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An ISM Analysis of the Critical Success Factors in ERP Implementation

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Abstract. Enterprise Resource Planning (ERP) offers many benefits in aligning business operations. However, these implementations can be problematic and prone to failure. Critical success factors (CSF) which can improve the success rates of implementation have been researched and an interpretive structural modelling (ISM) was conducted to identify the interrelationships between factors. An ISM based model was created and this was achieved by completing the self-interaction matrix (SSIM), reachability matrix and level partitioning. This led to an ISM-based model being created followed by a cross-impact matrix multiplication (MICMAC) analysis to identify the factor's relative driving power and level of dependence. The project revealed that top management support was the strongest CSF with a high driving power and low dependence. In addition, fourteen other factors displayed strong driving power with high dependence. The findings from the project were summarized into a recommended framework for manufacturing organizations to follow to increase the likelihood of a successful ERP implementation.

Keywords. Enterprise resource planning, ERP systems, ISM, MICMAC.

1. Introduction

Enterprise Resource Planning (ERP) is defined as: '*a set of business applications or modules, which links various business units of an organisation such as financial, accounting, manufacturing, and human resources into a tightly integrated single system with a common platform for flow of information across the entire business*' [1]. Companies are turning to ERP systems in their businesses due to the benefits that they bring including reduction of inventory, reduction in staff and IT costs and benefits including improved data visibility across departments and multiple sites, internal process improvement, better customer service and strategy enhancements including acquisitions [2]. However, implementing an ERP system can be highly complex and a challenge to get right in terms of meeting all the needs of all stakeholders, and as a result a great percentage of implementation projects fail [2].

There are a number of factors that if handled properly, they can ensure the successful implementation of an ERP system. The list of critical success factors (CSFs) is long, including the lack of upper management involvement and commitment, the lack of experience, the miscalculation of the required resources, the politics within the organization, the various communication breakdowns, the lack of ownership, and the lack of end-user involvement. This list is not exhaustive, and a number of studies have been presented on CSF for ERP implementation.

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The aim of the present paper is to identify and prioritize these CSF and then investigate the relationships among them. For this reason, Interpretive Structural Modelling (ISM) technique is used for deducting a structured model of the relationships of these variables.Ccross-impact matrix multiplication (MICMAC) analysis complements this analysis for classifying these variables as per their driving and dependence power.

2. Critical Success Factors for Implementing ERP systems

A number of papers have presented the CSFs for implementing ERP systems. These are usually extracted through either thorough literature reviews, or surveys collecting data from practitioners. As mentioned in the introduction, the list of CSFs is relatively long. For the needs of the present study, a thorough literature review was conducted for identifying the CSFs. The filtering of the papers reviewed (using keywords such as “successful ERP implementation”, “Critical success factors for ERP implementation”, “ISM and critical success factors in ERP implementation” and “Interrelations of Critical success factors in ERP implementation”) ended up in eight research papers [3-10] deemed to be the most appropriate for such a study. These factors were then ranked in order of occurrences within each source (table 1) resulting in 20 CSFs.

Table 1. CSFs identified from thorough literature review

Critical Success factor	Number of occurrences	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
Project Management / Planning / KPIs	20		4	2	2	6	6		
Top Management support	17	1	4	1	1	4	4	1	1
Project team / skills levels / effectiveness	16		3	3	2	4	4		
External support – vendors / consultants	13		2		4	5	1	1	
Alignment of ERP with business strategy	12	1	3	1	1	4	1	1	
Understanding of business requirements	11		2	2		3	4		
User training	11	1	2		1	5	2		
Data quality	10	1	1		1	5	2		
User involvement	10		1	1		6		1	1
Change Management	9	1	2		1	2	3		
Internal communications / silos	9		4		1	1	1	1	1
Low levels of customization	8	1	1		1	4	1		
Integration / companywide commitment	8	1	2		1	3			1
Business process re-engineering	7		1		2	3	1		
Quality of testing	4	1				2	1		
Managing IT legacy system	4						4		
Organizational culture / readiness	2		1						1
Realistic expectations of implementation	2			1	1				
Dedicated resources	2			1	1				
Implementation plan for multi-site	2						1		1

