enterprise resource planning (ERP) system, project driven enterprise (PDE), business process, case study, productivity ratio

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A FRAMEWORK OF ERP SYSTEM EVALUATION OF PROJECT DRIVEN ENTERPRISE: A CASE STUDY

Abstract

Nowadays enterprise resource planning (ERP) systems are worldwide a standard solution implemented in a great number of manufacturing companies worldwide. The implementation of an ERP system is performed to integrate business processes, allocate company's resources efficiently and provide important data for decision support. Implementing an ERP system is expensive and time-consuming. Therefore a great number of research activities are focused on key success factors of ERP implementations. But what does a successful implementation of ERP system mean? If an ERP project was completed according to the schedule, the budget was not exceeded and the scope was realized, it means that the implementation was successful? Implementation of an ERP system is a long-term undertaking, and not only a short-term project that is finished just after the system installation. Especially for a project driven enterprise that realizes engineer-to-order production, the evaluation should encompass a long period of time. In the article a methodology based on ERP data analysis and end users' satisfaction is proposed. This research is based on a real data, extracted from ERP system of a polish company that realizes prototyping production in the area of machine tools construction.

1. INTRODUCTION

Enterprise resource planning system is defined as "a configurable information systems' packages that integrate information and information-based processes within and across functional areas in an organization" [1]. The American Production and Inventory Control Society (APICS) have promoted the systems since 1980 by extending the Manufacturing Requirements Planning (MRP II) operation system to other subsystems of the company such as finance, marketing and personnel. The MRP II was meant rather for repetitive production (motor industry, furniture manufacturing, electronic industry, etc.) where the great number of various products is produced on the same subassembly line. Therefore the implementation of an ERP system in a company that performs a prototyping production is difficult because it requires a use of non-standard solutions for the business support process [2], [3]. There are, of

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course, some examples of standard applications that support project driven production proposed by SAP, IFS or Oracle but each case requires building an individual concept of business support. Implementation of an ERP system on the one hand maintains discipline but on the other hand decreases flexibility of organizations. The process of implementation of an ERP system in project driven enterprise (PDE) is time consuming and expensive. The company should delegate the best people for the ERP project ,who would take part in the implementation process and who cannot carry out operation work. It means that a lot of disturbances in operation activity might result from the ERP system implementation. Notwithstanding the disadvantages, the manufacturing companies decide to implement ERP because it brings the following benefits [4]:

- increases and improves the capabilities and power to compete with other competitors.
- enhances the information flow to and from customers, suppliers, and other business partners outside the enterprise in a tightly coupled mode, and flexibility to operate in worldwide market.
- improves the flow of information through a centralized system, better system integration and communication among internal business processes.
- improves business processes and practices, and business performance.
- cuts costs in activities related to business administration, processing, and system maintenance, and ensures ongoing system support from the vendor.

For PDE the following additional benefits of ERP system can be outlined:

- building of product knowledge database (history of each project).
- monitoring of accumulating costs of projects.
- improving of price estimation for new prototype projects.

The assumed benefits should be formulated as a list of goals to evaluate the ERP system. Proper evaluation of the ERP system requires an exact determination of main goals and evaluation criteria.. To determine the evaluation criteria the general questions concerned with scope of ERP implementation should be answered:

- what are the strategic goals of ERP system implementation in project driven enterprise?
- which functional area of enterprises will be covered by ERP system?
- which business processes have to be supported by ERP system?
- what measurements have to indicate efficiency of the business processes?
- what data are required to calculate the measurements?

The study is based on a case of a polish company X that realizes engineer-to-order production of complex machine tools in the machine construction industry. The products are prototypes and the average production cycle is about six months. The X company is a typical project driven enterprise. There is a project manager dedicated to the performance of each order who would build a project team. In 2001 the X company has selected the ERP system. The software firm (polish company) has experience in implementing the software in one of its branches and guaranteed tailoring of the software to individual customer requirements. The implementation and adaptation of the software was completed in two years. The start of the production process of the ERP system took place in January 2003. The evaluation of ERP efficiency system in the company X is performed in two steps. In the first step, the database of ERP system was explored and analyzed. Next, the required research among the end users of the ERP system was carried out. On the basis of the results of the research, an improved business processes strategy of the company is prepared.

