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Assessing Value of ERP Systems: A Formative Construct Analysis

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ABSTRACT

ERP systems have the potential to provide value across multiple dimensions: from operational and managerial to strategic. As with any other information technology, the value of ERP systems can be assessed using different metrics. The available methods of ERP value assessment such as financial performance indicators for the organization do not provide multidimensional contribution of ERP systems. Very few studies in ERP value literature have quantitatively measured and validated ERP value across multiple dimensions. Using the Balanced Scorecard (BSC) approach, this study conceptualizes and validates measures of ERP value across four dimensions of BSC: internal business oriented ERP value, customer-oriented ERP value, learning and growth-oriented ERP value, strategic and financial-oriented ERP value. The measurement model for ERP value indicates the robustness of measures used in the study.

Keywords

ERP systems, ERP value, Balanced Score Card, ERP Benefits.

INTRODUCTION

The ERP systems are integrated software packages that automate core corporate activities such as finance, human resources, and logistics. Many companies have implemented ERP systems to integrate their data flows and improve their business operations (Banks et al., 1999). The basic purpose of ERP systems is to integrate operations throughout an organization. Due to the infrastructural and multidimensional nature of ERP investments, it can be difficult for organizations to determine which aspects of the organization are affected by ERP investments and which effects can be attributed to ERP systems. ERP value has been assessed in some of the earlier studies using financial indicators such as return on assets or profitability (Nicolaou, 2004) or sales per employee and profit margins (Hitt et al, 2002). However, some other studies indicate intangible benefits of ERP systems such as information visibility or new and improved processes (Deloitte Consulting, 1998).

Shang and Seddon (2000) provide a more comprehensive classification of ERP benefits by analyzing 233 ERP-vendor success stories published on the Internet. They also used 34 follow-up interviews to confirm the content of their analysis. Shang and Seddon classify ERP benefits into five categories: operational, managerial, strategic, IT infrastructural and organizational. The operational benefits are described as those that arise from automating basic and repetitive operations, and from streamlining business and information processes. Managerial benefits arise from the use of data to better plan and manage production, manpower, inventory and physical resources (operational efficiency and effectiveness) and to monitor and control the financial performance of products, customers, business lines or geographic areas. The organizational benefits include benefits from facilitating business learning, empowering staff, improving employee morale and satisfaction, and increasing employee focus on core activities related to customers and markets.

It seems that ERP systems provide benefits across multiple dimensions. Therefore, to assess ERP value, an approach such as the balanced scorecard (BSC), which takes into account value contribution across multiple dimensions, seems more appropriate. The BSC approach (Kaplan and Norton, 1992; 1993) integrates multiple perspectives of IT value in a single evaluation framework and has been suggested in prior IT value literature as a framework for strategic information systems management (Chand et al., 2005; Jain and Ramesh, 2005; Martinsons et al., 1999). In this paper, we develop measures for assessing ERP value using BSC approach and then quantitatively analyze the measurement model using formative construct analysis.

This paper is organized as follows. First, we provide a review of different measures of ERP value as reported in the prior literature. In the next section, we discuss the BSC approach and then present measures for ERP value developed in this study.

We follow it up with a description of our methodology to validate these measures using formative construct analysis. We then present the result of our analysis and conclude the paper with contribution to literature.

MEASURES FOR ERP VALUE

The basic purpose of ERP systems is to integrate operations throughout an organization. Therefore, ERP systems cut across business functions and business units. This makes assessing ERP value difficult. Therefore, in the current literature, multiple conceptualizations exist for ERP value.

In their classification of ERP benefits, Gattiker and Goodhue (2000) underline the multifaceted nature of ERP benefits. They identify ERP benefits as belonging to one of four major categories: 1) improving information flow across sub-units, standardizing and integrating to facilitate communication and better coordination; 2) enabling the centralization of administrative activities such as accounts payable and payroll; 3) reducing IT maintenance costs and increasing the ability to deploy new IS functionality; 4) moving an organization away from inefficient business processes and towards accepted best practices. From this standpoint, the benefits of an ERP system in an organization can be realized across multiple dimensions – operational, tactical, and strategic.