3. Interpretive Structural Modelling

The 20 CSFs listed in Table 1 provide an indication of the key areas that an organization should be focusing on when implementing an ERP project. However, how all the factors interrelate with each other is not clear. Interpretive structural modelling methodology (ISM), proposed by Warfield [11] for investigating the variables that define a problem and their interrelationships, can be used in this context. ISM is a structured approach that is based on interviewing a small number of experts. Starting with the CSF that have been identified from the literature review, the interviews are focused on revealing if there is an interrelationship among the factors that have been predefined by the researcher. The outcome of this interviews is analysed through the development of matrixes that allow the visualization of the interrelationships. ISM is composed of eight consecutive steps, that have been presented in detail in past papers [12, 13] (fig. 1).

Figure 1. ISM process.

The ISM is based on the coding of the experts' opinion into matrices. A workshop was organized for completing the SSIM. The selection of the experts for participating was based on their years of experience in implementing ERP systems. During the workshop, the CSFs were presented to the experts and were discussed in detail. They were asked to reach a consensus for every pair of variables, identifying the existence or not of the relationship between them. This information was used for the development of the SSIM matrices (Table 2). The four symbols that have been used to denote the direction of the relationship between the variables (i and j) are: V when variable *i* has an impact on variable *j*, A when variable *j* has an impact on variable *i*, X when variable *i* and *j* have impact on each other; and finally, O when variable *i* and *j* are unrelated.

Table 2. Structural self-interaction matrix (SSIM) of CSFs

Factor No.	Critical Success Factor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Project Management / Planning / KPI's		A	A	O	O	O	V	V	V	X	V	O	V	V	V	O	A	A	V	V
2	Top Management support			V	V	V	V	V	O	V	V	O	V	V	V	O	O	V	V	V	V
3	Project team composition / Skill levels / effectiveness				X	V	A	V	V	V	V	V	V	V	V	V	V	X	V	V	V
4	External support- vendors / consultants					A	A	V	V	O	O	X	V	O	V	V	V	O	V	O	V
5	Aligning ERP type / modules with business strategy						A	O	O	V	X	V	V	X	V	O	V	A	V	V	V
6	Understanding of business implications and requirements							V	O	A	V	V	X	V	V	O	V	V	V	V	V
7	User Training								V	V	V	O	O	A	O	V	O	A	A	A	O
8	Data Quality									A	O	O	A	O	A	A	A	A	A	A	A
9	User Involvement										A	A	V	V	V	V	V	V	V	O	V
10	Change Management											V	A	V	V	O	V	V	V	A	V
11	Project team internal communication inc. interdepartmental												O	V	O	O	V	V	V	X	O
12	Low levels of customisation													O	O	O	O	O	V	O	V
13	Internal Integration / Companywide commitment														V	V	O	V	V	V	V
14	Business Process re-engineering															X	V	A	O	A	O
15	Quality of testing																O	O	V	A	O
16	Managing IT legacy system																	A	V	A	O
17	Organistional culture / readiness																		V	V	V
18	Realistic expectations of implementation																			A	V
19	Dedicated resources for project / department owners																				V
20	Implementation plan for Multi- site																				

As is indicated in fig. 1, the next step requires establishing the reachability matrix. This is completed in two sub-steps: the development of the initial reachability matrix and then the development of the final reachability matrix. The initial reachability matrix (IRM) is based on the SSIM after it is transformed to a binary matrix, by substituting the symbols V, A, O and X by 0 and 1 applying rules described in detail in [13]. The final reachability matrix is obtained by incorporating the transitivity. If the transitivity rule is not satisfied, the experts are asked to review and modify the SSIM. The revised SSIM is again then worked out and tested for the transitivity rule. This process is repeated until the reachability matrix meets the requirements of the transitivity rule [14]. The final reachability matrix is presented in table 2.

