Middle-East Journal of Scientific Research 19 (6): 747-759, 2014
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2014.19.6.12515

A FPN Based Risk Assessment Model for ERP Implementation in Small and Medium Enterprises

S. Vijayakumar Bharathi, R. Raman and Dhanya Pramod

Symbiosis Centre for Information Technology (SCIT), Symbiosis International University (SIU), Rajiv Gandhi Infotech Park, Hinjewadi, Pune, Maharashtra State 411 057 India

Abstract: This research brings out a risk assessment model by selecting certain critical pitfalls related to the implementation phase of Enterprise Resource Planning (ERP) in Small and Medium Enterprises (SMEs). The model can be used to predict the impact of risk that will lead to the failure of ERP implementation. This paper is a part of the continuing research in assessing the ERP decisions for SMEs which involved five phases namely planning, acquisition, implementation, usage & percolation and extension. SMEs are subject to ERP implementation risks. These risks have been identified based on extensively referring to earlier research and the associated components for preparing the assessment model are defined. Formulation of rules for risk assessment is based on the concept and application of Fuzzy Petri Nets (FPN). Then the model is developed as a tool using the visual basic application. This paper attempts to use FPN due to the simple and efficient ability to quantitatively evaluate the risks inherent in the implementation phase of ERP adoption by SMEs.

Key words: ERP Adoption · SMEs · Failure Prediction · Risk · Fuzzy Petri-Nets · Implementation

INTRODUCTION

Implementation of information technology and adoption of enterprise system into the operational routine has been one of the key drivers of sustainability and growth of the organization from the recent past. Irrespective of the size and nature the impact of internationalization and commercialization has rendered the role of enterprise system as mandatory requirements in organizations. The dawn of the millennium has seen the metamorphosis of Enterprise Resource Planning (ERP) from a geographical, industry vertical and adoption perspective. The developing countries in particular are witnessing not only the steady but steep growth of ERP market during the last decade and in particular the horizon of ERP application has broadened to encompass even the Small and Medium Enterprises (SMEs) [1,2]. The large corporations churning out billions of dollars are already outfitted with the state-of-the-art information technology enablers that are positioned to streamline, integrate and optimize business operations. On the contrary such enablement of information technology is very low in the SME segment. Most of these units are still using manual processes and spreadsheets based IT enablement in their core business processes. While the ERP market is saturated for larger organizations, it is still sunrise for their smaller counterparts. The upshot is that a growing number of SMEs are willing to adopt ERP. Here willingness to adopt is twofold, namely the SMEs has accepted the significance of central creation and mutual sharing of operational data for ensuring intra-organizational efficiency and clarity of information flow. The other reason is that the large corporations are now looking at extending the integration of business process with SMEs for which standardization is the key. SMEs will need double-decker integration in the long-run. Double-decker integration comprises at the first deck the ERP solution to seamlessly integrate the core business processes in order to ensure timely, accurate and transparent information across intra-organizational processes in the short run and in the second deck extend such integration to inter-organizational processes with their larger counterparts. The business relationship between the large corporations and SMEs exhibits one of

Corresponding Author: S. Vijayakumar Bharathi, Symbiosis Centre for Information Technology (SCIT), Symbiosis International University (SIU), Rajiv Gandhi Infotech Park, Hinjewadi, Pune, Maharashtra State 411 057 India.

the highest levels of mutuality between the supplier (SMEs) and the customer (large companies). Hence there is a real need for the SMEs to get prepared to meet and accept the extension.

SMEs implementing ERP makes significant efforts in terms of investments in time, resources and capital. The implementation results in significant process changes and ROI can be comprehended in terms of the benefits that the company can produce. The improved business processes in post implementation stage are proven to increase the company's ability to gain financial performance [3]. But there are several issues and challenges faced by SMEs in their attempt to narrow down the gap between their operations and ERP. Implementing ERP is a very capital intensive investment for which there was no certain return on investment [4]. Extreme examples of failure, abandonment of projects, huge cost of migration of the system and related bitter experiences have not spared even larger global companies. According to a study the probability of ERP failure ranged from 40 to 60 percent and another study identified the failure rate between 60 to 90 percent [5,6]. Many researchers in the past have also analyzed that ERP implementation could fail due to various internal and external factors affecting the organization's very existence [7-9]. It is even more complicated and challenging for SMEs to implement ERP because of their limitation to expertise, scope, ERP availability options, finance (both investment and costs) are vulnerable to various risks that can lead to failure par irrevocable in nature [10].

The SMEs are inherent with certain genetic limitations in SMEs such as a low capital base, limited generation of surplus funds for re-investment due to tight working capital cycle, lack of awareness of business opportunities, inadequate exposure to the international environment, limited geographical diversity of markets, outdated technology and inadequate infrastructure facilities. ERP projects have often found to be complex and risky and many reasons contribute to its success or failure. In the past there have been alarming stories of failure or abandonment of the whole ERP project leading to irrevocable losses to large corporations. The Chaos Report of 2009 revealed that successful projects (completed on time, budget and scope) constituted only 32% of all projects succeeding, while 44% were challenged (overruns on time cost and scope) and 24% failed (cancelled prior to completion or delivered and never used). These numbers denoted that there has been a diminution in the success rates when compared with the earlier study. It is quite discouraging to note that the 2009 figures represented the highest failure rate since 2000 [11]. One of the main reasons found were related to the inadequacy or absence of risk management practices in ERP project.

We found that in the current literature few research studies mention about the risks involved in ERP projects with specific reference to SMEs. Hence there is a strong need for developing a simple and robust quantitative assessment framework and also to build and implement it to measure the risks inherent in ERP Adoption Projects. This paper is an attempt to develop a risk assessment model using Fuzzy Petri-Net so as to enable the SMEs to assess and validate the impact of risk in the ERP implementation phase. The paper is divided into four sections. The second section covers the review of literature to reinforce the need for risk assessment in ERP Implementation projects. The third section introduces the concept and reasoning of Fuzzy Petri-Net (FPN) as a model for evaluating and predicting the identified hazards. Part four explains the development of visual basic application tool for incorporating the FPN rules for assessing the risk identified and its findings. The final segment is about the future scope of employment and determination.

