Predictive Analysis of Critical Success Factors for Enterprise Resource Planning Systems Implementation

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ABSTRACT
Businesses must use ERP and modify their systems to respond to the continually developing business environment, advances in technology, and growing competition. Most studies omit insights into the priority of ERP systems and CSFs from the instance of ERP stakeholders. Therefore, this study identified factors that led to understanding the stakeholder's satisfaction upon ERP implementation and assessed the interrelationship between the factors. A survey was conducted among organizations implementing ERP systems cross-sectional, which included 132 ERP system managers and users. The descriptive-analytical approach deployed in this study shows that four categorizations of CSFs ERP system can have a positive impact directly on the Satisfaction categorization of ERP system. This study provides a rating of categorized CSFs from the perspective of Managers and users across different organizations. It also enables decision-makers to create appropriate prediction techniques to discover the strengths and limitations of the implemented ERP system and and identifying the most suitable choice within various industries, place a greater importance on "best of fit" solutions rather than "best practice" alternatives. This research shows that four categorizations of CSF ERP systems can positively impact the satisfaction categorization of ERP systems. It also provides a ranking of categorized CSFs from the perspective of managers and users across different industries.

General Terms
Enterprise resource planning systems (ERP), ERP implementation, critical success factors, smart equation

Keywords
CSFs ERP system, predictive analysis, smart implemented ERP, cross sectional study

1. INTRODUCTION
Enterprise resource planning (ERP) is used by organizations to manage the optimal use of resources through the use of a packaged software-based system as a total integrated information processing system[1]. researchers have presented ERP success measures in multiple aspects, including operational, managerial, strategic, administrative, and organizational, ERP success must be distinguished and assessed against the objectives established for each point of the ERP lifecycle[2][3][4]. however, identifying factors that led to understanding the stakeholder's satisfaction upon ERP implementation and assessing the interrelationship between the factors enables decision makers to create appropriate prediction techniques to discover the strengths and limitations of the implemented ERP system. This paper is structured as follows; Section One Introduction, Section Two Research Methodology, Section Three Literature Review, Section Four Data Collection, Section Five Reliability Analysis, Section Six Data Analysis then the conclusion.

2. LITERATURE REVIEW
Numerous academics have thoroughly researched the identification of critical success factors (CSFs) for ERP implementation concluded from different sectors within different countries and industries. Wicaksono et.al, 2022 have categorized The critical success factors (CSFs) for ERP implementation into three categories organizational, Technological and process[1]. Epizitone and Olugabra,2020 have categorized The critical success factors (CSFs) for ERP implementation into four categories resource, Culture, Project and process[2]. Taghavi et al.,2019 have categorized The critical success factors (CSFs) for ERP implementation into six categories protective factors, cultural factors, software and IT infrastructure capabilities of the organization, Process and Motivational factors. Previous comprehensive study have been established to predict satisfaction with ERP system implementation that concluded by Five categories Organizational factors, Management factors, Social factors, Technical factors and Satisfaction factors[3].

There were categorization definitions conducted from the comprehensive study[3]as follows:

Organizational factors: Those set of factors considering change management and business process reengineering.

Management factors: Those set of factors consider time and budget.

Social factors: Those set of factors consider top management, vendor relationships, consultant support, and communication.

Technical factors: Those set of factors considering system quality, and information quality measurements.

Satisfaction factors: Those set of factors considering user satisfaction, perceived usefulness, perceived ease of use, internal support, result demonstrability and compatibility.

3. RESEARCH METHODOLOGY
This study aims to use a predictive approach which helps in deciphering the connections between variables[5]. we proposed a smart framework for CSFs of ERP Systems (figure 1)in which four CSFs categorizations of ERP systems (Management Factors (G2), Social Factors (G3), Technical Factors (G4), Organizational Factors (G1)) give impact to satisfaction factors (G5) categorization of ERP system implementation positively. Analysis of satisfaction categorization factors in the implementation of the ERP system tested the following four hypothese (figure 1):

