Practical Risk Assessment Methodology for ERP Project Implementation

G. Thangamani

***Abstract*—Risk and complete uncertainty can potentially have serious consequences on the Enterprise Resource Planning (ERP) implementation. Risk management is one of the ten knowledge areas propagated by the Project Management Institute (PMI). Furthermore, risk management in the ERP system implementation context is a comprehensive and systematic way of identifying, analyzing and responding to risks to achieve the project objectives. This paper examines a practical approach to risk assessment using Monte Carlo simulation for ERP implementation. Risk Assessment Table (RAT) was developed as risk assessment model and Monte Carlo simulation was used to assess the project value at risk and its uncertainty. An overall risk management framework was also developed and the same was used to explore various risks, categorize them per their sources, assesses those risks and their variability. This approach supports the important project stakeholders such as customer, contractor or developer, consultant, and supplier to meet their commitments and minimize negative impacts on ERP project performance in relation to cost, time and quality objectives. The methodology was demonstrated using a case study on a ERP implementation project.**

***Index Terms*—ERP, Monte Carlo simulation, risk assessment, value @ risk.**

I. Introduction

Enterprise Resource Planning (ERP) is a suite of integrated software applications that allow seem-less integration of business processes and information by using a common database and standard procedures. They also automate many of the back-office functions as well as integrates all aspects of operations like product planning, product development, production, logistics and sales & marketing [1]. Generally, ERP packages is also having workflow engines which help to automate workflows so that information and documents are passed to various users for transactions processing and to managers and directors for review and approval as per references [2] and [3].

ERP system provides several advantages to the organization. Most of the operational difficulties such as meeting production schedules, reducing inventory, reducing operational costs, increasing productivity, providing better control over materials, improving quality etc. are minimized by ERP systems. ERP also helps to breakdown silos and enhances cooperation among various functions results in higher quality of product and service, reduced time to market, improved production with lower cost and finally improved market share with customer satisfaction [4].

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G. Thangamani is with the Indian Institute of Management Kozhikode, Kerala, India (e-mail: gtmani@iimk.ac.in).

Although there are several advantages are associated with ERP systems, many of the ERP systems failed to deliver results or ineffective [5]. Most of the failures are due to poor implementation of ERP systems. Generally, ERP system calls for massive change to reap the benefits. Critical issues should be addressed properly in ERP implementation. Selection of proper ERP package, management of consultant, commitment of top management, proper reengineering of existing business processes, integration with other information system software, proper training of employees places important role in success of ERP implementation. Standish Group International (SGI) estimated that 90% of SAP R/3 ERP projects run late [6]. This group also studied more than 7400 IT projects and disclosed that 31% were abandoned after starting, 34% were running late or over budget and some of them were scaled down or modified. Only 24% were completed on time and on budget [7].

Since ERP system implementations is typically a massive project for an enterprise and their failures leads to wastages of money and time; it is essential for the companies to proactively identify and mitigate the various risks associated with the implementation process.

II. Literature Review

There are several research papers are available in the literature to outline the critical success factors of ERP implementation [8]-[12]. Reference [13] compared successful and unsuccessful ERP implementation using case study methods. Ineffective strategic planning, poor communication and insufficient project team skills are some of the reasons for failures. The authors reasoned out that proper change management practices, proper stakeholder relationships and cultural readiness of the organization are key success factors for ERP implementation. Reference [14] highlighted business, technical and cultural issues of ERP implementation in Rolls Royce. It outlined the need for business process reengineering (BPR), proper communication and change management techniques. The importance of training both for senior and end training, matching processes to the software configuration are outlined. Reference [15] suggested six factors which can lead to successful ERP implementation (1) project team structure, (2) implementation strategy, (3) database conversion strategy, (4) transition technique, (5) risk management strategy and (6) change management strategy. Inadequate BPR, inappropriate software selection, low level of top management commitment, low quality consultancy services are some of the ERP risk factors [16].

