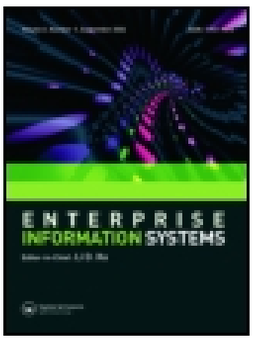

Enterprise Information Systems

ISSN: 1751-7575 (Print) 1751-7583 (Online) Journal homepage: http://www.tandfonline.com/loi/teis20

Enterprise resource planning (ERP) implementation using the value engineering methodology and Six Sigma tools

Jun-Der Leu & Larry Jung-Hsing Lee

To cite this article: Jun-Der Leu & Larry Jung-Hsing Lee (2016): Enterprise resource planning (ERP) implementation using the value engineering methodology and Six Sigma tools, Enterprise Information Systems, DOI: 10.1080/17517575.2016.1215537

To link to this article: http://dx.doi.org/10.1080/17517575.2016.1215537

Published online: 04 Aug 2016.

ENTERPRISE INFORMATION SYSTEMS, 2016
http://dx.doi.org/10.1080/17517575.2016.1215537

Taylor & Francis
Taylor & Francis Group

Enterprise resource planning (ERP) implementation using the value engineering methodology and Six Sigma tools

Jun-Der Leu[a,b] and Larry Jung-Hsing Lee[a]

[a]Department of Business Administration, National Central University, Taoyuan City, Taiwan; [b]Department of Business Administration, Munich University of Applied Sciences, München, Germany

ABSTRACT

Enterprise resource planning (ERP) is a software solution that integrates the operational processes of the business functions of an enterprise. However, implementing ERP systems is a complex process. In addition to the technical issues, companies must address problems associated with business process re-engineering, time and budget control, and organisational change. Numerous industrial studies have shown that the failure rate of ERP implementation is high, even for well-designed systems. Thus, ERP projects typically require a clear methodology to support the project execution and effectiveness. In this study, we propose a theoretical model for ERP implementation. The value engineering (VE) method forms the basis of the proposed framework, which integrates Six Sigma tools. The proposed framework encompasses five phases: knowledge generation, analysis, creation, development and execution. In the VE method, potential ERP problems related to software, hardware, consultation and organisation are analysed in a group-decision manner and in relation to value, and Six Sigma tools are applied to avoid any project defects. We validate the feasibility of the proposed model by applying it to an international manufacturing enterprise in Taiwan. The results show improvements in customer response time and operational efficiency in terms of work-in-process and turnover of materials. Based on the evidence from the case study, the theoretical framework is discussed together with the study's limitations and suggestions for future research.

ARTICLE HISTORY
Received 31 March 2015
Accepted 17 July 2016

KEYWORDS
Enterprise resource planning (ERP); Value engineering (VE); Six Sigma

1. Introduction

Enterprise resource planning (ERP) is an integrated set of software packages to support the cross-functional operations of an enterprise. It provides a process-oriented information platform to enable an enterprise-wide operational efficiency (Jacobs and Bendoly 2003; Gronau and Kurbel 2010). The implementation of ERP system is a complex project, in which the perspectives refer to information technology, business operations, software application as well as organisational change should be well considered in an integrated manner (Sammon and Adam 2010; Galoppin and Caems 2007). However, according to the industrial evidences, the ERP projects have relative high failure rate, meanwhile approximately 60–90% of ERP projects showed unsuccessful results (Lall and Teyarachakul 2006; Lapointe and Rivard 2005; Zhang et al. 2005). After analysed 562 respondents from survey in 2015, Panorama Consulting (2015) reveal that the failure rate of ERP implementation is 21%, which is an increase of 5% from last year. However, 55% respondents

CONTACT Jun-Der Leu leujunder@mgt.ncu.edu.tw; leu@hm.edu No.300, Jhongda Rd., Jhongli District, Taoyuan 32001, Taiwan

reported that the implementation budgets were overrun and 75% of projects exceeded their initial estimated timeline.

ERP implementation is similar to an engineering project, which involves the cooperation of cross-functional teams and consultants, coordination of technical and behaviour activities, long implementation time as well as large amounts of money. To it, many ERP providers developed their own methodologies to support the effective realisation of the software projects, for example the ASAP of SAP, and the AIM of Oracle (Franz 2014). Most of the ERP implementation methodologies are based on the system engineering thinking, in which the available resources in terms of professional capability, IT infrastructure, business know-how are well organised and so as to achieve the desired project quality under limited time and budget (Meinhardt et al. 2010; Grüne et al. 2009; Kwahk and Lee 2008). Again, these implementation methodologies consider the project realisation in a life-cycle base and so as to divide the project execution into several mutually exclusive time phases, in which the planning, control, monitoring as well as activities are executed based on a qualitative approach. By these approaches, the ERP implementation could be systematically organised, yet the decision and planning accuracy have still room for improvement.

System engineering (SE) is a well-accepted approach in the engineering field, in which the solving concept is normally developed to be a framework, and quantitative models are integrated to the framework to support the project execution (Blanchard and Fabrycky 1998). Similar to SE, Value engineering (VE) is an effective methodology that focuses on function analysis and lifecycle costing with quantitative evaluation to increase value creation. IT integration and the manufacturing decisions related to technology, human resources, quality, production planning and organisation. Organisations must identify their informational needs, select the most appropriate ERP package based on their organisational characteristics and then manage the ERP so that it benefits the organisation (Somers and Nelson 2003). By using new styles, applying a creative design, improving operational processes, developing innovative methods, reducing cost and time and improving quality and safety can meet customer needs and the company strategy (Ibusuki and Kaminski 2007). An extended model was developed to combine the target cost and VE as a system model. The combined model focuses on the requirements, functions and components of assembly, manufacturing and supply to provide further information for engineering the cost-value-ratio of products and increasing product value (Behncke, Maisenbacher, and Maurer 2014). Value-based management primarily applies data-driven conceptual approaches. The benefits of designing model-driven decision-making for performance and risk optimisation by implementing value-added performance metrics and applying robust optimisation methods to mitigate risk serve to sequentially optimise the physical and financial dimensions of a business (Hahn and Kuhn 2012). Various value propositions provide precursors for measuring the relative success or failure of ERP implementation. A set of value-based objectives can enrich the implementation of ERP. Value-driven tasks and alternatives can optimise the ERP selection and implementation processes (May, Dhillon, and Caldeira 2013). Applying a set of value propositions derived from a resource-based perspective on the various roles of the stakeholders in the value chain can achieve competitive advantage and influence ERP implementation. Value propositions also act as a foundation for elucidating the difficulties associated with improving ERP systems (Johansson and Newman 2010). Six Sigma is a disciplined data-driven approach that is designed to continually improve process quality and productivity to obtain bottom line profitability by minimising process variations, thereby leading to a consistent and predictable output. The approach focuses on minimising defects and variations, and measures excellence based on defects per million (Lin et al. 2013). The Six Sigma process involves identifying solutions to eliminate the root causes of performance problems that result in inconsistent processes, while preserving the integrity of the basic process to minimise the occurrence of defects, variations and unnecessary costs resulting from poor quality (Srinivasan et al. 2014). However, to ensure effective implementation, other management tools are needed to solve complex problems. Six Sigma, which emphasises defect-free manufacturing, fulfils this requirement. Both VE and Six Sigma are widely used in various industries. In Figure 1, we map

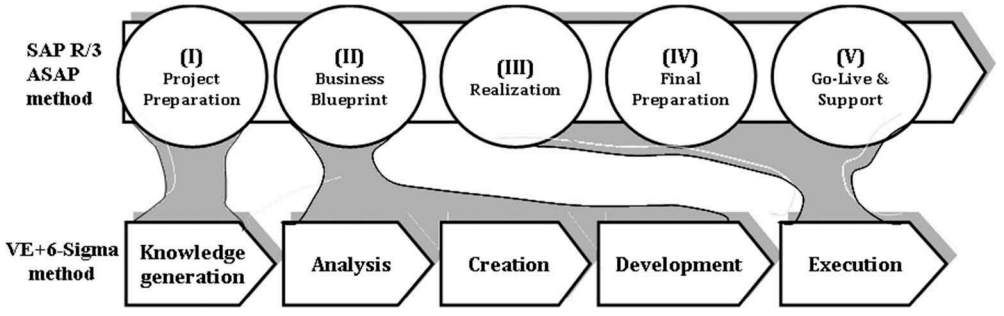

Figure 1. Mapping the implementation framework of the ASAP and VE-based methods.

the ERP implementation framework of ASAP and the VE (Value engineering)-based method developed in this paper. Similar to the ASAP framework, our proposed model comprised five phases, and some of the main steps of the ASAP model were included in our model. We used the VE methodology with numeric measurements to create an innovative value and Six Sigma methodology that ensures overall quality.

