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# SELECTED METHODS OF PROJECT AND DATA ANALYSIS

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**Purpose:** Presentation of selected methods of project and data analysis – describes how data on ongoing projects should be collected, so that it can be used later, by applying the appropriate methodology.
**Design/methodology/approach:** Literature research of the subject was carried out.
**Finding:** Having a methodology for data collection leads, in the long term, to the implementation of a system that allows the use of this methodology. The system should provide information to help make better decisions, reducing or eliminating the risk of project failure.
**Practical implications:** Development of a methodology of data collection and analysis on this basis.
**Originality/value**: The implemented projects are comparable with each other and, on this basis, it can be argued that identifying the risks that have occurred in the past, during the implementation of various stages of projects, can contribute to more effective risk management during the implementation of current and future projects.

**Keywords:** company management, data analysis methods, project risk.

**Category of the paper:** General review.

## 1. Introduction

The basis for the operation of automotive production companies is the implementation of successive projects. Extensive engineering centres, working closely with manufacturing companies, are responsible for developing existing, as well as completely new product concepts. This continues until the developed solutions are implemented in production. When a project involves cooperation with a key business partner or aims to implement very important strategic objectives of the company, the success or failure of the project may determine whether the company remains competitive in the market in relation to other companies.

Regardless of the market segment a company is involved in, the implementation of its projects is always accompanied by numerous challenges, the nature and complexity of which are extremely varied. Nevertheless, the common feature that connects the encountered difficulties, is the fact that each of them brings with it a risk to the project. It can jeopardize the planned implementation of a project or even lead to its complete failure. In order to avoid failure, people – such as project managers, operations managers or leaders of individual functional teams – use methods that support the management of a wide range of risks. The purpose of such action is to prepare for the occurrence of a given negative risk, called a threat. This is done in order to be able to react appropriately when the danger occurs, thus eliminating – or at least reducing – its undesirable effects. The concept of risk is also associated with the possibility of events, whose nature may lead to positive consequences, in which case the risk is called an opportunity (PMBOK Guide, 2012). The role of the person responsible for the stage of the project affected should be to make it happen.

In the case of companies, whose operation is closely based on the successful implementation of projects, it is very important to pay attention to various aspects of the tasks performed. The aim is to improve the efficiency of operations, reduce unplanned costs and, above all, to achieve the intended objectives in accordance with the plan. In such a situation, it is therefore important to draw appropriate conclusions after the completion of each project, as well as throughout its duration, to draw the appropriate conclusions. This should include, but not be limited to: task management, cooperation with sub-suppliers and the quality of work performed by the various functional groups. Information on these issues can be useful for future risk management, as awareness of past threats or opportunities, combined with knowledge of how to deal with such situations, can contribute to the rapid implementation of an appropriate response to the relevant risks.

However, the reality is that once a project has been completed, there is not enough time to analyse it and draw valuable conclusions from it, as another project is started very quickly. In such a situation, sharing the knowledge gained during the project with other employees of the company, let alone cataloguing it correctly, may be impossible, and certainly very difficult. Therefore, it would be very useful to have a tool supporting quick archiving of the possessed information and knowledge, as well as, to some extent, enabling to make conclusions on the basis of the possessed data.

An obstacle to the practical use of such a tool is the fact that each of the implemented projects is – to some extent – innovative and unique, so their comparative analysis will not always make sense. However, if a group of projects – that are twinned in certain respects – is examined, comparing them can provide useful information and lead to conclusions that can help with risk management of similar projects, that will be carried out by the company in the future.

Such a situation occurs in the case of companies associated with the automotive industry, which carry out many programmes, consisting of similar projects, for individual clients. An example can be a company that carries out projects involving the design and implementation for production of many types of exhaust systems that are structurally similar to each other, based on components supplied by specific suppliers and are designed and developed through the work of permanent functional groups, cooperating with each other within the organisational structure of the company. This means that the implemented projects are comparable with each other and, on this basis, it is possible to argue that identifying the risks that have occurred in the past, during the implementation of different stages of projects, can contribute to more effective risk management during the implementation of current and future projects (Gembalska-Kwiecień, 2017).

## 2. Project analysis methods

The more complex the projects, the more analysis they can undergo. When preparing for them, it is good to first define – as precisely as possible – the purpose of the conducted application and the way, in which the information will be obtained.