The top five risk factors such as inadequate ERP selection,

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ineffective strategic thinking and planning, ineffective project management techniques, bad managerial conduct and inadequate change management are outlined by the reference [17].

From the perspectives of the client-organization and that of the experts, reference [18] grouped the risks involved in ERP implementation. Six categories of risks related to organization, specialized skills, project management, system, user and technology were identified by them. There are several risk management processes are available in the literature. Some of the them are PMI [19], Standards Australia 1999 [20], SAFE methodology [21] and Risk diagnosing methods. Most of them are too general for ERP applications.

Though there are several studies available to manage risks in ERP project implementation, we still lack literatures on practically managing risks and uncertainties to effectively implement ERP project. Reference [22] provided a risk assessment methodology useful for product innovation and development value chain, which can be adapted for ERP projects. This paper proposes an overall ERP life cycle model and the same is used to explore various risks, categorize them per their sources, assesses those risks and their variability. This paper also examines a modified approach to risk assessment using Monte Carlo simulation for ERP implementation. Risk Assessment Table (RAT) was developed as risk assessment model and Monte Carlo simulation was used to assess the project value at risk and its uncertainty.

III. The Proposed ERP Implementation Life Cycle Model

The process of implementing ERP in any organization has several stages. It is starting with initiating the project, planning, development, Testing and Training, Review & Improve, Go-live and finally Sustain. The details of various phases are given below.

A. Phase 0: Initiate

This phase is about the getting approval for the ERP project. The initial documents such as project charter must be created in the beginning. The documents should address the goals, objectives, and deliverables of the project, the business reason for doing the project, initial project team, their roles and responsibilities, the investment details and the draft project plan. This project charter shall be approved by the project sponsor. The project manager can schedule a project kick-off meeting after approval.

B. Phase 1: Plan

This is the crucial stage in ERP implementation. Proper study and research must be undertaken within the organization considering internal and external environment, the project team should select the right ERP package of the organization meeting the current and future requirements. The user requirements, Business Process Reengineering (BPR) requirements, best practices requirements are to be completely laid out. Gap analysis ought to be performed to understand the current situation and future position of the organization. The hardware and infra requirements are to be laid out. Finally, the detailed project plan shall be prepared with timelines and cash flows.

C. Phase 2: Develop

This is the actual software development considering processes available in the organization. Some processes may require heavy customization, and some may call for full adaptation of the software vendor modules. The great deal efforts are necessary to integrate existing application and databases to the new software and hardware systems. The entire development requires functionality testing to ensure adequacy of the ERP systems.

D. Phase 3: Testing and Training

One of the major reason for ERP failure is that the installed products are not meeting the stakeholders' expectation and hence testing, and training has been mentioned as separate phase to provide more focus. It is the process of checking the quality of the product. The provides enough confidence that developed products are meeting the stakeholders and end user requirements. Structured training shall be given to the end users so that their feedback will be useful for improvements.

E. Phase 4: Feedback and Review

This phase is about collection of feedback from various users and reviewing their requirements and making changes if required. This phase will also helpful for evaluating the deployment plan and the project team can finalize deployment method.

F. Phase 5: Go-Live

The "big bang" and "phased methods" are used for introducing new system to the organization. Each of this method has their own pros and cons. The project team should select the best strategies for actual implementation. Post implementation re-review shall be undertaken after the go live. Subsequently, the project team can hand over the project to the support team. The project team can also initiate the actions for project closure.

G. Phase 6: Sustain

Activities like bug fixing and enhancements are to be carried out in this phase. Effort shall also be made to derive maximum values from the ERP system.

The complete ERP implementation life-cycle are mentioned the Fig. 1. Fig. 2 provides the details on efforts needed by the project team during various phases of ERP implementation life cycle.

Fig. 1. ERP implementation life cycle framework.