Literature Review: ERP Implementation is a complex and costly process for SMEs and serious lessons of failure have always reinforced the caveats of ERP. Quite a number of researches have also underscored the need for defining and evaluating the Critical Failure Factors (CFFs) over and above the Critical Success Factors (CSFs). As a strategic IT initiative, ERP can have long term and irreversible implication on the SME. It is very imperative that the underlying risk at every phase of the ERP Adoption life cycle is carefully considered and evaluated. Though considerable research literature exists for risk assessment of the SMEs fewer number of research content is found with the use of Petri-net, specifically Fuzzy Petri-Net (FPN) approach for risk prediction. A conceptual model using FPN was developed for ERP failure prediction in SMEs by preparing a two-tier structure comprising of risks and risk factors. These factors modeled using the fuzzy evaluation algorithm to quantify the risks contributing during the planning stage of ERP adoption in SMEs [12]. To reduce the ambiguities and uncertainties inherent in qualitative data analysis fuzzy theories of were used to identify ERP critical success factors. Fuzzy Analytical Hierarchy Process (FAHP) was used to evaluate and prioritize critical success factors of ERP [13]. The Fuzzy Analytic Network

Process was used to develop a framework to assess the organizational preparation for ERP implementation which included three types of readiness namely project management, organizational and change management [14]. A FPN based evaluation process for ERP implementation was proposed to emphasize the human-related critical factors that impacted ERP implementation. The evaluation indexes were divided into superior and inferior index and coded. The codes used the evaluation algorithm to quantitatively measure ERP implementation risks [15]. Another FPN based model was developed to identify the risks and risk factors during the ERP acquisition phase comprising of factors relating to vendor, product and consultant selection. The model was explained with an example of how FPN rule based algorithm can be used to assess whether a factor will or will not contribute to the dangers inherent in the learning stage of ERP adoption in SMEs [12]. The concept of failure analysis was studied in order to improve the system reliability. An interesting approach to sequential failure analysis in a manufacturing environment was proposed by the application of fuzzy logic based Petri nets. Risky attributes of the system were tracked using FPN and then prioritized based on the criticality so as to perform corrective actions [16]. It is very imperative for organizations to meticulously manage their homework relating to identifying, defining and quantifying the risk during ERP Implementation. While larger corporations are not spared of implementation failure it is really likely that SMEs is totally vulnerable to failure if proper risk assessment practices are not in place. The identification and assessment of risk in projects relating to Information/Enterprise systems has been a topic of immense interest to both researchers and practitioners. A theoretical account of risks and controls was broken by placing certain key risk factors for business, technology and organizational perspectives and controls were prescribed for mitigating those risks [17]. Seven groups of critical failure factors for ERP were identified namely vendor and consultant, human resources, management, project management, processes, organizational and technical [18]. The success rate of ERP implementation had been less than 30% and the main reason for failure was found to be poor management of the implementation of ERP [19].

Produced by Carl Adam Petri in his Ph.D thesis way back in 1962, Petri nets can be articulated as a tool for systems study and modeling. Aside from being a mathematical representation, Petri net is also a visual or graphical representation of a system. The Petri net model is primarily used to understand the structure and behaviour of a modeled system for improvements. The two main concepts of Petri nets are events and conditions. The activities that occur in an organization are called events which are state of the system dependent. The states are explained by conditions which can be read as a logical description of the province which is true or false. Hence the events are conditioned dependent and an event's happening results in the state being true which is called as post-term. Parallel happenings are said to be independent of each other. Though a wide variety of systems modelling are done through Petri nets, it basic characteristics are confined only to either of the two outcomes of a state. If in a scenario if the results cannot be precisely one of the two, or so to say if there is an element of uncertainty and inaccuracy in the prediction of the outcome the classical Petri nets will have to be improvised.

The improvisation of the use of Petri nets in the context of vagueness is enabled through the concept of Fuzzy logic. Fuzzy logic was introduced by Lotfi A. Zadeh in the mid 1960s based on his work on Fuzzy sets [20], which is used to model vague, inaccurate or ill-defined systems. In other words fuzzy logic can be used to model the human way of reasoning when the respondents are uncertain and imprecise while responding. Fuzzy logic can be used on all the four objects of Petri nets namely transitions, tokens, arcs and places. A fuzzy transition may correspond to an 'if-then' production rule and is realized by truth values such as fuzzy inference algorithms. In fuzzy logic the token in the standard Petri net can have a linguistic variable, e.g. if a response from a respondent is interpreted as a linguistic variable then its term set can be T (responses) = {strongly agree to strongly disagree}. A fuzzy place has a predicate or property associated with it. A token in that spot is identified by that property and a level which it possesses that attribute. The required value of a corresponding input token may be influenced by a fuzzy arc. The generalized form of Petri nets is a fuzzy Petri net and is appropriate when modeling a process in an imprecise environment which lack well-defined measurements [21].

The Fuzzy Petri-Net Model for Risk Prediction in ERP Adoption for SMEs: In this paper we have taken in an effort to use FPN model the respondent's perception about a risk factor towards the 'contribution' or 'no contribution' to a particular risk and in turn predict the impact of that risk on the implementation phase of ERP in SMEs. From the proposed fuzzy Petri Net model the following definitions have been derived.

Fuzzy Petri Net: This represents fuzzy production rules of a rule-based system. It contains two types of node; places and transitions wherein circle represented place and the bar represents transitions. Each situation may or may not contain token associated with a truth value between 0 and 1. The transition has a certainty factor associated between 0 and 1 and directed arcs connect places to transition.

Definition and symbols….

A fuzzy Petri net structure can be defined as an 8-tuple

FPN = (P,T,D,I,O,f,α,β)

Where

- P= {p1, p2,… pn} is a finite set of places
- T= {t1, t2,…, tm} is a finite set of transitions
- D={d1,d2,….dn} is a finite set of propositions
- $P \cap T \cap D = \Phi$, |P|=|D|,
- I: T→P8 is the input function, a mapping from transitions to bags of places,
- O: T→P8 is the output function, a mapping from transitions to bags of places,
- F: T→ [0,1] is an association function, a mapping from transitions to real values between 0 and 1
- α: P> [0,1] is an association function, a mapping of places to real values between 0 and 1
- β: P>D is an association function, an objective mapping of places to propositions

Fuzzy Production Rule: It explains the fuzzy relationship between two propositions.

If d_{j1} or d_{j2} ….. d_{jn} then d_k (C.F = μ_1). This rule type is modeled in fuzzy Petri-net Figure 1A and the fuzzy reasoning process of this type of rule is modeled in Figure 1B.

If dj1 and dj2 ….. djn then dk (C.F = μ I). This rule type is modeled on fuzzy Petri Net Figure 2A and the fuzzy reasoning process of this type of rule is modeled in Figure 2B.

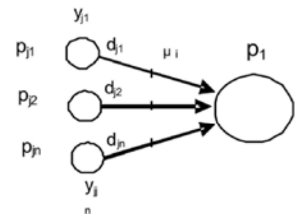

Fig. 1A

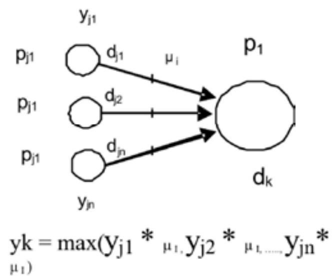

Fig. 1B

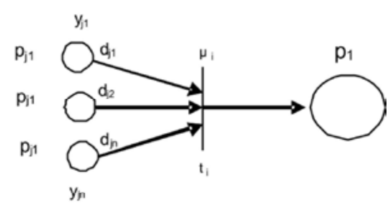

Fig. 2 A

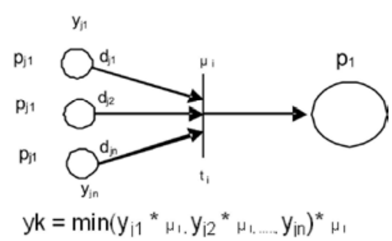

Fig. 2 B

From amongst the five distinct phases of ERP Adoption namely planning, acquisition, implementation, usage and extension, the scope of this paper is limited exclusively to the implementation phase of the ERP. The centre of gravity of ERP adoption by SMEs is contained in the implementation decisions. Implementation decisions spell out the success or failure of the ERP and should be capable of bridging the gap between the business expectation and the ERP deliverables. It is a common myth in SMEs that ERP implementation issues revolve around a set of connected computers, while in reality it is a person related, business initiative. As a result, many enterprises have always resisted to or have failed to implement and use ERP [22]. A set of eleven risks has been identified in this phase and certain attributes or risk factors have been defined for each of the risks is presented in Table 1.

