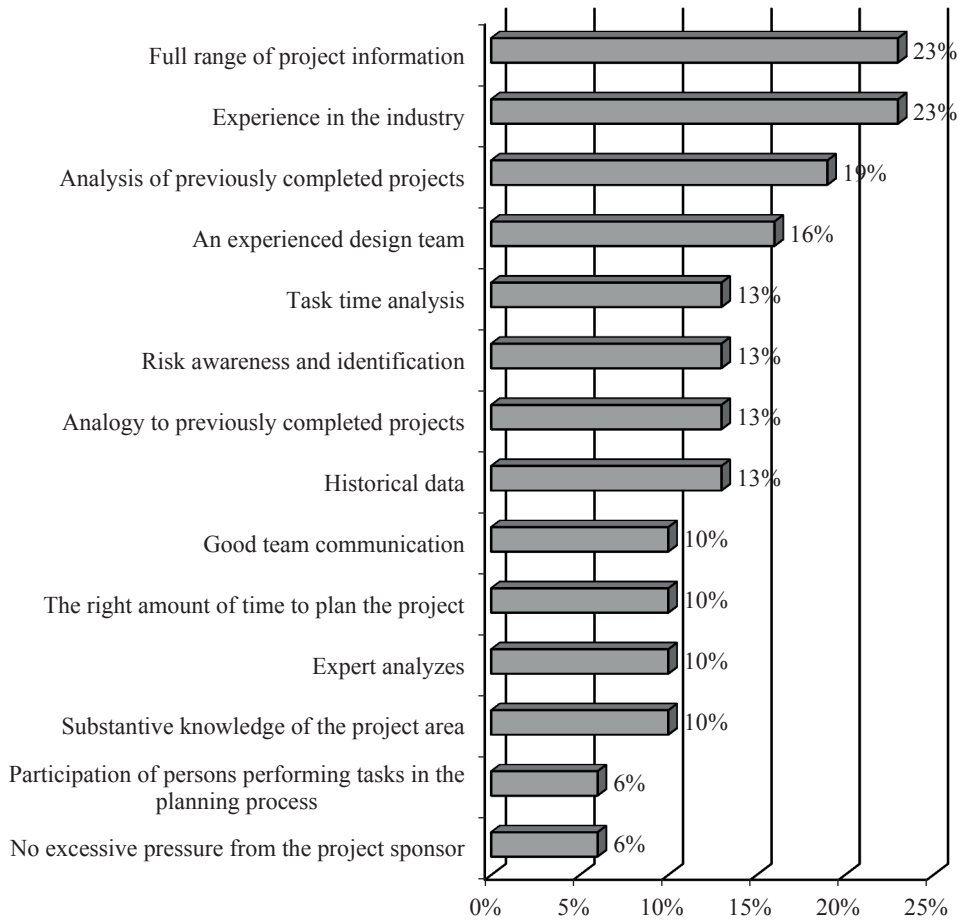

Fig. 4. The conditions for accurate assessment of the duration of tasks in the project

Source: own study.

According to the authors, this proves that while access to information about the project is a key criterion when choosing the technique for estimating the duration of tasks, the asymmetry of information in organizations causes a lack of satisfaction with the techniques and tools used, and leads to a reduction in the effectiveness of work in project teams, and the available time for reliable estimation significantly affects the quality of the results obtained.

Question 5. Are initial estimates verified during real time or after completion of the project?

From among the surveyed group, 34% of respondents indicated that they sometimes verify their estimates with the actual duration of tasks, while 22% admitted that they compare the results often, and only every tenth respondent always does it. Almost a third of respondents rarely verify their estimates, and 2% never.

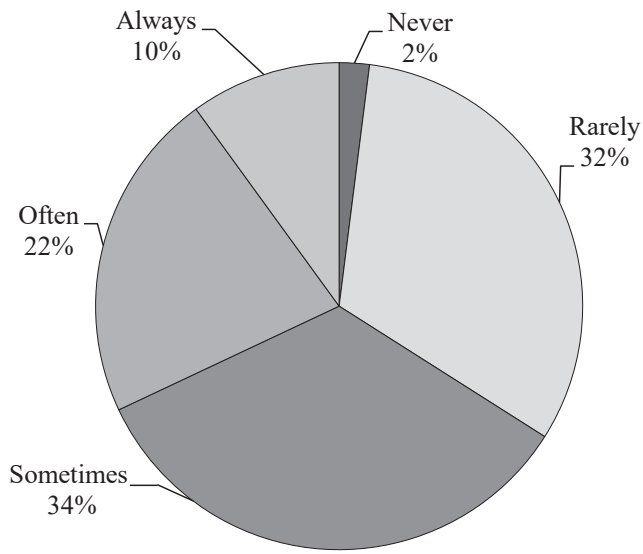

Fig. 5. Verification of primary estimates against real time

Source: own study.

