

# Method of Forecasting the Characteristics and Evaluating the Implementation Success of IT Projects Based on Requirements Analysis

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## Abstract

Currently, the actual task is the analysis of the requirements for the IT project in order to forecast the characteristics and evaluate the implementation success of IT projects. The purpose of this study is forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis. The paper further developed the method of forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis. This method consists of: neural network-based forecasting the project characteristics based on requirements analysis; interpretation of the obtained values of project characteristics based on the success rate of the IT project; assessing the degree of IT project implementation success on the basis of the project success rate; forecasting the success category of the IT project (successful, challenged, failed) based on the degree of the project implementation success. The input data for the improved method of forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis are the requirements for the IT project, and the result of this method is the conclusion on the success category of an IT project, which allows to make an informed choice of the project for its further implementation. The proposed method differs from the known ones in that it allows forecasting the success of project implementation, comparing projects comprehensively according to the main characteristics and projected value of the degree of project implementation success (and not only in cost and duration, as it happens now), as well as allows to make an informed choice of IT project by the developer and the customer for further implementation.

## Keywords

IT project, IT project requirements, success rate of the IT project, the degree of IT project implementation success, success category of an IT project, method of forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis.

## 1. Introduction & state-of-the-art

Analysis of statistics on the success of IT projects for 1994-2019, according to various statistical companies (including The Standish Group International (Chaos reports)) [1-10], is represented in Figure 1. Successful projects are those that were completed on time, within the budget, with the necessary capabilities and functions. Projects that were overdue, overspent or did not have the necessary capabilities and functions are considered challenged. Projects that have been canceled before completion or have been delivered but are never used are considered failed.

Lately, more projects are meeting original goals and business intent and being completed within budget. Compared to last years, fewer projects are deemed failures (Figure 2) [6].

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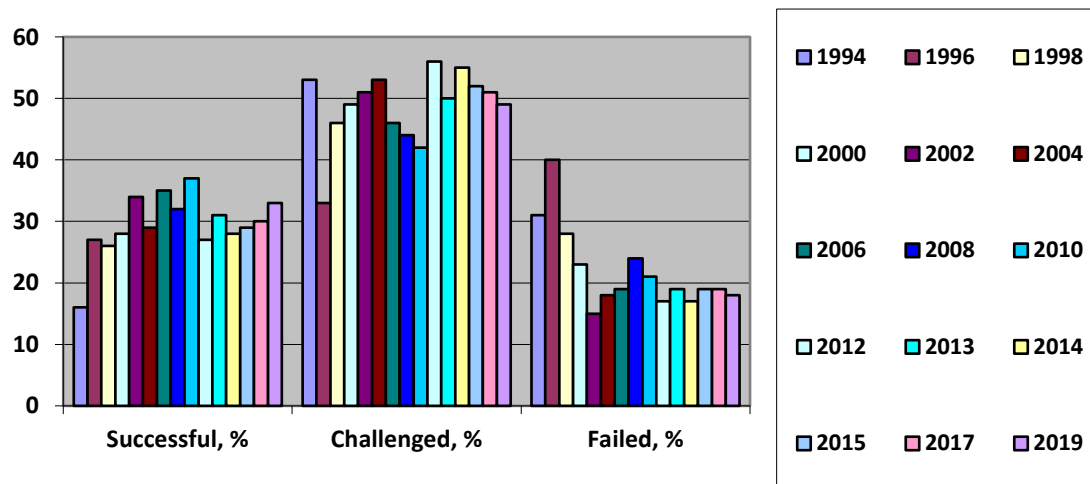


Figure 1: Statistics of success of IT projects in 1994-2019 [11, 12]

