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An Assessment of Factors Affecting Erp Implementation: A Systemic View

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Abstract*: *The emergence of globalization and economic liberalization has paved a new path to global industrial scenario. The impact of globalization and economic liberalization resulted in a paradigm shift in the way of carrying out business. Industries worldwide are coming up with modern tools and techniques to face the global competition and the pressure of gaining success is increasing as never before. Enterprise Resource Planning (ERP) was one such tool which emerged in the era of globalization, it plays a vital role in improving the performance of the firm at large and in yielding long term benefits which are essentials for any firm to sustain and prosper. ERP results in providing a central database wherein the data can be accessed, updated and automated. The data redundancy is eliminated which results in saving time and money. This paper focuses on building a System Dynamic model of ERP implementation management with special reference to manufacturing and service industries of North-Karnataka. This System Dynamic model is based on the results of Factor Analysis and causal loops obtained from Structural Equation Modeling. The contour plots obtained for different parameters assists managers of implementing firms in decision making which in turn lead to ERP implementation success. This system dynamic model so developed assists the managers in policy planning and in taking appropriate measures to overcome the hurdles and for hassle- free implementation of ERP at large.

Index Terms*: *Globalization, Enterprise Resource Planning, System Dynamics, Structural Equation Modeling

I. INTRODUCTION

Industries around the world are facing the challenges of globalization which is literally insisting the industries to meet the global standards. The growing customer expectations, expanding markets and severe competition have pressurized the industries to stay updated with the global scenario in terms of technology, tools and techniques so as to gear up and stay ahead of others. In addition to 5M's man, money, material, machine and method, one more element playing a significant role in the modern technological era is 'Information'. Industries have repository data with them to deal with their day to day transactions, often in the fragmented mode. The challenge exists in converting this fragmented mode of data in the integrated form, in the form of a central database and in automating the same. The conversion of the fragmented data into a central database which covers all the functions of the organization and automation of the processes is performed by Enterprise Resource Planning (ERP).

Legacy systems that were used by the firms earlier maintained the database of each function separately and therefore lacked in integration. They did not possess a central database which would refer to organization database at large. This inconsistency was overcome by ERP which resulted not only in providing a central database by integrating the databases of all individual functions of the firm but also performed the automation of the processes.

Liping and Stefan (2009) [1] defines ERP as a highly integrated information system to manage all aspects of business operation that includes purchasing, sales, marketing, distribution, manufacturing, design, production, accounting and customer service etc. Kwasi (2007) [2] defined ERP as the programs that aim to provide single integrated software to hard multiple corporate functions including finance, human resources, manufacturing, materials management and sales and distribution. Carl and Lessing (2005)[3] defined ERP as a packaged business software systems that allows an organization automate and integrate its business process, share common data and practices across the enterprise and produce and access information in real time environment.
Originally ERP systems were implemented only by large scale organizations due to complexity involved in their business and the scope. Later on, Small and Medium size Enterprises (SME) started implementing these systems and took part in the trend. ERP systems, if implemented aptly yield long term benefits and improve the overall performance of the organization. Post-globalization era marked the beginning of emergence of several tools and techniques, ERP is one among them. One cannot ignore the fact that ERP implementations yield long term benefits to the implementing organization such as performance improvement, profit, productivity and customer satisfaction. Therefore it is vital for the firm to focus on these factors and to develop suitable strategy to take care of the obstacles that hinder the ERP project. The current business situation in India is going through a challenging phase and strategic management of ERP implementation is the need of the hour. There are various issues and challenges associated with ERP implementation, several projects run out of budget, schedule and resources which are a major concern. Enterprise-wide commitment is a major requirement for ERP project to succeed.

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Zhang (2002) [4] reported that ERP projects, on an average 17.8% run out of budget and 2.5 times longer than the intended schedule and delivers 30% of the promised benefits. Nede and Govinda (2013) [5] conducted a study to identify the issues and challenges associated with ERP implementation. The results of which reveal that unrealistic expectation of benefits and Return on Investment (ROI), minimal support from vendors and consultants, data transfer errors, poor project management and lack of top management support led to the failure of ERP project. Therefore organizations implementing ERP need to have a proper understanding of problems and challenges that might arise during ERP implementation. The implementing firms need to come up with appropriate strategies for successful ERP implementation to reap the benefits of ERP. ERP implementation if implemented with proper pre-planning leads to improvement in the performance of the organization and yield long term benefits which are essentials for any organization to prosper.