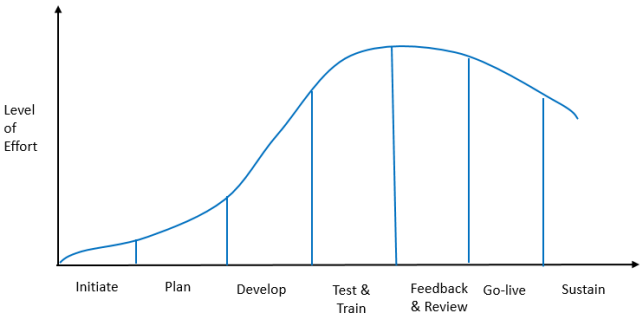

Fig. 2 ERP implementation life cycle – effort graph.

IV. The Proposed Risk Assessment Methodology for ERP Implementation

ERP implementation and risk are tightly linked; both are infinite in their variety and result that their combination usually defies accurate description. The environment in which the conception and development of ERP project takes place is complex and involves several phases as described in the project implementation life cycle. Hence, systematic risk assessment methodology is essential for any ERP implementation project. The proposed risk assessment method helps to identify risks associating in implementing ERP through all the seven phases of ERP. The companies could focus their effort in important delivery system aspects, so that the ERP value delivered as intended.

The risk assessment method mentioned in reference [22] was suitably modified for ERP implementation projects to arrive at various phases and steps. The proposed method consists of two phases. The Phase A is about development of Risk Assessment Table and Phase B is about Monte Carlo Simulation to handle uncertainties in risk sources.

TABLE I: Sources of Risks and Their Failures Modes

Risk Sources	Failure initating Events/Actions/Conditions
Strategic Sources	No clear goals and objectives
	Poor ERP implementation strategy
	Wrong team formation (Client, vendor etc.)
	Lack of champion
Organizational/Management	Poor cultural readiness
	Poor organizational maturity level
	Retension of key employees
	Inadquate communication system
	Inadequate training
	Failure to convince key users
	Lack of coordination
	Bad managerial conduct
	Poor planning
Technology Sources	Not good technical infrastructure
	Issues of data migration and analysis
	Wrong package selection
	Poor system architecture
	Poor legacy system management
Processes Related	No change management process
	No risk management process
	Inadequate communication
	Inadequate new process education and training
	Poorly implemented BPR
	Lack of process streamlining
Project Management	Inadequate budget
	Inadequate timing
	Poor project creep management
	Inadquate risk management
	Cash flow issues
	No proper investment analysis
	Ineffective PM techniques
People (internal)	Commitment issues with leadership team
	Poor leadership
	Lack of internal experts both in internal processes and technology
	Failure to mix both internal and external experts
	Workforce resistance to change
	User insecurity
People (external)	Ineffective consulting services
	Lack of comittment
	Incomplete development
	Poor capture of "as-is" process
	Lack of technical expertise
	Poor post-implementation support
	Poor understanding of needs and wants
	Development errors
	Too many contractors/subcontractors

TABLE II: EXPECTED VALUE @ RISK (%)

