Praise Worthy Prize

International Review on Computers and Software (I.RE.CO.S.), Vol. 9, N. 11
ISSN 1828-6003 November 2014

A Fuzzy Petri-Net Model for Predicting the Post-Implementation Risks of ERP in Small and Medium Enterprises

Dhanya Pramod[1], S. Vijayakumar Bharathi[2], R. Raman[3]

Abstract – *A model using Fuzzy Petri Nets (FPN) is developed for assessing the risk associated with the post-implementation phase or the usage phase of Enterprise Resource Planning (ERP) in Small and Medium Enterprises. This paper has identified a well defined set of risk factors from the existing research literature. The usage of FPN is because of its simplicity of usage and the efficiency in quantifying the risks inherent in the post-implementation or the usage stage of ERP adoption by SMEs. The model represented in the report will be an authentic character from a project risk management perspective to validate and quantify the risk inherent in the usage phase of ERP adoption.* **Copyright © 2014 Praise Worthy Prize S.r.l. - All rights reserved.**

Keywords: *ERP Adoption, SMEs, Risk Assessment, Post Implementation, Usage, Fuzzy Petri-Nets*

I. Introduction

ERP is accepted as a strategic business growth differentiator among the Indian Small and Medium Enterprises (SMEs).

SMEs have shown considerable interests to implement ERP from a business process streamlining perspective as well as a competitive advantage for enhanced business opportunities [1].

Nevertheless, the SMEs are inherent with certain genetic limitations such as a less mobilization of capital, limited surplus generation for ploughing back into business, working capital imbalances, not aware of business opportunities, poor exposure to the global business environment, limited market diversity geographically, obsolete technology and not enough infrastructure support. 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 big corporations [2]. The organizational change brought in by ERP implementation calls for a set of management competencies.

One of major critical challenges faced by organizations is relating to transition from a pre to post ERP environment to enable the usage of ERP in conducting business transactions. In other words project management competencies and change management have been listed as critical success factors in several studies [3]-[5].

According to the Chaos Report of 2009, only 32% of projects were successfully completed on time, with budget and scope, while 44% were challenged due to cost, time and scope overruns and failed projects which were constituted by cancellation before completion or delivery and never utilized accounted for 24%.

It can be noted from earlier work that there has been a decrease in the success rates over the past time horizon. It is rather discouraging to note that the 2009 figures represented the highest failure rate since 2000 [6].

Amongst other one of the critical drivers to failure was related to the inadequacy or absence of risk management practices, specific to ERP projects.

In our ongoing research on ERP we found that many SMEs were using certain tailor-made and off-the-shelf applications in core business functions. They have not yet matured to integrate business processes and ensure the acceleration of data flow over material flow. Moreover, we strongly consider that SMEs do not adopt any formal Risk Analysis techniques to measure and examine the risks inherent in the ERP adoption phases.

The primary ground is their limited exposure and affordability to the knowledge areas of Project Management. In the existing literature on post implementation this research will identify and determine a set of well-defined risk factors inherent in the post implementation or usage phase of ERP adoption.

Through expert opinion, these risks have been grouped and suitably named for modeling purposes.

Though numerous risk assessment techniques are already researched upon the motivation of this composition is to research the use of Fuzzy Petri-Nets for risk assessment in post implementation phase of ERP in SMEs which is currently not sufficiently handled in the existing research literature. The paper is divided into four sections.

The next section will bring out the relevance of past research works with regard to post-implementation risk factors and also the use of assessment tools for validation. The third part of the report explains the Fuzzy Petri-net model conceptualization by defining the notations and rules for risk assessment. This section also explains the operation of risk assessment for all the risks and tabulates the findings, namely, value of risks and risk contribution verdict. The fourth and terminal section is about conclusion and highlighting the scope of future work in this respect.

II. Related Work

According to a study, structural and organizational reasons significantly contributed to the non-adoption of ERP in SMEs [7]. It was found in SMEs, the personal and business reasons dominated the decision process for using ERP rather than scientific process and integration requirements. A set of 30 CSFs were identified out a comprehensive collection analysis of the earlier literature on ERP projects.

These CSFs were then ranked and prioritized using Analytical Hierarchy Process. It was found that the top ten factors, amongst others was periodical and timely communication about changes, updates and expectations with the users of an ERP system can improve the user confidence in the organization. Some of the other factors which were place reasonable higher in the ranking were periodical feedback on user satisfaction, and gap analysis in the training cycle [8].

The usage of ERP was explained by developing an integrative model which featured two aspects namely technical and organizational. The technological aspect defined the relevance and significance of project management and system configuration and the organizational aspects explained the role and involvement of leadership and organizational fit. The post-implementation success or ERP usage justification was significantly dependent upon these two aspects [9].

ERP system acceptance in the organization is predominantly impacted by the systems and service quality, individual and team impacts.

Interestingly, information quality did not chip in to the post implementation success of ERP [10]. The success in ERP implementation and gaining performance improvements should be validated as separate dependent variables. The reasoning was while the former is based on the outcomes of project delivery, the latter evaluates the post ERP environment which is driven by the usage and percolation of ERP into the functional routine of the organization [11].

The ERP benefits were widely perceived from a technology platform perspective and needed a robust control mechanism for managing the usage. The focus of this work was the usage of ERP which demands changes to the existing work related exercises and new, improved reporting environments in the organization. The percolation of ERP into the business processes was inversely proportional to the requirements and challenges of management control. The imbalance between percolation of ERP and management control lead to the inadequate usage of the ERP system. One of the major cause to the defeat of ERP implementation is the fact that ERP implementation is perceived only as a financial accounting based control [12].

The uncertainty created due to enterprises systems in production planning and scheduling was studied and termed as ERP-controlled fabrication. It is really important to identify the uncertainties that ERP can bring into the core productive working environment. In other words, users should be able to smoothly and confidently transition from a pre to the post ERP environment to handle the uncertainties of working with ERP [13].