Although having reliable information is crucial for estimating the duration of tasks, and the analysis and verification of estimation error on the basis of previously implemented projects is one of the simplest ways of gathering knowledge about the real units of duration of activities, a large group of respondents rarely or never verifies their estimates. In the authors' opinion, a large impact on whether the verification is carried out may be a different nature and specificity of the implemented projects, as well as the culture, the applied project management methodologies and organizational project maturity.

Question 6. Is the analysis of the original estimates and the actual duration of tasks in the project the basis for better project planning in the organization?

In relation to the acquisition and accumulation of knowledge and experience from implemented projects (lessons learned), the respondents indicated whether, and at what levels of the organization, information on past tasks was collected.

The research shows that at the level of project teams and the entire organization, most respondents analyze the results obtained and accumulate experience, but at the individual level as many as 45% of respondents admitted that they do this rarely or never.

According to the authors, it is at the individual level that this practice should be most often used, because the project manager, i.e. the directly managing person, present throughout the duration of the project, thus having access to very detailed information is crucial for building added value. Acquiring this knowledge and experience can be achieved in many ways - during meetings, workshop brainstorming, interviews, in the form of surveys or reports. It should be remembered that the 'hot' applications are the most valuable and are ideal material for building a register of project experiences. In turn, the register is the basis for creating one integrated experience report after the end of the project. Another important element is the Project Management Office (PMO), which, based on information collected from various projects, can create one standardized document available to everyone. The database of lessons learned should serve as a common source of knowledge for project managers and other interested persons. Therefore, it is not enough for it to be orderly and functional, but it must also be publicly available.

Table 8. Is the analysis of primary estimates and actual project duration times the basis for better project planning in the organization? (in %)

Responses	I make this summary only individually, for my own needs	We draw conclusions for the future together in a team	We use experience at the entire organization level
Never	22.5	7.7	10
Rarely	22.5	10.3	7.5
Sometimes	32.5	35.9	17.5
Often	15	35.9	47.5
Always	7.5	10.3	17.5

Source: own study.

Question 7. What are the main reasons for delays in projects implemented in your organization?

The respondents considered the most important reasons for delays to be: change to the scope of the project during its implementation (23%), erroneous estimates of work efficiency (23%), delays of subcontractors (17%), as well as limited personnel resources (14%). Other reasons indicated by the respondents were an excess of obligations not related to the project (14%), lack or poor communication with other project contractors (14%) and the negative impact of key stakeholders (14%).

It is worth emphasizing that many of the delays in implemented projects indicated by the examined reasons should be identified during risk analysis, which, together with estimating the duration of tasks, is an integral part of project planning.

The project ends on time if all tasks are completed within the planned time. Collecting data on the reasons for delays enables to identify areas of project management that need improvement. This allows for an appropriate response and a deliberate change in the areas that limit organizations the most.