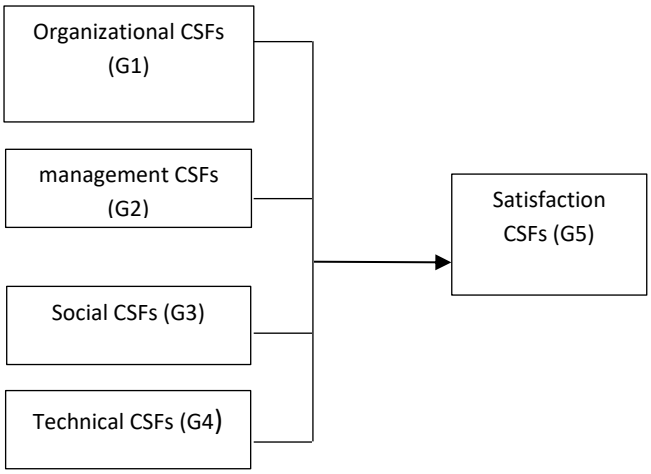

Figure 1:Research model

In the figure 1 research model, the hypothesis in this research are:

H1: organizational CSFs affects the satisfaction level of success ERP systems implementation significantly.

H2: Management CSFs affects the satisfaction level of success ERP systems implementation significantly.

H3: Social CSFs affects the satisfaction level of success ERP systems implementation significantly.

H4: Technical CSFs affects the satisfaction level of success ERP systems implementation significantly.

Table 2 Operational Variables

Composite Variables of Categorizations of CSFs-ERPsystems implementation	Indicators
Group(G1) Organizational factors	Change management (CM)
	Business process reengineering (BPR)
Group 2(G2) Management factors	Time (TIME)
	Budget (BUD)
Group (G3) Social factors	Top management (TM)
	Vendor support (VS)
	Consultant support(CS)
	Communication (COMM)
Group (G4) Technical factors	System quality (SYSQ)
	Information quality (IQ)
Group (G5) Satisfaction factors	Demonstrability (DEM)
	Perceived usefulness (PU)
	Ease of use (EOU)
	Internal support (INT SUPP)
	Compatibility (COMPAT)

Operational variables of organizational CSFs (G1), Management CSFs(G2), Social CSFs(G3), Technical CSFs (G4) and satisfaction CSFs (G5) are shown in table 2.

Our data set included in this study was collected from a Likert scale questionnaire questionnaire prepared and sent to ERP managers and users who used and interacted with ERP system. Within different organizations from different countries. the questions were created using items used in earlier studies components of ERP systems implementation[4][5][6][7][8]. Each item employed a five-point likert scale, with 1 denoting severe disagreement and 5 denoting complete agreement. The independent variables are Management Factors (G2), Social Factors (G3), Technical Factors (G4), Organizational Factors (G1).the independent variable is satisfaction categorization of the implemented ERP system(G5) , it is constituting five dimensions namely, demonstrability, internal support, compatibility, perceived usefulness and ease of use.There were exclusion and inclusion criteria on the reliability of the questionnaire for each stakeholder. the questionnaire were distributed according to the system stakeholder the distribution quantities were shown in figure (2). There are 172 questionnaires that are returned from 172 respondents that are included in the ERP system, but only 132 questionnaires are valid,57 from managers and 75 from users. Table 2 shows the valid respondents' rate according to the limitation of the number respondents from each stakeholder's perspectives.

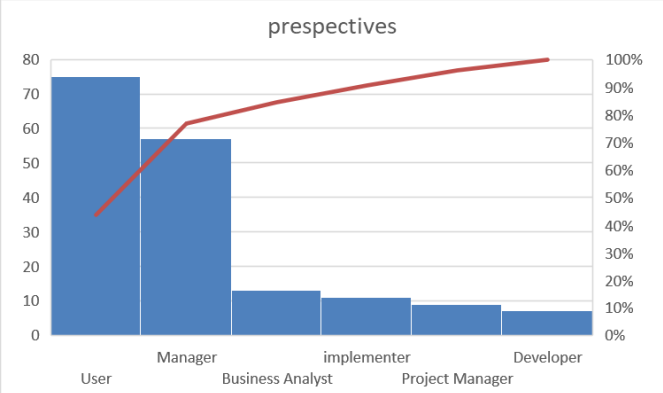

Figure 1. Distribution quantities of the ERP system's stakeholders

accordingly, the analysis of questionnaire responses includes only Managers and Users responses out of five other jobs perspectives because each of other jobs perspectives business analyst , implementer, project manager and developer are less than 30 respondents is not validated according to the limit theory as stated that the validation limit is 30 respondents or more then out of the returned 172 questionnaires distributed to all target populations 132 questionnaires were analyzed. The data were collected from August 2023 till November 2023 means 4 months. The response rate was as shown in Table (2) about 76.7%.