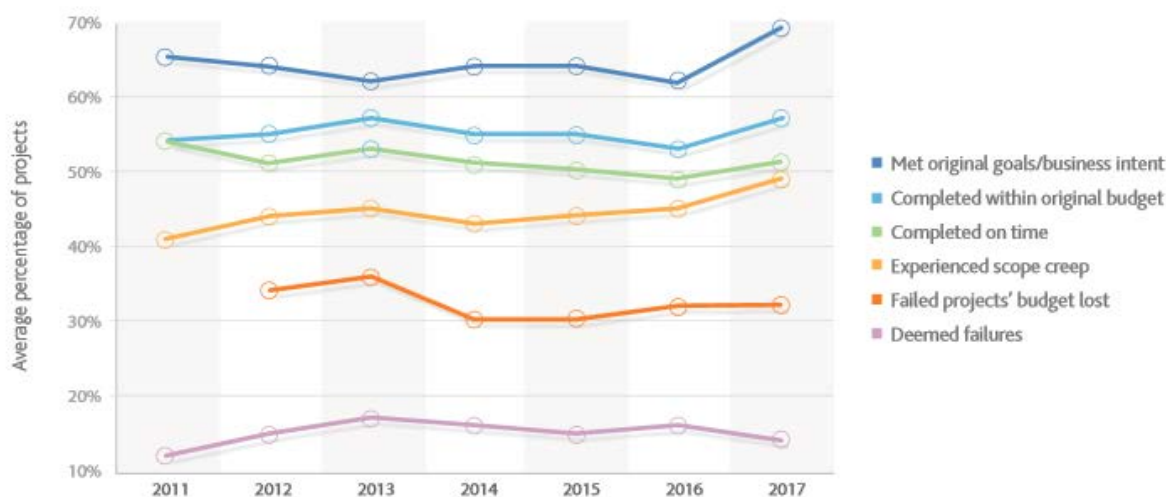


Figure 2: Project Performance Metrics [6]

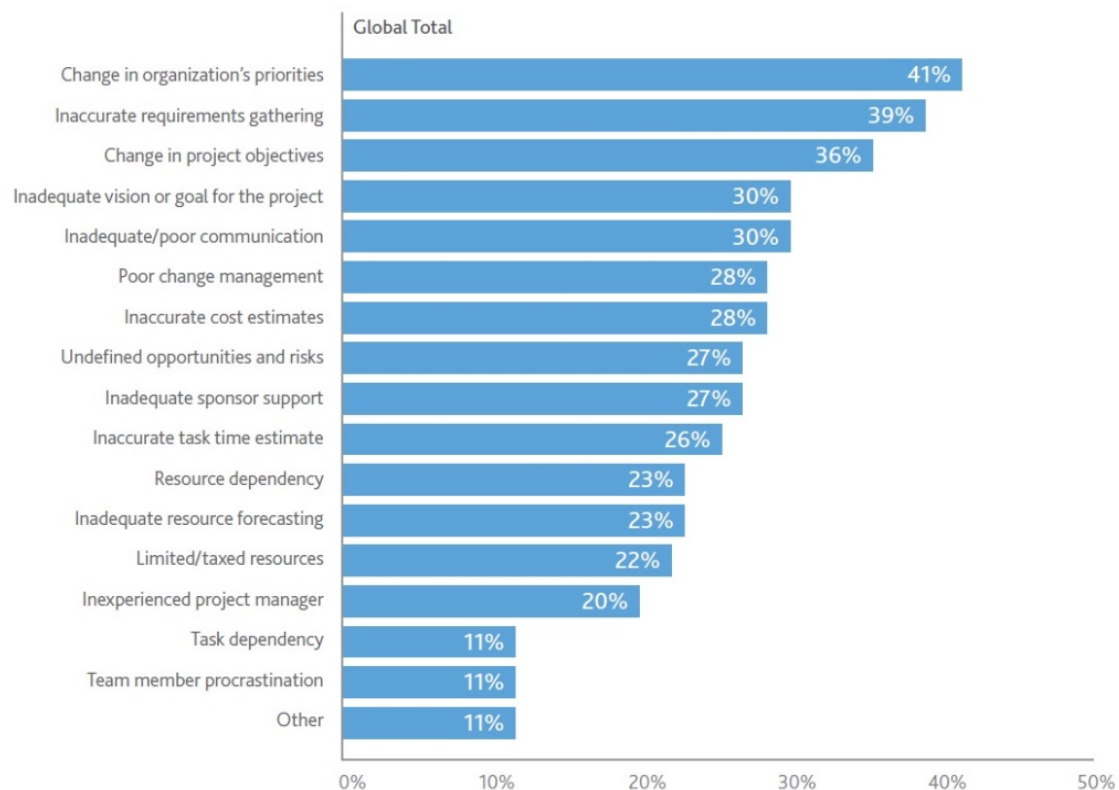
Obviously, the share of challenged IT projects is about half of all projects. The share of failed projects is about 1/5 of all projects. Only 1/3 of all projects are successful projects that can be relied on and worth spending money on.

