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EVALUATION OF THE INFLUENCE OF SELECTED FACTORS ON A SUCCESSFUL ERP SOFTWARE IMPLEMENTATION

Based on a pilot study, a list of critical success factors for an IT project was developed. These factors were subjected to statistical analysis on the basis of the results of a questionnaire. Two samples of projects, called "success" and "failure" respectively, were analysed. The groups were distinguished in order to evaluate the influence of selected factors on the success of an implementation project. Furthermore, a non-parametric test was applied, in order to conduct statistical data analysis, which confirmed the influence of the majority of the selected factors on the success of an implementation project.

Keywords: *critical success factor, research hypothesis, statistical significance, system implementation, project dimension*

1. Introduction

The implementation of an enterprise resource planning (ERP) system in a company is a time consuming and costly process. The cost of implementation ranges from thousands to millions of PLN. The process of ERP implementation requires a significant time commitment from both the company's employees and external professionals and often leads to multiple changes in the business processes of a company, development of new procedures and, as a result, to managerial and operational staff training. Therefore, many companies regard the switchover to a new IT system as a painful and cumbersome process [4], [5].

According to the 2009 edition of the Standish Group report [11], 32% of all IT projects were completed on time, on budget and the software delivered the required

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level of functionality. However, as many as 44% of the projects were over budget or late, and 24% of them were terminated before completion or were not utilized after their implementation.

For several years, scholars from many countries have been conducting research, in order to establish a link between the success of an IT project and the influence of various factors [3], [6–9]. Among many factors, one may distinguish essential critical success factors which are necessary for the success of any organization. Critical success factors are studied in different sets and contexts depending on the expected results of research. Some enquiries concern the influence of selected project factors on the general level of satisfaction of the user or on a specific dimension of the project. A variety of published ranks of factors, as well as changes in the implementation process itself, suggest a need to continue research into this subject matter. The results of previous research deepen the existing knowledge, lead to the discoveries of new factors and most frequently change the existing knowledge about the influence of factors on the success of implementation. It is believed that the evaluation of selected factors with respect to software functionality, budget and duration of the implementation process would help managers in making decisions related to planning future implementations, and this in turn would help in attaining anticipated goals, such as higher efficiency in the implementation process and greater satisfaction for users of the implemented systems.

2. Success factors vs. process areas

Among many publications concerning success factors for IT projects, the primary focus was placed on the work of SOMERS and NELSON [7], who analyzed 110 publications related to this subject matter. In the first stage of our research, a pilot survey was conducted, in order to single out 17 factors. An attempt to rank the selected factors and thus prove they are clearly linked with the specific activities of an enterprise was undertaken.

Three factors crucial in the implementation process were distinguished, namely: ERP package selection, top management support and a close, long lasting relationship with suppliers who support the company during the operation of an ERP system. The remaining 14 factors were analyzed with respect to the categories of process areas described in the CMMI model (capability maturity model integration). Process areas in this model group together certain processes and enable directing actions towards the development of a company's maturity, in operational processes, as well as in project management. Version 1.1 of the CMMI model contains 25 process areas organized into four categories related to the business of a company. In brief, the four categories include the following elements [10]:

1. Process management: process focus, process definition, training, process performance, innovation and deployment.

2. Project management: planning, monitoring and control, supplier agreement, integrated project, risk, integrated teaming, integrated supplier, quantitative project management.

3. Engineering: requirements, development, technical solution, product integration, verification, validation.

4. Support: configuration, process and product quality, measurement and analysis, decision analysis and resolution, environment for integration, causal analysis and resolution.

The primary purpose of this analysis was to confirm the influence of selected factors on project management and the business of a company in its broadest spectrum. The results showed that the selected factors represent all four categories but the majority of them, as expected, relate to the categories of project management and engineering (Table 1).

Table 1. Classification of project success factors according to CMMI categories

No.	Project success factors	Process area category
1	User training and education	1
2	Appointment of steering committee	2
3	Selection of project leader	2
4	Involvement of key employees and users	2
5	Commitment of required resources	2
6	Experience of the implementation team	2
7	Communication of the implementation team with the rest of the company	2
8	Specifying management and user requirements	3
9	Ability to modify standard functions	3
10	Use of suppliers' tools and technology implementation	3
11	Business process reengineering (BPR)	3
12	Data conversion and customization to the ERP package	3
13	Effective project management	4
14	External expert support	4

A pilot survey was carried out in order to select the most highly ranked factors*. The questionnaire consisted of 10 questions. In one of the questions, the respondents were asked to evaluate the influence of the factors on the success of project implementation on a scale of 0 (no influence at all) to 5 (high influence). Based on the rank of total and average values of these evaluations, it was ascertained that the factor

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most influential on the implementation process is the involvement of key employees and users and top management support (Table 2). Other factors in the ranking were user training and education, effective project management, as well as ERP package selection. Business process reengineering (BPR) was in last place. Thus, among the 6 most highly ranked factors distinguished in the survey, two belong to the group of strategic factors, whereas the remaining four belong to separate categories of process areas, each category represented by one factor.