1.1. Literature review

In the last few years the number of scientific publications dealing with ERP systems increased rapidly [6] in the following areas: implementation of ERP systems, optimization of ERP systems, management through ERP systems, the ERP software, ERP and supply chain management, case studies. Some researchers add to the classification [11] ERP selection, ERP success factors, and cultural issues in ERP. Many researchers investigated critical factors (e.g., top management support, sufficient training, proper project management, communication, etc.) to the success of ERP implementation. For example Hong and Kim [5] define the concept of organizational fit of ERP and examine its impact on ERP implementation on the basis of surveys from 34 organizations. Motwani et al. [7] use a case study methodology grounded in business process change theory, to understand the factors that lead to the success or failure of ERP projects. The results from comparative case study of 4 firms that implemented an ERP system suggest that a cautious, evolutionary, bureaucratic implementation process backed with careful change management, network relationships, and cultural readiness have a positive impact on several ERP implementations. Al Mashari et al [10] present a taxonomy of the critical success factors in ERP implementation process that measurement takes place in a balanced perspective, and for the purpose of providing useful information that can enable the decision making process and, which can help deliver the corporate objectives and therefore lead the business competitively forward. Mabert et al [8] on the basis of a series of case studies and an extensive survey analyses the impact of different sizes of companies on ERP implementations across a range of issues. The same team of scientists [9], empirically investigates and identifies key differences in the approaches used by companies that managed their implementations on time and/or on/under-budget versus the ones that did not, using data collected through a survey of US manufacturing companies that have implemented ERP systems. They proposed evaluation of ERP systems on the basis of ROI, Pay back, NPV and other methods. Wei and Wang [12] present a comprehensive framework for combining objective data obtained from external professional reports and subjective data obtained from internal interviews with vendors to select a suitable ERP project. A hierarchical attribute structure is proposed to evaluate ERP projects systematically. The evaluation of ERP is based on three general levels that encompass: project factors, software system factors and vendor factors. Nicolaou and Bhattacharya [13] examine the long-term financial performance effects of ERP system changes/revisions for firms that have previously reported ERP adoptions. The effect of investments in ERP systems on a firm's long-term stock price performance and profitability measures such as return on assets and return on sales are presented by Hendricks et al [14]. The results of the research are based on a sample of 186 announcements of ERP implementations.

2. RESEARCH METHODOLOGY

In the research area of ERP systems, case study methods are very useful because the process of implementation is unique even in the enterprises within the same industry. Each case has to be analyzed individually to propose a general relationship, models or evaluation methods. Rather than using large samples and following a rigid protocol to examine a limited number of variables, case study methods involve an in-depth, longitudinal examination of a single instance or event: a case. They provide a systematic way of looking at events, collecting data, analyzing information, and reporting the results. As a result the researcher may

gain a sharpened understanding of why the instance happened as it did, and what might become important to look at more extensively in future research. Case studies lend themselves to both generating and testing hypotheses [15]. There are several types of case study method: exploratory, critical instance, program effects, prospective, cumulative and embedded case [16], [17]. Exploratory case studies condense the case study process: researchers may undertake them before implementing a large-scale investigation. Where considerable uncertainty exists about program operations, goals, and results, exploratory case studies help identify questions, select measurement constructs, and develop measures; they also serve to safeguard investment in larger studies. Critical instance case studies examine one or a few sites for one of two purposes. Correct application of the critical instance case study crucially involves probing the underlying concerns in a request. Program effects case studies can determine the impact of programs and provide inferences about reasons for success or failures. In a prospective case study design, the researcher formulates a set of theory-based hypotheses in respect to the evolution of an on-going process and then tests these hypotheses at a pre-determined follow-up time in the future by comparing these hypotheses with the observed process. Cumulative case studies aggregate information from several sites collected at different times. The cumulative case study can have a retrospective focus, collecting information across studies done in the past, or a prospective outlook, structuring a series of investigations for different times in the future. A case study containing more than one sub-unit of analysis is referred to as an embedded case study. The research questions used in this research (formulated in the introduction of this paper) belong to exploratory types of question. The selected case of enterprise is selected from several ERP system implementations as a representative example of project driven enterprise.