Among the reasons for possible failures of IT projects are [13]:

- Unclear and incomplete requirements
- Insufficient participation of users in the project
- Absence or insufficiency of necessary resources
- Bad planning
- Frequent changes of requirements
- Novelty of the used technology for the organization
- Absence or insufficiency of appropriate project management
- Absent or insufficient support by senior management the project and project team
- Incorrect understanding of purposes or not enough analysis of project requirements

A majority of errors are made at the initial stages of the project life cycle. IT projects whose requirements contain insufficient, inaccurate, incomplete and contradictory information cannot be successfully implemented [13]. The analysis of a large number of projects conducted in [14-16] confirmed the fact that the main place of occurrence of errors and problems is the stage of formulating requirements, i.e. in fact at the end of the stage of formulating requirements it is possible to identify and eliminate the lion's share of all errors and problems.

Statistics show that gathering inaccurate requirements is one of the software failures' causes (Figure 3) [6, 17].



**Figure 3:** The primary software failures' causes [6]

It is desirable to identify and eliminate defects in the requirements before they begin to affect later stages of development. Early stages of the life cycle affect the quality of software more than later stages, so the time spent on quality control in the early stages gives the opportunity to reduce defects, to reduce development time, and to reduce costs at later stages [15, 16, 18-25].

The analysis of methods and tools of determining the characteristics of projects [26-30] showed that they focus on ready projects, rather than on existing requirements, i.e. unsuitable in the early stages of the life cycle of IT projects. The investigation of requirements analysis' methods and tools [31-37] showed that they are aimed at monitoring the requirements implementation, rather than determining the forecasted values of the IT projects' characteristics. In [38] the prediction method for probable recovery of partially missing or completely lost data based on the improvement of an ensemble of two GRNNs by the additional use of extended-input SGTM neural-like structure is proposed. Therefore, the existing requirements analysis' methods and tools are not acceptable for quantifying the characteristics of an IT project based on the analysis of requirements, for characteristics forecasting and for assessing the IT projects' success.

Consequently, with the purpose of providing the required success of the IT project, it is necessary to perform a requirements analysis. The purpose of such analysis is the opportunity of assessing the project's possible success based on the requirements analysis, as well as supporting the developer and customer in choosing a project from many alternative projects (currently the developer and customer are guided only by intuition and the project's cost and duration).

Thus, *the actual task* is the analysis of the requirements for the IT project in order to forecast the characteristics and evaluate the implementation success of IT projects, as well as support the developer and the customer in choosing an IT project from a variety of alternative IT projects. Given the above, *the purpose of this study* is forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis. Herewith, the implementation success of IT projects is the timely implementation of the IT project within the allocated budget and with the implementation of all necessary capabilities and functions.

## 2. Method of forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis

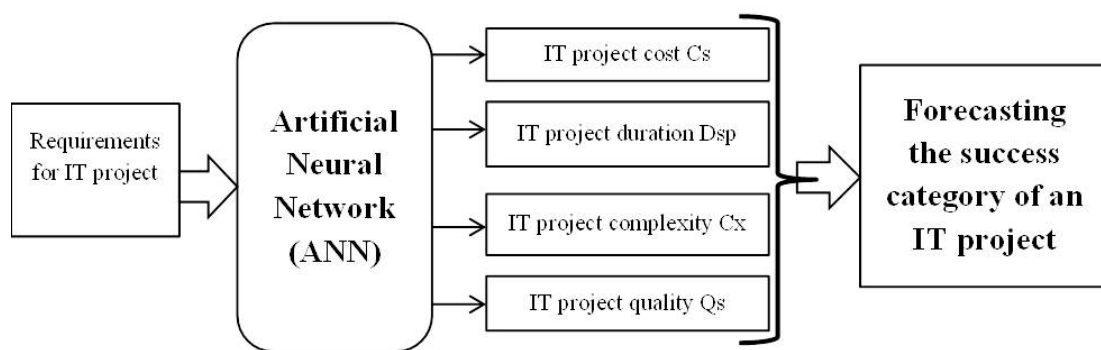
In [15, 16] the authors considered the problem of predicting the characteristics and evaluating the success of software projects' implementation based on the analysis of software requirements specification. The authors of [15, 16] probably evaluated the success of the software project at the design stage on the basis of the predicted values of the main software project characteristics [39] – project duration, cost, complexity, cross-platform, usability, quality. We apply the described approach to forecasting the success of the implementation of IT projects based on the analysis of their characteristics. The success of the implementation of IT projects will probably be evaluated on the basis of the following 4 characteristics – the duration of the IT project  $D_{sp}$ , the cost of IT project  $C_s$ , the complexity of IT project  $C_x$ , the quality of IT project  $Q_s$ .