Table 2. Rank of total and average values of marks on factors influence on the success of the project

Symbol	Critical success factor	Sum of answers	Average	Standard deviation
CSF1	involvement of key employees and users	332	3.82	1.215
CSF2	top management support	323	3.71	1.150
CSF3	user training and education	316	3.63	1.212
CSF4	effective project management	314	3.61	1.252
CSF5	ERP package selection	307	3.53	1.119
CSF6	business process reengineering	277	3.18	1.317

In the next stage of the research, the results of the survey were subjected to statistical analysis, in order to evaluate the significance of the influence of factors and possibly confirm their influence on the three traditional constraints of the project management triangle [2], i.e. time, budget and scope. Here, for the purpose of the research into the success or failure of an implementation project, these contraints are called the project dimensions.

Contrary to the previous pilot survey, the group of respondents was now limited to individuals holding key positions in a company, e.g. chairman, project manager, both on the supplier's and customer's side. Such individuals have full access to information on the status and development stages of a software implementation project. In order to reach more companies, an electronic version of the questionnaire was created. The questionnaire was promoted on the Goldenline social network website within the groups of chairpersons, managers and company owners, where a link to the questionnaires was posted.

3. Researched enterprises

The researched enterprises were divided into groups according to their size. Medium-sized enterprises of 50–249 employees formed the largest group (31), the second in size was the group formed by large enterprises (24), the third one – the group of small enterprises (18). The smallest group in number was formed by large

enterprises of over 2000 employees (18). For obvious reasons, micro-enterprises having fewer than 10 employees were not included in the questionnaire.

As for the industry sectors represented by the 87 researched enterprises (Figure 1), the two largest groups included industrial good manufacturers (12 enterprises) and those in the 'other' category (13 enterprises), the next most frequent groups included electronic industry enterprises (8), motor industry enterprises (8), fast moving consumer good (FMCG) enterprises (7), chemical industry enteprises (7).

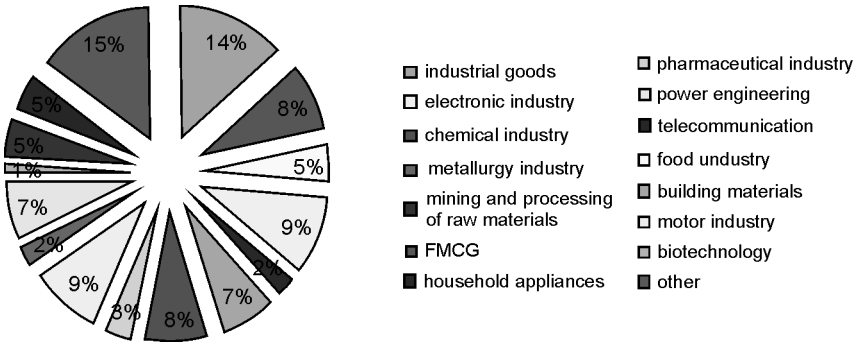


Fig. 1. Industry sectors represented by the researched enterprises

As far as ERP package selection is concerned, it was observed that the three most commonly implemented systems among the researched enterprises were SAP (28%), Oracle (8%) and Microsoft Dynamics AX (18%).

4. Statistical analysis of questionnaire data

The objective of the research was to evaluate the influence of the selected factors on each dimension of succesful implementation: time required for project completion, budget and the required functionality of the implemented system. Therefore, the respondents were asked to evaluate the level of each factor's "commitment" to the implementation process with respect to the three dimensions. The data obtained from the questionnaire was exported electronically to a statistics program*, which enabled the statistical analysis of the questionnaire data and testing of the hypotheses under examination.