On the grounds of considerations above, in this study we applied VE as a basic structure to develop an ERP implementation methodology, and incorporated Six Sigma techniques to manage mismatches and develop a supportive tool for ERP implementation. The remainder of this study is organised as follows. In Section 2, we review the literature on ERP, and then show findings and gaps in literature. In Section 3, we propose a methodology for improving ERP system implementation. In Section 4, we develop a theoretical framework that outlines the processes for evaluating the implementation process, and validate the effectiveness of the proposed model using a case study of an international manufacturing firm that used the proposed model. We discuss our findings in Section 5. In Section 6, we present our conclusions and recommendations for future research.

2. Literature review

In this section, we review the literature on ERP implementation, VE and Six Sigma to inform the development of an implementation framework with improved value and quality. We then discuss the findings and identify gaps in the literature.

2.1. *Implementation of the ERP planning system*

Because ERP systems require a considerable investment of resources and ERP implementation projects are invariably complex and difficult, appropriate and effective project planning can increase the chances of successful implementation (Umble, Haft, and Umble 2003). Typically, an ERP system takes between 1 and 5 years to implement. The implementation process has been examined from the organisational innovation and technology assimilation perspectives to explain the role of one or multiple factors in determining business process outcomes. Numerous studies have focused on the implementation processes in various organisational settings and environments to help further the development of more prescriptive mechanisms and tools (Sarkis and Gunasekaran 2003). Koch and Mitlohner (2010) used effort estimation based on social choice to enhance the capacity for ERP implementation projects to adapt and customise complex systems, and even change the organisation. Karimi, Somers, and Bhattacherjee (2007) stated that ERP implementation projects should consider factors relating to the functional, organisational and geographic perspectives.

2.1.1. *Implementation strategies of ERP systems*

ERP systems can have three alternative strategies: self-development, outsourcing and a dedicated software package. Self-development and outsourcing are based on information system requirements that are analysed in accordance with business strategies. Outsourcing and dedicated software packages can reduce software and maintenance costs. However, the software functions typically require customisation (Akmanligil and Palvia 2004). The strategic implementation models of ERP systems can be categorised as big-bang, iterative and roll-out. When the big-bang model is applied, all of the required system modules are simultaneously configured and implemented in parallel by the firm. This methodology is suitable for relatively simple organisational structures where implementation only takes a short time. The iterative methodology comprises multiple phases with specific targets in each phase. Each development phase begins only after the completion of the preceding phase, and the process continues until the entire system is complete. With the roll-out model, new and original systems operate in parallel, and modules are developed for individual business units. After successful adoption, the new system is extended to the entire enterprise. Another critical issue in the strategic planning of ERP implementation is the selection of the ERP solutions. Jafarnejad et al. (2012) showed that general system features, project management, software quality and functionality, vendor capability, cost and technology are the major criteria in the ERP selection process. The main challenges include selecting and configuring the software, revising business practices, securing sufficient ERP development and operating staff, and the deployment process (Holsapple and Sena 2005). Ip and Chen (2004) proposed an IDEF methodology to integrate macroscopic environment of re-engineering and focused on the managerial and organisational aspects of ERP. The methodology connects management and organisation to a virtual ERP system for customisation, validation and documentation. The proposed implementation strategy enables the organisation to make use of the rapid advancement of ERP implementation.

2.1.2. *Framework for the ERP system implementation*

The framework for the systematic life cycle management of IT projects involves project selection, strategic implementation and performance evaluation (Stewart 2008). In industrial practice, ERP implementation projects are conducted on the strategic, tactical and operational levels. The strategic level includes evaluation of the current legacy system, project vision and objectives, implementation strategies, consultants and benchmarking. The tactical level comprises client consultation, business process change, software selection and the implementation approach. Finally, the operational level includes business process modelling, system configuration, final preparation and system deployment. Sohrabi and Vanani (2011) further stated that effective collaboration is needed between the managerial and operational planning levels of the total value system. Based on an assessment of the relevant organisational and technical factors, an ERP implementation framework has been proposed using design science guidelines in which the organisational factors include management commitment and support, change management, ERP implementation strategy, use of consultants, and the composition and skills of the ERP team, and the technological factors include customisation avoidance, technology use, user training and selection of the appropriate ERP architecture.

2.1.3. *Success of an ERP implementation project*

Mandal and Gunasekaran (2003) pointed out that the successful implementation of the ERP system SAP was attributable to closely following the specific pre-implementation, implementation and post-implementation strategies. Effective pre-implementation strategies include adopting risk and quality management protocols in change management, splitting the project into subsystems to improve cross-functional communication, using a phase-based approach rather than a radical approach, applying appropriate planning styles for various tasks and planning the recruitment, selection and training of the project team personnel. Effective implementation strategies include

formulating a network to identify user requirements and collect user feedback, providing a professional and stimulating work environment, promoting collaboration between users and developers while developing the system, recruiting intra-project teams and employing intra- and inter-industry networking personnel for system migration. Effective post-implementation strategies are critical for user acceptance of ERP systems. Because IT systems and structures tend to change continuously (even after the completion of a project), effective post-project evaluation strategies are useful for measuring the effectiveness of an ERP system. Chau et al. (2009) established a process model integrating Six Sigma with enterprise system. The model enables an enterprise to keep ahead through the continual promotion of innovative ideas about products, services and technologies and make use of the enterprise systems effectively and efficiently. Tchokogué et al. (2005) showed that the successful implementation of SAP R/3 by Pratt & Whitney Canada was the result of constant and shared efforts among all stakeholders at the strategic, functional and operational levels. Specifically, they prioritised change management, unified the orientation of top management, mobilised all managers, allocated sufficient internal and external resources and provided adequate training and coaching. Several key factors of successful organisational transformation were considered, such as a rigorous and detailed plan based on a proven model, favourable conditions for organisational change, familiarity with the SAP system, a culture of change, relatively positive history of undergoing change, adequate financial resources and time frame, and a substantial number of dedicated players to facilitate the system migration. Many attempts at ERP implementation have been unsuccessful due to the complexity of the process.

Kini and Basaviah (2013) argued that ERP implementation failure results in financial investment loss, operation disruptions, potential revenue loss, customer dissatisfaction, poor employee morale, high employee turnover and poor system recovery. Wang, Gao, and Ip (2010) set up a model to handle the resilience of an enterprise information system for the maximum recovery ability. The result shows that the model and algorithm work from an example by using genetic algorithm (GA). Aloini, Dulmin, and Mininno (2007) identified processes, expectations, interactions and correspondence failures as four causes of ERP project failure. Akkermans and van Helden (2002) identified the presence and attitudes of the surrounding stakeholders, i.e. top management, project management, project champions and software vendors, as the root performance drivers of the core process. Al-Mudimigh, Zairi, and Al-Mashari (2001) stated that top management commitment and support, business case, project management, change management, training and communication are the CSFs of ERP.