II. OBJECTIVES

The main objective of this paper is to develop system dynamic model which is based on results of factor analysis and causal loop of structural equation modeling. The system dynamic model so developed will facilitate the ERP consultants and managers to make better decisions of different aspects of ERP implementation project at large because of simulation facilities provided by system dynamic software.

III. METHODOLOGY

- Extensive literature and content analysis of various journals, websites of ERP consultants and books was carried out in order to identify the dimensions related to ERP implementation.
- An instrument (Questionnaire) was developed based on literature survey and personal discussions with consultants and project managers and this questionnaire was refined to improve the clarity with respect to length, format as well as clarity of instructions.
- Questionnaire survey was carried out among the manufacturing and service industries of North-Karnataka that have implemented ERP in their firms.
- Factor Analysis was carried out to summarize these large variables into smaller set of representative desired variables, Factor Analysis resulted in seven factors and these factors were found affect ERP implementation project.
- Structural Equation Modeling (SEM) was performed to establish the causal relationships among the factors obtained from Factor Analysis.
- A System Dynamics (SD) model was built based on the causal loops obtained from Structural Equation Modeling

IV. RESULTS AND DISCUSSIONS

Efficient management of ERP implementation needs to be perceived by providing importance to all the factors; its interaction with each other that assist in, scientifically establishing the cause- effect analysis to govern the ERP project progress. These will form the basis for organization to be competitive in the current global industrial scenario. It is crucial to develop policies for appropriate management of ERP implementation that provides a helping hand in improving the competitiveness of manufacturing and service industries of North- Karnataka region.

The characteristics of ERP implementation system are complex in nature. They are frequently changing, the actors in the system are firmly coupled, and they intermingle strongly with one another and with environment. Everything is connected to everything else, nonlinearity effect is rarely proportional to cause, and numerous factors interact in decision-making. The dynamics of systems arise impulsively from their internal structure. They are adaptive and evolving in nature and are characterized by tradeoffs. These characteristics can be determined by using System Dynamics. System Dynamics is a methodology applied for understanding the behaviour of complex systems over time. It comprises feedback loops along time delays that influence the behaviour of the complete system. System dynamics differ from other approaches in that it makes use of cause and effect diagrams and feedback loops besides the stock and flow diagram.

J.W Forrester, (1958 [6]) defined System Dynamics as computer-aided approach for solving complex problems with a focus on policy analysis and design. Richardson, (1996 [7]) pointed out that basis of System Dynamics is that dynamic behaviours are closely linked to an underlying structure of feedback loops. Moreover, in order to get improved understandings concerning linkages between behaviour and structure, a computer model is required because the human mind does not have the capacity to manage the behaviour of these complex structures (Forester, 1971 [8]). Hence, a system dynamics computer model is the consequence of an iterative process of comparing and contrasting a set of assumptions concerning the system structure and the known behaviors of the same.

A. A System Dynamic approach to ERP implementation

ERP implementation projects are of complex nature and they fit in to the class of high-order, nonlinear, feedback systems. The character of the dynamic feedback structure of these systems has a tendency to challenge the intuitive decisions. A number of parameters are vague in nature. The mental models used are often logically incomplete. The realities are relatively different from that of the mental model expectations because of ambiguous indirect causalities, which simple mental models cannot capture. Therefore, complexity of system dynamics often surpasses the cognitive capability of the human brain and responds to dynamic complexity. It is clear from above discussions that, features vital for ERP implementation management can be mapped to different modules undertaken as an independent study.

Our systemic view of ERP implementation management, models it as an integrated approach.
The vital factors involved in the ERP implementation management are developed from the perceptions of the stakeholders through factor analysis. The motivation behind stakeholder management was to try to construct a framework that is responsive to the concerns of professoriate that are responsive to advancements in technology as well as environmental variations. Stakeholder management was used to supplement management's comprehension of the strategic alternatives they can produce. From the above standpoint, a questionnaire survey was carried out among firms of North-Karnataka that have implemented ERP and are in the process of implementation of ERP. Factor analysis was deployed on the data collected, using SPSS software. From factor analysis seven factors were evolved. These factors are named as latent variables in Structural Equation Modeling (SEM), which are defined by a set of measurable variables. Causalities among these latent variables were established through structural equation modeling using AMOS 20 software. The figure 1 demonstrates the integrated causal diagram.