Risk Sources	Failure initating Events/Actions/Conditions	Effect(s)	Likelihood	Impact on Project Value (%)	Current Controls ineffectiveness	Expected Value @ Risk (%)
Strategic	No clear goals and objectives	Loosing competive advantage, Hampered growth, No integrated info, Poor quality reporting, Poor data quality, Poor CRM, Reduced business analytics, Poor supply chain, Ineffective regularotory compliance, Inefficient workflow, Higher cost of operation, Poor visibility on organization performance, Redundancy in work, Poor customer satisfaction.	0.25	0.8	0.8	0.16
	Poor ERP implementation strategy					
	Wrong team formation (Client, vendor etc.)					
	Lack of champion					
Organizational/Management	Poor cultural readiness		0.35	0.5	0.6	0.105
	Poor organizational maturity level					
	Retension of key employees					
	Inadquate communication system					
	Inadequate training					
	Failure to convince key users					
	Lack of coordination					
	Bad managerial conduct					
	Poor planning					
Technology	Not good technical infrastructure		0.2	0.4	0.35	0.028
	Issues of data migration and analysis					
	Wrong package selection					
	Poor system architecture					
	Poor legacy system management					
Processes	No change management process		0.3	0.3	0.3	0.027
	No risk management process					
	Inadequate communication					
	Inadequate new process education and training					
	Poorly implemented BPR					
	Lack of process streamlining					
Project Management	Inadequate budget		0.4	0.25	0.5	0.05
	Inadequate timing					
	Poor project creep management					
	Inadquate risk management					
	Cash flow issues					
	No proper investment analysis					
	Ineffective PM techniques					
People (internal)	Commitment issues with leadership team		0.4	0.6	0.5	0.12
	Poor leadership					
	Lack of internal experts both in internal processes and technology					
	Failure to mix both internal and external experts					
	Workforce resistance to change					
	User insecurity					
People (external)	Ineffective consulting services		0.3	0.4	0.4	0.048
	Lack of comittment					
	Incomplete development					
	Poor capture of "as-is" process					
	Lack of technical expertise					
	Poor post-implementation support					
	Poor understanding of needs and wants					
	Development errors					
	Too many contractors/subcontractors					

TABLE III: EXPECTED VALUE @ RISK (%) WITH DISTRIBUTION PARAMETERS FOR MONTE CARLO SIMULATION

					BetaPERT Distribution Parameters			
Risk Sources	Likelihood (%)	Impact on Project Value (%)	Current Control Ineffectiveness (%)	Expected Value @ Risk (%)	Most likely Value @ Risk (%)	Best Case	Worst Case	Simulated Sample Value (%)
Strategic Sources	25.0%	80.0%	80.0%	16.00%	16.00%	10.00%	25.00%	16.50%
Organizational/Management	35.0%	50.0%	60.0%	10.50%	10.50%	5.00%	15.00%	10.33%
Technology	20.0%	40.0%	35.0%	2.80%	2.80%	2.00%	4.00%	2.87%
Processes	30.0%	30.0%	30.0%	2.70%	2.70%	1.00%	4.00%	2.63%
Project Management	40.0%	25.0%	50.0%	5.00%	5.00%	4.00%	9.00%	5.50%
People (internal)	40.0%	60.0%	50.0%	12.00%	12.00%	8.00%	15.00%	11.83%
People (external)	30.0%	40.0%	40.0%	4.80%	4.80%	2.00%	6.00%	4.53%
Total Project Value @ Risk (%)					53.80%			54.20%
					Single Point Estimate			Simulated Sample Estimate

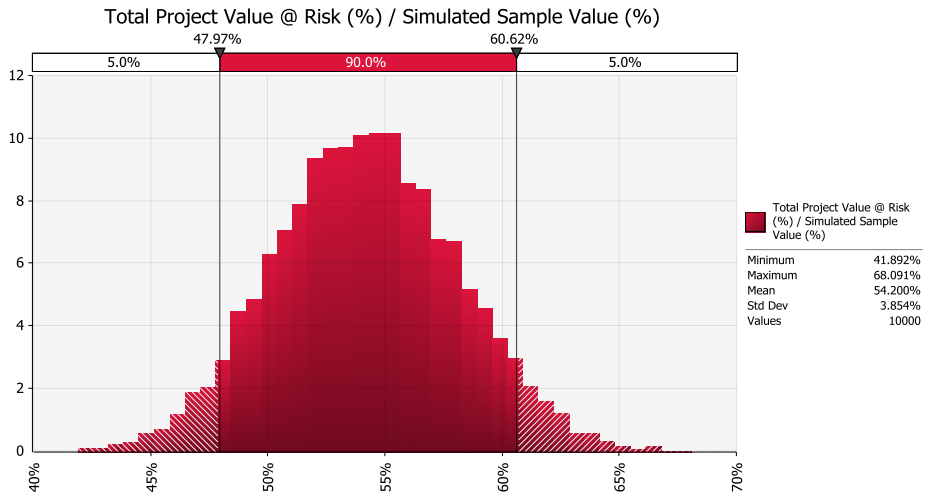

Fig. 3. ERP project value at risk (%) – normal distribution.