Training needs, best practices selection and adoption, compatibility, efficiency and competitive pressures were listed as antecedents for the usage of ERP in organizations. The usage of ERP was also related to enhanced decision making because ERP can be extended to data analytics and business intelligence. The cross country analysis of ERP implemented firms in Portugal the usage of ERP was constrained by the complexity of ERP features, while in contrast the same complexities were found to be facilitating the ERP usage amongst Spanish firms [14]. The compatibility factor was also found critical for ERP usage amongst Portuguese firms.

A study analyzed the choice to retain or return the external expertise for subject matter in a post ERP implementation scenario in organizations. The study defined two models namely distributed or hybrid model and centralized functional-support structure.

The former model related to returning the SMEs while the latter related to holding them. From a small and medium enterprise perspective, it would be a wise choice to retain the services of process owners who were part of the ERP implementation to transfer knowledge from time to time [15]. The study recommended retention for sustaining the fast and steady usage of ERP throughout the organization. The determinants for usage of ERP was examined which were the attitude to use, performance expectancy, and self-efficacy and effort expectancy were significantly impacting the behavioral intention towards ERP usage. ERP usage effectiveness is dependent on behavioral intentions and facilitating conditions for such usage [16].

Past research works have indicated failures of ERP which reinforces need of a very deliberate and well laid out strategy to choose, specify and assess factors that drive success in ERP adoption by SMEs. Studies found that 75% of the project failed, time and cost overruns resulted in many ERP abandoned at different stages of its life cycle [17], [18]. Further, studies found that 25% of ERP projects had cost overruns, 20% could not be continued and 40% failed to accomplish the desired business objectives [19] [20]. A case based experience of SMEs on the various risks associated with ERP Projects was presented and proposed a project risk and characteristics analysis to realize the potential risks during ERP implementation [21]. A case study based approach was used to identify and evaluate the alignment of business expectations and ERP functionalities [22].

We found from related works, that several methods were adopted for assessing the ERP adoption risks. However, in comparison very few studies contained the use of Petri-net more specifically the use Fuzzy Petri-Net

(FPN) for predicting risk perceptions. A study identified and defined the risks embedded within the different ERP adoption lifecycle stages viz., planning, acquisition and implementation, and developed a conceptual model using Fuzzy Petri-Net for quantifying and measuring the risks [2] [23] [24].

Further, certain risk factors were named in the product and vendor selection during ERP acquisition and a Fuzzy Petri net based conceptual model [1] was explained for risk judgment and measurement. Fuzzy theories are used to enhance the certainty and clarity during quantitative data analysis. An Iranian company manufacturing refrigerators used Fuzzy Analytical Hierarchy Process (FAHP) for the evaluation and prioritization of ERP Critical Success Factors (CSFs) [25].

The Fuzzy Analytic Network Process (FANP) framework was used to evaluate the current state of organizational readiness for ERP system implementation.

The framework identified three parts, namely "project management readiness", "organizational readiness" and "change management readiness" as readiness components of ERP. A framework containing five primary categories of critical success factors were chosen to examine the ERP success. These categories related to vision and goals of the project, support systems and processes, culture, social element of organization and human factors [26]. For managing the project risk during the software design phase a study used the technique of fuzzy multiple regression analysis. The study brought out the significant of risk management during the software development life cycle [27] It is critical for organizations to meticulously evaluate the uncertainties in order to capitalize the upside benefits and minimize the downside losses.

It is understood that ERP decisions have a long term implications to organizations and ERP investment becomes sunk costs if not planned carefully. To accomplish the quantitative and qualitative objectives of selecting the enterprise software it was proposed to develop a decision support system that integrates the organisational givens [28]. The integrated system solved the ERP selection challenge by providing an objective hierarchy structure of suitability both functional and non-functional.

III. The Fuzzy Petri-Net Model for Assessing Risk

Fuzzy Petri nets (FPN) are proper non-deterministic and convenient means of knowledge representation and reasoning and it is represented by fuzzy production rules.

The two types of nodes namely places and transitions are denoted by circle and bar respectively. Each place 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.

FPN has widespread application to describe and analyse parallel and concurrent behaviour of many physical and social systems.

A host of control problems have used FPN to model various issues which includes control of CNC-milling machines [29], control of nuclear instrumentation for safety [30], autonomous vehicle control [31] [32], railway traffic control, control of excavation robot [31] etc. The relevant research work in the area of risk management in ERP Projects includes Characteristics Analysis Method (CAM) [20], literature review study of risk management practices [34], Delphi Technique and Analytical Hierarchy Process [35]. An application for risk management for modeling, optimal adaptation and implementation of an ERP system was proposed [36] [37]. However, there is no considerable contribution to the existing research knowledge on risk management using Fuzzy Petri nets.

In the recent past we have attempted to use FPN for modeling the risk prediction in ERP implementation projects and found that FPN provides an effective and easy means of representing and quantifying risks appropriately in the different phases of ERP adoption for SMEs. We believe that this area need more research exploration in order to strengthen the quantitative analysis of risk management using Fuzzy Petri nets which motivates us to research in this area.

For the proposed fuzzy Petri Net model the following definitions have been derived. Fuzzy Petri Net is a rule-based system that is represented by means of fuzzy production rules. It comprises of two kinds of nodes; places and transitions wherein place is denoted by circle and transition is denoted by bar. Each place need not necessarily hold a token which is associated with a truth value ranging between the values of 0 and 1.

A certainty factor associated between 0 and 1 represent the transition and the places to transition are linked by means of directed arcs.

Definition and symbols

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

$$FPN=(P,T,D,I,O,f,\alpha,\beta)$$

where:

$P=\{p1,p2,\dots pn\}$ is a finite set of places

$T=\{t1,t2,\dots,tm\}$ is a finite set of transitions

$D=\{d1,d2,\dots.dn\}$ is a finite set of propositions

$P\cap T\cap D=\Phi,|P|=|D|$,

I: $T\rightarrow P\infty$ is the input function, a mapping from transitions to bags of places,

O: $T\rightarrow P\infty$ is the output function, a mapping from transitions to bags of places,

F: $T\rightarrow[0,1]$is an association function, a mapping from transitions to real values between 0 and 1

α: $P\rightarrow[0,1]$is an association function, a mapping from places to real values between 0 and 1

β: $P\rightarrow D$ is an association function, a objective mapping from places to propositions.