B. Model Description

Identification of the vital factors affecting the ERP implementation guides us to understand the underlying relationships between same. The factors obtained through factor analysis brings to fore the critical parameters supporting the ERP implementation management. The seven factors evolved from stakeholders perspectives are: Risk management, Project management, Pre-implementation planning, External support, Post-implementation support, Organization culture and Assessment of resources and schedule. Structural equation model was developed using AMOS 20, to determine the causalities among the factors obtained from factor analysis. Specification search was carried out on various competing models developed and best-validated model was used to authenticate the causalities. The causal relationships obtained from SEM, mainly signify the conceptual relationships developed and denote other relationships, which otherwise were ambiguous. The causalities arrived at are represented in figure 1.

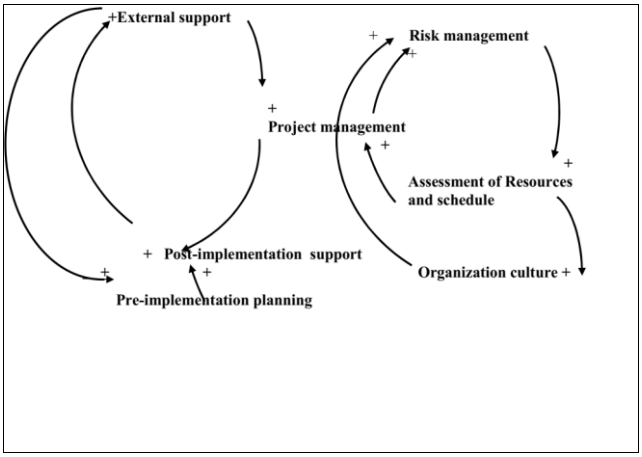

Fig. 1 Causal loop of ERP implementation management system

C. A System Dynamic model of ERP implementation

The causal loop diagram shown in the figure 1 was used to construct the flow diagram of ERP implementation management and is shown in figure 2.

The flow diagram consists of four level variables namely, Pre-Implementation Planning (PIP), Organization Culture (OC), Post-Implementation Support (PIS), and External Support (ES). The auxiliary variables are employed for each variable and they carry the values obtained from the factor analysis. The arrows indicate the direction of impact of one factor over the other.

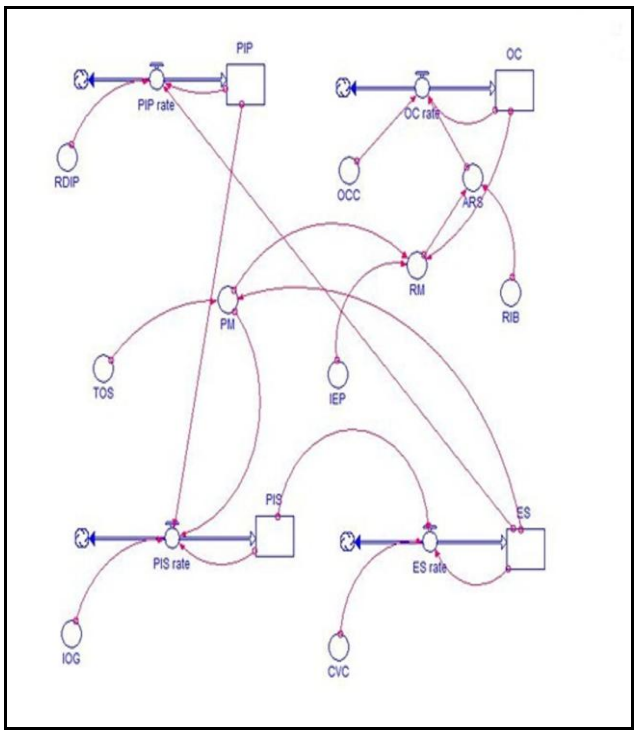

Fig. 2 Flow diagram for ERP implementation management in manufacturing and service industries of North-Karnataka.