The method of statistical inference was applied, in order to analyze the obtained data and to confirm or deny the existence of differences between two groups. Two

*Licence to PASW Statistics software, number 1064, used in the ARIADNA program of cooperation between SPSS and academic units.

samples of data were distinguished in the process of project segregation performed by the respondents, who classified their projects as either successes or failures. The respondents evaluated project success with respect to each of the three dimensions of success, hence the results obtained consisted of two groups of data related to time required for project completion, budget of the project and the required functionality of the implemented software, respectively. The number of successes was lower than the number of failures for each dimension. In the case of the first dimension, the time required for project completion, there were 39 successful projects and 48 projects which could not be completed on time. In the case of the second dimension, the budget, there were 16 enterprises in the first group and 20 in the second one. In the case of the required functionality of the implemented software, there were 20 enterprises in which the implemented ERP system fulfilled the expected functionality and 24 enterprises in which it did not. The sample sizes for each pair of groups are not identical, but the differences between them are small enough (39 and 48, 16 and 20, 20 and 24, respectively) to enable statistical comparison.

The results obtained for both groups were compared by means of the non-parametric Mann–Whitney U test ([1], pp. 716–722) for two reasons: due to the violation of the assumption of the normality of data and the assumption of a bimodal distribution, since the categorization of a project as a "success" or "failure" might have been influenced by a factor such as the experience of a project manager and could therefore forejudge the outcome. The Mann–Whitney U test enables assessment of the differences between two independent and arbitrarily chosen samples, not necessarily equal in size. The realization of the test statistic is calculated by the use of the following formula ([1], p. 717):

$$U = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1 \tag{1}$$

where: n_1, n_2 – sample sizes, R_1 – sum of the ranks for the sample of size n_1.

The hypotheses are bi-directional, with the alternative hypothesis H_1 being simply the contradiction of the null hypothesis H_0. The null hypothesis is the assumption of no difference between the two groups in question, whereas the alternative hypothesis assumes the contrary – the existence of a difference between the groups. Therefore, sets of null and alternative assumptions were created for each of the six selected factors and the alternative should be adopted if there exist grounds for discarding the null hypothesis. Confirmation or rejection of the hypothesis of the lack of influence of the selected factors on the success of the implementation process was possible under the applied method of inference. It was investigated whether there exists a significant difference between the level of "commitment" of a selected factor in the "success" sample and in the "failure" sample, where the "success" sample contains the companies which implemented the ERP system on time and the "failure" sample

contains the companies which did not. The results of the test of the influence of the critical factors on each of the project dimensions are presented in Table 3. In the table, n is the number of enterprises in a sample, p – statistical significance, H_0 – null hypothesis, H_1 – alternative hypothesis In the case of any relevant grounds for discarding the null hypothesis, the alternative hypothesis was assumed.

Table 3. Statistical analysis of the influence of the six selected factors on the project outcome in the three dimensions of successful implementation

Group	Time			Budget			Functionality		
	"Success" $n_1 = 39$		"Failure" $n_2 = 48$	"Success" $n_1 = 16$		"Failure" $n_2 = 20$	"Success" $n_1 = 20$		"Failure" $n_2 = 24$
	Median	p	H_0/H_1	Median	p	H_0/H_1	Median	p	H_0/H_1
CSF1. Involvement of key employees and users									
"Success"	4.29	0.036	H_1	4.56	0.008	H_1	4.61	0.0001	H_1
"Failure"	3.77			3.77			2.75		
CSF2. Top management support									
"Success"	4.34	0.0001	H_1	4.17	0.292	H_0	4.61	0.0001	H_1
"Failure"	3.37			3.75			2.62		
CSF3. User training and education									
"Success"	4.17	0.009	H_1	4.31	0.041	H_1	4.58	0.0001	H_1
"Failure"	3.48			3.55			2.42		
CSF4. Effective project management									
"Success"	4.23	0.001	H_1	4.27	0.053	H_0	4.61	0.0001	H_1
"Failure"	3.33			3.50			2.40		
CSF5. Business process reengineering									
"Success"	3.20	0.915	H_0	3.31	0.867	H_0	4.53	0.0001	H_1
"Failure"	3.27			3.30			2.00		
CSF6. ERP package selection									
"Success"	3.76	0.285	H_0	4.00	0.031	H_1	4.53	0.0001	H_1
"Failure"	3.53			3.23			2.47		

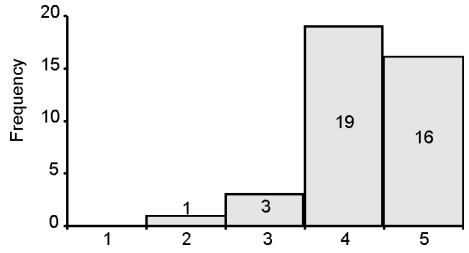
The statistical analysis of the influence of the CSF2 factor, i.e. evaluation of the influence of top management support (Figure 2) on the result of an implementation project, is used to illustrate the method of inference applied.