Fuzzy Production Rule: The fuzzy relationship between two propositions is described through the Fuzzy Production Rule.

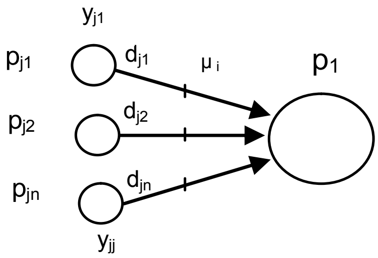

Fig. 1(a). Fuzzy Production Rule

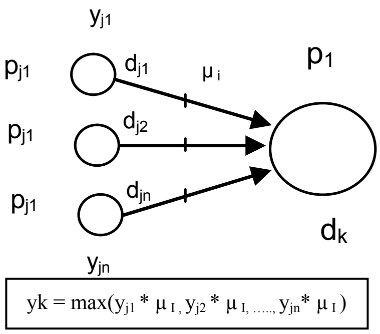

Fig. 1(b). Minimum Value Rule

If d_{j1} or $d_{j2,\dots,}d_{jn}$ then d_k (C.F = μ_I). Fig. 1(a) depicts the fuzzy Petri Net rule type and Fig. 1(b) denotes the fuzzy reasoning process of this type of rule.

If d_{j1} and d_{j2} ….. d_{jn} then d_k (C.F = μ_I). Fig. 2(a) depicts the fuzzy Petri Net rule type and Fig. 2(b) denotes the fuzzy reasoning process of this type of rule [2] [22] [23] [38] [39] [40].

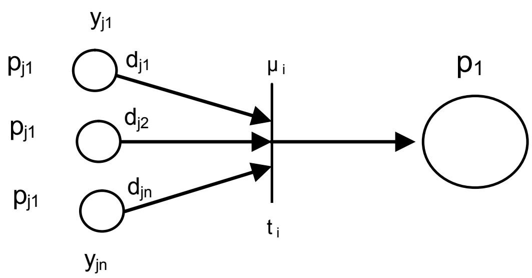

Fig. 2(a). Fuzzy Reasoning Process

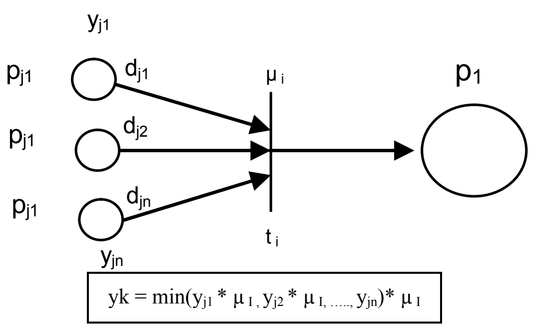

Fig. 2(b). Maximum Value Rule

Planning, acquisition, implementation, usage and percolation and extension were identified as the five distinct phases for ERP adoption in SMEs [41].

The scope of this paper is limited to the fourth phase of ERP adoption. In other words factors contributing to risk in only the post-implementation stage or usage phase of ERP in SMEs have been considered in the risk assessment model using fuzzy Petri-nets.

In this phase eighteen risk factors were placed and grouped into six risk headings which are given in the Table I below. The fuzzy Petri Net based model is explained below.

At place P_0 d_0 is the risk of failure in the Usage Phase of ERP Adoption. At place P_i (i = 1, 2…..,6). D_i represents Risks identified that are associated with the Usage Phase. The risk of failure in usage will be measured with the help of these risks.

At place p_{ij} (i = 1, 2…..,6), (j = 1, 2…..n), d_{ij} denotes the risk factor and the number of risk factors identified to explain the risks is denoted by n.

At place p_{ijk} (i = 1, 2…..,6), (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. In this paper we propose the underlying rules for deciding whether a factor will or will not contribute to risk. *SA* and *A* are understood as negative so they will contribute/lead to risk while *D* and *SD* are defined as positive because they are not contributors/drivers to risk.

D_{ijk} (i = 1, 2…..,6), (j = 1, 2…..n) (k = 1, 2…..m) where d constitutes the responses percentage (Ratio of number of responses to an choice to the total responses recorded for all the choices). If the percentage of responses are equally distributed to all the four choices namely SA, A, D & SD or if the sum of response proportion of negative and positive choices are equal (SA+A) = (D+SD) then that factor's incidence to risk is neutral. If for a risk factor, the proportion of responses in SA and A are greater than D & SD, then that factor will be a risk contributor and vice versa.

μ_i (i = 1, 2…..9) represents the certainty factor, $\mu_i \in [0, 1]$ 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 the purpose of demonstration we have fixed the certainty value at 9 (as a proportion 0.9). This based on the belief on the high level of awareness to the concept and context of ERP adoption by the respondents [42], [43], [44].

In the usage phase of ERP adoption (U_0), the risk called *ineffective communication with users (U_1)* is embeds two risk factors, namely *the absence of a formal and periodical feedback mechanisms (d_{11})* and *changes if any are not communicated (d_{12})*[20] [45]-[49].