The major CSFs are the provision of adequate user training, the identification of clear goals and objectives, and the participation and support of top management. Ke and Wei (2008) showed that top management can influence employees' values, cognisance and motivation to adopt an ERP system, and that the influence of leadership on the organisational culture contributes to the success of ERP implementation. Rajendran and Elangovan (2012) showed that the perceived benefits and challenges, and the organisational complexity play mediating roles in institutional pressure motivated ERP adoption drives. They recommended that stakeholders consider introducing facilitating factors, such as employee training and the provision of financial and technical support, that consultants should commit to training end users and that employee resistance should be managed through effective leadership, communicating the benefits of change and preparing for risk.

ERP implementation enables firms to reduce their transaction costs and improve their productivity, customer satisfaction and profitability (Beheshti and Beheshti 2010). Wang and Hwang (2012) stated that after an initial system failure, a new ERP system can reduce inventory by 16%, increase annual sales by 10% and provide a 20.6% return on investment. However, the benefits of ERP are not guaranteed, even after successful ERP implementation. For example, the distinct features of a firm, such as interdependence and differentiation among manufacturing plants (Chou and Chang 2008), can significantly influence the benefits of ERP implementation. Accordingly, focusing solely on efficiency can be harmful to an organisation's long-term success and competitiveness.

Table 1. The trend of ERP implementation from literature review.

Category	Related research
Implementation strategies	• Self-development and outsourcing should be determined based on the information system requirements (Akmanligil and Palvia 2004). • General system features, project management, software quality and functionality, vendor capability, cost and technology are the major criteria in the ERP selection process (Jafarnejad et al. 2012). • The decision-support objectives are moderately critical factors in ERP planning (Holsapplea and Sena 2005).
Framework for implementation	• IS projects should be organised based on the life-cycle concept and therefore a framework is necessary. ERP implementation projects are conducted on the strategic, tactical and operational levels (Stewart 2008). • Effective collaboration is needed between the managerial and operational planning levels of the total value system. An ERP implementation framework has been proposed using design science guidelines (Sohrabi and Vanani 2011).
Success of implementation project	• The successful implementation of the ERP system SAP was attributable to closely following the specific pre-implementation, implementation and post-implementation strategies (Mandal and Gunasekaran 2003). • The successful implementation of SAP R/3 by Pratt & Whitney Canada was the result of constant and shared efforts among all stakeholders at the strategic, functional and operational levels. Many attempts at ERP implementation have been unsuccessful due to the complexity of the process (Tchokogué et al. 2005). • The major CSFs are user training, goals and objectives, top management participation and support, project management, teamwork and composition (Kini and Basaviah 2013). • Success factors for ERP project implementation are top management commitment and support, reference cases, project management, change management, training and communication (Al-Mudimigh, Zairi, and Al-Mashari 2001). • Distinctive features such as the interdependence and differentiation of plants should be considered (Chou and Chang 2008).

2.2. *Findings and gaps in the literature*

The foregoing literature review reveals that ERP implementation is complex and difficult. Table 1 shows the trend of ERP implementation. Appropriate strategy, suitable framework and effective project planning can increase the chances of successful implementation. There are many ways to implement ERP systems, such as through self-development, outsourcing or software packages, or big-bang, iterative and roll-out approaches, etc. It seems that finding a suitable method is a way to success. Risk and quality management affect the implementation of such projects, and following a proven model can improve the chances of success. The critical success factors include user training, setting clear goals and objectives and senior management support and participation. Successful ERP implementation can reduce inventory and increase sales and return on investment. There is no single method that can be adopted to deal with different situations and complexities of implementing process, but with so many cases of failure the development of a suitable framework for ERP implementation could help to avoid mistakes in future projects.

VE is based on functional analysis to streamline the value of a system, product or service by developing a new style, design and process to reduce costs and improve quality and safety. Six Sigma is a disciplined data-driven approach to minimising defects and variations. By developing a VE-based theoretical framework combined with Six Sigma, a firm can follow the method step-by-step using the quantitative methods of VE analysis and Six Sigma to find the most suitable strategy and method to deal with the problems involved in ERP system implementation.

3. Research methodology

The research methodology was divided into six steps, as illustrated in Figure 2. The first step involved establishing the goal and determining the motivation for all members of the team. Given that the adoption of ERP systems has become essential in most enterprises, the proposed

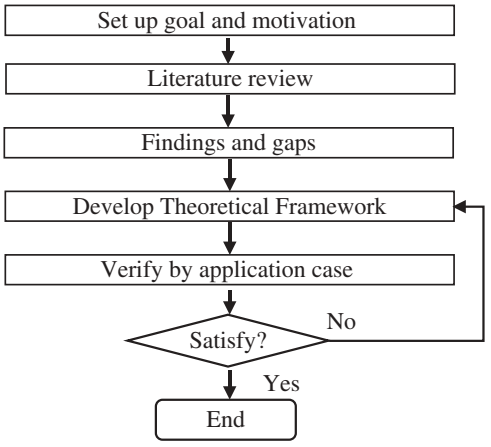

Figure 2. Research methodology.

framework had to enable system implementation with less than usual resource input and more output. We are tired of current system for not only being slow, but also for the mistakes that happened often. We need to request IT personnel to provide data from information system once in a while for further analysing. We thus used many management tools for performance improvement to determine implementation efficacy. The second step was the literature review, which allowed us to collect as much information as possible, focusing on ERP implementation, VE and Six Sigma. They are all effective ways, separately. Failure and successful implementing cases are collected. There are many methods suitable for adoption. However, with limited resources, we need to select only part of them. The third step was to summarise the findings so that we could learn from successful methods, avoid mistakes and identify gaps in the literature. In the fourth step we developed the theoretical framework. According to our experience with the management tools, including VE, failure mode and effect analysis (FMEA) and Six Sigma, and the findings and gaps in the literature, we constructed a framework for ERP system implementation. In the fifth step, we verified the framework using an application case. A series of trainings in VE, FMEA, Six Sigma, as well as ERP were proceeded to make sure correct usages. As the framework is adjustable, we were able to check it and improve it iteratively. The sixth step was to have a complete methodology before conducting the project.

4. Theoretical framework of the VE-based ERP implementation method

In this section, we describe the development of a theoretical framework for implementing ERP systems. We discuss how and why we decided to use VE and Six Sigma. An application case is provided to describe the implementation processes and prove that the developed framework is feasible. ERP implementation is a complex engineering process with a high failure rate. ERP requires enterprises to use a holistic and innovative approach to assess added-value creation processes to identify and solve problems. Moreover, the concept of traditional costing may not be suitable for all ERP implementation situations because of the trade-offs between cost, time and value. Therefore, in this study, we used value to replace both cost and time. We selected three management tools and modified the traditional VE framework to develop a FMEA to form a VE-based model. Figure 3 presents the framework. The model combines knowledge generation, analysis, creation, development and execution phases to create higher value for enterprises implementing ERP systems, which are detailed in the following subsections.