2.1. Data analysis

The proposed methodology is focused on the measurement of productivity rates of company X extracted from the ERP database. To evaluate an ERP system implementation, a reference evaluation model of a project driven enterprise is created. The model (see Fig. 1) determines the sets of data that have to be extracted from the ERP database and investigated to evaluate how the ERP system fulfills the main goals and supports business activities of company X.

In table 1, data extracted from the ERP system for last 5 years is presented. The data shows the number of records created in the ERP system in different functional areas of company X. The productive start of the ERP system was executed in 2003.

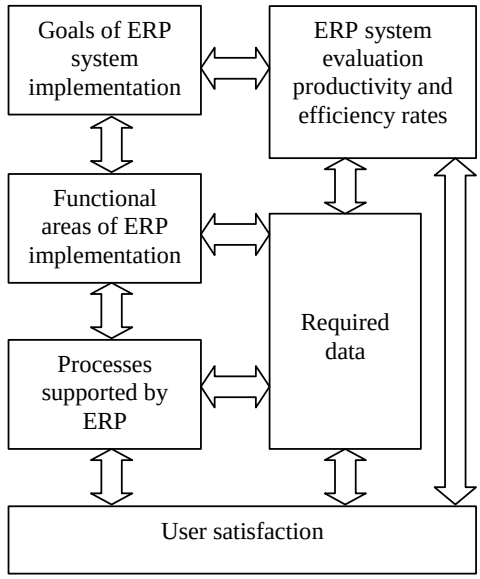

Fig. 1. The model of ERP system evaluation

Tab. 1. The data extracted from the ERP system of company X for the last 5 years

Data name	2002	2003	2004	2005	2006
Total number of indexes	462	2665	18439	33412	35246
Material indexes	21	314	3541	12457	10611
Part and product indexes	438	2350	14898	20952	24635
Number of suppliers	36	15	202	2296	849
Number of customers	562	26	96	138	247
Number of sell orders	598	88	308	2445	1223
Number of production orders	466	14741	9075	8437	8072
Number of purchase orders	252	11535	21943	19918	20032
Material turnovers	18803	108646	111576	102716	98378
Registered operations	1499	95749	60499	53001	33110

To analyze the performance of the ERP system, the major economic rates of company X should be processed (see Table 2). On the basis of the economical and ERP data the productivity ratios of the ERP system are calculated. The productivity ratios are calculated as a quotient of sales revenue and the data presented in table 1. For example the productivity of indexes is calculated as division of sales revenue by the total number of indexes.

Tab. 2. The economical data of company X for the last 5 years

Data name	2002	2003	2004	2005	2006
Sales revenue	57886295	70988495	87142615	88099914	105254729
Inventories	14914622	17149945	18543308	16673952	12477788
Raw materials	3566670	5327660	5019407	4932755	9323880
Working capital ratio	13,7	20,56	23,89	22,72	28,79
Quick ratio	0,59	0,84	1,11	1,08	1,20
Current ratio	1,45	1,77	2,16	1,93	2,21
Return of sales	0,13	0,14	0,15	0,09	0,15
Return of assets	0,20	0,20	0,22	0,11	0,16
Return of equity	0,36	0,32	0,31	0,20	0,24
Inventory turnover in days	94,04	88,18	77,67	69,08	43,27
Stock productivity	3,88	4,14	4,70	5,28	8,44

The productivity ratios are presented in table 3. The data from the ERP system from the year 2002 is not taken into consideration because the productive start of the system was in 2003.

Tab. 3. The productivity ratios of ERP

Data name	2003	2004	2005	2006
ERP productivity of indexes	26637	4726	2637	2986
ERP productivity of material indexes	226078	24610	7072	9919
ERP productivity of parts and products	30208	5849	4205	4273
ERP productivity of suppliers	4732566	431399	38371	123975
ERP productivity of customers	2730327	907736	638405	426133
ERP productivity of sell orders	806687	282931	36033	86063
ERP productivity of production orders	4816	9602	10442	13039
ERP productivity of purchase orders	6154	3971	4423	5254
ERP productivity of material turnovers	653	781	858	1070
ERP productivity of registered operations	741	1440	1662	3179

The evaluation of the ERP system based on the productivity ratios requires comparing values year-to-year. The faster the productivity index increase each year the better is the ERP system used in the functional area. The detailed analysis of the productivity ratios has to include the changes of economical ratios.

