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EEE Model for Evaluation of ERP Efficiency in Real Time Systems

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ABSTRACT
This study is designed to measure the efficiency of ERP systems in providing real time information. In this study, the research measures the efficiency rather than the performance-used in previous researches - as it is more comprehensive. The proposed ERP efficiency evaluation model depends on ERP phases'. EEE model measures the efficiency of implementation phase, post-implementation phase, and the impact of implementation phase on post implementation from technical perspective. A case study, a survey and a proposed experimental method are used to implement research model. Results indicate a significant relationship between ERP Phases'. In order to get an efficient post implementation phase, the implementation phase must be efficient.
Keywords - Enterprise Resource Planning, efficiency, implementation, post implementation, performance

I.   INTRODUCTION

ERP evolved from Manufacturing Requirements Planning (MRP), is defined as "an integrated information system that supports business processes and functions by managing the entire organization's resources efficiently and effectively" [1].In last decade Enterprise Resource Planning systems have drawn increasing attention as they provide a variety of benefits to a business such increasing operational efficiency, improving customer service, reducing cycle times, increasing effectiveness, and decreasing cost [2, 3, 4]. Yet it is important to measure ERP system efficiency for many reasons:-

Firstly, in spite of low cost and low risk, and high system quality of ERP [5], the failure rate of ERP ranged from 40 percentages to 60 percentages [6].

Secondly, new systems require major organizational changes that enforce managers to adopt processes for measuring the performance of daily business activities by concentrating on the intangible benefits connected with integrating new systems [7].

Thirdly, ERP systems are developed for unique purpose of increasing efficiency by improving an organization's information infrastructure, which can help to sustain operational performance [7].

Some researchers measured implementation phase efficiency such Michael rosemannjens Wiese, Business performance consulting, and Abbas Yousfi. Others researches measured post implementation phase efficiency such Woosang Hwang and few researches measured the efficiency of two phases such Shih-Wei Chou, and Yu-Chieh Chang.

This study measures ERP efficiency in terms of a two stage model.

The first stage is measuring the efficiency of implementation phase. [8] Investigated the problematic issue in the implementation of the ERP system. He reported that, it lies in the integration of the organization's primary functions with ERP software. There are three antecedences that govern the integration between software package and business processes.

[9] Addresses both customization and coordination improvements. Customization refers to the capability of handling the lack of fit between the organization's business processes and those offered by the ERP package designers. Coordination improvements refer to the capability of adapting to changing conditions, coordinating and synchronizing among different units of a firm.

[10] Addresses Interconnectivity, Which is a foundation for integration process in enterprise Systems. The process involves of integrating of all disparate equipment and technology including sharing of peripherals pathway for application, and file sharing as one unit.

The second stage is measuring the efficiency of post implementation phase

[11] investigated the core objective of access to real-time information. He reported that, it relies on system components such as hardware, software, and processes that can get together within the new system.

This study focuses on two phases' of ERP, because efficient initial stage not necessary leads to efficient system in long run. The efficiency of a post-implementation phase is measured by developing ERP Efficiency Evaluation model (EEEModel). To test the proposed model, we adopted a survey and proposed experimental methods of collecting data and assessing the hypotheses.

The paper is organized as follows section two reviews related works, section three explains Research model and hypothesis, section four discusses research experiment, section five shows results, and section six concludes the work.

II. Related Work

The literature available on ERP systems revealed that very few studies have been conducted with the intent to address the need for measuring ERP efficiency during and after implementation to avoid failure.

[11] Investigated the efficiency of ERP systems in providing real-time information in the context of performance and value. His study focused on implementation phase as argued that maximum efficiency is only achieved when there is strong alignment between the ERP system and the company's business processes. The study has been reported that the success or lack of a successful implementation can be partially measured by examining the four key antecedents of ERP system integration (Interconnectivity, Interoperability, Semantic consistency, and Convergent integration) and ERP performance. Results indicated a significant relationship between all possible pairs of variables, but no significant relationship between ERP performance and a model containing the four identified antecedents of ERP. Further, no significant relationship was found between ERP value and a model containing the four identified antecedents of ERP.