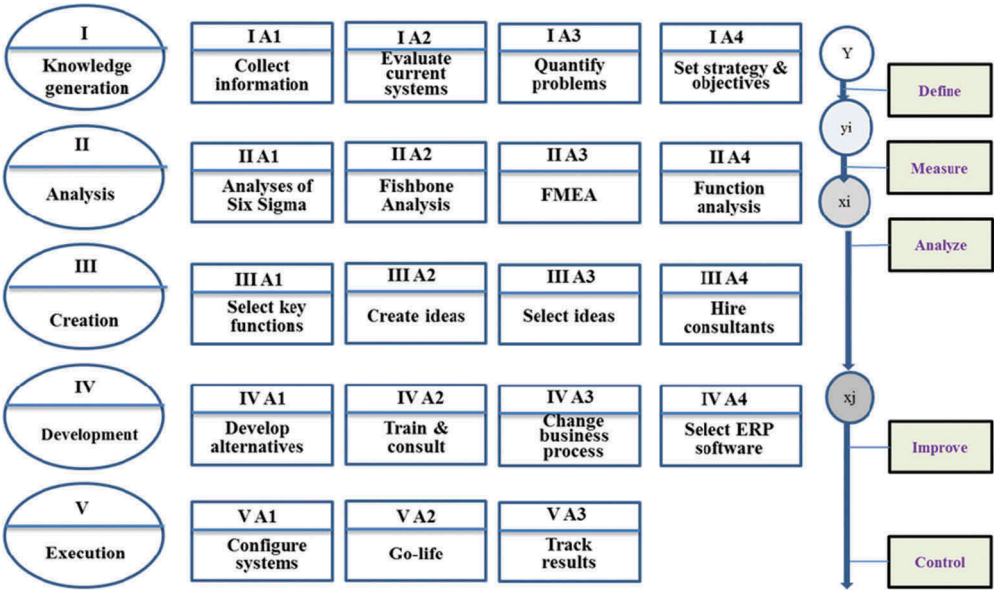

Figure 3. Framework of the VE-based ERP implementation method.

4.1. *Development of the theoretical framework of the VE-based ERP implementation method*

Our in-depth review of the relevant literature revealed that the development of a suitable theoretical framework for ERP implementation is essential to every enterprise that plans to adopt an ERP system. In this subsection, we describe in detail each phase in establishing a model for reference by practitioners and researchers.

4.1.1. *Knowledge generation*

In Phase I, a cross-functional team (comprising decision-makers, key business operations personnel, business function managers, IT department experts, human resource managers, financial planners, internal consultants and software providers) was responsible for collecting all of the relevant information (Step IA1). Next, all information that was relevant to the ERP system (e.g. software modules, system architecture, vendors, implementation methodology, consulting company, reference projects and budget) was collected, recorded and evaluated (Step IA2). All of the ERP related problems were measured quantitatively. Evidence from the reference projects was used to assist the team in reviewing the CSFs for and barriers to ERP implementation. In addition, the Six Sigma define-and-measure technique was used to provide a more structured approach to analyse each decision perspective. By following these procedures, useful knowledge was generated for further analysis.

Subsequently, the problems were quantified (Step IA3) by using Equation 1 to calculate the related costs, which comprise the sub-costs of ERP implementation (e.g. software, hardware, installation, consultation, training, aftersales service, maintenance, upgrade, infrastructure, shot-down and utility costs). The details of each factor were further quantified into a cost item, as shown in Equation 2. For example, Equation 2 can provide further details of the function costs, such as the cost of each software module or the hourly costs of training and consultations. When the ERP implementation strategy and objectives were identified (Step IA4), Phase I was complete.

$$Min.Y = \sum_i y_i, \forall, \tag{1}$$

$$\text{where } y_i = \sum_j x_j, \forall_{i,j} \tag{2}$$

Y: total cost of ERP implementation
y_i: sub-cost of ERP implementation
x_j: cost of each item in the sub-cost

4.1.2. *Analysis*

In Phase II, we evaluated the value of the ERP implementation activities. First, the VE study team performed a Six Sigma analysis (Step IIA1) to identify the current system problems. Next, a fishbone diagram (Step IIA2) was created to assist in group discussions on identifying which criteria were critical to successful ERP implementation. We found that the failure rate of ERP implementation was high in literature. Subsequently, the FMEA model (Step IIA3) was applied to predict and quantify the risk of failure and identify critical points that might cause failure and affect the entire organisation. In Equation 3, the risk priorities of the failure modes are expressed using the risk priority number (RPN). Finally, the function analysis (Step IIA4) was performed, in which the knowledge generated in Phase I was used to identify the key functions and determine their costs. This proactive approach to failure prevention can avoid considerable financial loss to an enterprise.

$$\text{RPN} = \text{Severity} \cdot \text{Occurrence} \cdot \text{Detection}. \tag{3}$$

The risk factors used in this study were the severity, occurrence and detection of failures before they reach the customer. These risk factors were evaluated using a 10-point scale, with values ranging from 1 (severity = no effect; occurrence = almost impossible; detection = almost certain) to 10 (severity = hazardous; occurrence = inevitable; detection = absolute uncertainty); thus, lower values indicated more favourable conditions (Chin et al. 2009).

In Step IIA4, the functions of each item were described using an active verb and a measurable noun. An item can have multiple functions. For example, the items can refer to ERP modules, implementation procedures or ERP implementation criteria. Equation 4 shows that the value index VI equals the function cost divided by the function worth, where the function cost indicates the actual cost, and the function worth is the minimal cost of performing that function. Thus, the higher the value of VI the greater the potential for improvement. The value of each function in Equation 5 was determined through team discussions. A function usually combines subfunctions that make different contributions to the function. A team can use the analytic hierarchy process or forced decision method to compare different subfunctions and find the weight for each. The functional analysis system technique (FAST) is an effective tool for evaluating existing procedures, structures and other objects, and was used as a problem-solving technique for identifying the required functions in the system. Finally, when the key functions were identified, Phase II was complete.

$$VI_{ij} = \frac{w_{ij} \times C_i}{B_{ij}}, \forall_{i,j}, \tag{4}$$

$$\text{where } \sum_j w_{ij} = 1, \forall \tag{5}$$

i main procedures defined in knowledge generation, $i = 1,2,\ldots,I$
j the function of each main operation, $j = 1,2,\ldots,J$
C_i the function cost of each main operation
W_{ij} weight of each function
B_{ij} the least cost required to perform the function

VI_{ij} value index for finding out the key functions

4.1.3. *Creation*

In Phase III, the team members selected the key functions (Step IIIA1) of ERP implementation. The solutions were formulated by creating ideas (Step IIIA2) based on the following guidelines: (a) illogical thinking was encouraged; (b) unconventional thinking was applied to overcome resistance to change; (c) planning or thinking logically was considered nonessential for producing insightful solutions; (d) mental blocks were removed and personal inhibitions were disregarded; (e) imaginative thinking was encouraged; (f) team members assisted each other in formulating unusual or abstract solutions; (g) team members encouraged each other and did not ridicule each other's suggestions and (h) ideas were accepted as potential solutions, regardless of whether they seemed absurd when first proposed. Next, the team members applied various evaluative methods to identify the most valuable solutions from the ideas selection (Step IIIA3). Based on those solutions, the most appropriate ERP consultants were hired (Step IIIA4).

4.1.4. *Development*

To facilitate managerial decision-making processes, Phase IV was designed to develop workable alternatives (Step IVA1) based on the selected solutions. The development rules are detailed as follows: (a) each alternative must be analysed thoroughly to ensure that the requirements are fulfilled; (b) the appropriate technology must be selected; (c) the team members must prepare the quotations, schedules and tests; (d) the team members must consider the necessity and effect of modifying the design; (e) the proposed changes should facilitate harmonic human relations; (f) all team members must be involved from the beginning of Phase I; (g) specific alternatives should be developed and (h) persuasive materials should be prepared.

The training and consultation processes (Step IVA2) were divided into the following three categories: (a) VE; (b) Six Sigma and (c) ERP. Because companies expect employees to learn and perform new skills, we recommend that companies develop level-based training based on the various organisational levels. The training was designed to target each Six Sigma role and the various responsibility levels. The training sessions comprised master black belt training, black belt training, green belt training, team training and champion training. The training was considered a knowledge transfer process and the comprehensive training programme was both technical and business-oriented. ERP system-related manuals were designed based on the diverse training requirements of the participants (Tchokogué, Bareil, and Duguay 2005). The consultants provided training regarding the ERP modules, and used their technical and organisational experience in implementing ERP systems to assist in selecting, configuring and implementing the ERP system.

To maximise the benefits of implementing an ERP system, the business processes (IVA3), organisational structure and culture, employee behaviours and business strategy must be aligned with the model implicit within the ERP package.