TABLE I
RISK AND RISK FACTORS FOR USAGE OF ERP

S. No.	Risk	Symbol	Risk Factors	Symbol
1	Ineffective communications with users	U_1	Absence of a formal and periodical feedback mechanism	u_{11}
			Changes, if any are not communicated	u_{12}
2	Failure to justify ERP in business operations	U_2	Less usage of ERP functionalities	u_{21}
			No periodical review of ERP usage	u_{22}
3	User resistance	U_3	No formal process for user-comfort review	u_{31}
			Using shortcuts outside the ERP system to complete tasks	u_{32}
			Insufficient training	u_{33}
			Fear of losing efficiency	u_{34}
4	Lack of top management motivation	U_4	No user encouragement	u_{41}
			Lack of trust in others	u_{42}
			Lack of patience in users	u_{43}
			Lack of users' confidence	u_{44}
5	Exploiting the ERP System	U_5	No ERP usage policy in place	u_{51}
			Lack of clarity of authorization and access control rights	u_{52}
			Poor information security practices	u_{53}
6	Unethical usage practices	U_6	Unauthorized use of legacy and out-dated systems	u_{61}
			Shortcut practices in the excuse of less time and expertise	u_{62}
			Faulty, inadequate or duplicated reporting of transactional data.	u_{63}

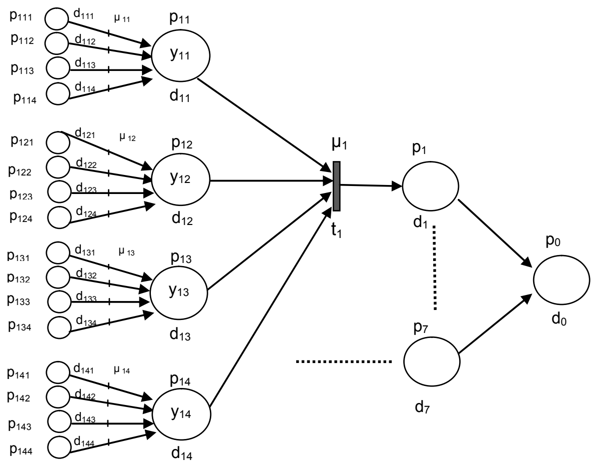

Fig. 3. FPN based Risk Assessment Model

The risk predicting values range from strongly agrees to strongly disagree (d_{111}…., d_{114}). Let us assume that the proportion of strongly agree responses is 30% then the value of d_{111} is 0.3, 40% of respondents agree, the value of d_{112} is 0.4, 20% of the respondents disagree, then the value of d_{113} is 0.20 and the remaining 10% of the respondents strongly disagree, the value of d_{114} is 0.10.

The notation μ represents the responses' strength or truth value, and it is based on the dependability of the responses. In other words, the degree of dependability of responses is directly proportional to the value of μ and vice versa. Here μ_{11} is takes the value of 0.9. Then the value y_{11} is a maximum of (0.3*0.9), (0.4*0.9), (0.2*0.9), (0.10*0.9) which is 0.36. The response option Agree (A) is contributing to this value of 0.36. Based on the rule stated earlier SA and A denotes negativity. So the risk factor absence of a formal and periodical feedback mechanism (d_{11}) will contribute to the risk (U_1).

In the same way we derive the values of the other risk factor based on the share of responses. Then the greater of the values of responses-proportion multiplied by μ_{11} will determine whether a risk factor would *contribute* or not contribute to the risk (U_1).

The second risk, *failure to justify ERP in business operations (U_2)* contains two risk factors, namely *less usage of ERP functionalities (d_{21})* and *no periodical review of ERP usage (d_{22})* [20] [46] [50] [51] [52] [53].

We can predict the value of risk factors based on the responses that range from strongly agree to strongly disagree (d_{121}…., d_{124}). Suppose the composition of responses denotes that, in d_{21} 20% agree, then the value of d_{121} is 0.2 and 80% of the respondents strongly disagreeing then the value of d_{124} is 0.8. If μ_{21} is assigned a value of 0.9 then value y_{21} is the greater of (0.2*9) and (0.8*0.9) which is 0.72. Option SD contributes to this value and since SD is a positive indicator less usage of ERP functionalities (d_{22}) will not lead to risk (U_2). The value of other risk factor d_{22} can also be arrived from the response proportions based on the same rule. Then the maximum of the proportion-of-response values multiplied by μ_{11} value will determine whether d_{22} will *contribute* or will not *contribute* to the risk.

There are four risk factors embedded in the risk *User resistance (U_3),* namely *no formal process for reviewing user-comfort (d_{31}), using shortcuts outside the ERP system to complete tasks (d_{32}), insufficient training (d_{33})* and *fear of losing efficiency (d_{34})* [54] [55] [56] [57] [58] [59]. The values of the risk factors are derived from the responses strongly agree to strongly disagree (d_{131}…., d_{134}). If 30% of respondents strongly agree for d_{31} the value of d_{131} is 0.3, 60% of them agree, then value of d_{132} is 0.60 and 5% of them strongly disagree the value of d_{133} is 0.05.

With the certainty value of μ_{31} value fixed at 0.9, the value of y_{31} will be the maximum of (0.3*0.9), (0.6*0.9) and (0.1*0.9) that is 0.54. The option agree has the highest value and hence the risk factor no formal process for reviewing user-comfort (d_{31}) will lead to the risk of (U_3). In the same manner the maximum value of y_{32} and y_{33} of other two risk factors d_{32} and d_{33} is calculated. The positive or negative perspectives to decide on the prevalence or the non prevalence of risk (U_3) will depend upon the product of proportion-of-responses value and μ_{31}.

A set of four risk factors namely four risk factors, namely *no user encouragement* (d_{41}), *lack of trust in others* (d_{42}), *lack of patience in users* (d_{43}), *lack of users' confidence* (d_{44}) [52] [60] [61] [62] [63] is defined under the risk (U_4) *Lack of top management motivation.*

The values of the risk factors are defined based on the responses ranging from strongly agree to strongly disagree (d_{141}…., d_{144}). Let us take $d_{42,}$ for which the responses are equally distributed between agreeing (A) and disagree (DA), that is 50% in each of these two options, then d_{42} will not be considered for determination of risk.

Similarly, values of the other three risk factors can be calculated on the basis of response proportion. The $\mu_{41,\ 43\ \&\ 44}$ values will remain at 0.9 and the value of $y_{41,\ 43\ \&\ 44}$ will be the product of responses share and μ. The contribution to risk by these factors will depend on the negative or positive attribute as defined earlier.