Table 2 response rate

Percentage		
invalid-Respondent	40	23.3%
valid Respondent	132	76.7%
Target population	172	100%

4. DETAIL ANALYSIS

To make the study more acceptable and recognized both reliability and validity has been confirmed. To study the reliability of the data gathered, Cronbach 's alpha coefficient calculated where Cronbach's alpha is a measure of internal consistency reliability for a questionnaire or scale, indicating

how well the items in the questionnaire correlate with each other. A higher alpha value typically suggests greater reliability. Values above 0.7 are generally considered acceptable, although this can vary depending on the context and purpose of the questionnaire.The calculated value of Cronbach's alpha for collected questionnaire is 0.9. This means that the questionnaire is reliable, and we can go further in the analysis.

Table 3 Reliability Statistics

Cronbach's Alpha	N of Items
.943	15

The study population is stakeholders within organization from various industries with a sample 132 of respondents sampling data is done using sampling technique.the measurement scale used is likert scale with the following rating levels: 1(strongly disagree) ,2(disagree), 3 (neutral), 4(agree) and 5(strongly agree).the likert scale is used to examinr how strongly the subjects agree or disagree[9]. The analytical technique used in this study using multiple regression analysis whose equatuations can be written as follows:

$$G_5 = \alpha + \beta_1 G_1 + \beta_2 G_2 + \beta_3 G_3 + \beta_4 G_4 + e$$

Notes

G_5 is the dependent variable (Satisfaction of ERP),

α is the constants,

β 1, β 2, β 3, β 4 are coefficient of the regression equation,

the independent variables are;

G1 = Organizational Factors

G 2 = management factors

G 3 = social factors

G 4 = Technical factors,

E = Error term

linear regression is a technique for simulating the relationship between one or more variables in which fitting of a line across the data points and the conversion of numerical inputs into numerical outputs are made possible by a machine learning technique[10].

5. RESEARCH RESULTS

Results of data processing revealed the number of valid respondents by 76.7% managers and users for ERP systems implementation and invalid respondents is 23.3% are other stakeholders for ERP systems implementation excluded for unreliable responses in which resulted with132 respondents with reliable responses .

The Categorization Correlation Analysis

Table 4 show that sample correlation coefficient value between Organizational factors(G1), Management factors(G2), Social Factors (G3), Technical factors(G4) has positive value and significant because significant value is more than 0.05 for satisfaction categorization variable and correlated. And briefly describes five categorizations' statistics. As it is indicated in the table the Satisfaction factors (G5) high dependency ($r > 0.5$) with (Management Factors (G2), Social Factors (G3), Technical Factors (G4), Organizational Factors (G1).

Table 4. correlations

		Organizational factors(G1)	Management factors(G2)	Social Factors (G3)	Technical factors(G4)	Satisfaction factors (G5)
Organizational factors(G1)	Pearson Correlation	1	.627**	.588**	.645**	.574**
	Sig. (2-tailed)		.000	.000	.000	.000
	N	132	132	132	132	132
Management factors(G2)	Pearson Correlation	.627**	1	.760**	.742**	.699**
	Sig. (2-tailed)	.000		.000	.000	.000
	N	132	132	132	132	132
Social Factors (G3)	Pearson Correlation	.588**	.760**	1	.826**	.732**
	Sig. (2-tailed)	.000	.000		.000	.000
	N	132	132	132	132	132
Technical factors(G4)	Pearson Correlation	.645**	.742**	.826**	1	.740**
	Sig. (2-tailed)	.000	.000	.000		.000
	N	132	132	132	132	132
Satisfaction factors (G5)	Pearson Correlation	.574**	.699**	.732**	.740**	1
	Sig. (2-tailed)	.000	.000	.000	.000	
	N	132	132	132	132	132

• Regression Analysis of CSFs categorization

In this study, employing a regression analysis to explore the categorization of Critical Success Factors (CSFs) in the context of satisfaction level for successful ERP systems implementation to identify the key composite variables that significantly influence the success of ERP Systems implementation. Through the analysis of various CSFs-ERP systems implementation and their respective impacts provide insights into the prioritization and categorization of critical factors for achieving success in ERP systems implementation. This regression analysis offers a quantitative framework for understanding the complex relationships between different CSFs and their implications that informing strategic decision-making and researchers and implementers to organize the work suitably.