The dynamic nature of different factors, affecting ERP implementation is explained below. The nomenclature used in the model is show in the table 1.

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Table 1 Nomenclature of variables and others used in the model

Sl. No.	Label used for variable	Name of the variable/ Description	Significance
Level Variables			
1	PIP	Pre-Implementation Planning	Includes those activities performed prior to implementation and bears an impact on the project.
2.	OC	Organization Culture	Defined in terms of the way people think, behave and practice and is crucial for the success of the project.
3.	PIS	Post-Implementation Support	Comprises of the activities that take place once implementation gets over. It includes refresher training, setting up of user help desk.
4.	ES	External Support	Signifies the support of consultants and vendors during and after implementation.
Auxiliary Variables			
1.	PM	Project Management	Includes of activities such as monitoring and evaluation of project.
2.	ARS	Assessment of Resources and Schedule	Resources in the form of software and hardware, budget and schedule are essentials of the project
3.	RM	Risk Management	Involves identification, prioritization, quantification and assessment of risks.
4.	RDIP	Requirements Definition and Identification of Project manager	Describes the requirements of the firm, selection of project manager to plan the schedule and other aspects of the project.
5.	OCC	Organization Culture conducive to Change	Culture that supports the change fosters the project at large.
6.	IOG	Identification of gaps	Indicates the gap between the ERP and the present system. Closing the gap is crucial for reducing future contingencies.
7.	CVC	Competence and Experience of Vendor and Consultant	Deploying experienced and competent consultants and Vendors result in hassle free implementation.
8.	TOS	Training on the new System	Training on the ERP package reduces the user's resistance to change and other complications in the project.
9.	RIB	Resources in the form of budget and infrastructure	Appropriate budget planning is crucial for project success.
10.	IEP	Investment on ERP Package	Package that matches the organization needs must be selected to avoid cost over runs.

Pre-Implementation Planning (PIP)

Pre-Implementation Planning includes the activities carried out before implementation. It involves activities such as conduction of feasibility study, requirements definition, selection of appropriate ERP package, decision on number of modules to be implemented and project planning. If these activities are planned thoroughly then ERP implementation can run smoothly. Feasibility study helps to understand the likelihood of the execution of the project. The project planning is initiated in the pre-implementation planning phase.Planning generally refers to a process, not an event, whereas changes are instituted in organizations, therefore, it is taken as a level variable. Requirement definition and identification of project manager is taken as surrogate variable. Pre-implementation planning requires the input and support from consultants and vendors and is known as external support.

PIP (t) = PIP (t - dt) + (PIP rate) * dt

INIT PIP = 0.2

PIP rate = (1-PIP)*RDIP*ES

Organization Culture (OC)

ERP implementation projects demand change management with respect to employee attitude, process and technology. Firms implementing ERP should be flexible enough to incorporate the changes to become accustomed to the new system. Organization culture plays a vital task in ERP projects as the project involves changes to be made in different aspects of the organization. Organization culture conducive for change is taken as surrogate variable. Assessment of resources and schedule influences organization culture because accurate assessment of these aspects reduces the complications of the project and improves the employee acceptance of ERP, thereby reduces user's resistance to change.

OC (t) = OC (t - dt) + (OC rate) * dt
INIT OC = 0.5
OC rate = (1-OC)*OCC*ARS

Post-Implementation Support (PIS)

Post-Implementation Support refers to the activities that are performed once the implementation gets over. It includes activities such as setting up of problem resolution mechanism and user help desk, evaluating the effectiveness of the existing system, gap analysis, identifying the areas of improvement and reporting the findings. Post-implementation support is crucial for overall success of the projects and to realize the benefits of the new system.

Identification of gaps is taken as surrogate variable. Post-implementation support can only be executed successfully only if pre-implementation planning and project management are carried out judiciously.

PIS (t) = PIS (t - dt) + (PIS rate) * dt
INIT PIS = 0.2
PIS rate = (1-PIS)*IOG*PIP*PM

External Support (ES)

External Support signifies the support extended by the people external to the organization namely consultants and vendors. Their support is needed throughout the implementation right from start to end of the implementation i.e. from requirement analysis to maintenance and up gradation. Consultants play a significant role in implementation process by performing requirement analysis, selection of package, customization and business process reengineering. External support plays a vital role in achieving the project success.