Umble, Haft, and Umble (2003) indicated that enterprises must clearly recognise their strategic goals and obtain managerial support before establishing their project management team. The ERP system was selected (Step IVA4) based on the business strategies and operational requirements. Before testing the hardware and software, enterprises must compare and adjust their operational processes and ERP software to ensure that the software is suitable.

4.1.5. *Execution*

Phase V was designed to ensure that the value alternatives were executed and that the projected benefits from the value study were realised. The processes are detailed as follows: (1) review the preliminary report; (2) conduct an executive meeting to determine the disposition of each value alternative; (3) establish action plans for the accepted alternatives and document the rationale for rejecting the alternatives; (4) obtain management commitments for execution; (5) set a time frame for reviewing and implementing each value alternative; (6) monitor the value achievements of the

implemented alternatives; (7) sign off the deliverables; (8) validate the benefits from implementing the system modifications and (9) ensure that the new practices become embedded by developing and implementing an execution plan. To reflect the organisational features, the system was first configured (Step VA1) based on all of the potential ERP system usage options, and then modified by recoding the ERP system to perform specific business processes. Next, the ERP system was deployed in a production environment to go live (Step VA2) by first activating the system, and then migrating from the old to the new system. The results were tracked (Step VA3) to ensure that the system was operating as intended.

4.2. *Application of the theoretical framework of the VE-based ERP implementation method*

We conducted a case study on a global manufacturing enterprise with integrated and professional capabilities in research and development and manufacturing. Initially, the case company's products were mainly television tuners and precision electronic components. Following steady growth, the case company then diversified its products and services. To meet the market demand and expand its business scope, the company's products are developed primarily to meet the demands in the optoelectronic (43%), information appliance (21%), consumer electronics (35%) and communications industries.

The management systems of the case company are internationally recognised and certified as meeting the relevant quality and environmental management standards. Through the close collaboration among the various plants located in Taiwan and China, the case company can provide flexible production scheduling, and can adjust its production capacity to meet specific customer requirements. In addition to providing its customers with superior products and satisfactory services, as a member of the global community, the case company is dedicated to developing green products and conducting business in accordance with the existing environmental protection requirements.

The case company applied the value engineering and Six Sigma method to improve the implementation of an ERP system. A project team was formed by members of the IT, finance, procurement, manufacturing, industrial engineering and quality assurance departments and third-party consultants. Some of the company's main suppliers were invited to attend meetings when needed, and several professors from various universities provided occasional guidance. One of the authors, a certified value specialist, acted as a consultant for the value study. The team convened weekly (8 hrs per week) to discuss the implementation of the ERP system, including knowledge generation, analysis, creation, development, execution and implementation. Following are the details of each phase.

4.2.1. *Knowledge generation*

The VE study team comprised members from various business units, including the company's IT, finance, procurement, manufacturing, industrial engineering and quality assurance departments and third-party consultants. In addition to attending training courses with the consultants, we also completed a 40-hr VE Module I training workshop. In Step IA1, the team collected a considerable amount of information on ERP, VE and Six Sigma.

John et al. (2006) showed that knowledge-sharing during ERP implementation is based on concepts such as truth, rationality, motivation, orientation, change, work, collaboration, control, coordination, responsibility, focus and time horizon. The team acquired further knowledge from the information and documents of ERP implementation. In Step IA2, the team studied numerous SAP R/3 ERP modules, including sales and distribution, material management, production planning, quality management, plant maintenance, human resources, finance and accounting, controlling, fixed asset management, project system, workflow and industry solution.

After examining the information on ERP implementation, the team acquired the relevant knowledge. For example, they defined ERP, identified the CSFs of ERP implementation and understood

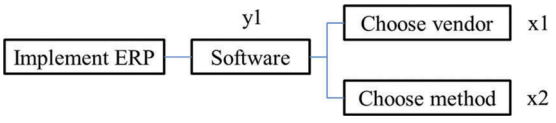

Figure 4. Defined steps of Six Sigma of ERP implementation.

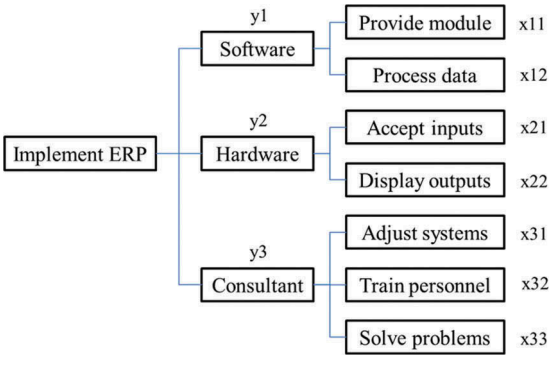

Figure 5. Measure of Six Sigma of ERP implementation.

how Six Sigma can improve the quality of ERP processes. Figure 4 shows some of the defined steps of Six Sigma for the ERP implementation process. Selecting the appropriate software is an essential criterion for successful ERP system implementation. Figure 5 shows the measurable elements of the ERP implementation criteria (e.g. the consultants' measurements are adjusting systems, personnel training and problem solving). Hardware improvements are also highly critical in successful ERP system implementation. In Step IA3 the team used Equation 1 to calculate the financial losses caused by the current system. The total annual loss from sales, work-in-progress (WIP) and materials was approximately US$1 million. In Step IA4, the team identified a failure in the case company's ERP implementation strategy. Specifically, the function of integrating the current information systems was no longer fulfilling the customers' requirements. Thus, the company's production capacity, business processes and organisational structure required adjustment. The company's objectives were identified as improving customer response times, increasing inventory turnover and reducing WIP, inventory levels and operational costs.

4.2.2. *Analysis*

In Step IIA1, the project team applied Six Sigma analysis to identify the current system problems, and a fishbone diagram (Step IIA2) was produced under the guidance of a quality manager from the firm (Figure 6). The team identified the following four items affecting the ERP system implementation: (a) software (e.g. inflexible system design, non-integrated system design and defective system design); (b) hardware (e.g. inadequate server size, high costs and obsolete technology); (c) methods (e.g. poorly defined procedures) and (d) human resources (e.g. failure to understand the system, unqualified staff and resistance to change).

Next, the team selected three critical elements (unqualified staff, non-integrated system design and high costs) with quality-related problems. In Step IIA3, the company's MIS department manager guided the team in focusing on three critical quality items (i.e. information, system and service quality). Based on the group discussions and the results of Equation 2, the four highest potential failure modes were identified as (a) reliability problems resulting from poor information quality, (b) timeliness problems caused by poor system quality, (c) reliability problems because of inadequate service quality and (d) responsiveness problems resulting from poor service quality. To

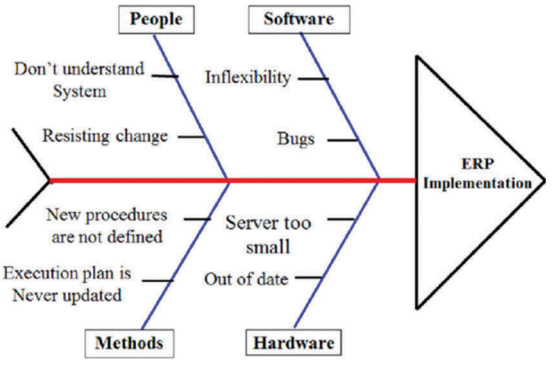

Figure 6. Fishbone diagram of the implementation of ERP systems.

resolve these problems, the company improved communications, provided additional staff training and developed an incentive programme (Table 2).

Based on the acquired knowledge, the team identified three critical items (software, hardware and consultation) for the function analysis. In Step IIA4, the items were described and the related initial costs and values were calculated. Table 3 shows the function analysis results. The key functions were identified as providing modules, printing outputs and accepting inputs. By applying how and why logic, the team used the skills of value standard to produce a FAST diagram (Figure 7). The diagram shows that the company's ERP system implementation goals were increasing efficiency and profits. The long-term functions were quality assurance and reducing costs. The main functions were installing software, reconfiguring hardware and system consultation.