Let's improve the developed in [15, 16] neural network method of predicting the characteristics and evaluating the success of software projects implementation based on analysis of software requirements specification for forecasting the success of the implementation of IT projects based on the analysis of their characteristics.

*Method of forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis* consists of the following stages:

1. Neural network-based forecasting the IT project's characteristics based on analysis of the requirements
2. Interpretation of the obtained values of project characteristics based on the success rate of the IT project
3. Assessing the degree of IT project's implementation success based on the project success rate
4. Forecasting the IT project's success category (successful, challenged, failed) on the basis of the degree of the project's implementation success

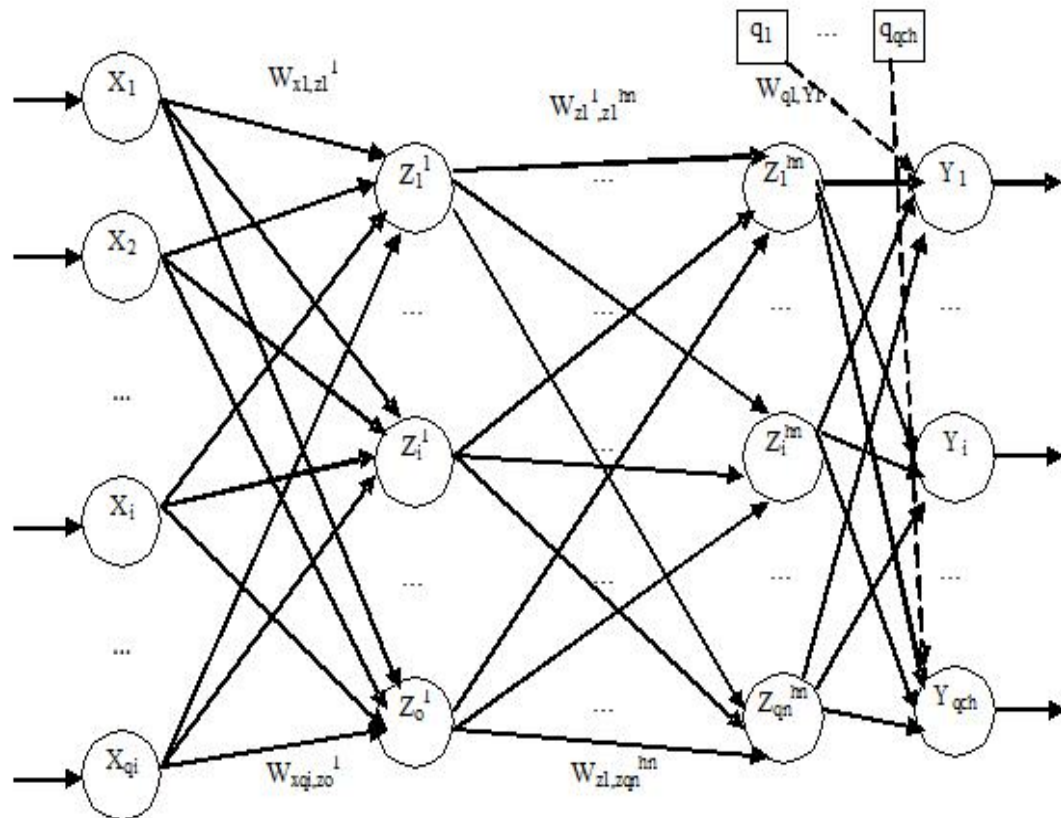
The concept of method of forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis is represented in Figure 4.