Competence and experience of vendor and consultant is taken as surrogate variable.

ES (t) = ES (t - dt) + (ES rate) * dt
INIT ES = 0.3
ES rate = (1-ES)*CVC*PIS

Project Management (PM)

Project Management forms vital part of ERP implementation. It consist of the activities such as supplying the project deliverables, monitoring and evaluation of the project, taking corrective actions as and when required, developing contingency plans. It monitors overall progress of the project, establishes the project schedule and provides the training and resources required as a part and parcel of the project.

Project management requires input from external sources such as consultants and vendors for successful execution of project plans.

PM = ES* TOS

Assessment of Resources and Schedule (ARS)

Accurate assessment of resources and schedule is a prime requirement for any project to thrive, so is the case with ERP implementation. Resources in the form of hardware, software, infrastructure, budget and human resource are essentials of ERP project. The assessment of project schedule is vital as many of the projects have reported of schedule overruns. Appropriate assessment of resources and schedule avoids budget and schedule overruns.

Resource in the form of infrastructure and budget are taken as surrogate variable. Accurate assessment of resources and schedule is influenced by risk management, well planned and executed risk management leads to accurate assessment of resources and schedule.

ARS = RIB* RM

Risk Management (RM)

Risk Management is crucial for any projects to handle the risks that come across throughout the life span of the project. ERP implementation is not free from the risk and needs appropriate risk management in its place to handle the implementation risks. Risk management involves identification, analysis and managing the risk factors associated with the project. It involves the avoidance of the risk by getting rid of its cause, mitigation of the risk by reducing the possibility of its occurrence and developing contingency plans to handle the risk. The sources of risk depend on nature and complexity of the project. Some of the sources of risks associated with ERP implementation reported from different studies are lack of top management, users resistance to change, poor comprehension of the new system, lack of change management, unrealistic schedule etc.

Investment on ERP package is taken as surrogate variable. Risk management is influenced by project management and organization culture because a well articulated project management and organization fosters risk management.

RM = IEP* OC*PM

Model simulation

System dynamics model developed for ERP implementation management was simulated using a system dynamics modeling package “STELLA”.

Base Run

The base run indicates the current position of ERP implementation in terms of the values attained from factor analysis. The variable having maximum factor loading is considered as the representative of the remaining variables of that factor. This representative variable is known as surrogated variable (Hair et.al., 2010, [8]). The value of the surrogated variable is considered for the analysis.

The base run is taken, maintaining all the parameters at the measured values. The model was simulated for 20 years to understand the impact of each factor on ERP implementation. Dynamic analysis of these variables will support in better understanding of ERP implementation management. The parameters of base run are shown in table 2.

Discussions on base run results

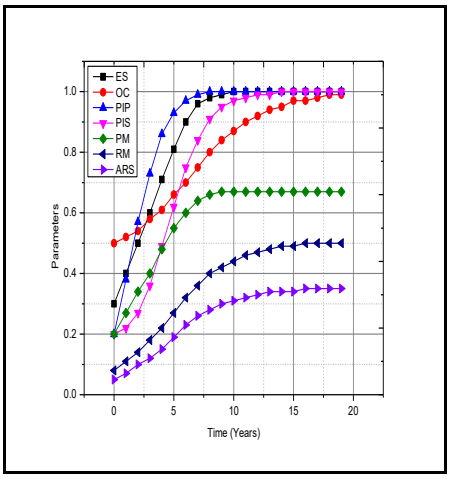

Fig. 3 Behaviour of ES, OC, PIP, PIS, PM, RM and ARS with time

Figure 3 shows the results of the base run and some of the important results are as follows:

1. To arrive at an External support (ES) of around 1 it takes 10 years.
2. In 18 years Organization culture (OC) will attain a value of 0.99.
3. To attain Post-implementation support of (PIS) of 1, it will take 14 years.
4. To achieve an Assessment of resources and schedule (ARS) of 0.35, it will take around 16 years.
5. To attain a Project Management (PM) of 0.67 it will take 9 years.
6. Pre-implementation planning (PIP) reaches a value of 1 in 8 years.