[12] Examined ERP performance in terms of a two-stage model—i.e. intermediate ERP benefits and overall ERP benefits. In their study, customization and Organizational mechanisms (OM) were chosen as the variables that may effect on ERP benefits, because they may affect standardization and integration. In addition, in the post-implementation stage of ERP, organizations may rely on customization and OM that brings business processes into alignment with the best practices of ERP. The study findings indicate that function adaptation and software configuration (such as customization) play a more important role in affecting intermediate benefits than alignment of organizational processes. The possible reason is that suitable functionality has a more direct influence on ERP benefits than process adaptation. The second implication relates to the mediation effect of ERP intermediate benefits. As the results indicated, customization affected overall benefits either directly or indirectly through intermediate benefits, while OM influenced overall benefits only indirectly through intermediate benefits.

[13] suggested metrics that are appropriate to the data warehouse .using metrics for knowing data warehouse response time, machine utilization, availability, user satisfaction or the quality of the data in the warehouse.they also suggested who should be responsible for measuring, who should be responsible for taking action to correct situations that are out of compliance with the standards, and recommends how to represent the results of the measurements to management.

III. ERP Efficiency Evaluation Model (EEE Model)

Following Shih-Wei Chou and Yu-Chieh Chang [12]. Our study examines ERP efficiency in terms of a two-stage model; implementation phase and post implementation phase. Our research model is based on the premise that the salient antecedents that affect the efficiency of the ERP should be carefully addressed. Quite few antecedents have been identified by a prior work including Interoperability [11], convergent integration [11], interconnectivity [10, 11], customization [9, 12], coordination improvements [9, 12], semantic consistency [10, 11].But in this study customization, coordination improvements, and interconnectivity are chosen for measuring the efficiency of ERP implementation phase, as this variables govern the integration between business processes and ERP package. In post implementation phase the study measures the impact of ERP real time antecedents (performance, availability, resource utilization, and semantic consistency) on business efficiency. Figure 1 lists the research ERP Efficiency Evaluation model.
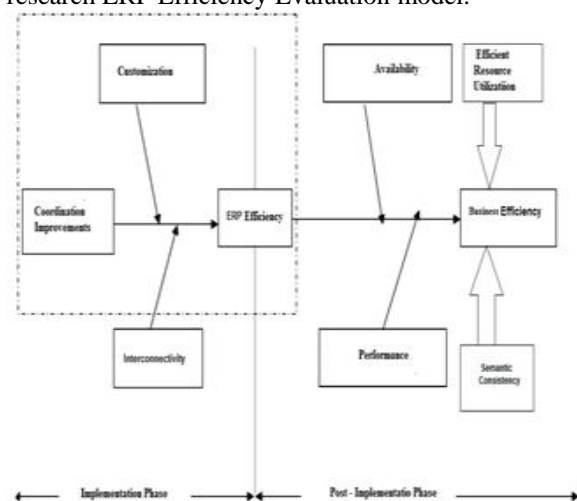

Figure 1: Research ERP Efficiency Evaluation Model.

3. 1 Research Hypotheses

The study expects that correct implementation positively increases business efficiency by improving system availability**,** performance, resource utilization, and semantic consistency.

This leads to research hypotheses:-

H1a. For a firm that has implemented ERP, greater customization, coordination improvements, and interconnectivity are not associated with greater efficiency of ERP accrued to that firm.

H1b. For a firm that has implemented ERP, greater customization, coordination improvements, and interconnectivity are associated with greater efficiency of ERP accrued to that firm.

H2a. For a firm that implemented ERP, greater business efficiency in post implementation phase (real time) is not associated with greater performance, availability, resource utilization, and semantic consistency.

H2b. For a firm that implemented ERP, greater business efficiency in post implementation phase (real time) is associated with greater performance, availability, resource utilization, and semantic consistency.

3.2 Research Methodology

To test the proposed model, three methods of collecting data are adopted to assess the hypotheses.

3.2.1 Case study

The first method is based on findings and proofs of [14], that a useful sampling method is to select only a few cases for more rigorous examination. The research model is implemented within National Bank in Egypt that provides real time information to its clients**.**

3.2.2 Survey

The second method is a questionnaire that is designed to measure implementation efficiency during the project run. The questionnaire has two sections. Section one has questions that target information technologies analyst in context of customization, coordination improvements, and, interconnectivity. Section two has questions that measure user belief about the effectiveness of ERP systems in context of performance, availability, and semantic consistency.