**Figure 4:** The concept of method of forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis

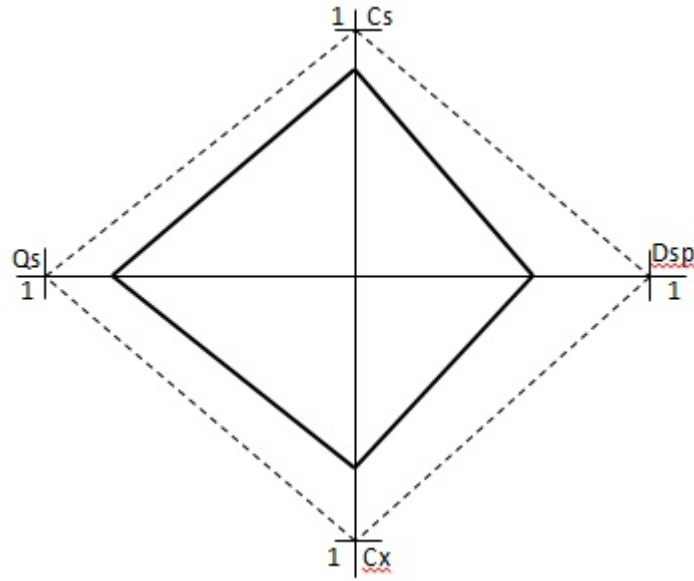
The first stage of the method is neural network forecasting of project characteristics based on the analysis of requirements, which consists in processing a set of requirements' indicators and in determining the values of the project's main characteristics. We will use an artificial neural network (ANN) to process a set of requirements indicators, to approximate indicators and to provide forecasted quantitative values of project characteristics. The result of the ANN will be a set of forecasted estimates of project characteristics. ANN will be implemented and trained so that all the values of the characteristics will be from the interval  $[0; 1]$ , where 0 – not enough data to forecast the characteristic (the method does not work in this case), 0.08 – the value of the characteristic negatively affects the project implementation's success (high cost, duration, complexity, low quality), 1 – the value of the characteristic has a positive effect on the project's success (low cost, duration, complexity, high quality).

The multilayer perceptron is the most suitable for solving the problem of requirements analysis and forecasting the characteristics of IT projects. If different type of neural network will be used to solve this problem, its nature will be artificially distorted, resulting in inconsistent results of the ANN. This approach can be summarized in the form of ANN of multi-layer-perceptron type – Figure 5.



**Figure 5:** Generalized scheme of ANN for requirements analysis and forecasting the characteristics of IT projects

Based on the obtained values of the project's main characteristics (ANN results), both the developer and the customer find it difficult to assess the IT project implementation's success in complex, as it is difficult to correctly interpret the obtained values of characteristics, so the second stage is the interpretation of the obtained project characteristics' values based on the IT project's success rate. For interpretation of the characteristics' values, let's introduce the concept of the success rate of the IT project. The IT project's success rate is a quantitative indicator of project implementation's success based on a set of the forecasted values of the project's characteristics. Let all four of these characteristics have the same impact on the IT project's success, and hence on the IT project's success rate. Because formulas and dependencies are absent, the graphical representation is the simplest and most obvious mode for determining the success rate of an IT project. For obtaining a graphical representation of the success rate of the IT project, let's create a coordinate system that has four axes (for the four characteristics of the project). Then the success rate of the IT project is the area of the figure formed by the forecasted values of the project characteristics. Since the ANN provides four characteristics, the IT project's success rate is the area of the quadrilateral outlined in the bold line in Figure 6. For further work, we will also need the maximum (best, standard) value of the IT project's success rate – the area of the quadrilateral (rhombus) outlined in the dotted line in Figure 6.