It should be remembered that the expectations with regard to the implementation of projects, as well as the manner of their analysis, may differ for various projects. A project, whose scope was twinned to many similar projects carried out in the past, and an innovative project, unique to a large extent, cannot be measured in the same way. In the first case, even a slight budget overrun may or may not mean a failure, if previous undertakings have been successful within the given financial scope. On the other hand, even a significant cost overrun of an innovative project may result from an unrealistic initial estimation, and therefore does not have to be the same as a lack of expected success. The danger of misclassifying a project as a failure can lead to inappropriate conclusions, so that project analysis should always take into account whether the demands placed on it were common sense (Atkinson, Crawford and Ward, 2006).

R. Atkinson – giving the definition of project management according to the BS6079 British Standard of 1996, saying about achieving project objectives in the assumed time, at defined costs and ensuring the required quality of its delivery and implementation – points out that the analysis of a project to determine whether it has been successful or unsuccessful can be done from the perspective of the "iron triangle", which is depicted in Figure 1 of the project constraints (Atkinson, 1999).

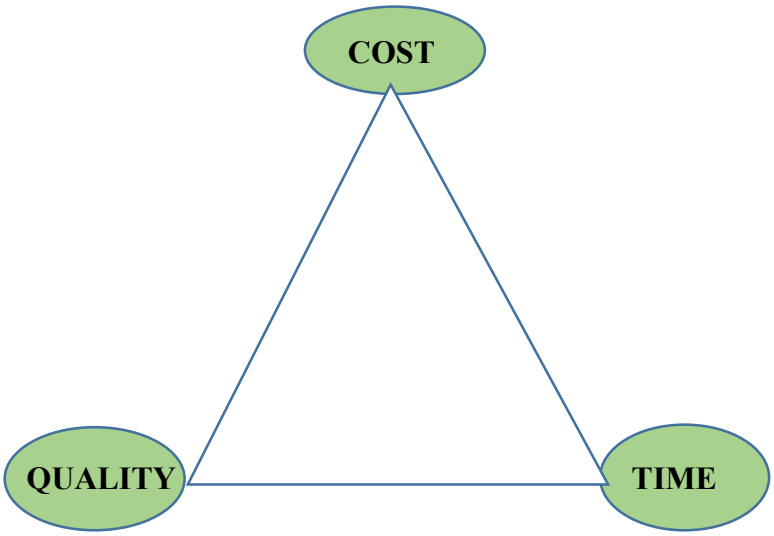


**Figure 1.** The iron triangle of project constraints
Source: Atkinson, R.: Project management: cost, time and quality, two best guesses and a phenomenon, it's time to accept other success criteria (Atkinson, 1999).

This means that the successful completion of a project is the same as the fulfilment of the assumptions given in the definition quoted above. Atkinson, however, draws attention to the necessity of analysing the project in terms of other criteria – defining time, cost and quality as insufficient to make a proper evaluation. He also draws attention to the possibility of tracking the progress of a project temporarily, throughout its duration, in order to assess whether it is going according to the plan, for example, through the earned value method. Progress determined in this way does not necessarily translate into success or moving in the right direction. Atkinson also draws attention to the basic question – who should define the criteria, by which the project and its realisation will be measured? He mentions key stakeholders, such as the project manager, the company's management board, the client and the project group, as well as other stakeholders, who are less directly involved in the project, but who may be influenced by it, e.g., potential clients. In relation to IT projects, Atkinson proposes four perspectives, from which a project should be analysed, to determine whether it has been successful:

1. the iron triangle perspective, whose success criteria are the aforementioned time, cost and quality,
2. the perspective of an IT system, the design of which should make it maintainable, provide good-quality information and enable effective use, while the system itself should be reliable and valid,
3. the perspective of achieving benefits for the organisation, which should improve its productivity and operational efficiency, increase profits, achieve strategic goals and learn,
4. the perspective of achieving benefits for the stakeholder community – the users should be satisfied, the impact on the environment and society should be positive, the information system should provide opportunities for personal and professional development, as well as profits for contractors.

Another way of analysis is proposed by Raz and Michael. They suggest that the evaluation of project management, including the analysis of the project itself, can be done by answering the question – how well does the project fit into the following characteristics (Raz and Michael, 2001):

- satisfies the client,
- satisfies the stakeholders involved,
- requires emergency, urgent meetings,
- has a high project management performance ratio,
- requires changes to the product after delivery to the client,
- has a low value – assuming that the objectives are achieved – of the ratio of the effort put into the project to the effort that was originally required to deliver the project/task,
- required changes in the plan.