ERP Failure Prediction Model: The fuzzy Petri Net based model is explained below.

At the place P0 d0 is the risk of failure in the Implementation Phase of ERP Adoption.

Table 1: Lists of the risk and its attributes (risk factors)

S. No.	Risk	Symbol	Risk Factors	Symbol
1	Unrealistic budgets and schedules	I_1	No clarity on the implementation road map	i_{11}
			Stakeholders not consulted while planning	i_{12}
			No clarity on budgeting for ERP Costs	i_{13}
			No support from Top Management for financing.	i_{14}
2	Antagonistic attitudes and people clashes	I_2	Role conflicts, no clarity on Project Owner's role	i_{21}
			Over dependence on external consultant since no internal expertise.	i_{22}
			Less delegation of authority to Project Owner	i_{23}
3	Inadequate project management	I_3	Confusion over the formation of the core-team	i_{31}
			Interdepartmental rivalries	i_{32}
			No clear-cut performance monitoring and evaluation mechanisms	i_{33}
4	Inefficient ERP Project Leadership	I_4	Lack of clarity and knowledge in identifying and prioritizing	i_{41}
			Wrong selection of people as process owners to support implementation	i_{42}
5	Lack of an effective implementation strategy	I_5	Unclear about the utility of the existing IT application	i_{51}
			Migration problems and data-format mismatch	i_{52}
			Imbalance between configuration and customization.	i_{53}
6	Mismatch and changes in requirements	I_6	Poor study on organizational and business requirements	i_{61}
			Poor quality of testing	i_{62}
			Mismatch between functional expertise and project expertise	i_{63}
7	Insufficient user involvement	I_7	Irregular involvement of process owners	i_{71}
			Nonparticipation by selected users	i_{72}
8	Change in project scope	I_8	No gap analysis	i_{81}
			Inadequate BPR	i_{82}
			Unplanned changes in scope of the project	i_{83}
9	Insufficient and inefficient training	I_9	Improper training calendar (With reference to time, user-group and duration)	i_{91}
	`		The trained resource is incapable of giving transitional training resulting in increased dependence of implementation partner or consultant.	i_{92}
			Non/less participation by users during training	i_{93}
10	Lack of Documentation	I_{10}	No documentation policy in place	i_{101}
			No documentation support to kernel-team resulting in over-burden.	i_{102}
			Too much information or too little information to users in reference manuals	i_{103}
11	Project Failure	I_{11}	Cost and Time overruns	i_{111}
			No clarity on ROI from ERP Investment	i_{112}

At place P_i (i = 1, 2…..11). Di represents Risks identified that are associated with the Implementation Phase. These factors will collectively lead to validate the risks of failure.

At place p_{ij} (i = 1, 2…..11), (j = 1, 2…..n), dij represent the risk factor and n represents the number of risk factors identified to explain the risks.

At place p_{ijk} (i = 1, 2…..11), (j = 1, 2…..n) (k = 1, 2…..m) where d_{ijk} represents the responses (choices) for a risk factor viz. strongly agree(SA), agree (A), disagree (D) and strongly disagree (SD) and m represents the number of choices (here 4 choices) for recording the response to a risk factor. SA and A are defined as negative which implies that they will contribute/lead to risk while D and SD are defined as positive because they will not contribute/lead to risk in this paper.

D_{ijk} (I = 1, 2….. 11), (j = 1, 2….. n) (k = 1, 2….. m) where d represents the percentage of responses (Ratio of number of responses to an option to the total responses recorded for all the options). If the percentage of responses are evenly spread in all the four options namely SA, A, D & SD or if the sum of the response proportion of negative and positive options is equal (SA+A) = (D+SD) then that factor may or may not contribute towards risk. If for a risk factor, the proportion of responses in SA and A is greater than D & SD, then that element will contribute towards risk and vice versa.

μ_i (i = 1, 2…..9) represents the certainty factor, $\mu_i\ ^a$ [0, 1] that is the strength of the belief in the rule.

T_1 (i = 1, 2…..9) represents the transition from input place to output place.

μ_{ij} (i = 1, 2….9), (j = 1, 2…..n) where μ represents the certainty factor of the responses to fire a risk factor. In this study, for illustration purpose 9 (as a proportion 0.9) is fixed throughout, because it is assumed that the respondents are well informed and are fully cognizant of the context and their reactions can be extremely