• Normality, Linearity and Homoscedastic

When performing linear regression analysis, there are three main assumptions to consider: normality, linearity, homoscedasticity.First assumption, Normality: This assumption states that the residuals (the differences between the observed and predicted values) should be normally distributed which means that the errors of the model should follow a normal distribution and the histogram of the standardized residuals diagram examines whether they are normally distributed or not and it. The following diagrams as shown in Figure 2 the residuals are normally distributed. The second assumption linearity means that there should be a linear relationship between the independent variable(s) and the dependent variable. Visually, this can be assessed by plotting the data and checking if the relationship appears to be roughly linear. If the relationship is not linear, it might indicate that a different model, such as polynomial regression, might be more appropriate. As shown in figure 2, it is indicated linear relationships between dependent and independent variables.

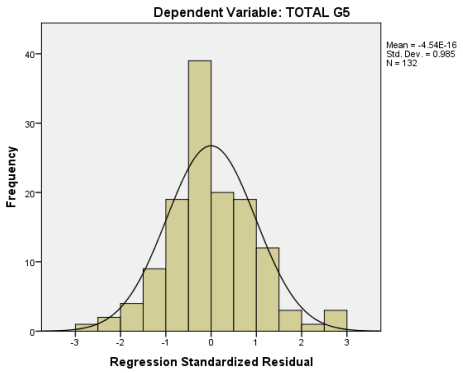

Figure 2. histogram-dependent variable: satisfaction factors (G5) of ERP Systems implementation

The Third Homoscedasticity assumption: refers to the assumption that the variance of the residuals should be constant across all levels of the independent variables and same variance (homoscedasticity) are met since the scatters do not make any curve and the scatters go along with the line. As shown in Figure 3 normal P-P plot of regression standardized residual, the homoscedasticity are met since the scatters do not make any curve and the scatters go along with the line.

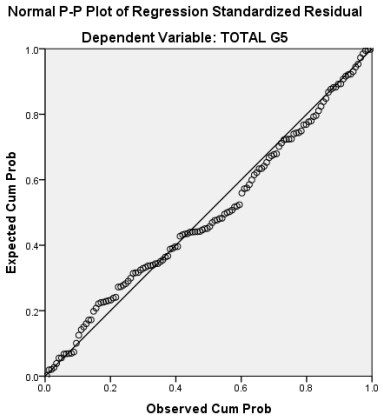

Figure 3. normal P-P plot of regression standardized residual

• Absence of Multi Collinearity

This assumption emphasizes that independent variables shouldn 't be highly correlated or perfectly correlated. Multicollinearity is when they are highly correlated whereas singularity is when the independent variables are perfectly correlated. In order to check whether there is high relationship between independent variables Variance inflation factor was used to detect multi collinearity. And based on the rule of thumb, a maximum VIF of ten or more is considered an indication of the presence of interdependence multi collinearity was found to be absent within the independent variables of this study in which as it is indicated in table 4.10 the value of VIF ranges from 1.872 to 3.758 which is less than 10 and this indicates that there is no multi collinearity.

• Partial Test (T)

Analysis of partial influence is used to find out how closely the influence of each independent variable with the dependant variable Satisfaction factors (G5) .the results of data processing can be seen in table 5.

Table 5. Partial Hypothesis Testing Results (t test)

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.964	.196		4.918	.000		
	Organizational Factors (G1)	.071	.063	.084	1.128	.261	.534	1.872
	Management Factors (G2)	.166	.070	.218	2.382	.019	.355	2.816
	Social Factors (G3)	.228	.090	.266	2.528	.013	.270	3.703
	Technical Factors (G4)	.272	.095	.304	2.871	.005	.266	3.758

a. Dependent Variable: Satisfaction factors (G5)

• Simultaneous Test (F)

To know the significance of an influence of the independent variables (G_1,G_2,G_3,G_4) simultaneously on dependent variable (G_5) used F test. The results of hypothesis

Table 6. Result of Simultaneous Test (F)

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	33.080	4	8.270	51.973	.000[b]
	Residual	20.209	127	.159		
	Total	53.289	131			

a. Dependent Variable: Organizational Factors (G1), Management Factors(G2), Social Factors(G3), Technical Factors(G4)

b. Predictors: (Constant), Satisfaction Factors (G5)