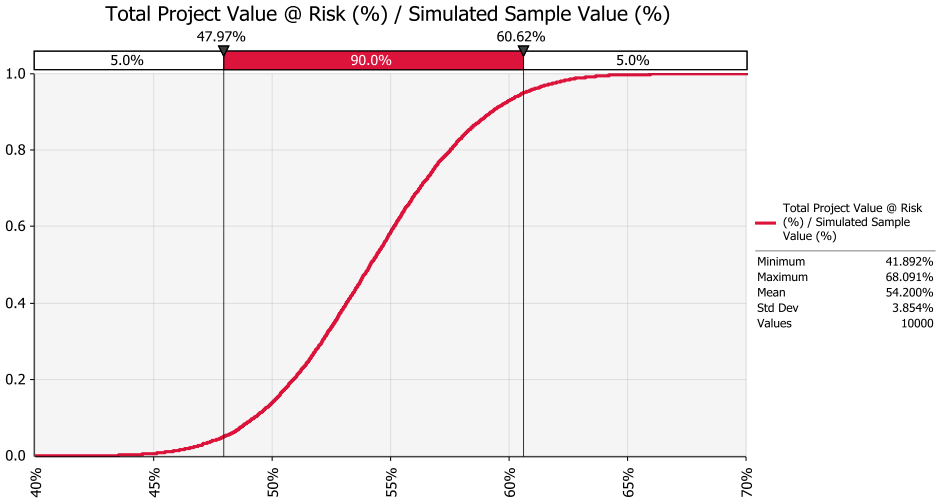

Fig. 4. ERP project value at risk (%) – pareto graph.

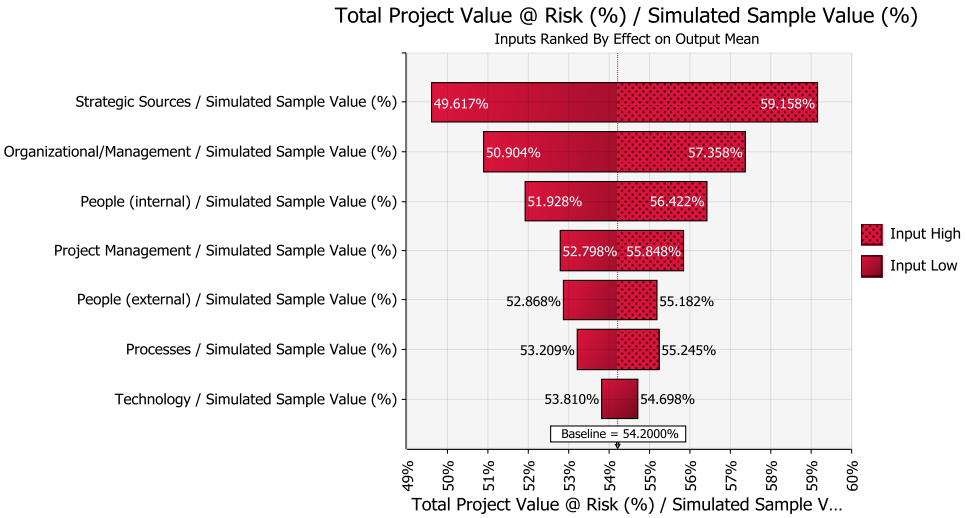

Fig. 5. Sensitivity analysis of various risk sources – tornado diagram.

A. Development of Risk Assessment Table

In this method, Risk Assessment Table (RAT) which is basically a modified Failure Modes and Effect Analysis (FMEA) for assessing the risks in delivering ERP value. This RAT provides opportunity to estimate overall risk value of entire ERP project. The following steps were adopted for risk assessment.