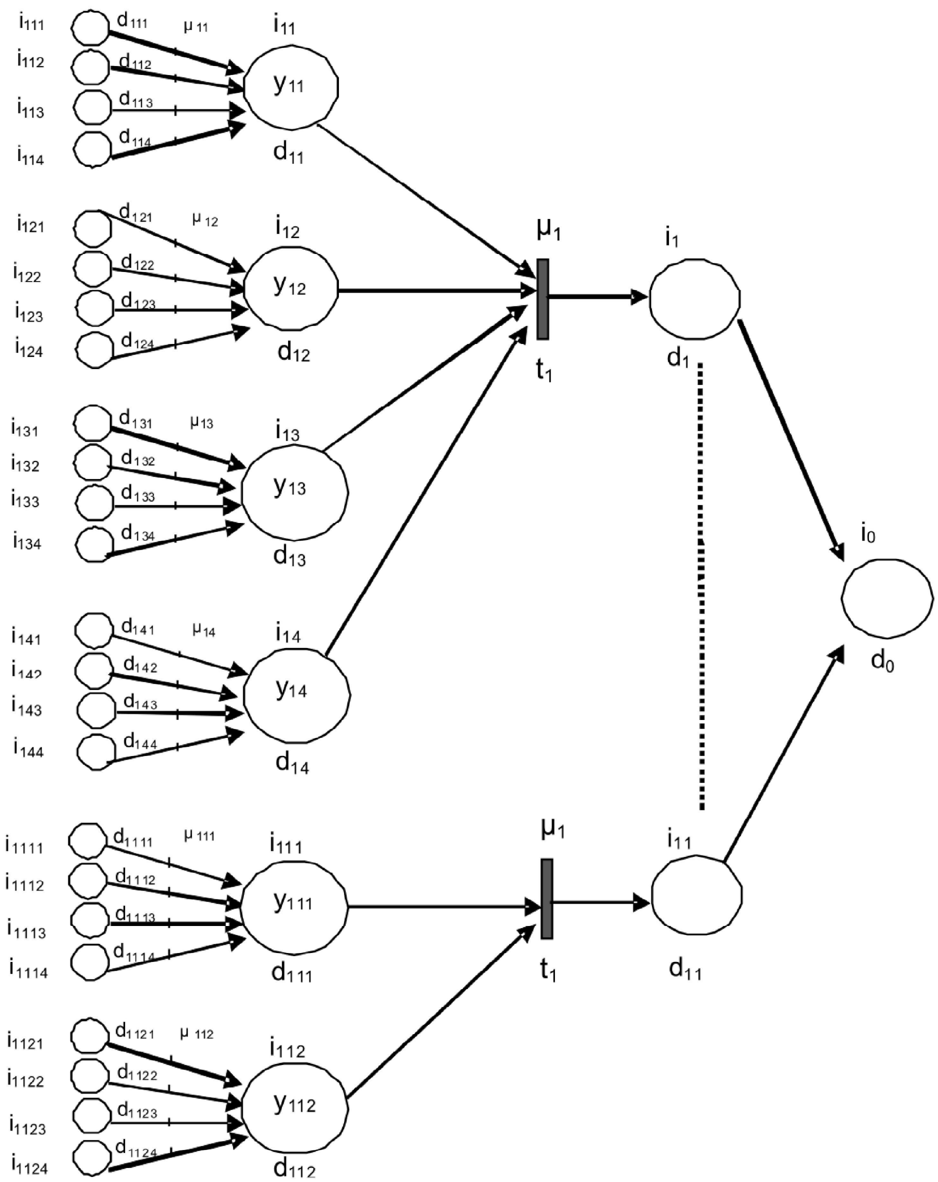

Fig. 3: Pictorial Representation of FPN

reliable. Using the notations and algorithm the pictorial representation of the FPN model is presented in Figure 3.

In the subsequent paragraphs we present the quantitative analysis based on the inter-related components namely the risk, risk factors and responses of the FPN.

In the implementation phase of ERP adoption (I_0), the risk called unrealistic schedules and budgets [23] (I_1) is explained by means of four risk factors namely no clarity on the implementation roadmap [24] (d_{11}), stakeholders not consulted during implementation planning [25] (d_{12}), no clarity on the budgeting for ERP costs, (d_{13}) and lack of top management support for financing [3], (d_{14}). The values for predicting the risk is based on the responses which range from strongly agree to strongly disagree (d_{111}…. d_{114}) given by the respondents. For example for d_{11} if 30% of the respondents say strongly agree then the value of d_{111} is 0.3, 50% of respondents say agree then the value of d_{112} is 0.5, 10% of the respondents say disagree then the value of d_{113} is 0.10 and 10% of the respondents strongly disagree, then the value of d_{114} is 0.10. The durability of responses or truth value is denoted by μ, the value of which is the weight assigned based on the reliability of the responses. For example if μ_{11} is assigned a value of 0.9 then it implies a high degree of dependability of responses. Then the value y_{11} is the maximum of (0.3*0.9), (0.5*0.9), (0.15*0.9), (0.05*0.9) which is 0.45. This value of 0.45 is arrived from the response option Agree (A). As stated earlier, since SA and A denotes negative it means that no clarity on the implementation roadmap (d_{11}) is one of the decisive factors leading to risk of Unrealistic Schedules and Budget (I_1). Similarly the values of all the other three risk factors can be arrived based on the proportion of responses. Then the maximum of the balance-of-response values multiplied by their respective μ values will determine whether a risk factor would contribute to the risk or otherwise.

Antagonistic attitudes and People clashes [26], (I_2) is attributed through three risk factors namely role conflict and no clarity on the project owner's role [27] (d_{21}), over dependence on external consultant [26, 28], (d_{22}) and less delegation of authority to project owner [29] (d_{23}). Through the responses ranging from strongly agree to strongly disagree (d_{211}.... d_{214}) we can predict the value of risk factors. For instance, in d_{21} 30% of the respondents agree then the value of d_{211} is 0.3 and 70% of the respondents strongly disagreeing then the value of d_{214} is 0.7. If μ_{21} is assigned a value of 0.9 then value y_{21} is the greater of (0.3*9) and (0.7*0.9) which is 0.63. The value of 0.63 is the highest and it is arrived from option SD. As defined earlier, SD is positive which denotes that role conflict and no clarity on the project owner's role (d21) will not contribute to risk of Antagonistic attitudes and People clashes (I2). Similarly the value of other risk factors d_{22} and d_{23} can be arrived based on the proportion of responses. Then the maximum of the balance-of-response values multiplied by μ22 and μ23 values respectively will determine whether d22 and d23 will contribute or will also not contribute to the risk.

Inadequate Project Management [30]is backed with three risk factors namely confusion over the core team formation [30] (d_{31}), interdepartmental rivalries [31] (d_{32}) and no clarity on performance monitoring and evaluation [23] (d_{33}). Based on respondents' perceptions ranging from strongly agree to strongly disagree (d_{311}.... d_{314}) we can arrive at the value of risk factors. Say for example for d_{31} if 20% of respondents strongly agree the value of d_{311} is 0.2, 75% of them agree then value of d_{312} is 0.75 and 5% of them strongly disagree the value of d_{313} is 0.05. μ_{31} value is assigned in 0.9 then the value of y_{31} will be the maximum of (0.2*0.9), (0.75*0.9) and (0.05*0.9) which is 0.68. The value of 0.68 is arrived out of the response option agree hence it can be inferred that the risk factor confusion over the core team formation (d_{31}) will contribute to the risk of Inadequate Project Management (I_3). Similarly, maximum value of y_{32} and y_{33} of other two risk factors d_{32} and d_{33} is calculated as a product of proportion-of-responses value and μ_{32}, μ_{33}, to decide the positive or negative perspectives. This position will determine whether these risk factors will lead to or not lead to the risk.

Ineffective ERP Project Leadership [26,30, 32] (I_4) is defined through lack of clarity in identifying and prioritizing tasks [33] (d_{41}) and wrong selection of people as process owners to support implementation [34] (d_{42}). The values of the risk factors can be arrived from the responses ranging from strongly agree to strongly disagree (d_{411}.... d_{414}). For d42, if the answers are equally spread across all the options, that is 25% in each of the four choices, then that element will not be taken into consideration for determination of risk. In the same way the value of other risk factor d41 can be calculated on the basis of response proportion. The value of y_{41} will be the maximum of proportion-of-responses and μ_{41} of 0.9 of that risk factor. The negative or positive attribute as defined earlier will determine whether the factor would contribute to the risk (I_4) or otherwise.

Lack of an Effective Implementation Strategy [35] (I_5) is supported by three risk factors namely unclear about the utility of the existing IT application [36,37] (d_{51}), migration problems and data format mismatch (d_{52}) and imbalance between configuration and customization [23] (d_{53}). The risk-factors values can be arrived from the given range of responses from strongly agree to strongly disagree (d_{511}.... d_{514}). For d_{51} for example if 80% of the respondents strongly agree its value is 0.8 while 20% agree the value is 0.2. The value of μ_{51} being 0.9 the value of y_{51} will be the maximum of (0.8*0.9) and (0.2*0.9) which is 0.72. In this outcome since 0.72 is arrived out of negative attribute of responses namely strongly agree this risk factor will contribute towards the risk (I_5). Suppose if same assumptions are made for risk factor (d_{52}) 20% of the respondents strongly agree, 20% of the respondents agree, 50% of the respondents disagree and 10% of respondents strongly disagree then their values would be 0.2, 0.2, 0.5 & 0.1 respectively. μ_{52} being 0.9 the value of y_{52} will be the maximum of (0.2*0.9), (0.2*0.9), (0.5*0.9) and (0.1*0.9) which is 0.45. Since the maximum value is based on a positive attribute of responses namely disagree this risk factor will not contribute to the risk (I_5).