Let us consider that the main goal of the ERP system implementation by company X was inventory reduction. The inventory reduction should be referred to as the sales level on the basis of the stock productivity ratio (Sales revenue/ Inventories). The last row in table 1 shows that the stock productivity increases year to year (especially 2005 and 2006). The inventory reduction (increasing productivity of material turnovers) should result with the increasing of the current ratio, inventory turnover in days and working capital. To determine the impact of the ERP system on economical ratios the Pearson correlation coefficient is calculated (1) for the ERP productivity of material turnover and current ratio, inventory turnover in days, working capital and inventories productivity ratio (see table 4).

$$r_{xy} = \frac{\sum_{i=1}^{n}(x_i - \bar{x}) \cdot (y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2} \cdot \sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2}} \quad (1)$$

Where x, y – statistical variable

Tab. 4. The Pearson correlation coefficient

	ERP productivity of material turnovers
Working capital ratio	0,946
Current ratio	0,749
Inventory turnover in days	-0,996
Stock productivity	0,965

The values of the Pearson coefficient show a very strong correlation between the ERP productivity of material turnover and the ratios recounted in table 4. The correlation between Inventory turnovers in days is negative because the ratio indicates that the material turnover in the company X is quicker and quicker. Strong correlation between the ERP productivity of material turnover and the stock productivity provides evidence that the ERP system improves the inventory management in company X very well. To evaluate how the material management in company X can be further improved a detailed analysis of the ERP data is required. Figure 2 shows a diagram of the selected material (very expensive and used up in great volume) on the basis of an ABC analysis. The diagram proves that this material has been well managed since 01.06.2005.

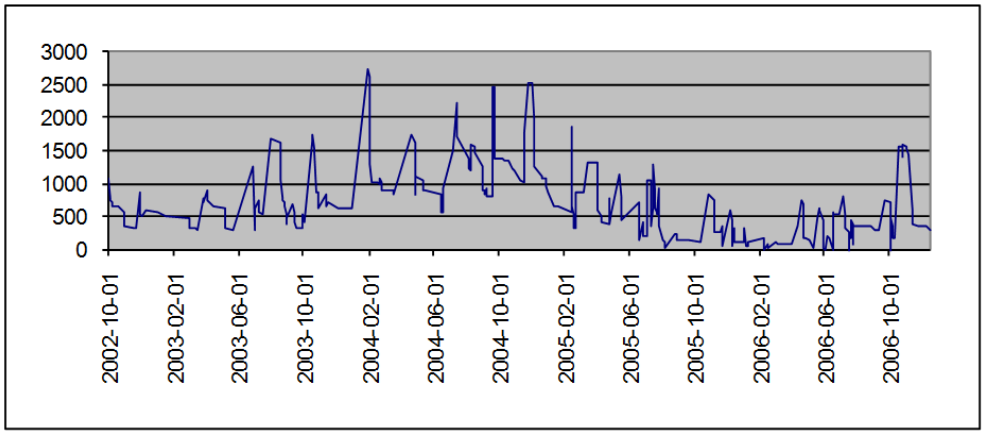

Fig. 2. An example of material turnover in company X

For a detailed answer of the question ‘what could be done better in the functional area of material management?’ the statistical analysis of all-important material indexes should be executed.

The methodology of the ERP system evaluation was presented only for a material management functional area. The analysis shows that the ERP system supports inventory reduction in company X very well. To evaluate other functional areas such as purchasing or the sales department the same steps should be done for different economical ratios.

2.2. User satisfaction performance

To evaluate a level of user satisfaction a short survey is prepared. The survey contains the following questions:

1. The general opinion about the ERP system on the scale 0 (very poor) to 5 (very good).
2. The main factors, which obstruct the using of ERP.
    - ERP system failure.
    - Lack of instructions.
    - Lack of training.
    - Incorrect data.
    - Slow working of ERP system.
    - Other.
3. Average time of work with ERP system in a day.
4. Which data are missing to take operational decisions?
5. Give two propositions to improve the ERP system functionality.