Based on the output in table 6 obtained significance value of 0.000 smaller than than than 0.05 or 0.000< 0.05. the significance value is smaller than α *=(0.05).*This means there is a significant effect simultaneously between the Organizational Factors (G1), Management Factors(G2),Social Factors(G3), Technical Factors(G4) on the satisfaction of successful ERP implementation (G5) cross-sectionally.According to the above table the B value for all the critical success factors is positive implying that all the independent variables are positively associated with the dependent variable. In which a unit increase in top Organizational Factors (G1) will result in 0.071increases in Satisfaction of ERP implementation. A unit increase in Management Factors(G2) leads in 0.166 increase in satisfaction of ERP implementation. A unit increase Social Factors(G3) will result in 0.228 increases in satisfaction of ERP implementation. A unit increase Technical Factors(G4) will result in 0.272increases in satisfaction of ERP implementation. This indicates that all the independent variables are positively related to the satisfaction of ERP implementation.

• Coefficient of Determination R^2

By using SPSS version 20 the following results were determined from regression analysis. the below table 6 indicated correlation is .788 which shows existence of linear relationship between the dependent and the independent variables. The coefficient of determination or adjusted R square value is 0.621 which indicates that 62 % of Satisfaction of ERP implementation successfulness is explained by the chosen critical success factors or all the chosen independent variables were critical for successfulness of ERP at the rate of 62%, while the remaining 42%is the contribution of other factors besides

the Organizational Factors (G1), Management Factors(G2), Social Factors(G3), Technical Factors(G4).

Table 7. Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.788[a]	.621	.609	.3989	.621	51.973	4	127	.000

6. RESULT DISCUSSION

Factors Regression analysis assess whether there is a relationship between the dependent variable and the independent variable or not. And to achieve the desired objective of this study multiple regression analysis was assessed between the dependent variable Satisfaction of ERP implementation and the independent variables (management factors G2, Social factors G3, Technical factors G4)**.** By applying the regression analysis we develop the following equation which can be used to predict the range of critical success factors by using the maximum and minimum value of the dependent variable (Satisfaction of ERP).

G5= 0.964 + 0.071 G1 + 0.166 G2 + 0.228 G3 + 0.272G4 + e

Based on Simultaneous test results as shown in 5 ,the significance level is 0.000 or below 0.05 then H_O is rejected and H_a is accepted which means management factors, social factors ,technical factors and organizational factors have positive effect on the satisfaction of ERP implementation successfulness signficantlly.this indicates that in improving the satisfaction of ERP implementation requires management factors, social factors ,technical factors and the satisfaction of ERP implementation will be higher**.** Where the resulted G_5 should be the following values that predict the CSFs of ERP Satisfaction.

$$1.761 < G5 < 4.94$$

According to the value of G_5 revealed unsatisfied ERP system implementation if it close to 1.761 while satisfied ERP system implementation if it close to 4.94 in which help providing a more comprehensive understanding of the relationship between variables, controlling confounding factors, predicting outcomes, and testing hypothesis.

7. CONCLUSION

The research was conducted on large size of correspondent that related to Satisfaction ERP system implementation within this cross-sectional study. Therefore, the results are suitable for different organizations that have to implement ERP system as generalized framework. Analysis results show that there are four categorizations of CSFs ERP system that can give positive impact directly to the Satisfaction categorization of ERP system. Analysis results show that organizational factors categorization have least rank than other factors. predicting the satisfaction Categorization of ERP system for any organization need to focus on the four categories of ERP system CSFs to apply our contributed prediction equation. Then according to the minimum values of independent variables results by unsatisfaction of implemented ERP while at maximum value results by satisfaction of implemented ERP which that the predicted value must be between those values . the comprehensive understanding of the relationship between variables, controlling confounding factors, predicting outcomes, and testing hypothesis lead to the contributed smart CSF-ERP smart equation. A cross-sectional dataset is used as a cross-validation technique to assess the model's generalizability, which helps provide a more reliable estimation of the model's predictive capability.In summary, the effectiveness and reliability of the contributed regression equation in predicting satisfaction categorization within ERP implementation were assessed, ensuring its validity and applicability in practical settings.

8. FUTURE WORK

Implement longitudinal surveys to track satisfaction levels among users and managers over time. By collecting data at multiple points throughout the ERP implementation process and beyond, you can identify trends, patterns, and changes in satisfaction levels, providing valuable insights into the long-term impact of ERP systems.

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