Mismatch and changes in requirements [38] (I_6) is underpinned by three risk factors namely poor study about organizational and job requirements [26,39] (d_{61}), poor quality of testing [40] (d_{62}) and mismatch between functional expertise and project expertise [19,41] (d_{63}). The values of these two risk factors are based on responses that range from strongly agree to strongly disagree (d_{611}…. d_{614}). For example in d_{61} if it is assumed that 60% of the respondents strongly agree while 40% agree then their values would be 0.6 and 0.4 respectively. The μ_{61} being 0.9 the value of y_{61} is the greater of (0.6*0.9) and (0.4*0.9) which is 0.54. In this risk factor, since 100% of the responses are distributed between the negative attributes of strongly agree and agree, irrespective of such proportion of distribution this risk factor will contribute to the risk (I_6). Similarly, the value of other risk factor d62 will be computed on the basis of response proportion. The value of y_{62} will be the maximum of proportion-of-responses and μ_{62} of 0.9 of that risk factor. Accordingly, based on negative or positive attribute as defined earlier the risk factor will contribute to or not contribute to the risk (I_6).

Insufficient User Involvement [42,43] (I_7) is explained by means of two risk factors namely the irregular involvement of process owners [25] (d_{71}) and non-participation by selected users [44-46] (d_{72}). Based on respondents' perceptions ranging from strongly agree to strongly disagree (d_{711}…. d_{714}) we can arrive at the value of risk factors. Say for example for d_{71} if 30% of respondents strongly agree the value of d_{711} is 0.3, 60% of them agree then value of d_{712} is 0.60 and 10% of them disagree the value of d_{713} is 0.05. The μ_{71} being 0.9 the value of y_{71} will be the maximum of (0.3*0.9), (0.60*0.9) and (0.10*0.9) which is 0.54. The value of 0.54 is arrived out of the response option agree hence it can be deduced that the risk factor irregular involvement of process owners (d71) will contribute to the risk of Insufficient User Involvement (I7). Likewise, the maximum value of y72 can be computed as a product of proportion-of-responses value to determine the positive or negative perspectives. This perspective will determine whether the risk factors will contribute to or not contribute to the risk.

Change in Project Scope [19,45,47], (I_8) is supported by three risk factors namely no gap analysis [48,49] (d_{81}), inadequate business process reengineering [39,50] (d_{82}) and unplanned changes in project scope [51] (d_{83}). The values of these two risk factors are based on responses that range from strongly agree to strongly disagree (d_{811}…. d_{814}). For example in d_{81} if it is assumed that 70% of the respondents strongly disagree while 30% disagree then their values would be 0.6 and 0.4 respectively. The μ_{81} being 0.9 the value of y_{81} is the greater of (0.7*0.9) and (0.3*0.9) which is 0.63. In this risk factor, since 100% of the responses are distributed between the positive attributes of strongly disagree and disagree, irrespective of such proportion of distribution this risk factor will not contribute to the risk (I_8). Similarly, the value of other risk factor d82 and d83 will be computed on the basis of response proportion. The value of y_{82} and y_{83} will be the maximum of proportion-of-responses and μ_{82}, μ_{83} of 0.9 of that risk factor. Accordingly, based on negative or positive attribute as defined earlier the risk factor will contribute to or not contribute to the risk (I_8).

Insufficient and inefficient training [52,53] (I_9) is backed with three risk factors namely improper training calendar [48,54] (d_{91}), trained resource incapable of giving transitional training [55] (d_{92}) and none/less participation by users during training [50,56], (d93). Based on respondents' perceptions ranging from strongly agree to strongly disagree (d_{911}…. d_{914}) we can arrive at the value of risk factors. Say for example for d_{91} if 20% of respondents strongly agree the value of d_{911} is 0.2, 75% of them agree then value of d_{912} is 0.75 and 5% of them strongly disagree the value of d_{913} is 0.05. μ_{91} value is assigned at 0.9 then the value of y_{91} will be the maximum of (0.2*0.9), (0.75*0.9) and (0.05*0.9) which is 0.68. The value of 0.68 is arrived out of the response option agree hence it can be deduced that the risk factor improper training calendar (d91) will contribute to the risk of Insufficient and inefficient training (I9). Similarly, maximum value of y_{92} and y_{93} of other two risk factors d_{92} and d_{93} is calculated as a product of proportion-of-responses value and μ_{92}, μ_{93}, to decide the positive or negative perspectives. This position will determine whether these risk factors will lead to or not lead to the risk.

Lack of Documentation [50] (I_{10}) is attributed through three risk factors namely no document policy in place (d_{101}), no documented support to kernel-team resulting in over-burden (d_{102}) and too much or too little information to users in reference manuals [57] (d_{103}). Through the responses ranging from strongly agree to strongly disagree (d_{1011}…. d_{1014}) we can predict the value of risk factors. For instance, in d_{101} 30% of the respondents agree then the value of d_{1011} is 0.3 and 70% of the respondents strongly disagreeing then the value of d_{1014} is 0.7. If μ_{101} is assigned a value of 0.9 then value y_{101} is the greater of (0.3*9) and (0.7*0.9) which is 0.63. The value of 0.63 is the maximum and it is arrived from option SD. Hence it denotes that no document policy in place (d_{101}) will not lead to risk due to lack of documentation (I_{10}). Similarly the

Table 2: Values of the risk attributes (risk factors)

S. No.	Risk Symbol	Risk Factor	Risk Values	Factor	+ / -**
1	P_1	i_{11}	y_{11}	0.45	-
		i_{12}	y_{12}		
		i_{13}	y_{13}		
		i_{14}	y_{14}		
2	P_2	i_{21}	y_{21}	0.63	+
		i_{22}	y_{22}		
		i_{23}	y_{23}		
3	P_3	i_{31}	y_{31}	0.68	-
		i_{32}	y_{32}		
		i_{33}	y_{33}		
4	P_4	i_{41}	y_{41}	NA	NA
		i_{42}	y_{42}		
5	P_5	i_{51}	y_{51}	0.72	-
		i_{52}	y_{52}	0.45	+
		i_{53}	y_{53}		
6	P_6	i_{61}	y_{61}	0.54	-
		i_{62}	y_{62}		
		i_{63}	y_{63}		
7	P_7	i_{71}	y_{71}	0.54	-
		i_{72}	y_{72}		
8	P_8	i_{81}	y_{81}	0.63	+
		i_{82}	y_{82}		
		i_{83}	y_{83}		
9	P_9	i_{91}	y_{91}	0.68	-
		i_{92}	y_{92}		
		i_{93}	y_{93}		
10	P_{10}	i_{101}	y_{101}	0.63	+
		i_{102}	y_{102}		
		i_{103}	y_{103}		
11	P_{11}	i_{111}	y_{111}	NA	NA
		i_{112}	y_{112}		

*Responses spread evenly throughout the given response-options

** Negative denotes that the responses relating to SA and/or A is greater than SD and/or D and hence will contribute towards risk. While positive denotes responses relating to SD and D that will not contribute to the risk. Y values with negative perspectives only will be considered for risk measurement.

value of other risk factors d_{102} and d_{103} can be arrived based on the proportion of responses. Then the maximum of the balance-of-response values multiplied by µ102 and µ103 values respectively will determine whether d102 and d103 will contribute or will also not contribute to the risk.