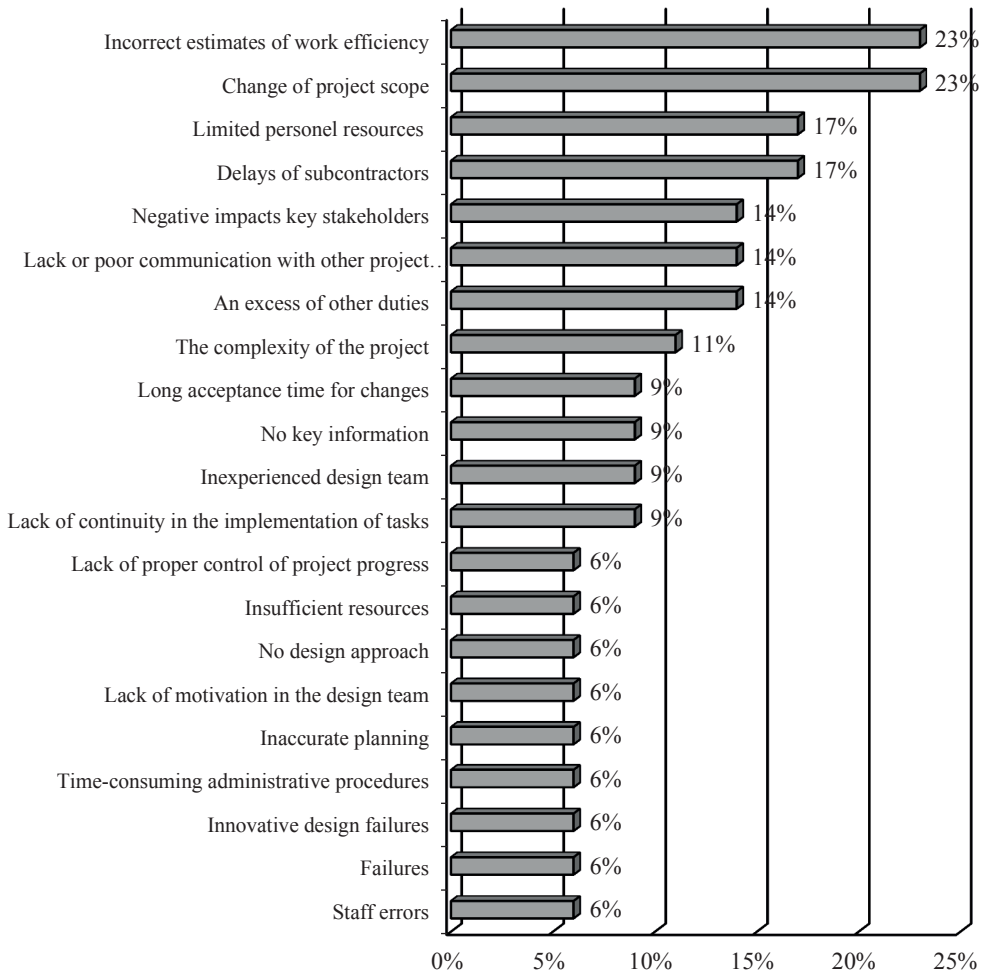

Fig. 6. The main reasons for delays in projects

Source: own study.

During the project, often the strategy, budget, market conditions or even senior management can change several times. Flexibility and the ability to adapt to changes is the key to the successful completion of the project. However it should be remembered that while it is not possible to stiffen the framework in a once defined project, changes in the requirements and scope of the project are notorious.

As a result of such actions, the changes will be accompanied only by superficial, rapid analyses that are derived from the tight deadlines and pressure exerted by key stakeholders. As a consequence, after several changes to the scope of the project, the entire previously carefully prepared project plan becomes completely useless, and the vision of completing the project within the assumed deadline inevitably recedes.

Question 8. What are the most difficult obstacles to the reliable estimation of the duration of tasks in projects?

The vast majority of respondents (63%) indicated too little time as an obstacle to the reliable estimation of the duration of tasks in the project. The next most common obstacles were: a disregarding approach to project planning (44%) and making estimates as expected but not related to reality (39%). Every third respondent admitted that the lack of similarity to previously performed tasks hinders the reliable estimation of their duration.