Exploiting the ERP System (U_5) is comprised of three risk factors namely *no ERP usage policy in place* (d_{51}), *lack of clarity of authorization and access control rights* (d_{52}) and *poor information security practices* (d_{53}) [64] [65] [66]. The risk-factors values are derived from the proportion of responses ranging from strongly agree to strongly disagree (d_{151}…., d_{154}). In case of d_{51} if 40% of the respondents strongly agree its value is 0.6 while 40% agree the value is 0.4. The value of μ_{51} being 0.9 the value of y_{51} will be the maximum of (0.6*0.9) and (0.4*0.9) which is 0.54. In this outcome since 0.54 is resulted from a negative attribute of response that is strongly agree. Hence we state that d_{51} will contribute towards the risk (U_5).

For risk factor (d_{52}) 10% of the respondents strongly agree, 20% of the respondents agree, 60% of the respondents disagree and 10% of respondents strongly disagree then their values would be 0.1, 0.2, 0.6 & 0.1 respectively. μ_{52} being 0.9, the value of y_{52} will be the maximum of (0.1*0.9), (0.2*0.9), (0.6*0.9) and (0.1*0.9) which is 0.54. In this case (d_{52}) will not contribute to the risk (U_5) because the maximum value denotes disagree (DA) which is a positive attribute.

There are three risk factors that lead to the risk of *unethical usage practices* (U_6). These factors are *unauthorized use of legacy and out-dated systems* (d_{61}), *shortcut practices in the excuse of less time and expertise* (d_{62}) and *faulty, inadequate or duplicated reporting of transactional data* (d_{63}) [55] [58] [67] [68]. The responses that range from strongly agree to strongly disagree (d_{161}…., d_{163}) defines the values of these three risk factors. In d_{61} if it is assumed that 30% of the respondents strongly agree while 70% agree, then their values would be 0.3 and 0.7 respectively. The μ_{61} being 0.9 the value of y_{61} is the greater of (0.3*0.9) and (0.7*0.9) which is 0.63. In this risk factor, 100% of the responses are distributed between the two negative attributes of strongly agree and agree. Hence d_{61} *will* contribute to the risk (P_6) irrespective of the proportion of the responses. Similarly, the value of other two risks factor d_{62} and d_{63} will be calculated on the basis of response proportion. The value of y_{62} and y_{63} will be the maximum of the product of proportion-of-responses and $\mu_{62\text{-}63}$ of 0.9 of these risk factors. Whether d_{62} and d_{63} will contribute to or not, contribute to the risk (P_6) will depend upon the negative or positive attribute as defined earlier.

Table II below presents the assessed value of all the 18 risk factors comprised in the 6 risks identified in the usage phase.

TABLE II
ASSESSED VALUES OF RISK FACTORS

S. No.	Risk Symbol	Risk Factor	Risk Factor Values	+ / - **
1	U_1	u_{11}	y_{11}	
		u_{12}	y_{12}	
		u_{13}	y_{13}	
		u_{14}	y_{14}	
2	U_2	u_{21}	y_{21}	
		u_{22}	y_{22}	
3	U_3	u_{31}	y_{31}	
		u_{32}	y_{32}	
		u_{33}	y_{33}	
4	U_4	u_{41}	y_{41}	
		u_{42}	y_{42}	
5	U_5	u_{51}	y_{51}	
		u_{52}	y_{52}	
6	U_6	u_{61}	y_{61}	
		u_{62}	y_{62}	
7	U_7	u_{71}	y_{71}	
		u_{72}	y_{72}	
		u_{73}	y_{73}	

*The responses are evenly spread across the given response-options
** Negative sign implies that the sum of SA and/or A is greater than SD and/or D and hence will contribute towards risk. The positive sign denotes non-contribution if the sum of SD and/or D is greater than SA and/or A. For risk measurement, only the Y values with negative perspectives are considered [2] [23] [24].

The contributors to the risk will be based only on the values derived from the options Strongly Agree and Agree which are negative perspectives of responses. We state that these values are the identified risk contributors in the post-implementation or usage stage of ERP Adoption.

The lower the values lower will be the risk perceived and vice versa. To bring about a better clarity of the reality during the field survey, the different contexts are described to illustrate the combination of responses amongst the four choices namely SA, A, SD and D in the above analysis [2] [23] [24].

IV. Conclusion and Scope for Future Work

By proposing a fuzzy Petri Net based conceptual model, we have explained the risk prediction for ERP failure in the post-implementation or usage phase in the Small and Medium Enterprises. The application of this model in reality will be conducted on data collected from the proposed field survey.

Currently this risk prediction model is being extended to all the other four phases of ERP adoption so as to arrive at an end-to-end risk evaluation and measurement model throughout the ERP adoption life cycle in the SMEs. Furthermore, work is in progress in the testing of the model in software tool specially developed by the authors using the synergies of spreadsheet modeling with Visual Basic for Applications (VBA). This tool embeds colour-coding features in red and green in order to highlight the degree of contributing or not contributing towards a particular risk in any of the phases of ERP adoption.

This tool after testing and going live will be a simple, easy to understand, yet robust instrument for SMEs to evaluate and measure the ERP risks.

References

[1] S. Bharathi, S. Parikh, A comparative study on the conceptual and contextual perception about CSF for ERP adoption in the SMEs., *Journal of Arts, Science and Commerce,* Vol. 3, pp 38-46, 2012.

[2] V. Bharathi, R. Raman, D. Pramod, A FPN Based Risk Assessment Model for ERP Implementation in Small and Medium Enterprises, *Middle-East Journal of Scientific Research,* Vol. 19, n 6, pp 747-759, 2014.

[3] T. H. Davenport, Mission Critical: Realizing the Promise of Enterprise Systems, *Harvard Business School Press,* Boston, MA, 2000.

[4] P. Mandal, A. Gunasekaran, Issues in implementing ERP: a case study, *European Journal of Operational Research*, Vol. 146, pp. 274-283, 2003.

[5] J. Motwani, D. Mirchandani, M. Mandal, A. Gunasekaran, Successful implementation of ERP projects: evidence from two case studies, *International Journal of Production Economics, special issue, Information technology/information systems in 21st century manufacturing,* Vol. 75, pp. 83-96, 2002.