Project Failure [40] (I_{11}) is defined through cost and time overruns [24] (d_{111}) and no clarity on RoI from ERP investment [3] [25], (d_{112}). The values of the risk factors can be arrived from the responses ranging from strongly agree to strongly disagree (d_{1111}…. d_{1114}). For d_{112}, if the answers are equally spread across all the options, that is 25% in each of the four choices, then that element will not be taken into consideration for determination of risk. In the same way the value of other risk factor d111 can be calculated on the basis of response proportion. The value of y_{111} will be the maximum of proportion-of-responses and μ_{111} of 0.9 of that risk factor. The negative or positive attribute as defined earlier will determine whether the factor would contribute to the risk (I_{11}) or otherwise.

In the second phase, an evaluation for each of the eleven risks identified in the implementation stage will be determined by taking into consideration the values of risk factors as given in the Table 2 given below.

While evaluating the values of the risk factor only negative perspectives of responses namely Strongly Agree and Agree will be considered for contributing towards risk. All these values will contribute towards the risk identified in the implementation stage of ERP Adoption. In other words, the lowest value amongst the risk factors will determine the minimum amount of risk in the planning phase of ERP Adoption. In the above analysis various scenarios are explained to illustrate the

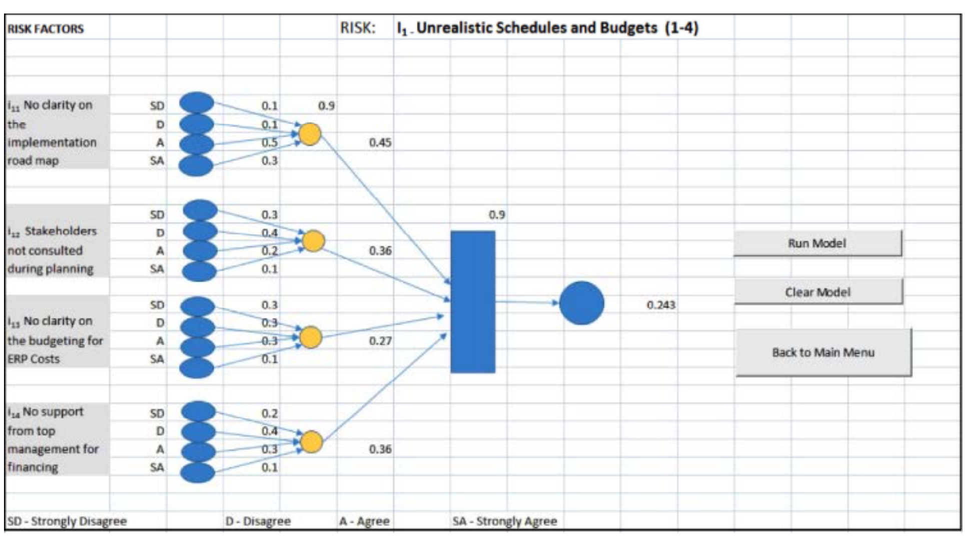

Fig. 4:

mix of responses between the four options namely SA, A, SD and D in order bring out an understanding of the reality during the planned survey.

Visual Basic Application Generated Model: All the risks and the risk factors explained above were modelled in Visual Basic Application (VBA) for testing purposes. The risk assessment model for Unrealistic schedules and budgets (I_1) is presented below in Figure 4.

Based on the fuzzy rule defined in section 3 above we can compute the risk value of I_1. From the above figure it can be found the risk value existing in 'Unrealistic Schedules and Budgets' is 0.243. This value is arrived by the product of the minimum value of the four risk factors multiplied by the certainty factor 0.9 (μ_1). Similarly all the other risks and risk factors can be modeled in VBA which can be then utilized as a tool for comprehensive risk assessment of ERP projects in SMEs.

CONCLUSION

This paper has proposed a conceptual model using FPN for ERP failure prediction due to hazards in the implementation phase of ERP Adoption in the Small and Medium Enterprises. This conceptual model will be tested with live data by means of a survey to validate its applicability in real-life business. This risk prediction model using FPN can be further extended to all the other four stages of ERP adoption to arrive at a comprehensive risk evaluation and measurement model for ERP Adoption in SMEs. Moreover this paper also introduces a software tool is being developed using the synergies of spreadsheet modeling with Visual Basic Applications (VBA). This tool will be used to comprehensively identify those risk factors contributing or not contributing towards a particular risk in any of the implementation phase of ERP adoption. We consider that SMEs will find this tool a simple, easy to understand and effective reference instrument for risk assessment of ERP Projects. The instrument is being further developed to extend its usage to all the five phases of ERP adoption in SMEs. The effect will be to enable SMEs to assess and assess the risk of failure of ERP adoption from an end-to-end perspective. Moreover, we believe that our risk assessment tool can be used for any type of project in the future.

REFERENCES

1. Julien, P.A., 1998. Introduction in Julien, P-A. (Ed.), The State of the Art in Small Business and Entrepreneurship, Ashgate, Aldershot, pp: 1-20.
2. Allen, B. Hamilton, 2000. Insights Enterprise Resource Planning, Big Money Down the Drain? Information Technology Group, http://www. boozallen. com/ publications/article/658713
3. Bharathi, V. and Y L. Rakesh, 2012. A Study on ERP Adoption in SMEs for Improving Operational Performance and ROI. Available at SSRN 2186257. http:// ssrn. com/abstract=2186257 or http://dx. doi. org/10.2139/ssrn.2186257
4. Bharathi, V. and S. Parikh, 2012. A comparative study on the conceptual and contextual perception about CSF for ERP adoption in the SMEs. Researchers World Journal of Arts, Science & Commerce, 3(1): 38-46.
5. Langenwalter, G.A., 2002. Enterprise resources planning and beyond: integrating your entire organization. CRC Press. pp: 12.
6. Ptak, C. and E. Schragenheim, 2000. ERP: Tools, Techniques and Applications for Integrating the Supply Chain, Boca Raton, Fl: St. Lucie Press.
7. Ribbers, P.M.A. and K.C. Schoo, 2002. Program management and complexity of ERP implementations, Engineering Management Journal, pp: 14- 45.
8. Soh, C., S.S. Kien and J. Tay-Yap, 2000. Cultural fits and misfits: is ERP a universal solution?" Association for Computing Machinery, Communications of the ACM, pp: 43- 47.
9. Willis, T.H. and A.H. Willis-Brown, 2002. Extending the value of ERP, Industrial Management & Data Systems, pp: 102-35.
10. Austin, R.D. and L.N. Nolan, 1999. Manage ERP initiatives as new ventures, not IT projects, Harvard Business School Working Paper 99-024, Harvard University, Cambridge, MA.
11. Chaos Summary, 2009. The 10 Laws of Chaos, Standish Group Chaos Summary 2009. http://www.portal. state.pa.us/portal/server. pt/ document/standish_group_chaos_summary_2009_ pdf. (Accessed on April 20, 2013).
12. Bharathi, V., P. Dhanya and R. Raman, 2012. A Conceptual Model for ERP Failure Prediction using Fuzzy Petri-nets for Small and Medium Enterprises. European Journal of Scientific Research, 87(3): 330-338.