4.2.3. *Creation*

In Step IIIA1, the VE team selected the key functions of ERP implementation. Next, various methods were used in Step IIIA2 to identify solutions, and the team identified software and hardware as the main areas requiring improvement. In Step IIIA3, the most valuable solutions were selected. Service quality is critical for the successful implementation of ERP systems. Conversely, new hardware can improve the performance of the ERP system. Thus, the team was able to select from various solutions. The team continued engaging in creative activities to identify various approaches to improving the ERP implementation process, and the most valuable solutions were selected by eliminating, combining, rearranging and simplifying the various solutions. Finally, the group selected suitable consultants in Step IIIA4.

4.2.4. *Development*

In Step IVA1, the team used VE methods to screen the proposed solutions and select feasible alternatives for further development. Invariably, using new technologies and developing new service methods can increase efficiency, reduce costs and improve satisfaction. During this process, the final executive plans were developed to persuade management to accept the final alternatives and execute the Six Sigma improvement. Training and consultations with experts are essential tasks for successful ERP system implementation. In Step IVA2, approximately 3,000 person-hrs were required to conduct training courses and hold meetings on VE, Six Sigma and ERP to overcome technical complexity, improve expertise and reduce organisational resistance to change. In Step IVA3, the case company examined and then adjusted its logistical (inbound and outbound), operational and financial processes to meet the needs of its customers. In Step IVA4, the case company decided to adopt T-Company's web-based ERP as its ERP system. After purchasing the source code, the case company's IT personnel modified the system to suit the company's requirements. To increase software efficiency, a web-based system was developed.

Table 2. FMEA of ERP implementation.

Product process	Potential failure mode	Potential effect(s) of failure	Severity (S)	Potential cause(s)/Mechanism(s) of failure	Occurrence (O)	Current process controls	Detection (D)	RPN = S · O · D	Action taken
Information quality	Not accuracy	Wrong outputs	8	Wrong inputs	4	Manual rules	3	96	()
	Timeliness problem	Cannot get in time information	8	Delaying	6	Manual rules	4	192*	Training
	Completeness	Wrong outputs	8	Shortage of information	3	Manual rules	3	72	()
	Not relevance	Wrong decision	7	Wrong inputs	3	Audit procedure	3	63	()
	Not consistency	Confused	6	Wrong confirmation	2	Check	2	24	()
	Not visibility	Wrong decision	7	Operation instruction	2	Audit procedure	1	14	()
	Conflict	Confused	6	Wrong confirmation	1	Meeting	1	6	()
	Communication problem	Wrong outputs	8	Operation instruction	1	Negotiation	1	8	()
	Transformation	Wrong decision	7	Wrong confirmation	1	Meeting	1	7	()
System quality	Difficult to use	Cannot get in time information	8	System design problem	4	Negotiation	3	96	()
	Reliability problems	Unstable	10	Hardware problems	5	Contract	4	200*	Communication
	Unflexibility	Cannot deal special jobs	6	System design problem	4	Negotiation	4	96	()
	Functionality	Lack of some functions	5	Software problems	3	Contract	3	45	()
	Stability	Unstable	9	Operation problems	3	Manual rules	2	54	()
	Integration	Multiple operations	6	System design problem	2	Negotiation	2	24	()
	Response time	Can't get in time information	8	Delaying	2	Manual rules	1	16	()
	Auditing problem	System break down	9	Operation problems	1	Audit procedure	1	9	()
	Control error	System error	8	Operation problems	1	Manual rules	1	8	()
Service quality	Reliability problems	Waiting for service	8	Vendor's problem	6	Contract	4	192*	Incentive programme
	Responsiveness problem	Losing money	9	Contract problem	4	Contract	4	144*	Incentive programme
	Assurance lacking	Losing money	9	Communication problem	3	Contract	3	81	()
	Service level	Lack of some functions	7	Contract problem	2	Negotiation	2	28	()
	Lack of experience	Some problems unsolved	7	Vendor's problem	2	Vendor selection	2	28	()
	Project management	Resource waste	6	Not right people	2	Assigned	1	12	()
	Training problem	System not function well	6	Planning problem	1	Negotiation	1	6	()
	Technical competence	Some problems unsolved	7	Vendor's problem	1	Vendor selection	1	7	()
	Domain knowledge	Waste time and money	8	Vendor's problem	1	Vendor selection	1	8	()

Remark: * Significant () Insignificant

Table 3. Function analysis of ERP implementation.

Sub item	Function (A) Verb	Noun	Kind	Estimated initial cost (B)	Worth (C)	Value index (D) = (B)/(C)	Priority
Software	Provide	Modules	B	$213,793	$109,500	2.0*	1
	Process	Data	S	$366,014	$321,261	1.1	()
Hardware	Accept	Inputs	B	$102,930	$62,419	1.6*	3
	Print	Outputs	S	$127,681	$69,288	1.8*	2
Consulting	Adjust	Systems	B	$37,321	$28,456	1.3	()
	Train	Persons	S	$6,360	$5,433	1.2	()
	Solve	Problems	S	$1,347	$1,674	0.8	()

B = Basic function
* Significant
S = Subfunction
() Insignificant
RS = Required subfunction

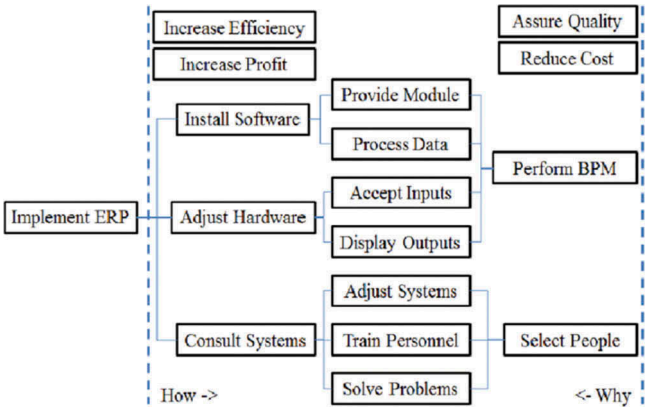

Figure 7. FAST diagram for ERP implementation.

4.2.5. *Execution*

In this phase, the preliminary report was reviewed. Executive meetings were conducted to determine the disposition of each value alternative to establish action plans for the accepted alternatives. Subsequently, a commitment was obtained for system implementation, and a time frame was set for reviewing and executing each value alternative. In Step VA1, the new ERP system was configured based on the company's requirements before deployment. In Step VA2, a dual-system strategy was applied during deployment to ensure that the system would be free of defects. In Step VA3, the value achievements of the implemented alternatives were monitored and validated. An execution plan was developed and maintained to maximise the benefits from implementing the new ERP system to ensure that the new practices became embedded. The results of the project show that the case firm reduced its customer response times and WIP by 30% and 50%, respectively, and increased its material turnover by 35%. Table 4 and Figure 8 detail the results. However, the economic recession in 2009 affected the WIP and material turnover.

Table 4. The results of ERP implementation of the case company.

	2006	2007	2008	2009	2010	2011
Customer response time (Days)	7.8	6.6	5.4	4.6	3.6	2.8
WIP($)	$4,169.0	$2,849.6	$2,102.2	$2,553.5	$4,298.7	$3,320.2
Turnover of materials (Times)	11.0	15.0	18.2	13.0	11.3	7.0

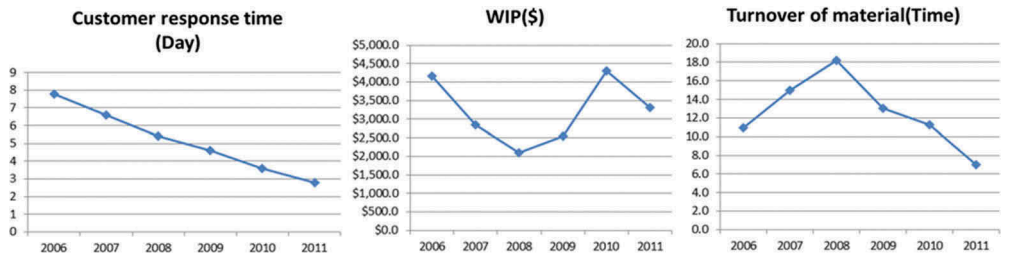

Figure 8. Results of ERP implementation of the case company.