1. Determine Risk Sources Categories: Identification of risk sources provides a basis for systematically examining the situation and ability of ERP project to meets its objectives. The risk sources are both internal and external to the project. Establishing categories for risk sources provides a mechanism for collecting and organizing risks.

2. Identify potential risk events and actions: Sit down and

create a list of every possible risk event and opportunity you can think of. If you only focus on the threats, you could miss out the chance to deliver unexpected value to the customer or client. Ask your team to help you brainstorm during the project planning process, since they might see possibilities that you do not.

3. Determine causes: By asking several "whys" (Five Whys) repeatedly will lead to root causes (deficiency or sources of variability) of risk events and actions.

4. Determine the Effects (consequences) of each risk event if it happens.

5. Determine likelihood: What are the chances a certain risk will occur? Rate each risk with the probability from zero to one.

6. Determine current control: What are the exiting control mechanism is in place to minimize the impact of risk if it happens? Rate each control with probability from zero to one.

7. Determine impact on project value (%): What would happen if each risk occurred? Would your final delivery date get pushed back? Would you go over budget? Identify which risks have the biggest effect on your ERP project's outcomes and estimate them in terms of monitory value and calculate percentage value affecting.

8. Calculate Percentage Value @ Risk: It is the multiplication of risk sources likelihood, impact of project value percentage and current control.

The RAT will help the organization in recommending corrective actions for overall implementation of ERP. The various sources of risks and their failure initiating events or actions for the case study are given in Table I. The excel model of the RAT method is given in Table II. As per the methodology, Value @ Risk (%) guides the organization for better understand their ERP implementation risks and providing scope for corrective action to implement ERP without scarifying its value. The case study detailed in this research to demonstrate the usefulness of this approach.

B. Monte Carlo Simulation

The project managers should find ways to handle uncertainties in project risk sources for successful completion of ERP project. The major constraints of ERP project are cost, schedule, scope and quality. All constraints will have impact on value of project. Monte Carlo approaches are very useful in determining impact of identified risks by running simulation over possible range of outcomes. A random sampling performed by using uncertain risk variable inputs to generate the range of outcomes with confidence measure for each outcome. A mathematical model is used for connecting input risk variable with that of output variable (in our example the entire project value at risk). This will help to prioritize various risk sources and to make informed decisions on project. The following steps were adopted for Monte Carlo Simulation.

1. Identify the project input risk variables

2. Establish output variables (in our case it is Value @ Risk; obtained through multiplying likelihood of occurring, impact on project value by that variable and current control)

3. Establish relationship for the correlated variables (if any)

4. Establish mathematical model connecting inputs and outputs. In our case, betaPERT distribution was used to model variations in input variables because of uncertainties. (The betaPERT distribution is a continuous distribution. It describes a situation where you know the minimum, maximum, and most likely values to occur. It is useful with limited data. It is like the triangular distribution, except the curve is smoothed to reduce the importance of peak. The betaPERT distribution is often used in project management models to estimate task and project durations. The parameters of the distribution are Minimum, Most Likely, Maximum).

5. Perform simulation runs for the identified variables and the correlations

6. Statistically analyze the results of the simulation run.

The steps 1 and 2 for the below mentioned case study are given in Table I and II. Steps 3 to 6 are given in the Table III. The simulation was carried out using the software package @Risk. The statistical results of simulation of the case study are given in Fig. 3 to 5.

V. Case Study: ERP Implementation in A Home Appliances Manufacturing Company

The majority risk assessment methods address the financial aspects and does not include other aspects of value delivery. The implementation of Risk Assessment Table (RAT) was provided in the Fig. 3 which helps to analyze risk in all aspects. Value @ Risk (%) numbers were developed for the ERP implementation (refer simulation step 2). The simulation results are available in Fig. 3 to 5.