Table 3. Final reachability matrix including transitivity (in blue)

Factor No.	Critical Success Factor	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Driving Power
1	Project Management / Planning / KPI's	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
2	Top Management support	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	20
3	Project team composition / Skill levels / effectiveness	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19
4	External support- vendors / consultants	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19
5	Aligning ERP type / modules with business strategy	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19
6	Understanding of business implications and requirements	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19
7	User Training	1	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	16
8	Data Quality	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
9	User Involvement	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19
10	Change Management	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19
11	Project team internal communication inc. interdepartmental	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	19
12	Low levels of customisation	1	0	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	18
13	Internal Integration / Companywide commitment	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
14	Business Process re-engineering	0	0	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	1	0	0	5
15	Quality of testing	1	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0	1	0	1	8
16	Managing IT legacy system	1	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1	0	1	0	1	6
17	Organistional culture / readiness	1	0	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	18
18	Realistic expectations of implementation	1	0	0	0	0	0	1	1	1	1	1	0	1	1	1	0	0	1	1	1	12
19	Dedicated resources for project / department owners	1	0	0	1	1	0	1	1	1	1	1	0	1	1	1	1	1	1	1	1	16
20	Implementation plan for Multi- site	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1	2
	Dependence	17	1	11	13	14	11	17	20	15	15	15	13	15	17	16	17	14	18	14	18	

The reachability matrix is then further analysed through level partitioning. Through this process, the CSFs can be ranked, and the digraph can be developed. The reachability and antecedent set for each factor is obtained from the final reachability matrix. The reachability set for a particular factor consists of the factor itself and the other factors that it may help to achieve. The antecedent set consists of the factor itself and the other factors that help in achieving it. Subsequently, the intersection between reachability and antecedent set is attained. The variable for which the reachability and the intersection sets are the same is given the top-level variable in the ISM hierarchy. Such a top-level variable would not help achieve any other variable above their own level. After the identification of the top- level variable, it is discarded from the other remaining variables. This means that the process is iterative and carries on till all variables are discarded. For the present study, it required 11 iterations.

Then, the ISM model can be developed in the form of a digraph. A digraph is the graphical representation of the variables and their interdependence. Nodes and edges are used for visualizing the relationships. The partition table is the starting point for developing the digraph. Finally, the digraph is changed to an ISM model by substituting nodes of the factors with statements. Figure 2 illustrated the final ISM model.

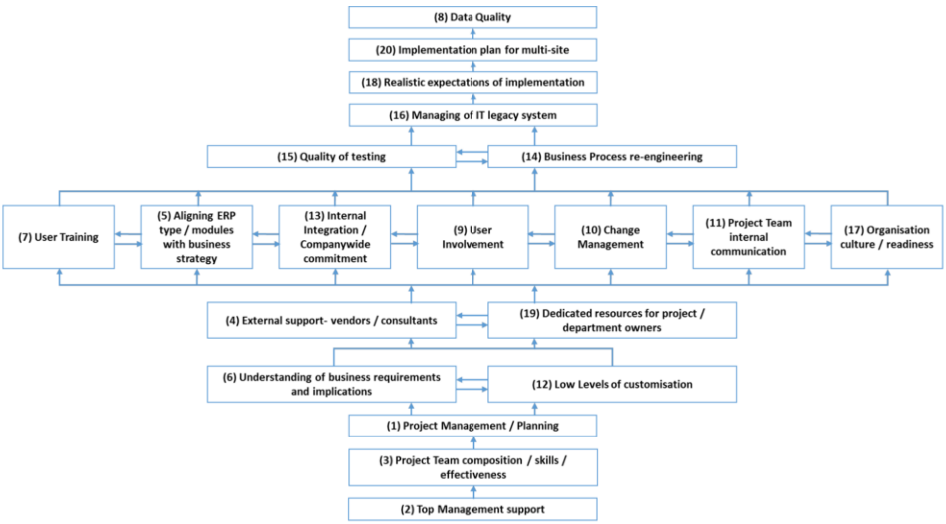

Figure 2. ISM digraph for CSF in ERP implementation.