Poston and Grabsky (2001), in their analysis of the impact of ERP systems on organizational performance, found that while organizations adopting ERP systems reported a decrease in the ratio of employees to revenue and an improvement in the cost of goods sold, there was little or no improvement in residual income or ratio of general and administrative expenses to revenue. From this standpoint, the value of ERP systems can be seen in the reduction in the number of employees or in the reduction in cost of goods sold.

In one of the most comprehensive studies of ERP impacts on organizational level financial indicators, Nicolaou (2004) reported significant differences in overall differential measures of return on assets (ROA) for ERP-adopting organizations than for the matched control organizations four years after ERP installation. However, differential ROA performance was significantly worse for ERP-adopting organizations as the year of installation ended. The differential profitability (as measured by return on sales) did exhibit a significant improvement, however, this was within time periods of two years and four years after system completion. With regard to expense ratios, the ratio of the cost of goods sold to sales was significantly lower for ERP-adopting organizations four years after system completion, but no significant differences between the adopting and matched organizations were observed in any of the other time periods.

In another study by Hitt et al. (2002), ERP adopters were found to exhibit better performance in terms of sales per employee, profit margins, return on assets, inventory turnover (lower inventory/sales), asset utilization (sales/assets), and accounts receivable turnover. While some studies do indicate positive impacts of ERP on organizational performance, some others provide mixed evidence. For example, in a comparative study of financial performance of ERP adopter and non-adopter organizations, Nicolaou (2004) reports that there was no significant difference between ERP adopter and ERP non-adopter organizations in terms of ratio of cost of goods sold to sales in many time periods after ERP implementation.

In one of the earliest studies of actual benefits from ERP systems, Deloitte Consulting's (1998) study of 85 global companies, 90% of which had revenues over US$1 billion, reported both *tangible* benefits including cost savings (34% of organizations) and faster processing (19%), and *intangible* benefits including improved information visibility (63% of organizations), new/improved processes (31%), and improved customer responsiveness (20%).

Prior research also provides evidence of other types of benefits from the implementation of ERP systems such as labor, process and inventory cost savings, improved decision-making, and savings from dismantling legacy systems (Davenport et al., 2002; Ross 1999). Another way to categorize the benefits of ERP systems that has been reported in prior literature is based on the use of technology (in an automating role) or the use of data held in ERP systems (informating role). For instance, using ERP to automate existing processes helps organizations to improve process control, while the informating role helps managers to use ERP systems for better decision support and better customer service (Lorenzo, 2001).

Table 1 summarizes various measures of ERP value reported in the current literature. While current literature provides a plethora of measures for assessing ERP value, none of the measures is as comprehensive as those based on BSC approach. The BSC approach has been used earlier to assess benefits of ERP systems from multiple perspectives (Edwards, 2001; Markus and Tannis, 2000; Sedera et al., 2001). However, majority of current BSC measures are based on those obtained using case studies. There are not many studies reported in the literature that have assessed ERP value measures based on BSC approach quantitatively.

This study aims to address this gap and provides a more robust and validated measures for assessing ERP value based on BSC approach. In the next section, we discuss the BSC approach used in this study.