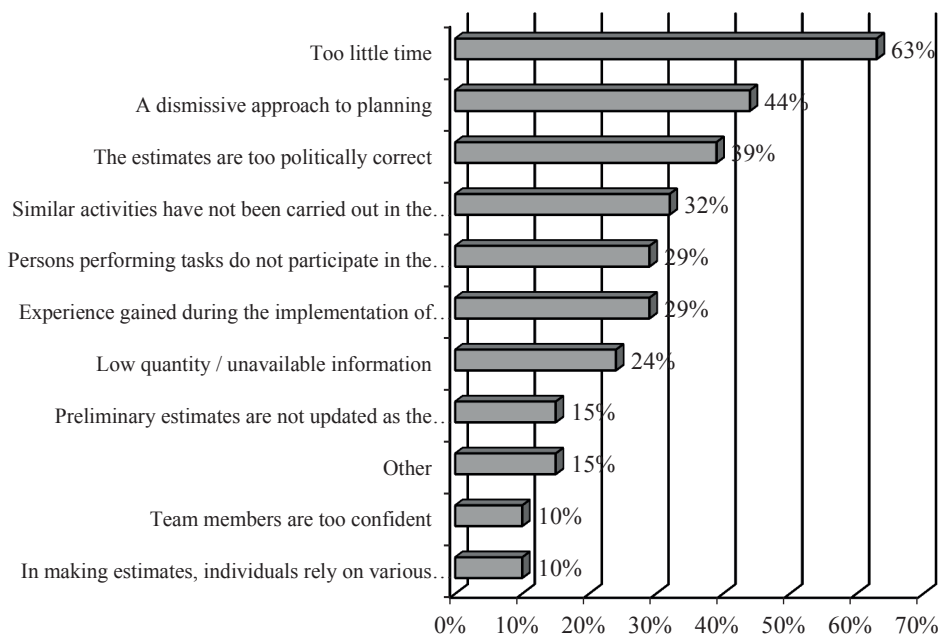

Fig. 7. Obstacles to the reliable estimation of the duration of tasks in the project

Source: own study.

According to the authors, a question should be asked here. What activities should the organization take to reduce the negative impact of obstacles indicated by the respondents on the reliable estimation of the duration of tasks?

The implementation of innovative projects, unlike those previously carried out in the organization, characterized by high uncertainty and lack of information relevant at the planning stage, is certainly a great difficulty in making estimates of the duration of individual tasks. Thus one will not expect to get valuable results using simple tools or techniques, however this is different in the case of other factors indicated by respondents.

Building awareness about the benefits of correctly carried out estimates and gathering knowledge about projects implemented in the past, increasing commitment to task duration estimation, risk analysis, as well as choosing the right tools or techniques taking into account their limitations and the specifics of the tasks performed, will significantly reduce the negative impact of these factors and, consequently, obtain satisfactory results. One should also remember about active time management in projects. Verification of the forecasts made, allows for the ongoing analysis of the assessment status and deviations, which gives the possibility of introducing corrective actions. Experience shows that each subsequent forecast is better than the previous one. People who prepare them usually learn and draw conclusions from previous mistakes.

4. Conclusion

In the study, the authors attempted to answer several research questions which concerned learning the most commonly used methods and practices for estimating the duration of tasks in projects, analyzing the effectiveness of estimates, outlining the conditions conducive to conducting a reliable analysis of the time-consuming tasks, as well as the obstacles that appear at the planning stage. As part of the research presented, a survey was conducted on 80 respondents with knowledge in the field of project management, actively participating in the implementation of the projects.

The analysis of the involvement of respondents in estimating the duration of tasks in projects indicates a great awareness of how important an element of planning is the estimation of time consuming tasks and the benefits of minimizing the estimation error. Studies have shown that tools and techniques for estimating the duration of tasks in projects are widely used, and their selection is determined by the amount and quality of information available, the specifics of the project being implemented, and the time available to conduct analyses. The dominant methods of estimating the duration of tasks turned out to be estimation by analogy, questions to contractors, making decisions together in a team, as well as intuitively.

Regarding the effectiveness of tools and techniques for estimating the duration of tasks, the respondents indicated that the techniques based on collected data and experience on the tasks performed, i.e. those from the hard group, are more effective because they have a significantly lower level of uncertainty.

The study showed that a large proportion of the respondents rarely or never verify the original estimates against real time, despite the fact that the analysis and

verification of estimation error based on previously implemented projects is one of the simplest ways of gathering knowledge about the real units of task duration.

According to the respondents, the most important conditions for an accurate assessment of the duration of tasks in a project are: industry experience, having a full range of project information, analysis of previously completed projects and an experienced project team.

The respondents considered the most important reasons for delays in projects to be: change the scope of the project during its implementation, erroneous estimates of work efficiency, delays in subcontractors and limited personnel resources.

The research showed that the most important obstacles to the reliable estimation of the duration of tasks in projects are: too little time, a disregarding approach to planning and making estimates as expected, but not related to reality.

It is the authors' conviction that the conducted research shows some regularities that can be observed as part of the collected research sample in terms of estimating the duration of tasks in projects. Certainly, this research should be continued and deepened in the future, to broaden knowledge in this area of project management.

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