Table 2: Parameters of the Base run

Sl. No.	Factor	Input(surrogate variable)	Value(obtained from survey)
1	Pre-Implementation Planning	Requirements Definition and Identification of Project manager	0.76
2	Post-Implementation Support	Identification of Gaps	0.65
3	External Support	Competence and Experience of Vendor and Consultant	0.74
4	Organization Culture	Organization culture conducive to change	0.71
5	Project Management	Training on the new system	0.67
6	Assessment of Resources and Schedule	Resources in the form of budget and infrastructure	0.7
7	Risk Management	Investment on ERP package	0.76

Behaviour as a result of interacting factors

The impact of one parameter (over another parameter) is carried out. The impact of external support (ES), pre-implementation planning (PIP) and organization culture (OC) on others is shown in figure 4(a), 4(b) and 4(c) respectively. For a change in external support from 0.3 to1, post-implementation support (PIS) changes from 0.2 to 1[figure 4(a)]. Similarly, for a change in pre-implementation planning (PIP) from 0.2 to 1, organization culture changes from 0.5 to 0.99 [figure 4(b)]. Same is the case with all other parameters. The main difficulty in this type of graphs is that the time dimension is masked i.e. the time taken to reach these values cannot be observed. Graphs 4(a), 4(b) and 4(c) illustrate the interaction among the factors.

To enhance the understanding of the results, the following types of graphs are included:

1. Variation of all the factors against time
2. Variation of different parameters with regard to another common parameter.
3. Contour plots for three parameter variation