Study	ERP value (the dependent variable)	Theme/Central Thesis/Findings
Lorenzo (2001)	Improvement in process control, better decision support, and better customer service	ERP benefits can realized from automating role or from informating role in the organization.
Poston and Grabsky (2001)	Organizational performance as measured by residual income, cost of goods sold, ratio of employees to revenue, ratio of selling, general, and administrative expenses to revenue	ERP systems add value by improving revenue to employees ratio or reducing the cost of goods sold. However, there is no improvement in residual income or ratio of selling, general, and administrative expenses to revenue.
Hitt et al. (2002)	Sales per employee, profit margins, return on assets, inventory turnover (lower inventory/sales), asset utilization (sales/assets), and accounts receivable turnover	ERP adopters were found to exhibit better performance on nearly all financial performance indicators compared to non-ERP adopters.
McAfee (1999)	Fraction of orders shipped late, average lead time, standard deviation of lead time for all orders	While there was a transient decrease in three performance parameters immediately after ERP implementation, all performance parameters indicated marked improvement subsequently.
Murphy and Simon (2002)	IRR, NPV of ERP projects	NPV and IRR for ERP projects was found to be highly significant.
Shang and Seddon (2002)	ERP benefits are realized in operational, managerial, strategic, IT infrastructure and organizational areas	ERP value is a multidimensional construct.
Hunton et al. (2003)	Organizational performance (ROA, ROS, ATO, and ROI)	ROA, ATO, and ROI is greater for ERP adopters than for non-adopters.
Nicolaou (2004)	ROA, ratio of cost of goods sold over sales	ERP adopters were found to exhibit better performance than ERP non-adopters.
Hendericks et al. (2007)	Firm profitability, stock returns	Evidence of some improvement in firm profitability due to ERP, but not in stock returns. The improvement in profitability was found to be stronger among early adopters of ERP systems.
Table 1: ERP Value Measures		

BSC APPROACH

The basic premise of the balanced scorecard (BSC) as a tool for ERP value measurement is that ERP systems create value for an organization not only in financial terms but also across areas such as internal process improvements, customer satisfaction, flexibility, and organizational learning. Therefore, the BSC approach advocates the integration of financial and non-financial perspectives to comprehensively assess ERP value within an organization. The four perspectives suggested in the BSC approach include financial, internal, learning and growth, and customer perspective (Kaplan and Norton, 1992; 1993). The financial perspective takes into account the economic impact of information systems at the organizational level. Suggested measures of IT value under this perspective include sales revenue, return on investment, and profitability (Jain and Ramesh, 2005).

The internal business perspective focuses on business process improvements that impact a business directly and therefore, affect its financial bottom line. Some of the ERP value measures under the internal business perspective include throughput

rate, improvements in accounts receivable, and process optimization (Jain and Ramesh, 2002). The emphasis in customer perspective is on meeting the requirements and expectations of external customers. Information systems add value to an organization from an external customer's perspective by improving response and delivery times, enhancing customer service through customer relationship management (CRM) applications, or offering customized products and services (Jain and Ramesh, 2002). Finally, the fourth perspective, learning and growth, emphasizes improvements in the learning capabilities of an organization's employees. That ERP contributes by enhancing employee skills or improving organizational learning has been documented in prior ERP value literature (Jain and Ramesh, 2002).

ERP VALUE MEASURES BASED ON BSC APPROACH

Considering that validated measures for ERP value using the balanced score card approach are not readily available in current literature, the measures listed in Table 2 were developed specifically for this study. However, these measures were developed based on guidance available in current literature (Jain and Ramesh, 2005). Based on the suggestions of Petter et al. (2007), each of the BSC dimension was conceptualized as the first order formative construct. The decision to specify each of the dimensions for BSC as a formative construct was based on the fact that items indicated in Table 2 predict the dimension rather than the dimension predicting the indicator. Also, items are not interchangeable which makes each of the BSC dimension used in this study to assess ERP value as a first order formative construct (Petter et al., 2007). Additionally, overall ERP value which is an aggregation of ERP value across each of the dimensions was conceptualized as second order formative construct. It follows logically that each of the BSC dimension is independent of each other and cannot be interchanged. Therefore, overall ERP value is considered as a second order formative construct.