[6] Standish Group. Chaos Summary 2009: The 10 Laws of CHAOS. On-line). Disponível: http://www. portal. state. pa. us/portal/server. pt/document/690719/chaos_summary_2009_pdf,(29 de dezembro de 2010).

[7] G. Buonanno, P. Faverio, F. Pigni, A. Ravarini, D. Sciuto, M. Tagliavini, Factors affecting ERP system adoption: a comparative analysis between SMEs and large companies, *Journal of Enterprise Information Management,* Vol. 18, n. 4, pp 384-426, 2005.

[8] V. Bharathi, O. Vaidya, S. Parikh, Prioritizing and ranking critical success factors for ERP adoption in SMEs. *AIMS International Journal of Management*, Vol. 6, n. 1, pp 23-40 2012.

[9] Y. Zhu, Y. Li, W. Wang, J. Chen, What leads to post implementation success of ERP? An empirical study of the Chinese retail industry, *International Journal of Information Management*, Vol. 30, n. 3, pp 265-276, 2010.

[10] P. Ifinedo, B. Rapp, A. Ifinedo K. Sundberg, Relationships among ERP post-implementation success constructs: An analysis at the organizational level, *Computers in Human Behavior,* Vol. 26, n. 5, pp 1136-1148, 2010.

[11] J. Ram, D. Corkindale, M. L. Wu, Implementation critical success factors (CSFs) for ERP: Do they contribute to implementation success and post-implementation performance? *International Journal of Production Economics,* Vol. 144, n. 1, pp 157-174, 2013.

[12] H. Teittinen, J. Pellinen, M. Järvenpää, ERP in action—Challenges and benefits for management control in SME context, *International Journal of Accounting Information Systems*, Vol. 14, n. 4, pp 278-296, 2013.

[13] S. C. Koh, S. M. Saad, Managing uncertainty in ERP-controlled manufacturing environments in SMEs, *International Journal of Production Economics,* Vol. 101, n.1, pp 109-127, 2006.

[14] P. Ruivo, T. Oliveira, M. Neto, ERP use and value: Portuguese and Spanish SMEs. *Industrial Management & Data Systems*, Vol. 112, n. 7, pp 1008-1025, 2012.

[15] K. P Gallagher, V. C. Gallagher, Organizing for post-implementation ERP: A contingency theory perspective, *Journal of Enterprise Information Management*, Vol. 25, n. 2, pp 170-185, 2012.

[16] P. Alleyne, M. Lavine, Factors influencing accountants' behavioural intentions to use and actual usage of enterprise resource planning systems in a global development agency, *Journal of Financial Reporting and Accounting,* Vol. 11, n. 2, pp 179-200, 2013.

[17] X. T. Thavapragasam, *Cultural influences on ERP implementation success,* Proceedings of the First Australian Undergraduate Students' Computing Conference (Page 93 Year 2003, Harvard Business School Press).

[18] A. Parr, G. Shanks, A Model of ERP Project Implementation, *Journal of Information Technology*, Vol. 15, n. 4, pp 289-303, 2000.

[19] N. Gibson, C. Holland, B. Light, A case study of a fast track SAP R/3 implementation at Guilbert, *Electronic Markets,* Vol. 9, n. 3, pp 190-193, 1999.

[20] L. Fitz-Gerald, J. Carroll, *The role of governance in ERP system implementation,* Proceedings of the 14th Australasian conference on information systems (Year 2003).

[21] P. Iskanius, Risk Management in ERP Project in the Context of SMEs, *Engineering Letters*, Vol. 17 n. 4, pp 266, 2009.

[22] Bengoud, K., Benmoussa, R., Saib, S., Abd, A., An approach for the identification of misalignment in ERP implementation, (2014) *International Review on Computers and Software (IRECOS),* 9 (6), pp. 906-919.

[23] V. Bharathi, D. Pramod, R. Raman, A Conceptual Model for ERP Failure Prediction using Fuzzy Petri-nets for Small and Medium Enterprises. *European Journal of Scientific Research,* Vol. 87, n. 3, pp 330-338, 2012.

[24] V. Bharathi, D. Pramod, R. Raman, A Fuzzy Petri-Net Based Conceptual Model for Risk Prediction in Enterprise Resource Planning (ERP) Acquisition Decisions for Small and Medium Enterprises, *Journal of Computer Science,* Vol. 9, n.1, pp 139-146, 2013.

[25] M. Amalnick, A. Ansarinejad, S. Ansarinejad, L. Hatami-Shirkouhi, *A Group Decision Making Approach for Evaluation of ERP Critical Success Factors Using Fuzzy AHP*, Proceedings of the IEEE Computer Modeling and Simulation (EMS), Fourth UKSim European Symposium (Page. 212 Year 2010).

[26] J. Razmi, M. S. Sangari, R. Ghodsi, Developing a practical framework for ERP readiness assessment using fuzzy analytic network process, *Advances in Engineering Software,* Vol. 40, n. 11, pp 1168-1178, 2009.

[27] Elzamly, A., Hussin, B., Managing software project risks (Design Phase) with proposed fuzzy regression analysis techniques with fuzzy concepts, (2013) *International Review on Computers and Software (IRECOS),* 8 (11), pp. 2601-2613.

[28] C. G. Şen, H. Baraçlı, S. Şen, H. Başlıgil, An integrated decision support system dealing with qualitative and quantitative objectives for enterprise software selection, *Expert Systems with Applications*, Vol. 36, n. 3, pp 5272-5283, 2009.

[29] M. M. Hanna, A. Buck, R. Smith, Fuzzy Petri nets with neural networks to model products quality from a CNC-milling machining centre, *Systems, Man and Cybernetics, Part A: Systems and Humans, IEEE Transactions*, Vol. 26, n. 5, pp 638-645, 1996.