Another important aspect of project analysis, especially when projects end in failure, is to focus on the proper cause of the events that occurred. This topic is taken up by R.J. Sauser, R.R. Reilly and A.J. Shenhar in their work on the analysis of a failed NASA project to send a space probe to collect data on the weather conditions on Mars. These authors argue that the reasons for failure are often rooted in poor project management and not, as it may seem, in technical problems (Sauser, Reilly and Shenhar, 2009). Their proposed approach to analysing twinned projects is based on determining to what extent they are similar. Then, determining how this translates into choosing the right approach to managing the project at the beginning of the project and even when the project is not going as expected. Sauser, Reilly and Shenhar suggest using various contingency theory structures to conduct a retrospective analysis of successful or unsuccessful projects.

It can be concluded from these examples, that a proper project analysis can be a very difficult task, but one that leads to finding answers to questions that are crucial in the context of future projects. In order for them to be successful, it is important to understand not only how to conduct an analysis, but also how to understand project success and what factors lead to it.

## 3. Factors determining the success of projects

The implementation of a risk management process aims to ensure the successful outcome of a project. For a project to end successfully, it is not only necessary to define how success is to be interpreted, but it is also reasonable to determine which factors lead to success. The aim is for the risk analysis to be carried out in a way, that is focused on the opportunities and threats associated with these factors.

T. Cooke-Davies answers the question of what are the key factors for project success. In his opinion, the factors that lead to success – when considered in the context of project management – which influence not exceeding the timeframe, are as follows (Cooke-Davies, 2002):

- the adequacy of company education on risk management,
- the maturity of organisational processes for assigning responsibility for risks,
- the adequacy, with which the visible risk register is maintained,
- the adequacy of current risk management plan,
- the adequacy of documentation on project responsibility allocation,
- ensuring that projects – or phases thereof – do not exceed three years in duration, whenever possible, and ideally do not exceed one year in duration.

Another group of factors, that Cooke-Davies mentions, are those that affect not exceeding cost tolerances:

- allowing changes to the scope of the project only through the scope change control process,
- maintaining the integrity of the base used to measure performance.

However, Cooke-Davies points out, that a distinction must be made between the concepts of success, considered in the context of project management, and understood in terms of the successful outcome of a project. This means that a project, carried out in accordance with the time plan and the assumed costs, does not necessarily lead to the achievement of the organisation's objectives and, therefore, it cannot be said to have been successful. The key factor for an individual project is the existence of processes in the organisation that involve mutual cooperation between project managers and operational managers. The purpose of implementing these processes is to effectively achieve the benefits of projects (Cooke-Davies, 2002).

The last group of factors Cooke-Davies highlights are those leading to successful project delivery, what he refers to as corporate success. The practices leading to it are:

- managing in terms of project portfolios and programmes, enabling the company to provide the necessary resources to a group of projects, whose implementation aligns with the company's strategy and business objectives;
- having appropriate project, programme and portfolio monitoring methodologies, that provide direct insight into the day-to-day aspects of performance, as well as the ability to track whether completed projects, programmes and portfolios are delivering the intended strategic benefits;
- the company's commitment to continuous development and effective learning from the experience gained through the implementation of projects.

Practices related to this should include the involvement of employees of the organisation in the development of processes related to project management, through the utilisation of knowledge and skills acquired by them.

Project success may also be considered from another perspective. J. Turner, based on the works of J. Wateridge and R. Muller, presents four conditions necessary to ensure project success (Turner, 2004):

- The criteria determining the success of a project should be established with the participation of stakeholders before the project begins. These criteria should be reviewed and updated during the project,
- the project owner and the project manager should work together and see their working relationship and the project as a partnership,
- the project manager should have enough authority to decide how to deal with the encountered circumstances, while the project owner should communicate how they think the project should be carried out,
- the project owner should take an interest in the project.

The conditions presented above are very important in the context of a successful project, because, if the first one is not fulfilled, a situation may arise, in which some project stakeholders do not share a common vision of what the purpose of the project is. In such a situation, they may perceive the results as a failure. Another reason is the need to define, from the very beginning, a clear direction, in which the project should be carried out – taking into account, among others, the time and expenses incurred – so that the activities of the project team are carried out in accordance with the defined direction. Otherwise, different perceptions of how individual tasks should be carried out can lead to project results, that are significantly different from those assumed before the project started.