13. Amalnick M.S., A.A.S. Ansarinejad and K. Hatami-Shirkouhi, 2010. A group decision making approach for evaluation of ERP critical success factors using fuzzy AHP. Proceedings of the Fourth UKSim European Symposium on Computer Modeling and Simulation, Nov. 17-19, IEEE Xplore Press, Pisa, pp: 212-217. DOI: 10.1109/EMS.2010.42
14. Razmi, J., M.S. Sangari and R. Ghodsi, 2009. Developing a Practical Framework for ERP Readiness Assessment Using Fuzzy Analytic Network Process. Advances in Engineering Software, 40(11): 1168-1178. DOI: 10.1016/j.advengsoft.2009.05.002
15. Wang, S., G. Wang and G. Gao, 2006. Fuzzy Petri Net-based Evaluation to the Process of ERP Implementation, Proceedings of the 2006 IEEE Asia-Pacific Conference on Services Computing APSCC'06) 0-7695-2751-5/06
16. Torshizi, A.D. and S.R. Hejazi, 2010. A Fuzzy Approach to Sequential Failure Analysis Using Petri nets, International Journal of Engineering and Production Research, 21(2): 53-60.
17. Grabski, V.S., S.A. Leech and B. Lu, 2001. Risks and Controls in the Implementation of ERP Systems, The International Journal of Digital Accounting Research, 1(1): 47-68 ISSN: 1577-8517 DOI:10.4192/1577-8517-v1_3
18. Amid, A., M. Morteza and A.Z. Ravasan, 2012. Identification and classification of ERP critical failure factors in Iranian industries, Information Systems, 37(3): 227-237. doi:10.1016/j.is.2011.10.010
19. Iskanius, P., 2009. Risk Management in ERP Project in the Context of SMEs, Engineering Letters, 17(4): 17_4_08.
20. Zadeh, L.A., 1965. Fuzzy Sets, Information Control, 8: 338-353. http://www-bisc.cs. berkeley. edu/Zadeh-1965.pdf (Accessed on 05.10.2013)
21. Virtanen, H.E., 1995. A Study in Fuzzy Petri Nets and the Relationship to Fuzzy Logic Programming, http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.30.7790&rep=rep1&type=pdf (Accessed on 05.10.2013)
22. Bharathi, V. and S. Parikh, 2009. A Unified Theory of Critical Success Factors for ERP Adoption by SMEs. Proceedings of the International Conference on Global Interdependence and Decision Sciences (ICGIDS) Global Interdependence and Decision Sciences, ASCI, Hyderabad India, December 2009. Available at SSRN: http://ssrn.com/abstract=2190778 or http://dx.doi.org/10.2139/ssrn.2190778
23. Wong, A.P., Y.K. Chau, H. Scarbrough and R. Davison, 2005. Critical Failure Factors in ERP Implementation. Proceedings of the 9th Pacific Asia Conference on Information Systems (PACIS 2005). Published in: Pacific Asia Conference on Information Systems 2005, Sections, 1-8(1-6): 492-505. http://www.researchgate.net/publication/221228770_Critical_Failure_Factors_in_ERP_Implementation/file/e0b49519a6a57476dd.pdf (accessed on 05.10.2013)
24. Haddara, M. and A. Elragal, 2013. ERP adoption cost factors identification and classification: a study in SMEs, International Journal of Information Systems and Project Management, 1(2): 5-21, DOI: 10.12821/ijispm010201
25. Kale, P.T., S.S. Banwait and S.C. Laroiya, 2010. "Enterprise Resource Planning Implementation in Indian SMEs: Issues and Challenges", Journal of Manufacturing Technology Management, 21(6): 758-780. Emerald Group Publishing Limited 1741-038X DOI 10.1108/17410381011064030
26. Sumner, M., 2000. Risk factors in enterprise-wide/ERP projects, Journal of Information Technology, 15: 317-327.
27. Ahmed, Z.U., I. Zbib, S. Arokiasamy, T. Ramayah and L.M. Chiun, 2006. Resistance to Change and ERP Implementation Success: The Moderating Role of Change Management Initiatives, Asian Academy of Management Journal, 11(2): 1-17.
28. Kronbichler, S.A., H. Ostermann and R. Staudinger, 2010. A Comparison of ERP-Success Measurement Approaches, Journal of Information Systems and Technology Management, 7(2): 281-310. ISSN online: 1807-1775, DOI: 10.4301/S1807-17752010000200003
29. Hare, J.T., 2011. Why ERP Implementations Fail: Beyond the Obvious, Oaug Insight Winter 2011. http://www.oubpb.com/files/ERPRA_Why_Implementations_Fail_Beyond_the_Obvious_OAUG_Insight.pdf. (Accessed on 02.10.2013)
30. Aloini, D., D. Riccardo and M. Valeria, 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
31. Scipioni, R., 2009. Software Implementation Disaster Avoidance Guidelines. http://www. idii.com/wp/rsFailure Avoidance.pdf (Accessed on 05.10.2013)
32. Turcich, J.M., 2011. Get this ERP Project back on track or pull the plug!, http://ltadvisors.com/wp-content/uploads/2011/11/White_paper_project_rescue_.pdf (Accessed on 05.10.2013)