[30] H. S. Son, P.H. Seong, A quality control method for nuclear instrumentation and control systems based on software safety prediction, *Nuclear Science, IEEE Transactions,* Vol. 47, n. 2, pp 408-421, 2000.

[31] G. G .Rigatos, Fuzzy stochastic automata for intelligent vehicle control, *Industrial Electronics, IEEE Transactions,* Vol. 50, n. 1, pp 76-79, 2003.

[32] L. Zouaghi, A. Alexopoulos, A. Wagner, E. Badreddin, Mission-based online generation of probabilistic monitoring models for mobile robot navigation using Petri nets, *Robotics and Autonomous Systems,* Vol. 62, n. 1, pp 61-67, 2014.

[33] F. Y. Wang, Agent-based control for fuzzy behavior programming in robotic excavation, *Fuzzy Systems, IEEE Transactions,* Vol. 12,

n. 4, pp 540-548, 2004.

[34] D. Aloini, R. Dulmin, V. Mininno, Risk management in ERP project introduction: Review of the literature, *Information & Management,* Vol. 44, n. 6, pp 547-567, 2007.

[35] S. M. Huang, I. C. Chang, S. H. Li, M. T. Lin, Assessing risk in ERP projects: identify and prioritize the factors, *Industrial management & data systems,* Vol. 104, n. 8, 681-688, 2004.

[36] I. Zafiropoulos, K. Metaxiotis, D. Askounis, Dynamic risk management system for the modeling, optimal adaptation and implementation of an ERP system, *Information Management & Computer Security,* Vol. 13, n. 3, pp. 212-234, 2005.

[37] M. Ojala, I. Vilpola, I. Kouri, Risks and risk management in ERP Project-cases in SME Context, *Business Information Systems (BIS),* 2006

[38] J. Wang, Petri nets for dynamic event-driven system modeling, *Handbook of Dynamic System Modeling,* 2007 pp 1-17.

[39] J. Wang, *Automotive Supply Chain Performance Influencing Path Analysis Based on Fuzzy Petri Net*, Proceedings of the IEEE Information Management, Innovation Management and Industrial Engineering, International Conference, Vol. 1, (Page 359 Year 2009).

[40] S. Wang, G. Wang, G. Gao, Fuzzy Petri Net-based Evaluation to the Process of ERP Implementation". Proceedings of the IEEE Services Computing APSCC'06 Asia-Pacific Conference, (Page 11 Year 2006)

[41] V. Bharathi, S. Parikh, *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, (Year 2009).

[42] Looney, C. G. (1988). Fuzzy Petri nets for rule-based decision making. Systems, Man and Cybernetics, IEEE Transactions on, 18(1), 178-183.

[43] Chen, S. M., Ke, J. S., & Chang, J. F. (1990). Knowledge representation using fuzzy Petri nets. Knowledge and Data Engineering, IEEE Transactions on, 2(3), 311-319.

[44] Gomes, L., & Steiger-Garção, A. (1995). Programmable controller design based on a synchronized colored Petri net model and integrating fuzzy reasoning. In Application and Theory of Petri Nets 1995 (pp. 218-237). Springer Berlin Heidelberg.

[45] P. Ruivo, T. Oliveira, M. Neto, ERP use and value: Portuguese and Spanish SMEs, *Industrial Management & Data Systems,* Vol. 112, n. 7, pp 1008-1025, 2012.

[46] Ö. Y. Saatçioglu, *What determines user satisfaction in ERP projects: benefits, barriers or risks? Journal of Enterprise Information Management,* Vol. 22, n. 6, pp 690-708, 2009.

[47] C. Lambeck, R. Muller, C. Fohrholz, C. Leyh, *(Re-) Evaluating User Interface Aspects in ERP Systems--An Empirical User Study,* Proceedings of the IEEE System Sciences (HICSS), 47th Hawaii International Conference (Page 396 Year 2014).

[48] S. A.Shad, E. Chen, F. M. Azeem, Enterprise Resource Planning-Real blessing or a Blessing in Disguise: An Exploration of the Contextual Factors in Public Sector". *arXiv preprint arXiv:1207.2860, 2012.*

[49] T. R. Bhatti, *Critical success factors for the implementation of enterprise resource planning (ERP): empirical validation*, Proceedings of the second international conference on innovation in information technology, (Page 110 Year 2005).

[50] S.Wei, A. C. Loong, Y. M. Leong, K. B. Ooi, *Measuring ERP system success: a respecification of the Delone and McLean's IS success model,* Proceedings of the Symposium on progress in information & communication technology, (Page 7 Year 2009)

[51] O. Zach, Exploring ERP system outcomes in SMEs: A multiple case study". http://aisel.aisnet.org/ecis2011/7/ (Accessed on 10.10.2013)

[52] Haddara, O. Zach, *ERP systems in SMEs: A literature review,* Proceedings of the IEEE System Sciences (HICSS), 44th Hawaii International Conference (Page 1 Year 2011) http://brage.bibsys.no/hia/bitstream/URN%3ANBN%3Ano-ibsys_brage_19110/1/Haddara_2011_ERP.pdf (Accessed on 15.10.2013)

[53] F. A. Mirbagheri, G. Khajavi, Impact of ERP Implementation at Malaysian SMEs: Analysis of Five Dimensions Benefit, *International Journal of Enterprise Computing and Business Systems,* Vol. 2, n. 1, 2013. International Manuscript ID : ISSN22308849-V2I1M3-012013

[54] M. R. Sumner, J. Bradley, *CSF's for Implementing ERP within SME's*, Proceedings of the AMCIS, (Page. 550 Year 2009) http://www3.cis.gsu.edu/dtruex/courses/CIS8670/Articles/CSFsImplementingERPinSMEs-Sumner-AMCIC2009.pdf (Accessed on 11.10.2013)

[55] A.I. Nicolaou, Firm performance effects in relation to the implementation and use of enterprise resource planning systems, *Journal of Information Systems*, Vol. 18, n. 2, pp 79-105, 2004.