A. Jaafari, on the other hand, lists the following activities as key factors for managing a project in a way, that will lead to its success (Jaafari, 2001):

- recognition and proactive management of complexity – depends on the ability to manage in real time the variables and their impact on the strategic objectives,
- decision-making processes based on the chosen strategy,
- integration of project phases, so that the focus on achieving business objectives occurs at each stage of the project,
- consideration of environmental variables, such as the perception of the project by the surrounding community, safety during project implementation, environmental impact, delivery of the project in compliance with legal requirements.

Significant work has also been done by W. Belassi and O.I. Tukel in identifying factors determining the success of the project. Defining an unambiguous way to measure the degree of success – or failure – of a project is not easy, because the various stakeholders involved in the implemented project perceive these issues in different ways – a project completed with success,

perceived from the perspective of the client, may be considered a complete disaster from the point of view of the management of the organisation that implemented it (Belassi and Tukel, 2001).

Such a situation may occur when the project objective required by the client has been achieved, but the financial outlays incurred were so high, that, as a consequence, the project has lost the business case underlying the decision to proceed with it.

Achieving ultimate project success is also difficult because the factors leading to it change as the project progresses. Belassi and Tukel emphasise that the outcome of any project will depend, to varying degrees, on an individual combination of many factors – however, skilfully identifying a group of those that are critical to a particular project will allow for a better assessment of the project and an understanding of what aspects of the project may be key to achieving the desired outcome. Belassi and Tukel categorise these factors into four groups described below (Belassi and Tukel, 2001). The first group consists in factors directly related to the scope of the project, meaning that they will vary according to the nature of the project:

- size and value of the project,
- the uniqueness of the activities carried out,
- the project life cycle,
- urgency of implementation of the project.

Factors related to the project manager (the first six listed below) and members of their team (the last four factors listed):

- the ability to delegate authority,
- the ability to compromise,
- the ability to coordinate activities,
- perception of their role and responsibilities,
- competences,
- commitment,
- technical experience/knowledge,
- communication skills,
- problem solving,
- commitment.

Factors relating to the organisation, within which the project is implemented:

- senior management support,
- the organisational structure of the project,
- support of functional managers,
- project leader.

Factors relating to the external environment (in which the project is implemented):

- political environment,
- economic environment,
- social environment,
- technological environment,
- natural environment,
- clients,
- competitors,
- sub-suppliers.

Based on the information presented – showing the effect of research carried out on the identification of key factors influencing the success or failure of a project – and professional experience, it was concluded that the key factors for automotive projects are primarily:

- availability of resources to carry out the intended activities,
- support of senior management, especially in conflict situations,
- consultation with the client and ensuring good relations between the client and the project manager,
- the fulfilment of responsibilities by the project manager, but also by the members of the project group.

## 4. Data analysis methods

In order to develop a project analysis methodology, for which it will be possible to implement it in the form of a spreadsheet-based tool, it is helpful to be familiar with data exploration issues. An extensive study on this subject is a publication by D. Handa, H. Mannila and P. Smyth, which presents the most important aspects of data analysis and drawing conclusions based on it.

The following methods of analysing and presenting data are described below:

- statistical method, based on the analysis of the probability of occurrence of given risks. The applicability of the method is based on the information available on the implementation of past projects;
- the method of graphical visualisation of data, which is described using examples that help to understand the functioning of the prepared tool using the methodology developed in this work.

The method should be used in the spreadsheet development process, as it can provide additional opportunities for the user to draw conclusions by observing the graphical presentation of data (Hand, Mannila and Smyth, 2006).

The method of statistical data analysis involves analysing the data held on past projects and their various stages individually, in a way that allows the statistical probability of the risks involved to be determined (Larose, 2006).

To illustrate these words, if, in the case of fourteen out of fifteen completed projects, in the first stage – which in each case was, for example, the initial preparation of the product concept – there was an extension of time for this stage due to the need to implement unplanned design changes, it is possible to determine the statistical probability of this occurrence, which is 93%. This means that, when conducting the next project, the project manager should look carefully at the reasons why this situation occurred in the past. If there have been no significant changes since the completion of the projects under consideration, the statistical probability that this stage will also be prolonged in the current project is high. Taking into account the costs of constructors' work, the scope of which usually exceeds the planned and budgeted level at this point, it becomes realistic to state that, in such a situation, the level of risk for the project may be high.