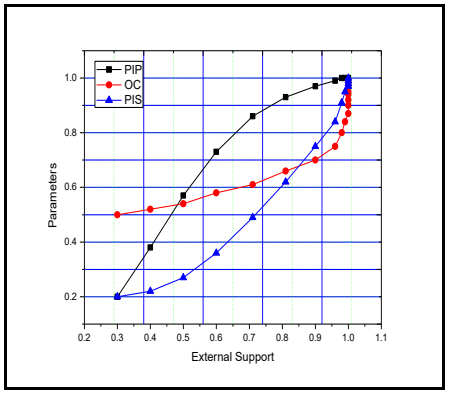

Fig. 4(a) Interaction among the factors

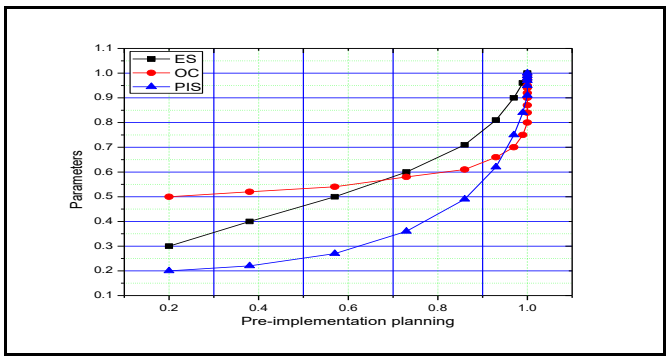

Fig. 4(b) Interaction among the factors

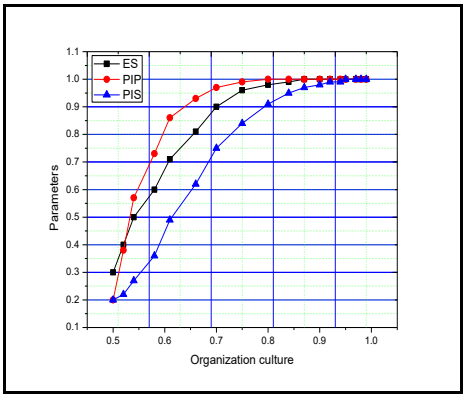

Fig. 4(c) Interaction among the factors

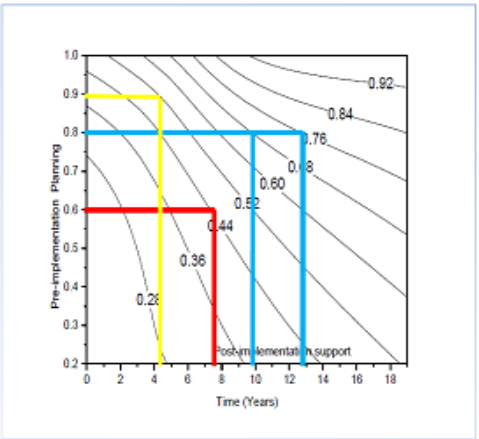

Fig. 5 Contours of 'PIP' with 'PIS' and time in the base run

Three-dimensional analysis is carried out to overcome the gap of the hidden time factor. The time is taken as the third dimension in this analysis. Three-dimensional plots are known as contour plots. A contour plot is principally a graphical technique used for representation of a three-dimensional surface by plotting constant *z* slices, called contours, on a Two-dimensional format. Explicitly, given a value for *z*, lines are drawn for connecting the (x, y) coordinates where that *z* value occurs. The contour plots give a better understanding of these factors where in the behaviour of these dimensions with respect to time as the third dimension is represented.

Figure 5 shows the contour plots of 'PIP' with 'PIS'' for the base run and some of the important observations made are:

1. As Pre-implementation planning (PIP) increases (0.1 to 1), Post-implementation support (PIS) factor also increases (from 0.28 to 0.92).
2. From the contour plot, for a specific value of Pre-implementation planning, the time taken to attain a specific Post-implementation support can be assessed.

Example: For a PIP of 0.6, PIS of 0.44 can be achieved in 7.5 years of time (Red lines).

3. With the same PIP, the time taken for higher PIS ishigher.

Example: With the PIP of 0.8 the time to achieve 0.68 PIS is 10 years and time to achieve 0.76 PIS is around 13 years (light blue colour).

The contour plots will also indicate the limiting values that could be attained and the span of the time required for the same.

Example: For the present scenario of the base run, PIS cannot reach beyond a value of 0.92 within a time span of 20 years i.e. the limiting value of RPF is 0.92 in 20 years time.

4. The contour plot also reveals that, for the base run conditions PIP cannot go beyond 1.0 and PIS beyond 0.92 cannot be reached.

For a constant PIS, time taken to reach it is less and less as PIP increases Example: For a PIS of 0.52, time taken to reach it at 0.4 PIP is 14 years, but the time taken to reach the same at 0.9 PIP, is 4 years. (Yellow lines).

V. Conclusions

ERP implementation is complex in nature and many parameters affect implementation process. With this point in view, a system dynamics model was built to understand the dynamic behaviour of parameters affecting ERP implementation management. Contour plots assist in examining methodologically the impact of one factor on the other over a time sphere. The contour plots help us to understand, the limiting values that can be accomplished with existing setup. They indicate the current status of ERP implementation in manufacturing and service industries and how it can be handled. It also presents a tool for the ERP implementation authorities to experiment the policy plans and predict the growth of ERP project before implementation.

This paper focused on highlighting the vital factors influencing ERP implementation from the stakeholder perspective and causalities among the factors was established. Data collected was subjected to Factor Analysis to evolve the factors affecting ERP implementation. Seven Factors evolved from Factor Analysis, these factors were vital for implementation of ERP. The causal relationships among the factors evolved from Factor Analysis were ascertained by Structural Equation Modeling and an overall causal loop was developed which ascertained the causal relationship among the factors evolved from Factor Analysis.

A System Dynamics model integrating the causalities was established to understand the dynamic behaviour of the system and it also allows the decision-makers to learn the mechanism of ERP implementation at large. The model was simulated for 20 years time period to exhibit different situations by varying the input values. The simulation graphs demonstrated the behaviour of the latent variables over the time duration. Contour plots were employed to further improve the understanding of these results. The distinctive characteristic of this analysis was that of the contour plots, they demonstrate the impact of one factor on the other over a time horizon. This allows the analyst to differentiate clearly the constraints of each strategy. This analysis was employed to identify the minimum value of driving factor to accomplish the objectives and therefore was valuable as decision support tool. The system dynamics model assists interactive simulation. It permits experimentation with different scenarios, and replicate the behaviour of the real system, there is no risk of disrupting it. This will definitely aid the ERP implementation authorities to probe changes to the system before implementing it in reality.

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