5. Discussion and implications

The framework proposed in this study was developed based on VE practices, Six Sigma techniques and ERP implementation methodologies. The strengths of these concepts were combined to form an innovative new model, using quantitative functional analysis and Six Sigma methods with five phases comprising 19 steps to avoid mistakes in project implementation. A value creation mechanism includes exchange, addition and synergistic integration constructs for improving the success rate of ERP implementation. The framework of the proposed model comprised five phases (knowledge generation, analysis, creation, development and execution). The proposed model was applied to support ERP system implementation in a global manufacturing enterprise, and the results revealed that the model was feasible. However, we did face many difficulties during those steps. (1.) We confronted the change resistance from our colleagues. We had to set up more seminars to communicate for commitment. (2.) Some implementing methods such as FMEA and Six Sigma were challenged by some high ranking managers. More supportive evidences were collected for future improvement. (3.) ERP selection was decided by team members during several value evaluation meetings, which lasted for few weeks. And some other minor difficulties in the process of the ERP implementation were solved immediately.

In industrial practice, the ASAP methodology is a mature framework for ERP system implementation. ASAP comprises four phases (the system implementation process, importing auxiliary tools, training and support services and change management). In particular, the system implementation process comprises five phases, which are detailed as follows. First, during the project preparation phase, the project purpose is defined, the entire project is organised and a clear focus is established. Second, during the business blueprint phase, the organisational structure and vision are set, and a blueprint is developed to re-engineer business processes and clarify the benefits of using a new system. Third, in the realisation phase, the system functions are set and confirmed based on the business blueprint. Fourth, during the final preparation phase, the system is tested and the system data are migrated in preparation for deployment. Finally, during the deployment and support phase, the system is operational and continuously improved. The roadmap of SAP R/3 implementation is a sequential process that requires approximately 6–12 months to implement, which is considerably shorter than the 2–3 years required for a standard SAP R/3 implementation project. However, the ASAP methodology is not suitable for every implementation of ERP. Previous studies have shown that the success of ERP implementation can be measured based on customer satisfaction, organisational impact, anticipated improvements in business performance, current profits and future business feasibility. After applying the proposed model, the performance of the case company improved considerably with respect to customer response times, work-in-process and material turnover.

The implications of this paper are divided into academia and industry. Looking from academia, this paper developed and clarified an ERP implementing model by using VE and Six Sigma-based methods. Past studies on ERP implementation have mainly focused on the customer satisfaction,

organisational impact, anticipated improvements in business performance of ERP implementations, but little attention has being given to the risk, quality and value management. The implications for industry of this paper are to provide firms that would like to enhance their information systems with a better understanding of the various ERP implementing practices that may be applied in their firms. Moreover, the management team could also use the case study of this paper as an example to review and identify areas where specific adjustments are required in their current ERP implementing practices.

6. Conclusion

In this study, we proposed a VE- and Six Sigma-based model for implementing an ERP system. Fishbone analysis, FMEA and function analysis were applied to identify key functions in implementing ERP. Training, consultation and business process management were performed before selecting an appropriate ERP software package. Finally, the ERP system was configured, deployed and then monitored. The results revealed that by applying the proposed model, the customer response times, work-in-process levels and material turnover improved considerably. Thus, the proposed model is feasible, and may be suitable for adaptation to other fields to advance value creation. The limitations of this study are that the problems of ERP implementation are highly complex. Consequently, the proposed method cannot solve all problems associated with ERP implementation. In addition, the proposed model only emphasises training, communication, software modification, customer response time and material turnover. Future studies should consider focusing on technological advancements, such as faster multicore processors, solid state storage devices, virtualisation, mobility, big data analysis, information modelling and cloud computing. Moreover, with the understandable concern about environmental issues brought on by global warming, the development of a next-generation system for sustainable ERP could be an important focus of future research.

Acknowledgement

This work has been developed within the framework of a research project funded by the Ministry of Science and Technology (MOST) Taiwan, reference MOST 104-2410-H-008-066.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the Ministry of Science and Technology, Taiwan: [Grant Number MOST 104-2410-H-008-066].

References

Akkermans, H., and K. van Helden. 2002. "Vicious and Virtuous Cycles in ERP Implementation: A Case Study of Interrelations Between Critical Success Factors." *European Journal of Information Systems* 11 (1): 35–46. doi:10.1057/palgrave.ejis.3000418.

Akmanligil, M., and P. C. Palvia. 2004. "Strategies for Global Information Systems Development." *Information & Management* 42 (1): 45–59. doi:10.1016/j.im.2004.01.001.

Al-Mudimigh, A., M. Zairi, and M. Al-Mashari. 2001. "ERP Software Implementation: An Integrative Framework." *European Journal of Information Systems* 10 (4): 216–226. doi:10.1057/palgrave.ejis.3000406.

Aloini, D., R. Dulmin, and V. Mininno. 2007. "Risk Management in ERP Project Introduction: Review of the Literature." *Information & Management* 44 (6): 547–567. doi:10.1016/j.im.2007.05.004.

Beheshti, H. M., and C. M. Beheshti. 2010. "Improving Productivity and Firm Performance with Enterprise Resource Planning." *Enterprise Information Systems* 4 (4): 445–472. doi:10.1080/17517575.2010.511276.