**Figure 6:** Graphical representation of the IT project's success rate

For finding the success rate of an IT project (ISP), let's divide the quadrilateral into four right triangles and find the area for each of the triangles by two known legs (characteristics' values), then add the resulting areas of the triangles:

$$S^{CsODsp} = \frac{1}{2} * Cs * Dsp, \quad (1)$$

$$S^{DspOCx} = \frac{1}{2} * Dsp * Cx, \quad (2)$$

$$S^{CxOQs} = \frac{1}{2} * Cx * Qs, \quad (3)$$

$$S^{QsOCs} = \frac{1}{2} * Qs * Cs, \quad (4)$$

$$ISP = \frac{1}{2} * (Cs * Dsp + Dsp * Cx + Cx * Qs + Qs * Cs). \quad (5)$$

According to formula (5), the maximum (best, standard) value of the success rate of an IT project is:

$$ISP^{max} = \frac{1}{2} * (1 * 1 + 1 * 1 + 1 * 1 + 1 * 1) = 2. \quad (6)$$

By itself, the IT project's success rate is uninformative for the developer and the customer owing to the difficulty of its value interpreting, so the third step is assessing the IT project implementation success' degree P on the basis of the project's success rate:

$$P = \frac{ISP}{ISP^{max}} = \frac{ISP}{2}. \quad (7)$$

The value of the IT project implementation success' degree is equally close to 0 indicates a low project implementation's success (such a project will be likely failed), and the value of the IT project implementation success' degree is equally close to 1 indicates a high project implementation success, i.e. such project will be probably successful.

The IT project implementation success' degree, obtained at the 3rd stage of the proposed method, is again uninformative for the developer and the customer because of the complexity and ambiguity of interpretation of its value in predicting the project's success category. For simplifying and

unambiguous interpretation of the value of the IT project implementation success' degree, the fourth stage of the method is forecasting the IT project's success category (successful, challenged, failed) based on the IT project implementation success' degree.

To do this, we will determine the threshold values of the degree of the IT project implementation success, according to which the conclusion about the success category of the IT project is made.

For establishing such thresholds (and for creating the rules for forming a conclusion on the success category of the IT project), an analysis of 34 different IT projects implemented by IT companies in Khmelnytskyi, for which according to the proposed method the degree of IT project's implementation success was determined and for which the success category was currently known. Based on this analysis, we developed *rules for determining the success category of the IT project*:

- If  $P \leq 0.18$ , then the IT project is probably failed
- If  $0.18 \leq P \leq 0.70$ , then the IT project is probably challenged
- If  $P \geq 0.70$ , then the IT project is probably successful

The improved method of forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis provides forecasting the IT projects implementation's success, comprehensively comparing the IT projects considering the main characteristics and the forecasted value of the IT project implementation success' degree (not only by cost and duration, as is currently the case) and making the informed choice of IT project by the developer and the customer for further implementation. Of course, defects in the IT project can be introduced in the next stages – during design and realization, but this method helps to reject IT projects with unsuccessful requirements, because, as shown above, IT projects with unsuccessful requirements cannot be successful.

### 3. Results & Discussion

For verifying the adequacy of the improved method of forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis, let's assumed that the ANN processed the requirements for 5 IT projects and provided the following values (Table 1). The obtained values of each of the IT projects' success rate, the degree of each IT project implementation success, as well as each IT project's success category are represented in Table 1.