[56] S. H. S Mahmoud, *User resistance factors in post ERP implementation,* Ph.D. Thesis, Universiti Teknologi Malaysia, 2012

[57] E.Hustad, D. H Olsen, *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 (Year 2012) http://www.icesal.org/2012%20PROCEEDINGS/docs/K11.pdf (Accessed on 05.10.2013)

[58] E. Hustad, A. A. Bechina, A study of the ERP Project Life Cycles in Small-and-Medium–Sized Enterprises: Critical Issues and Lessons Learned, *World Academy of Science, Engineering and Technology*, Vol. 60, 2011.

[59] Zach, ERP system implementation in small and medium-sized enterprises, *Ph.D. Thesis, Dept. Information Systems,* Faculty of Economics and Social Sciences, University of Agder, 2012 http://brage.bibsys.no/hia/bitstream/URN:NBN:no-bibsys_brage_32964/1/Zach_2012_ERP.pdf (Accessed on 16.10.2013)

[60] J.-H Wu, Y.M Wang, Measuring ERP success: the ultimate users' view, *International Journal of Operations and Production Management*, Vol. 26, n. 8, pp. 882-903, 2006.

[61] M. Haddara, *ERP adoption cost factors in SMEs,* Proceedings of the European and Mediterranean Conference on Information Systems, Athens, Greece, (Year 2011).

[62] A. Salajegheh, F. Kimiaee and H. Ahmadian Yazdi, *Project Management, A Solution for ERP Failures,* Proceedings of the 5th SASTech, Khavaran Higher-education Institute, Mashhad, Iran (Year 2011)

[63] R. Meissonier, N. Belbaly, *Emmanuel Houze schreibt man Emmanuel Houzé!! User resistance evolution in IT projects: A longitudinal analysis of a French high-tech SME,* Proceedings of the AIM Conference, (Page 318 Year 2006)

[64] Vilpola, I. Kouri, K. Vaananen-Vainio-Mattila, *Rescuing Small and Medium-Sized Enterprises from Inefficient Information Systems--A Multi-disciplinary Method for ERP System Requirements Engineering,* Proceedings of the IEEE System Sciences, 40th Annual Hawaii International Conference, (Page 242b Year 2007)

[65] A.Ravarini, M. Tagliavini, F. Pigni, D. Sciuto, *A framework for evaluating ERP acquisition within SMEs,* Proceedings of AIM 2000 Conference, Montpellier, France (Page 1 Year 2000).

[66] M. K. Ozlen, Current Enterprise Resource Planning snapshot in Bosnian small and medium enterprises, *Jurnalul Practicilor Comunitare Pozitive,* n. 3, pp 500-519, 2012.

[67] R. S. Raghavan., Risk management in SMEs, *Chartered Accountant*, 2005

[68] Y. Levy, T. J. Ellis, A systems approach to conduct an effective literature review in support of information systems research, *Informing Science: International Journal of an Emerging Transdiscipline*, Vol. 9, n. 1, pp 181-212, 2006.

Authors' information

[1,2]Symbiosis Centre for Information Technology (SCIT), Symbiosis International University (SIU).
E-mails: director@scit.edu
svkbharathi@scit.edu

[3]Symbiosis Institute of Business Management (SIBM), Symbiosis International University (SIU).
E-mail: director@sibmpune.edu.in

Dr. **Dhanya Pramod** is a Professor and Director at the Symbiosis Centre for Information Technology (SCIT), a constituent of the Symbiosis International University (SIU), Pune. Dr. Pramod is a Post Graduate in Computer Science from Pondicherry Central University, India and Ph.D in Computer Science from Symbiosis International University, India. She also holds a MBA from IGNOU, India. Her teaching and research interests are information security, networks and application security and aspect oriented programming. She has published papers in refereed journals and several conferences of international repute. She is a senior member of IACSIT, Singapore. She has a strong academic foundation and was the First Rank holder of university both at undergraduate and post graduate level.

Mr. **S. Vijayakumar Bharathi** is an Associate Professor at the Symbiosis Centre for Information Technology (SCIT), a constituent of the Symbiosis International University (SIU), Pune. Mr. Bharathi is a Post Graduate in Commerce from Bharathiar University, Coimbatore and in Management from Bharathidasan University, Trichy. He submitted his Ph.D thesis at Symbiosis International University, Pune in the area of ERP Risk Assessment for SMEs. He is an SAP-ERP trained and certified in SAP-TERP10 and SAP-Business ByDesign. His teaching and research interests include ERP, Enterprise Systems, Managerial Accounting, Business Process Analysis and Knowledge Management. He has published over 70 publications and papers published in several journal and conferences of National and International repute. He also has published cases ERP, KM and Business Process Mapping in the Case Centre (European Case Clearing House) Cranfield, United Kingdom one of which featured in the top 20 most viewed cases in the world in 2008. He is also an Accredited Management Teacher, (a prestigious national recognition conferred by AIMA, India). He is the recipient of the SAP University Alliances, Outstanding Academic Achievement Award in the SAARC Region for the year 2013.

Dr. **R. Raman** is a Professor and Director of the Symbiosis Institute of Business Management (SIBM), Pune, a constituent of the Symbiosis International University (SIU), Pune. He is also the Dean, Faculty of Computer Studies of Symbiosis International University (SIU). Dr. Raman is a Computer Science and Engineering graduate from Madras University, an MBA in Information Systems from the same University. He holds a Postgraduate Diploma in Software Marketing, M.Phil (Management) and Ph.D in Information Technology Enabled Services Strategy. He is a Six Sigma Green Belt and Six Sigma Black Belt Certified by RABQSA (Registrar Accreditation Board Quality Society of Australasia). He is also an Accredited Management Teacher, (a prestigious national recognition conferred by AIMA) and Green IT certified by ISEB.

His teaching and research interests are MIS, Disruptive Technologies, IT Infrastructure Management, IT Project Management, Management of ITeS and Green IT.

He has research papers in several refereed journals and also has presented papers in Indian and International conferences. He has a case study publication to his credit in the Case Centre (European Case Clearing House), Cranfield, UK.