33. Dixit, A.K. and O. Prakash, 2011. A Study of Issues Affecting ERP Implementation in SMEs, Researcher World Journal of Arts, Science & Commerce E-ISSN 2229-4686, ISSN 2231-4172, II(2): 77-85.
34. Donovan, B.O., L. Seymour, J. Geldenhuys, M. Isaacs and K. Kaulule, 2010. The Influence of Organisational Memory Mismatches and Coping Strategies on ERP Outcomes, Electronic Journal Information Systems Evaluation, 13(2): 165-176.
35. Daneva, M. and R. Wieringa, 2005. Requirements Engineering for Cross-organizational ERP Implementation: Undocumented Assumptions and Potential Mismatches, Proceedings. 13th IEEE International Conference on Requirements Engineering, pp: 63-74.
36. Themistocleous, M., Z. Irani, R.M. O'Keefe and R. Paul, 2001. ERP Problems and Application Integration Issues: An Empirical Survey". Proceedings of the 34th Hawaii International Conference on System Sciences, pp: 1-10.
37. Themistocleous, M., Z. Irani and P.E.D. Love, 2006. Enterprise Application Integration: An Emerging Technology for Integrating ERP and Supply Chains, Proceedings of the ECIS 2006 pp: 1087 - 1096, http://60.88.dyn.lse.ac.uk/asp/aspecis/20020089.pdf (Accessed on 08.10.2013)
38. Pan, Y.C. and Y. Tang, 2010. Review of Misfit Issues between ERP Principles and Organisations. Proceedings of the International Conference on Education and Management Technology (ICEMT), 2010 E-ISBN: 978-1-4244-8618-2 Print ISBN: 978-1-4244-8616-8 Digital Object Identifier : 10.1109/ICEMT.2010.5657545, pp: 65 - 69.
39. Ganesh, L. and A. Mehta, 2010. Critical Failure Factors in Enterprise Resource Planning Implementation at Indian SME, Asian Journal of Management Research, 1(1): 44-57.
40. Ganesh, L. and A. Mehta, 2010. A Survey Instrument for Identification of the Critical Failure Factors in the Failure of ERP Implementation at Indian SMEs. International Journal of Managing Public Sector Information and Communication Technologies (IJMPICT), 1(2): 10-22.
41. Sumner, M.R. and J. Bradley, 2009. CSF's for Implementing ERP within SME's. Proceedings of the Americas Conference on Information Systems, AMCIS 2009, http://www3.cis.gsu.edu/ dtruex/ courses/CIS8670/Articles/CSFsImplementingERPin SMEs-Sumner-AMCIC2009.pdf (Accessed on 11.10.2013).
42. Mukwasi, C.M. and L.F. Seymour, 2012. Enterprise Resource Planning Business Case Considerations: A Review for Small and Medium-Sized Enterprises. Journal of Innovation Management in Small & Medium Enterprise, pp: 1-15. Article ID 752328, DOI: 10.5171/2012.752328.
43. Bansal, V., 2013. Identifying Critical Success Factors for ERP in SMEs through a Case Study. International Journal of Future Computer and Communication, 2(5). DOI: 10.7763/IJFCC.2013.V2.208
44. Haddara, M. and O. Zach, 2011. ERP Systems in SMEs: A Literature Review, Proceedings of the 44th Hawaii International Conference on System Sciences - 2011. http://brage. bibsys.no/hia/bitstream/ URN%3ANBN%3Ano-ibsys_brage_19110/1/Haddara_2011_ERP.pdf (Accessed on 15.10.2013).
45. Basu, R., P. Upadhyay, M.C. Das and P.K. Dan, 2012. An approach to identify issues affecting ERP implementation in Indian SMEs (2012). Journal of Industrial Engineering and Management, 5(1): 133-154. - Online ISSN: 2013-0953 - Print ISSN: 2013-8423 http://dx.doi.org/10.3926/jiem.416 .
46. Hsu, L.L. and Y.T. Weng, 2006. Critical Factors Effect User Satisfaction and Impact of ERP System. Proceedings of the 11th Annual Conference of Asia Pacific Decision Sciences Institute, pp: 234-238. http://iceb.nccu.edu.tw/proceedings/APDSI/2006/234-238. pdf (Accessed on 16.10.2013).
47. Gross, J., 2009. How Small and Medium-Sized Businesses can Plan for ERP Implementation, http://e-technologymanagement.com/tm/articles/erp_implementation.pdf (Accessed on 15.10.2013).
48. Zach, O., 2012. "ERP System Implementation in Small and Medium-Sized Enterprises", Doctoral Dissertation, University of Agder, Faculty of Economics and Social Sciences Department of Information Systems. http://brage.bibsys.no/ hia/ bitstream/URN:NBN:no-bibsys_brage_32964/1/Zach_2012_ERP.pdf (Accessed on 16.10.2013).
49. Aarabi, M., M.Z.M. Saman, K.Y. Wong, H.M. Beheshti and N. Zakuan, 2011. Critical Success Factors of Enterprise Resource Planning Implementation in Small and Medium Enterprises in Developing Countries: a Review and Research Direction. Proceedings of Industrial Engineering and Service Science, 2011, pp: 153-158. http://www. academia.edu/1083186/Critical_Success_Factors_of_Enterprise_Resource_Planning_Implementation_in_Small_and_Medium_Enterprises_in_Developing_Countries_a_Review_and_Research_Direction (Accessed on 11.10.2013)

50. Safavi, N.S., M. Amini, A. Abdollahzadegan and N.H. Zakaria, 2013. An Effective Model for Evaluating Organizational Risk and Cost in ERP Implementation by SME, IOSR Journal of Business and Management (IOSR-JBM) e-ISSN: 2278-487X, p-ISSN: 2319-7668. 10(6): 70-75.
51. Wilson, W., 2006. 5 Steps to a Successful ERP Software Implementation, TurningPoint Systems, Inc. http://waynewilson.typepad.com/wayne_wilson_and_company/files/5_steps_to_a_successful_erp_software_implementation_v3.pdf (Accessed on 11.10.2013).
52. Noudoostbeni, A., N.A. Ismail and H.S. Jenatabadi, 2010. An Effective End-User Knowledge Concern Training Method in Enterprise Resource Planning (ERP) Based on Critical Factors (CFs) in Malaysian SMEs. International Journal of Business and Management, 5(7): 63-76. Published by the Canadian Center of Science and Education.
53. Nzaou, P.P., L. Raymond and B. Fabi, 2008. Adoption and risk of ERP systems in manufacturing SMEs: a positivist case study, Business Process Management Journal, 14(4): 530-550. Emerald Group Publishing Limited 1463-7154. DOI 10.1108/14637150810888064.
54. Hustad, E. and D.H. Olsen, 2012. The Dynamics of Critical Success Factors in ERP Implementation: An SME Failure Case. Proceedings of the 9th International Conference on Enterprise Systems, Accounting and Logistics (9th ICESAL 2012) 3-5 June 2012, Chania, Crete, Greece. http://www.icesal.org/2012%20PROCEEDINGS/docs/K11.pdf (Accessed on 05.10.2013).
55. Zouaghi, I. and A. Laghouag, 2012. Aligning Key Success Factors to ERP Implementation Strategy: Learning from a Case-Study. Proceedings of the 4th International Conference on Information Systems, Logistics and Supply Chain - Creative Logistics for an Uncertain World ILS 2012 - Quebec (Canada), August 26-29. http://halshs. archives-ouvertes.fr/docs/00/85/03/78/PDF/CR_2012-08-E5.pdf (Accessed on 07.10.2013).
56. Dlodlo, J.B., 2011. Enterprise resource planning in manufacturing SMEs in the Vaal Triangle, Mini-dissertation for the degree Masters in Business Administration at the Potchefstroom campus of the North-West University. Pp: 1-124. http://dspace.nwu.ac.za/handle/10394/7355 (Accessed on 12.10.2013).
57. Gopalan, B.R., 2010. Process Documentation: A Pre-Requisite for ERP Implementation, Knowledge Management Series, Published by G. Balu Associates, 1(2). http://www.gbaca. in/pdf/Process-Documentation.pdf (Accessed on 11.10.2013).