3.2.3 Experimental method

The third proposed method uses Enterprise Manager Grid Control 11g, which is Oracle's single, integrated solution for managing all aspects of the Oracle Grid and the applications running on it. Enterprise Manager also allows you to manage single instances of Oracle Database, Application Server, or Collaboration Suite using standalone consoles. Oracle enterprise manger 11g is used for measuring the efficiency of post implementation phase by measuring performance, availability, resource utilization antecedents.

IV. Experiment

4.1 Data

For this study, the intermediate variable ERP efficiency and   the overall variable business efficiency are identified as dependent variables and are influenced, either positively or negatively, by the independent variables. Respondents indicate, on a 5-point Likert scale (1 = strongly agree, 5 = strongly disagree).

4.1.1 Sample

The sample participants in the survey are 254 which consisted of 85 participants from the first category- information technologies, and 169 participants from the second category users. The purpose is to demonstrate the efficiency of the system from information technologies perspective and the availability of information in a true real time environment from the users' perception in terms of availability and performance.

4.1.2 System monitoring duration

ERP system is being monitored using oracle enterprise manager 11g for one year to conclude the result of the research.

V. Data analysis and results

5.1 Analysis methods

The Statistical Package for the Social Sciences (SPSS) is used firstly, to code and tabulate scores collected from the survey, and provide selected statistical values. They are median, mean, central tendency, variance, and standard deviation. Finally, to detect amount of the shared variance and the strength of relationship between the variables of interest, multiple least squares regression is used.

5.2 Research Results

5.2.1 First hypothesis

The statistical analysis of the first hypothesis using SPSS 17.0ANALYZE/REGRESSION/ LINEAR, indicates a **significant** relationship between ERP Efficiency and a model containing three predictor variables (customization, coordination improvements, interconnectivity). Table 1 displays a model summary of the multiple regression analysis for research hypothesis one.

Model Summary Generated from Multiple Regression Analysis

Predictors(constant)	B	Beta(B)	T-Test		F-Test		R	R2
			t	Sig.	F	Sig.		
Customization	.990	.735	9.913	.000				
Coordination Improvements	.185	.162	2.079	.039	34.098	.000a	.747a	.558
Interconnectivity	.208	.109	1.428	.157				

explanatory power of the model: The value of determination coefficient (R2) **.558**, means that any independent variable included in the model constructs 55.8% of the variance in the dependent variable (ERP efficiency).

Moral regression model: The value of the correlation coefficient multi R (**.747ᵃ**) indicates the presence of a strong correlation between the combinations of independent variables and the dependent variable, as the level of significance is less than 0.05. Then, there are at least one of the independent variables has a significant effect on the dependent variable.

Significant independent variables: in order to identify significant independent variables, we examine the values of the regression coefficients.
ϖ The value of the regression coefficient of the independent variable customization is (0.990).This indicates the existence of a positive relationship between this variable and the dependent variable (ERP Efficiency).Also, T test indicates that this relationship is significant and the effect of this variable is considered morally and statistically significant, as the level Of moral less than 0.05. Accordingly, it is accepted hypothesis, which states that "there is a statistically significant relationship between the customization and efficiency of the ERP system."
ϖ The value of the regression coefficient of the independent variable Coordination Improvements is (0.092).This indicates the existence of a positive relationship between this variable and the dependent variable (ERP Efficiency).Also, T test result indicates that this relationship is significant and the effect of this variable is considered morally and statistically significant, as the level of moral less than 0.05.

Accordingly, it is accepted hypothesis, which states that "there is a statistically significant relationship between the coordination improvements and efficiency of the ERP system."
ϖThe value of the regression coefficient of the independent variable interconnectivity is (0.208). This indicates the existence of a positive relationship between this variable and the dependent variable (ERP Efficiency). But the T test result indicates that the effect of this variable is not significant, as the level of significance greater than 0.05. Accordingly, it is rejected the hypothesis, which states that "there is a statistically significant relationship between interconnectivity and efficiency of the ERP system. In order to rank the independent variables, their beta values are examined and there is significance ranks.
1. Customization (beta = .735).
2. Coordination Improvements (beta = 0.162).
3. Interconnectivity (beta = .109).