The sensitivity analysis of various risk sources is provided in the Fig. 5. From this analysis, it is evident that company must work on strategic sources, organization/management sources and people internal sources on ERP implementation to minimize risk. The approach mentioned in this paper is useful for industries who want ensure success in ERP implementation.

VI. Results and Discussion

There were 7 risk sources identified for this case study. They are strategic, organizational/management, technology, processes related, project management, people (internal) and people (external). 46 failure initiating events and actions were brainstormed. This, almost exhaustive list is provided in the Table I and II. Based on experts' opinion, the Value @ Risk for each of the risk sources were estimated. For example, the strategy risk source, the value @ risk was estimated as 16% (refer Table III) which was estimated from Table II. BetaPERT distribution describes the situation where expert judgements are used to model variability in the input variables (in our case Value @ Risk for various risk sources). It is a continuous distribution using minimum, maximum, and most likely values for Value @ Risk. For strategy risks, most likely value at risk is 16%, best case is 10% and the worst case is 25%. This means any risk event in strategy category happens the value generated by this ERP project will reduce by 16% (most likely), the best-case value reduction is 10% and worst-case value reduction is

25%. Hence, the value at risk is having variability 10 % to 25%. Monte Carlo simulation was applied for this range to determine its uncertainty as per betaPERT. One sampled value of simulation is 16.5%. Likewise, the simulation was carried with random sample of 10000 for each the 7 risk sources; and based on their relationship the final simulation statistics were derived. These statistics are provided in the Fig. 3. For this project, the total project Value @ Risk is coming as 54.2% with the standard deviation of 3.854, minimum value as 41.892% and maximum value as 68.091% with 90% confidence.

Fig. 4 Pareto plot also indicates that 54.2% of value of project is under risk because of various sources. As per chart, the value at risk cannot exceed 60.62% at 90% confidence level. This shall be interpreted as the value of project will come down by 60.62% (at 90% confidence level) if the risk events happen and response actions are not implemented. Tornado diagram (Fig. 5) is useful for deterministic sensitivity analysis - comparing the relative importance of variables. For each variable/uncertainty considered, you will need estimates for what the low, base, and high outcomes would be. The sensitive variable was modeled as uncertain value while all other variables was held at baseline values (stable). This allows us to test the sensitivity/risk associated with one uncertainty/variable. For example, strategy risk source can increase Value @ Risk of the project from 49.6% to 59.16%. As per Tornado diagram, Strategy, Organizational/Management, and People (internal) are important sources of risks (having very high-risk value). For this ERP project, the Value @ Risk is very high and hence response actions should be placed appropriately to minimize project Value @ Risk. This practical risk assessment methodology was proved as one of the best method to estimate value at risk for any ERP implementation project. Monte Carlo simulation methodology using betaPERT distribution was found to be very effective in handling uncertainties associated with risk events.

VII. Conclusion

Risk assessment study conducted for the ERP implementation project generates proactive solutions for managing different sources of risks associated with ERP project effectively. Any company can also use these methodologies to find out their weaknesses in their ERP project implementation. This will help organizations to develop necessary learning and increase their capabilities, which lead to project success.

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G. Thangamani is working as an associate professor in Indian Institute of Management Kozhikode, India. He obtained his Ph.D. from IIT Madras and his thesis is entitled "Models for Assessment of Reliability Measures for Complex Systems". He earned his bachelor's degree in mechanical engineering with honours for scholastics achievements and did his M.E in industrial engineering from Anna University, Chennai. He started his career as a faculty in Pondicherry Engineering College, Pondicherry and worked for 4 years. Later, he was associated with some of the best companies in the world such as Whirlpool and GE for more than 13 years. His research interests are in complex system reliability prediction, business process modeling, analysis & reengineering, six sigma, lean approaches in manufacturing, service systems, product innovation and technology management and risk assessment. He has several publications in international journals and conferences.