Behncke, F. G. H., S. Maisenbacher, and M. Maurer. 2014. "Extended Model for Integrated Value Engineering." *Procedia Computer Science* 28: 781–788. doi:10.1016/j.procs.2014.03.093.
Blanchard, B. S., and W. J. Fabrycky. 1998. *System Engineering and Analysis*. 3rd ed. Richmond, TX: Prentice-Hall.
Chaua, K. Y., S. Liua, and W. H. Ip. 2009. "Enhancing Enterprise Information Integration Using Six Sigma." *Total Quality Management & Business Excellence* 20 (5): 537–546. doi:10.1080/14783360902863721.
Chin, K. S., Y. M. Wang, G. K. K. Poon, and J. B. Yang. 2009. "Failure Mode and Effects Analysis by Data Envelopment Analysis." *Decision Support Systems* 48 (1): 246–256. doi:10.1016/j.dss.2009.08.005.
Chou, S. W., and Y. C. Chang. 2008. "The Implementation Factors that Influence the ERP (Enterprise Resource Planning) Benefits." *Decision Support Systems* 46 (1): 149–157. doi:10.1016/j.dss.2008.06.003.
Franz, M. 2014. *Projektmanagement mit SAP Projektsystem: SAP PS erfolgreich anpassen und konfigurieren*. Bonn: SAP Press.
Galoppin, L., and S. Caems. 2007. *Managing Organizational Change during SAP Implementation*. Bonn: SAP Press.
Gronau, N., and K. Kurbel. 2010. *Enterprise Resource Planning: Architektur, Funktionen und Management von ERP-Systemen*, 1–33. 2nd ed. Oldenbourg Verlag München.
Grüne, G., M. A. Lindemann, S. A. Lockemann, and S. Meinhardt. 2009. *SAP Consulting: Inovative Gestaltung con Geschäftsprozessen in der Prozessindustrie*. Heidelberg: dpunkt Verlag GmbH.
Hahn, G. J., and H. Kuhn. 2012. "Designing Decision Support Systems for Value-Based Management: A Survey and an Architecture." *Decision Support Systems* 53 (3): 591–598. doi:10.1016/j.dss.2012.02.016.
Holsapplea, C. W., and M. P. Sena. 2005. "ERP Plans and Decision-Support Benefits." *Decision Support Systems* 38 (4): 575–590. doi:10.1016/j.dss.2003.07.001.
Ibusuki, U., and P. C. Kaminski. 2007. "Product Development Process with Focus on Value Engineering and Target-Costing: A Case Study in an Automotive Company." *International Journal of Production Economics* 105 (2): 459–474. doi:10.1016/j.ijpe.2005.08.009.
Ip, W. H., and B. Chen. 2004. "An Enterprise Model and the Organisation of ERP." *International Journal of Computer Applications in Technology* 21 (3): 79–86. doi:10.1504/IJCAT.2004.005933.
Jacobs, F. R., and E. Bendoly. 2003. "Enterprise Resource Planning: Developments and Directions for Operations Management Research." *European Journal of Operational Research* 146 (2): 233–240. doi:10.1016/S0377-2217(02)00546-5.
Jafarnejad, A., M. Ansari, H. R. Youshanlouei, and M. M. Mood. 2012. "A Hybrid MCDM Approach for Solving the ERP System Selection Problem with Application to Steel Industry." *International Journal of Enterprise Information Systems* 8 (3): 54–73. doi:10.4018/IJEIS.
Johansson, B., and M. Newman. 2010. "Competitive Advantage in the ERP System's Value-Chain and its Influence on Future Development." *Enterprise Information Systems* 4 (1): 79–93. doi:10.1080/17517570903040196.
Jones, M. C., M. Cline, and S. Ryan. 2006. "Exploring Knowledge Sharing in ERP Implementation: An Organizational Culture Framework." *Decision Support Systems* 41 (2): 411–434. doi:10.1016/j.dss.2004.06.017.
Karimi, J., T. M. Somers, and A. Bhattacherjee. 2007. "The Impact of ERP Implementation on Business Process Outcomes: A Factor-Based Study." *Journal of Management Information Systems* 24 (1): 101–134. doi:10.2753/MIS0742-1222240103.
Ke, W., and K. K. Wei. 2008. "Organizational Culture and Leadership in ERP Implementation." *Decision Support Systems* 45 (2): 208–218. doi:10.1016/j.dss.2007.02.002.
Keller, G. 1999. *SAP R/3 Prozessorientiert Anwenden*. New York, NY: Addison-Wesley.
Kini, R. B., and S. Basaviah. 2013. "Critical Success Factors in the Implementation of Enterprise Resource Planning Systems in Small and Midsize Businesses: Microsoft Navision Implementation." *International Journal of Enterprise Information Systems* 9 (1): 97–117. doi:10.4018/IJEIS.
Koch, S., and J. Mitlohner. 2010. "Effort Estimation for Enterprise Resource Planning Implementation Projects Using Social Choice – a Comparative Study." *Enterprise Information Systems* 4 (3): 265–281. doi:10.1080/17517575.2010.496494.
Kwahk, K. Y., and J. N. Lee. 2008. "The Role of Readiness for Change in ERP Implementation: Theoretical Bases and Empirical Validation." *Information & Management* 45 (7): 474–481. doi:10.1016/j.im.2008.07.002.
Lall, V., and S. Teyarachakul. 2006. "Enterprise Resource Planning (ERP) System Selection: A Data Envelopment Analysis (DEA) Approach." *Journal of Computer Information Systems* 47 (1): 123–128.
Lapointe, L., and S. Rivard. 2005. "A Multilevel Model of Resistance to Information Technology Implementation." *MIS Quarterly* 29 (3): 461–491.
Lin, C., F. Frank Chen, H. Wan, Y. M. Chen, and G. Kuriger. 2013. "Continuous Improvement of Knowledge Management Systems Using Six Sigma Methodology." *Robotics and Computer-Integrated Manufacturing* 29 (3): 95–103. doi:10.1016/j.rcim.2012.04.018.
Mandal, P., and A. Gunasekaran. 2003. "Issues in Implementing ERP: A Case Study." *European Journal of Operational Research* 146 (2): 274–283. doi:10.1016/S0377-2217(02)00549-0.
May, J., G. Dhillon, and M. Caldeira. 2013. "Defining Value-Based Objectives for ERP Systems Planning." *Decision Support Systems* 55 (1): 98–109. doi:10.1016/j.dss.2012.12.036.

Meinhardt, S., C. Kern, K. Kauffmann, and J. Jahraus. 2010. *SAP Consulting: Inovative Gestaltung con Geschäftsprozessen in der Konsumgüterindustrie*. Heidelberg: dpunkt Verlag GmbH.

Panorama Consulting. 2015. *2015 ERP REPORT A Panorama Consulting Solutions Research Report*. Denver, CO: Panorama Consulting Solutions.

Rajendran, R., and N. Elangovan. 2012. "Response of Small Enterprises to the Pressures of ERP Adoption." *International Journal of Enterprise Information Systems* 8 (1): 28–50. doi:10.4018/IJEIS.

Sammon, D., and F. Adam. 2010. "Project Preparedness and the Emergence of Implementation Problems in ERP Projects." *Information & Management* 47 (1): 1–8.

Sarkis, J., and A. Gunasekaran. 2003. "Enterprise Resource Planning – Modeling and Analysis." *European Journal of Operational Research* 146 (2): 229–232. doi:10.1016/S0377-2217(02)00545-3.

Sohrabi, B., and I. R. Vanani. 2011. "Collaborative Planning of ERP Implementation: A Design Science Approach." *International Journal of Enterprise Information Systems* 7 (3): 58–67. doi:10.4018/IJEIS.

Somers, T. M., and K. G. Nelson. 2003. "The Impact of Strategy and Integration Mechanisms on Enterprise System Value: Empirical Evidence from Manufacturing Firms." *European Journal of Operational Research* 146 (2): 315–338. doi:10.1016/S0377-2217(02)00552-0.

Srinivasan, K., S. Muthu, S. R. Devadasan, and C. Sugumaran. 2014. "Enhancing Effectiveness of Shell and Tube Heat Exchanger Through Six Sigma DMAIC Phases." *Procedia Engineering* 97: 2064–2071. doi:10.1016/j.proeng.2014.12.449.

Stewart, R. A. 2008. "A Framework for the Life Cycle Management of Information Technology Projects: Project IT." *International Journal of Project Management* 26 (2): 203–212. doi:10.1016/j.ijproman.2007.05.013.

Tchokogué, A., C. Bareil, and C. R. Duguay. 2005. "Key Lessons from the Implementation of an ERP at Pratt & Whitney Canada." *International Journal of Production Economics* 95 (2): 151–163. doi:10.1016/j.ijpe.2003.11.013.

Umble, E. J., R. R. Haft, and M. M. Umble. 2003. "Enterprise Resource Planning: Implementation Procedures and Critical Success Factors." *European Journal of Operational Research* 146 (2): 241–257. doi:10.1016/S0377-2217(02)00547-7.

Wang, J. W., F. Gao, and W. H. Ip. 2010. "Measurement of Resilience and its Application to Enterprise Information Systems." *Enterprise Information Systems* 4 (2): 215–223. doi:10.1080/17517571003754561.

Wang, W., and D. Hwang. 2012. "A Case Study of a Government-Sponsored Enterprise Resource Planning Project in a Chinese Apparel Company." *International Journal of Enterprise Information Systems* 8 (4): 63–76. doi:10.4018/jeis.2012100103.

Zhang, Z., M. K. O. Lee, P. Huang, L. Zhang, and X. Huang. 2005. "A Framework of ERP Systems Implementation Success in China: An Empirical Study." *International Journal of Production Economics* 98 (1): 56–80. doi:10.1016/j.ijpe.2004.09.004.