**Table 1**

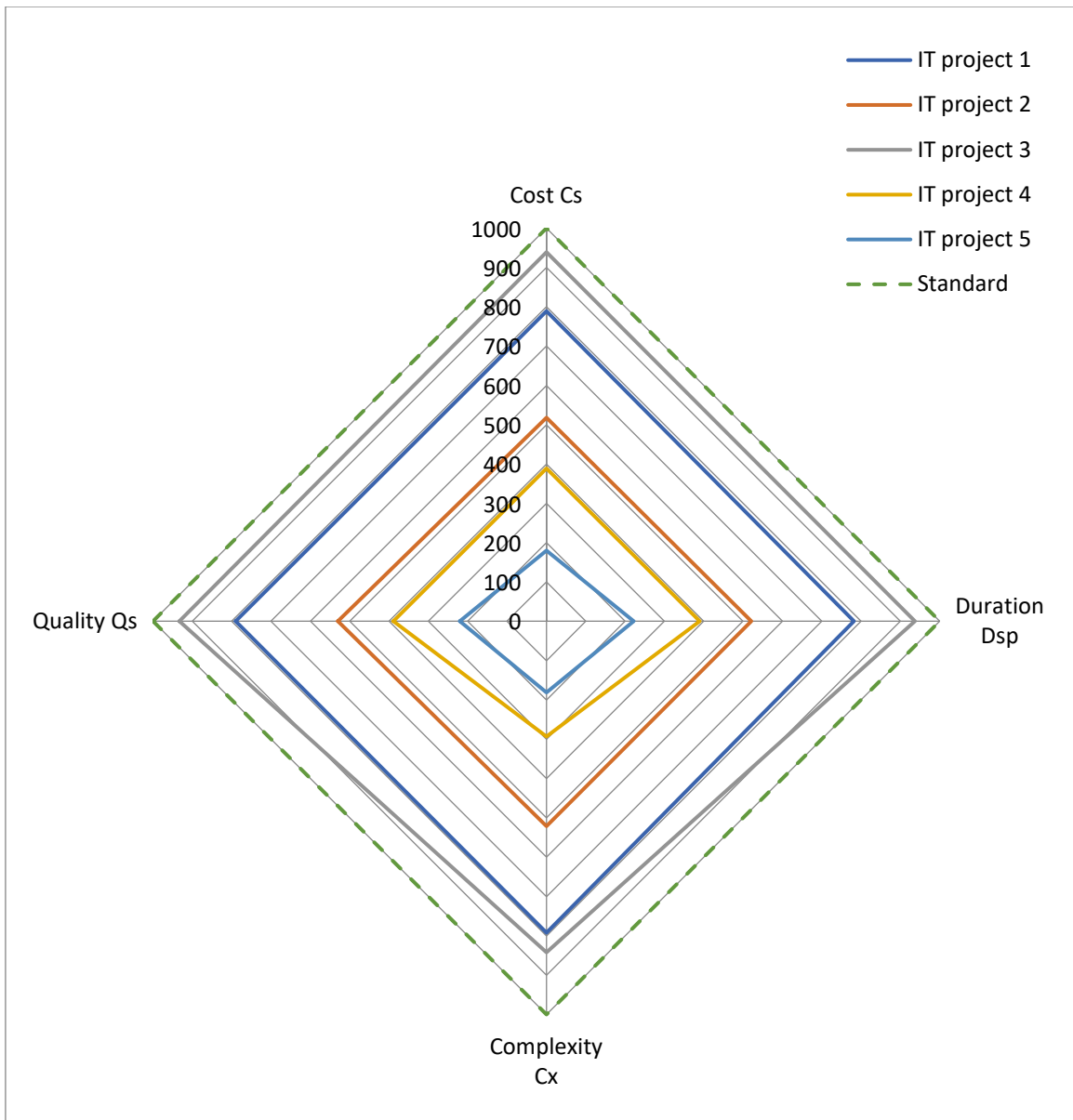
Results of the method of forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis

No	ANN outputs	Success rate of an IT project ISP	Degree of IT project implementation success P	Success category of an IT project
1	[0.789;0.782;0.792;0.790]	1.242666	0.621333	Challenged
2	[0.518;0.521;0.521;0.530]	0.5459945	0.27299725	Challenged
3	[0.939;0.937;0.842;0.933]	1.665235	0.8326175	Successful
4	[0.389;0.390;0.293;0.389]	0.265639	0.1328195	Failed
5	[0.180;0.222;0.181;0.220]	0.079781	0.0398905	Failed

Thus, of the five considered projects, only project №3 is projected to be successful, projects №1 and №2 are projected to be challenged, and projects №4 and №5 are projected to be failed. Therefore, for further work, the customer, of course, is recommended to choose and finance an IT project №3, because it has good requirements and is likely to be successful.

Graphical representations of success rate of 5 considered IT projects and of the standard (maximum, best) value of such an rate are represented in Figure 7.