5.2.2 Second hypothesis
        The second hypothesis which is concerned with the impact of real time antecedents of ERP(performance,availability,resource utilization, semantic consistency) on Business efficiency, which is answered using two tools:-

First tool: oracle enterprise manger 11g is using for measuring performance, availability, resource utilization antecedents.

Performance
        Performance is usually reflected in response time. While it isn't recommend a service level agreement (SLA) for response time, it is very important to measure how long a user has to wait for his or her answer to come back. Using SQL response time in Enterprise manager home page11g to measure performance rate as illustrated in figure 2. The SQL response time is (%) 276.65 of baseline. Baseline is a set of Automatic Workload Repository (AWR) snapshots collected over a period of time for performance comparison. This percentage indicates that response time exceeds Baseline response time which means that one or more SQL statements are performing slower than normal. Thus, the system performance is degrading. Also, automatic database diagnostic monitoring (ADDM) tool is used to analyze the performance of the system. The performance of the system is in low level for the presence of problems in customization of the application in the implementation phase.

Figure 2: Oracle Enterprise Manager Performance pages.

Availability

Availability is the percentage of time the system can be accessed by the users during scheduled hours. Scheduled hours may be 24 hours/day and 7 days/week for global systems or a subset such as 18 hours/day and five or six days/week.

From figure 3 in general section. The system is up from Dec 17, 2012 4:12:26 PM GMT + 02:00 up till FEB, 14, 2013, which confirmed the system is available during schedule hours. The availability of the system is in good level based on the data gathered from system users although of customization problems. Because of the system performs routine maintenance tasks.
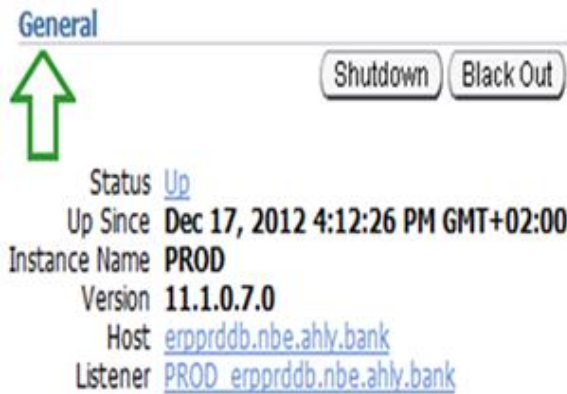

Figure 3: General part in Enterprise manager home page.

Resource Utilization

This includes the I/O, CPU usage, memory usage and the access to the disk. If the system consumes large resources then there's need to identify why and solve resource utilization problems, the information about the percentage of disk utilization should result in a better distribution and partitioning of the data on the array of disks.

User I/O

Mainly the system with poorly performing SQL can cause excessive physical reads and writes,

appearing to be an I/O issue. Active Sessions part in Enterprise Manager Homepage shows the amount of time the instance consumed using CPU and user I/O, and the amount of time it consumed in bottlenecks as illustrated in figure 4.
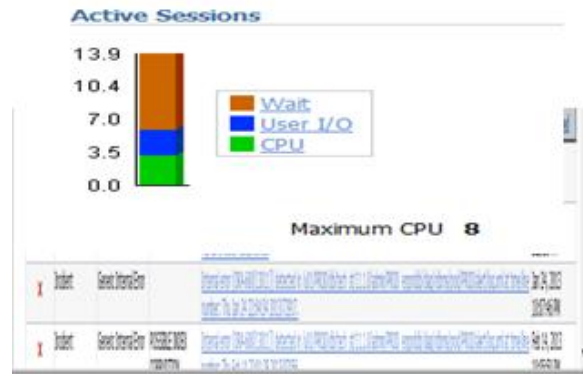

Figure 4: Active Sessions Resources.

From previous screen the bar chart shows that User I/O (Waits for blocks to be read off disk) is large indicates that, there is latency time produces because there are many I/O requests queued up against a disk, the latency increases as the wait time in the queue increases.

Memory usage

This is illustrated from Alerts and Related Alerts link in Enterprise Manager home page in figure 5. The alerts in majority are out of memory, because of request or more consume large resources more natural. The reasons for that SQL statement are not handled efficiently during implementation phase. Thus, the resources utilization of the system was not efficient due to the presence of problems in customization of the application in the implementation phase.