H_0 hypothesis. The level of top management support in the enterprises which implemented the ERP system on time was equal to the level of top management support in the enterprises which exceeded the time limit for ERP system implementation.

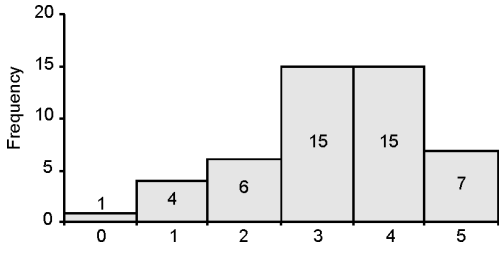
H_1 hypothesis. The level of top management support in the enterprises which implemented the ERP system on time was different from the one in the enterprises which which exceeded the time limit for ERP system implementation.

There were 39 companies in the sample of successful projects and 48 in the sample of failed projects. The realization of the U statistic equals 460, the p value of

0.0001 allows us to discard the H_0 hypothesis and adopt the alternative H_1 hypothesis, since it had been assumed that the null hypothesis should be tested at the $\alpha = 0.05$ level of significance.The results indicate that top management support in the process of implementation is significantly higher for enterprises in which the ERP system was implemented on time.



"Success" group histogram



"Failure" group histogram

Implemention time	*N*	Average	Median	Standard deviation	Min.	Max.
"Success" group	39	4.28	4.34	0.724	1	5
"Failure" group	48	3.25	3.37	1.229	0	5

Mann–Whitney U and Wilcoxon W test

Mann–Whitney U	Wilcoxon W	Z	Asymptotic significance	Exact significance	Estimate of point probability
460 000	1 636 000	–4.253	0.000	0.0001	0.000

Fig. 2. Statistical analysis of the influence of CSF2 on implementation time

The null hypothesis may also be tested by means of a test for the equality of the average values or medians for both groups. The results of these tests are presented in Figure 2 for the purpose of illustration. The comparison of the average values and medians for both groups demonstrates the differences between them, which also confirms the decision to reject the null hypothesis.

Nevertheless, the *U* test conducted for the CSF2 factor shows that the level of top management support in the implementation process in the enterprises which did not exceed the implementation budget does not differ significantly from the level of top management support in the enterprises which did exceed the implementation budget ($p = 0.292$). The test did not confirm the significant influence of the CSF2 factor on the implementation process with respect to the draft budget (Table 3). Similarly, the median test did not show any significant differences.

However, the results of U test confirmed significant influence of the CSF2 factor on the process of implementation of the ERP system with respect to the required functionality of the software.

5. Summary of the results

The conducted research (Tables 2, 3) showed that four factors influence the scheduled duration of ERP system implementation. These factors are the following: CSF1 – involvement of key employees and users, CSF2 – top management support, CSF 3 – user training and education and CSF4 – effective project management. On the other hand, the duration of ERP system implementation is not influenced by two factors: CSF5 – business process reengineering (BPR) and KCS6 – ERP package selection.

The analysis of the influence of each factor on the budget of implementation projects confirmed the substantial influence of the CSF1, CSF3 and CSF6 factors. The influence of the remaining three factors: CSF2 – top management support, CSF4 – effective project management and CSF5 – business process reengineering on the implementation process was not confirmed.

The research confirmed the significant influence of all these factors on the required functionality of ERP in the process of system implementation.

The method of statistical inference applied to the data obtained from the questionnaire did not confirm the greater influence of the CSF2 factor than of the CSF3 factor on the implementation process, which was observed in the results of the pilot survey (Table 2).

6. General conclusions

Owing to strong competition and the necessity to deliver high quality goods and services, as well as the desire to obtain greater profits with a simultaneous reduction of costs, more and more enterprises are deciding to implement an ERP system. However, according to research, many enterprises do not achieve the intended success in the implementation process. Therefore, this article presented results of research concerning the influence of selected factors on the success of an implementation project. The research was conducted on Polish enterprises in which an ERP system had been implemented.

The influence of six selected factors on the success of an implementation project was evaluated by the method of statistical analysis. The factors selected from the list of factors published in the literature on the subject are called critical factors for the success of an IT project. The dimensions of the project, i.e. the required functionality of the system, estimated completion time and budget of the implementation project, were established on the basis of PMI methodology. The results of the statistical data analysis confirmed the influence of the majority of the selected factors on project success. This underlines the importance of the researched factors in the implementation process and points out the necessity of ensuring their appropriate participation in the process of ERP system implementation.

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