Another method is graphical visualisation of data. It allows people to analyse the data through the organ of sight, and thus provides a chance to see a pattern in the data, that would be difficult to identify through algorithmic analysis by a computer (Hand, Mannila and Smyth, 2006).

The prepared spreadsheet, when developed, should also be able to visualise the entered data to provide the user with this opportunity.

However, it should be borne in mind that, before the selected method can be used, it is necessary to determine the way of collecting data concerning the implemented projects – recommendations for collecting these data are described in the following section.

## 5. Recommendations for the collection of project data

In order to make use of the data provided during the implementation of projects, it is essential to have a methodology for collecting it. Using Bechtel Oil, Gas and Chemicals as an example, J. Musgrove concisely describes how the company collected data on completed projects in the past, and how it introduced and is currently developing its Central Metrics Database (CMD), which contains historical information on completed projects (Musgrove, 2008). Musgrove clearly indicates that the company has suffered from the problems associated with the departure of experienced staff, so that knowledge of project implementation, as well as performance information, against which current projects can be compared, has been lost to

some extent. He also draws attention to the need to ensure limited access to the collected data, as they contain confidential business information, very important for the company.

The characteristics that a system that enables data collection should have are as follows (Musgrove, 2008):

- costs, resources and individual activities should have their own categories,
- the system should be able to store data on assumed and actual costs, as well as used resources,
- the system should provide the ability to categorise projects, so that the data held can be sorted in a way that enables it to be used.

The data collected included:

- project profit and cost
- the type of work that was carried out;
- the execution of construction works;
- the execution of special works;
- the project schedule;
- specific costs;
- project summary.

Musgrove also points out that data entered into the system may be entered incorrectly or, depending on the role within the company of the user entering it, false data may be entered. One possible solution is to appoint a controlling manager for each project, who will be responsible for validating the data and approving its completeness and accuracy. In the case of the described company, this solution led to the following benefits: the accuracy of the data was no longer questioned, as once it was approved by the controlling manager, it could not be changed and was considered valid.

As further points of development of the CMD system, the possibility of collecting data on specific characteristics of the projects concerned, e.g., cost ratios for materials, was identified, as well as the realisation of the need to be able to treat large projects as a set of smaller projects, so that they could be compared with each other.

T. Pickett and B. Elliot suggest that the use of historical project data can assist in strategic decision making and provide a competitive advantage over other companies in the market (Pickett and Elliot, 2007). This data helps in deciding, which projects should be carried out in the future and which should be discontinued.

However, in order to apply the data in its possession, a company should have an appropriate methodology and follow procedures defined for this purpose. In this situation, having a system that provides the ability to work with historical data provides an opportunity to increase the efficiency of project delivery and support the estimation, planning and control of future projects. The authors point out that it is necessary to analyse completed projects in order to

improve the performance of current and future projects. The development of systems to support this process is hindered by the vision of the necessary financial outlays to be incurred in this connection. This makes it all the more important to have the commitment and support of the company's management board, who should first recognise and understand the need for historical data. The benefit of using historical data is that it allows comparisons to be made, as well as plans and estimates of costs and activity times to be evaluated.

The first questions that arise are:

- how to collect all the important data?
- where to store the collected data?
- how to use the data you have to give you a competitive advantage?

In response to these questions, Pickett and Elliot highlight the following aspects:

- staff – the commitment and understanding of the data collection process by staff, both at senior management level and at the level of those directly entering data into the system, is essential for data collection to deliver the expected benefits,
- infrastructure – when thinking about collecting data using an IT system, consideration should be given to aspects, such as access to hardware and software, but also to where the data will be stored – on the company's server or perhaps in the cloud – and how it will be secured and backed up,
- categorisation – data collection should be carried out in a way that enables the data to be assigned to appropriate categories, so that it can be later segregated and searched,
- cost control system – necessary for the collected data to have real meaning for the company. The possibility of assigning categories to given costs finds its justification in the operation of this system, because, in this way, it is possible to not only monitor costs, but also compare them, thus estimating them with greater accuracy,
- project classification – necessary, so that the data held can be identified and organised in the required manner. By doing so, it is possible to avoid the danger that the projects being compared are so different from each other, that they should not be analysed together.