Figure 5: Log messages.

Second tool is questionnaire to confirm the results obtained from the soft ware tool. The statistical analysis of the second hypothesis indicates significant relationship between business efficiency and a model containing three predictor variables performance, availability, and semantic consistency. Table 2 displays a model summary of the multiple regression analysis for research hypothesis two.

Model Summary Generated from Multiple Regression Analysis

Predictors (constant)	B	Beta(B)	T-Test		F-Test		R	R²
			t	Sig.	F	Sig.		
performance	0.148	0.192	2.215	0.028				
availability	0.136	0.156	1.876	0.063	7.942	0.000	0.387	.150
Semantic consistency	0.092	0.184	2.098	0.038				

Explanatory power of the model: The value of determination coefficient of R2 (0.150),means that any independent variables included in the model constructs 15.0% of the variance in the dependent variable (business efficiency).

Moral regression model: The value of the correlation coefficient multi R (0.387) indicates the presence of a moderate correlation between the combinations of independent variables and the dependent variable, as the level of significance is less than 0.05. Then, there are at least one of the independent variables has a significant effect on the dependent variable.

Significant independent variables: In order to identify significant independent variables, we examine the values of the regression coefficients.-Show the following:

ϖ The value of the regression coefficient of the independent variable performance is (0.148), this indicates the existence of a positive relationship between this variable and the dependent variable (Business efficiency).Also, T test result indicates that this relationship is significant, as the level Of moral less than 0.05.Accordingly, it is accepted hypothesis, which states that "there is a statistically significant relationship between performance and business efficiency."

ϖ The value of the regression coefficient of the independent variable availability is (0.136), this indicates the existence of a positive relationship between this variable and the dependent variable (business efficiency). But the test result T indicate that the effect of this variable is not significant, as the level of significance greater than 0.05. Accordingly, it is rejected the hypothesis, which states that "significant statistical relationship between availability and business efficiency."

ϖ The value of the regression coefficient of the independent variable semantic is consistency (0.092), this indicates the existence of a positive relationship between this variable and the dependent variable (business efficiency).Also, T test result indicates that this relationship is significant, as the moral level of less than 0.05.

Accordingly, it is accepted hypothesis, which states that "there is a statistically significant relationship between semantic consistency and business efficiency".

In order to rank the independent variables, their beta values are examined and there is significance ranks.
1. Performance(beta=0.192)
2. Semantic consistency(beta=0.184)
3. Availability (beta = 0.156)

Previous results indicate a significant relationship between ERP Phases' that to get efficient post implementation phase implementation phase must be efficient.

VI. Conclusions

This research is a starting point that sheds some light into the phenomenon of ERP efficiency as related to ERP value. It is important to note that efficiency is not an event, nor is a milestone. But instead it is a process that unfolds through a series of adaptations, renewals, monitoring, transformations, and changes over time. This research revealed that changes ERP systems precipitated a direct impact on business processes, system effectiveness, and the ability of managers to perform their jobs, along with the level of job satisfaction. Results agreed with the findings of the researcher, Abbas Yousef. Interconnectivity variable does not have a significant role in implementation phase. The final results of the research confirmed that the customization and coordination improvements play an important role in the efficiency of the implementation phase and then the efficiency of post-implementation phase. Thus, in agreement with the findings of the Shih-Wei Chou and Yu-Chieh Chang study, post implemented phase

is fully affected with the success of implementation phase which depend on the degree that the software is configured and adapted according to business processes.

VII. Future Work

The research model is implemented using case study method by implementing the model in National Bank in Egypt. So there's a need to investigate more companies and monitor them in the two phases of ERP to increase the reliability and validity of the research results. Although, there are many issues within an ERP system that monitors the efficiency of ERP, this research focuses on two perspectives, information technologies analyst, and users with antecedents (customization, coordination improvements, interconnectivity, availability, performance, resource utilization, and semantic consistency) .The research framework suggested here can be further extended by incorporating some of other perspectives like The effect of internal environment such as Top management support, Organizational structure, IT readiness. And external environment such as Technological change, Level of competition, Rapid market change on the efficiency of ERP.

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