4. MICMAC Analysis

MICMAC analysis is an indirect classification technique based on the driving power and dependence of each factor that helps to understand the impact of each factor. The data for the MICMAC is extracted from the final reachability matrix (table 3). The driving power is the count of all the variables that are within the reachability set, whereas the dependence power can be calculated by the count of all the variables in the antecedent set. The MICMAC represents a quadrant that shows the factors as either driver, linkage, autonomous or dependence.

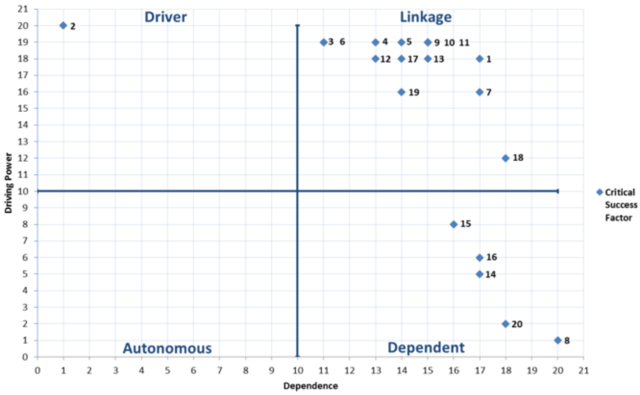

Figure 3. MICMAC analysis.

5. Discussion

Comparing the ISM model (figure 2) and the findings of the literature review (table 1) provides some interesting insights. If the 10 most frequently occurring CSFs from the literature were considered as the starting point for the implementation, then effort and resource would have been spent in CSFs that have lower driving power than others. Whilst a number of factors in the top 10 list would have helped to improve the ERP implementation in any factory, including top management support, change management, project management and user involvement, the factors that are missing would potentially have had a high impact on the success of the implementation project. The ISM process provides results that highlight the driving power and dependence of each of the factors and therefore their interrelationship with each other. This information enables a more accurate framework and set of recommendations to be developed.

The MICMAC analysis also allowed for the classification of the CSFs. The fact that none of the considered CSFs falls into the autonomous quadrant verifies the literature review findings. An autonomous CSF would indicate that it would be disconnected from the rest, which would be an anomaly. The CSFs thus in the other three quadrants indicate that they are correlated to each other to a degree. Five (5) CSFs are in the dependent quadrant as they had strong levels of dependence but had weak levels of driving power. These CSFs, namely “Quality of testing”, “Managing of IT legacy systems”, “Business process re-engineering”, “Implementation plan for multi-site” and “Data Quality” are the ones that are driven by the other, and for this reason effort should first be invested in sorting out the other. 14 CSFs are classified as “linkage” ones. These CSFs are unbalanced due to the fact that any change on these will affect others and furthermore feedback on themselves. These are quite sensitive, and any change will have multiple effects. Although they are intermediate factors, they make up the bulk of the CSFs for ERP implementation. The need to focus on developing these factors is a clear one as their impact in both driver and dependent form a circle of improvement and performance. For this reason, an improvement plan on these factors would increase the success of an ERP implementation. However, as they are so numerous, but also interrelated, lots of effort is required to ensure all the factors are focused on and achieve the required standards of performance. Finally, only one CSF (“top management support”) is characterized as “driver”. As the strongest factor in the driver quadrant, “top level management” has to be in place to facilitate the growth of the other factors in this ISM model. Zouaghi and Laghouag [5] explain that key managers should be interested enough and convinced the by the importance of the project.

6. Conclusions

In the present study, the interpretive structural modelling technique was presented and then used for identifying the interrelationships among the critical success factors when implementing ERP systems. The ISM hierarchy and the MICMAC results helped reveal these interrelationships. The critical success factors with the highest driving power were revealed. The results of the present study will be used for helping practitioners identify the steps that needs to be followed for successfully implementing ERP.

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