Pickett and Elliot draw attention to practical aspects of using the system (Pickett and Elliot, 2007). One of these aspects is the need for data standardisation – it reduces ambiguities and anomalies in the collected data. The first step in data normalisation is identified as the selection of projects that may provide unusable data. Reasons that may lead to data not having the required value can be considered:

- errors made in accounting or during project audits that translated into having inaccurate data,
- the size of the project significantly deviating from other projects of the same type – in such a situation, the data provided on the basis of the implementation of a project may be irrelevant if its scale was, for example, much smaller than that of other projects,

- projects implemented at a non-standard level – it is possible that the project implementation will be carried out in a completely different way than for the standard projects of this type, so the comparison of the data concerning them with the information about other projects will not make sense.

The course of normalisation for cost data is as follows:

- converting data to be in one common unit (e.g., currency),
- adoption of a common time frame,
- estimating missing cost data, if possible,
- ensuring that costs not incurred are not taken into account,
- classifying projects and their phases, if appropriate.

Once it has been identified which projects should provide useful information and the existing data has been normalised, it is necessary to move on to the issue of data collection. For this purpose, it is recommended to implement an information system in the company (Musgrove, 2008; Pickett and Elliot, 2007).

Once the company has the infrastructure in place to make use of the historical data, the question that needs to be answered is: How can the collected data be used to maximum advantage?

Examples of use are formulated as follows (Pickett and Elliot, 2007):

- ensuring the possibility of data comparison – having a database, it is possible to estimate on its basis, as well as to evaluate the created project plan and adopted indicators,
- calibration of the database – where, for example, the cost of materials fluctuates widely, it should be possible to consider it in such a way, as to determine when an increasing or decreasing price is a trend and when it is a more random fluctuation, dictated by non-standard situations and market conditions,
- pre-estimation of costs and lead times – the system should be able to perform calculations to determine costs and lead times based on the available data. Such information can be very helpful, as it is based on up-to-date information, so that the values generated can represent – with satisfactory probability – what costs the project will generate and what time will be needed for its implementation,
- strategic project planning – lessons learned from successful or unsuccessful projects can be of key importance for planning future projects, their implementation strategies and choosing which projects should be implemented by the company.

Pickett and Elliot cite the possibility of development and improvement of the functioning of a company using this system as the main objective of using a system for collecting and analysing historical data on completed projects.

## 6. Summary

Having a methodology for data collection leads, in the long term, to the implementation of a system that allows the use of this methodology. The system should provide information that helps to make a more accurate decision than if the company did not have this tool (Office of Government Commerce, 2010).

J. Rutkowski presents methods for portfolio analysis and their application in the evaluation of product innovation projects (Rutkowski, 2013). Before starting a new product project, the basic issue is how to effectively allocate the resources at one's disposal, so that the implementation of the project will bring the intended goal. It is also necessary to estimate the costs of project implementation, so that – in the long term – through their juxtaposition with the list of potential benefits, it is possible to assess whether the project has a business justification and to apply the presented methods of portfolio analysis. Rutkowski also points out that innovative companies usually have a smaller number of new product projects than non-innovative companies, but with a higher value. In this situation, having a system that allows the use of accumulated data on past projects can assist management in deciding which projects should be implemented and which should be cancelled, so that more resources can be used for selected projects.

Cost estimation and good planning skills are crucial for the successful delivery of projects (Corvellec, 2009; Pritchard, 2002; Smith and Fischbacher, 2009).

D. Dvir, T. Raz and A. Shenhar, on the basis of an analysis of more than one hundred R&D projects implemented in Israel, conducted an empirical analysis of the correlation occurring between aspects of project planning (e.g., requirements definition) and its success, considered from the perspective of, among others, the project beneficiary (Dvir, Raz and Shenhar, 2003). The results of their analysis confirmed that certain aspects of project planning can positively influence project implementation, and thus the success of a project. It was proven that, in the case of the analysed projects, taking time during planning to define project requirements positively influenced the outcome.

In this case, it is desirable to be able to use an information system based on historical data, speeding up the planning process and increasing the accuracy of estimating the values of variables that characterise projects (Ward and Chapman, 2003; Dowie, 1999; Gardiner, Stewart, 2010; Gembalska-Kwiecień, 2020).

In the future, while continuing the work on the topic addressed in this paper, it is recommended that the developed methodology of data collection and analysis is implemented in the form of a computer application (Office of Government Commerce, 2010; Project Management Association Poland, 2009; Perminova, Gustafsson and Wikstrom, 2008; Gembalska-Kwiecień, 2021).

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