From the 117 ERP users of Company X the questionnaire was completed by 32 employers. Among the investigated employers were 5 Operation Managers. The results of the first question are presented on the Fig. 3. Average user satisfaction is 3,5 (good).

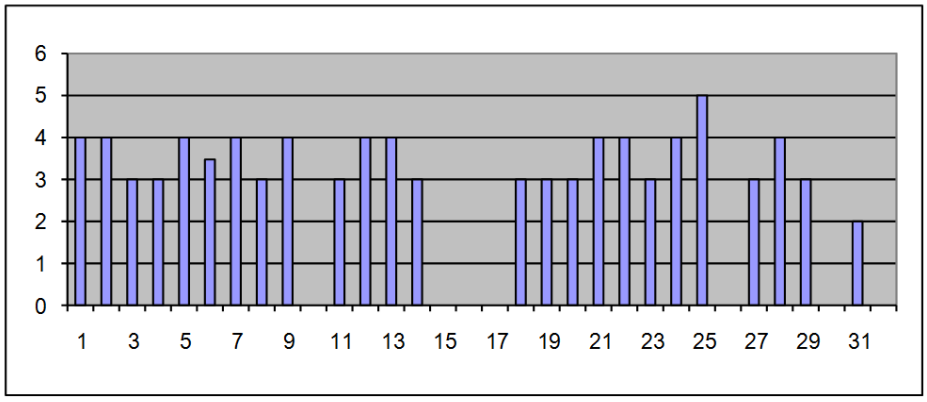

Fig. 3. The end user opinion about the ERP system in the X company

An analysis of main troubleshooting using ERP systems is presented in Fig. 4. Lack of training and slow working of the ERP are the most cited.

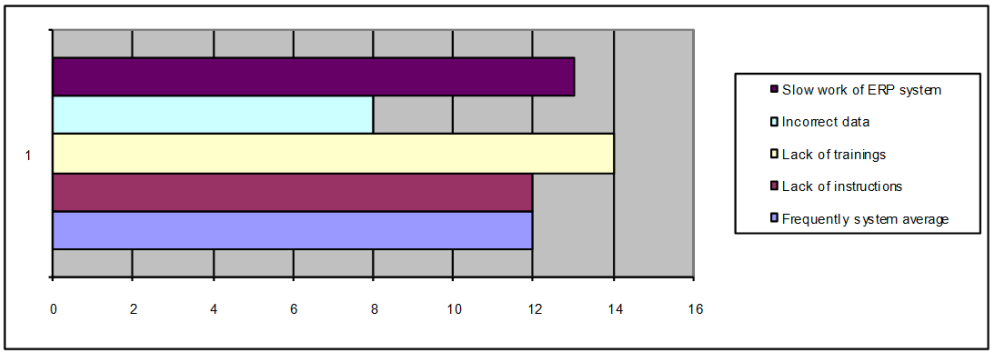

Fig. 4. The end user opinion about the ERP system in the company X

The average time of working with the ERP system in a day is 4.13 hours and the most used functionalities of the ERP system are in the areas of product design, material management and purchasing. If the level of user satisfaction is quite different from the results of the data evaluation a detailed analysis is required.

The realized analysis of user satisfaction shows that the functionality of the ERP system is evaluated as rather good in company X. Two of the next functional areas that should be evaluated are product design and purchasing. The methodology of ERP system evaluation in other functional areas can require specific data such as the number of delayed orders.

3. SUMMARY

In the paper the evaluation methodology of ERP systems is presented. The methodology is based on the impact investigation of ERP productivity ratio on economical factors and measurement of user satisfaction level. The proposed methodology is based on real data extracted from an ERP system and takes into account all events attached to the implementation of the ERP system. The methodology is probably more flexible and contrary to methods such as return on investment (ROI), economic value added (EVA) or total costs of ownership (TOC) and enables evaluation of a particular functional area of an enterprise. The proposed methodology enables us to show how in a historical perspective the ERP system affects the enterprise's economic efficiency.

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