**Figure 7:** Graphical representations of success rate of 5 considered IT projects

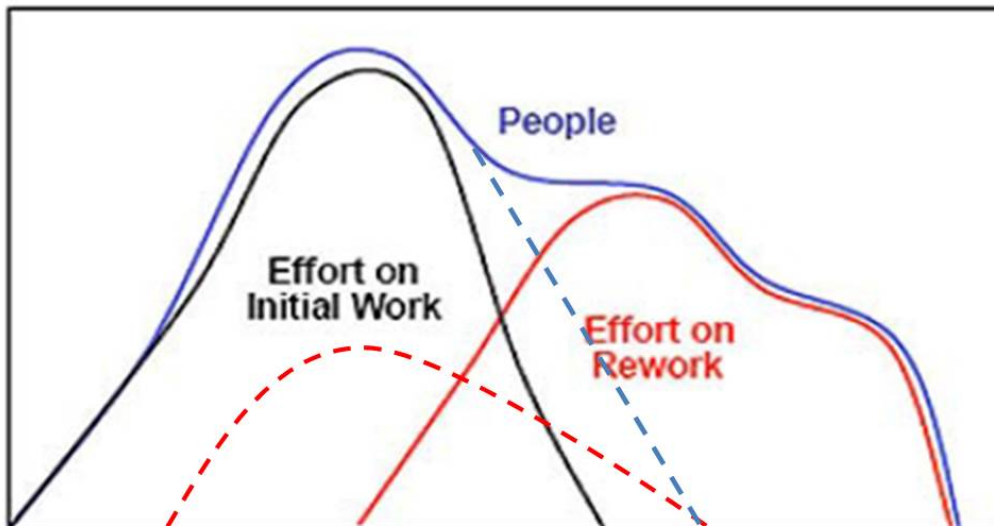
As is known from [40], all iterations during the IT project are divided into two groups:

- Planned – iterations, which are caused by the first need; it is known in advance when and where they will take place; they should facilitate the selection of optimal methods and tools for design and coordination
- Unplanned – iterations, which are caused by errors and/or unforeseen problems; their time and place are unpredictable; they lead to time-consuming processing (rework); they should be minimized

The improved method of forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis enables minimization of the unplanned iterations number, and thus reducing the time spent on rework at later stages of the project life cycle, and significantly reducing the rework after completion of initial work – thanks to early detection of defects of requirements and early elimination of the revealed defects.

In Figure 8 a solid black line shows time and human resources for initial work and a solid red line shows the time and human resources for rework, that correspond to the current state of affairs; the dotted red line shows the time and human resources required for rework, which become possible due to the use of the method proposed by the authors.





**Figure 8:** Comparison of time and human resources, which are spent for rework without using and with using the proposed method of forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis

#### 4. Conclusions

Currently, the actual task is the analysis of the requirements for the IT project in order to forecast the characteristics and evaluate the implementation success of IT projects. The purpose of this study is forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis.

The paper further developed the method of forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis.

The proposed method consists of: neural network-based forecasting the project characteristics based on requirements analysis; interpretation of the obtained values of project characteristics based on the success rate of the IT project; assessing the degree of IT project implementation success on the basis of the project success rate; forecasting the success category of the IT project (successful, challenged, failed) based on the degree of the project implementation success.

The input data for the improved method of forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis are the requirements for the IT project, and the result of this method is the conclusion on the success category of an IT project, which allows to make an informed choice of the project for its further implementation. The proposed method differs from the known ones in that it allows forecasting the success of project implementation, comparing projects comprehensively according to the main characteristics and projected value of the degree of project implementation success (and not only in cost and duration, as it happens now), as well as allows to make an informed choice of IT project by the developer and the customer for further implementation.

The improved method of forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis allows to minimize the number of unplanned iterations, and thus reduce rework time at later stages of the project life cycle, as well as significantly reduce rework after completion of initial work – due to early detection of defects of requirements and early elimination of the revealed defects.

The main directions for authors' further research are: development and realization of the artificial neural network that will forecast the IT project's characteristics based on the requirements' analysis; design and development of an ontology-based intelligent agent for semantic analysis (parsing) of project requirements, which will look for the indicators of requirements needed for ANN for forecasting the characteristics of the project based on them (this feature will provide the ability to work with requirements in modern conditions, when the requirements for the project often change – due to the speed and ease of requirements analysis; the user will be able to check the updated

requirements each time without spending a lot of time and effort); design and realization of an intelligent agent-oriented system of forecasting the characteristics and evaluating the implementation success of IT projects based on requirements analysis.

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