Dimension	Item	Item Description
Internal Business Oriented ERP Value	IBO1	The extent to which ERP has provided better coordination between functional and business units within the organization
	IBO2	The extent to which ERP has helped in monitoring performance
	IBO3	The extent to which ERP has helped in improving the quality of decisions
Customer Oriented ERP Value	CO1	The extent to which ERP has helped in improving service response time to customers
	CO2	The extent to which ERP has helped in anticipating customer needs better
	CO3	The extent to which ERP helps improve quality of the delivered products and services
	CO4	The extent to which ERP helps in providing customized products or services
Learning and Growth Oriented ERP Value	LGO1	The extent to which ERP has helped employees in gaining insights into organizational working
	LGO2	The extent to which ERP has provided support to continuously improve core business processes
	LGO3	The extent to which ERP helps in identifying new processes as a result of business process analysis
Strategic and Financial Oriented ERP Value	SFO1	The extent to which ERP has contributed to sales growth for the organization
	SFO2	The extent to which ERP has provided advantage over competitors
	SFO3	The extent to which ERP has facilitated business innovation in market strategy or creating new businesses
Table 2. Instrument Items		

Initially, for each of the dimensions of BSC, 3-4 items were developed based on the current literature and interviews with CIOs of the respondent organizations. These items are listed in Table 2. The items listed in Table 2 were measured using a seven point scale, 1 to 7. After the pre-test of the instrument, items CO3, CO4 and LG03 were dropped because respondents could not fully comprehend the items. For example, for item LG03, the meaning of business process analysis was not clear.

METHODOLOGY TO VALIDATE ERP VALUE MEASURES

The data collection procedure consisted of two phases. The first phase of data collection included preparing the pilot test survey instrument, pre-testing it for content validity and then conducting a pilot test with 30 organizations to obtain initial estimates for the reliability and validity of measures. The pre-testing for content validity was done through validation by three CIOs. The second phase involved refining the survey instrument based on the results of the pilot test, and administering the questionnaire to target respondents for final data collection.

The respondents identified in each organization were from senior management ranks such as vice-president–IT or director-IT. Data from 250 ERP implementations was received from a total list of 1000 implementations. Of the 1000 organizations to whom survey questionnaires was mailed, 285 responses were received – 251 were complete responses, while 34 were incomplete responses. The complete responses, therefore, represent a 25% response rate. This response rate is slightly higher than normally expected in mail surveys. It is believed that regular follow-up supported by personal phone calls helped boost response rate.

Sample demographics in terms of industry sectors and sales revenue is presented in Table 3 and Table 4.

Industry	% of organizations
Automobile	10.0%
Chemical	9.6%
Electrical	9.2%
Pharmaceuticals	6.8%
IT and Telecom	6.0%
Fast-Moving Consumer Goods (FMCG)	5.6%
Textiles	4.0%
Construction	3.6%
Banking/Finance/Insurance	3.2%
Cement	2.8%
Steel	2.8%
Media	2.4%
Other Manufacturing	11.6%
Other Services	22.7%

Table 3. Sample Demographics-Industry Sector

Sales Revenue (in $M)	% of organizations
< 500	62.0%
500 to < 1250	30.8%
1250 to < 2500	3.4%
2500 and more	3.8%
Total (N=237)	100%
Mean (SD)	$ 375 M (428.75)

Table 4. Sample Demographics-Sales Revenue

The validity and reliability of measures for formative constructs requires a different approach. Petter et al. (2007) provide a comprehensive survey of the literature and suggest two tests for assessing the validity and reliability of formative constructs. To examine the validity of formative constructs, Petter at al. (2007) suggest using principal component analysis to examine item weightings for measures. It is suggested to either eliminate the non-significant items (Diamantopoulos and Winklhofer,

2001) or retain the non-significant items to preserve content validity (Bollen and Lennox, 1991). To evaluate the reliability of formative constructs, based on Diamantopoulos and Siguaw (2006), Petter et al. (2007) suggest examining multi-collinearity among formative indicators to determine if VIF < 3.3. Following Petter et al. (2007), formative constructs validity was assessed in this study using principal component analysis, and construct reliability was evaluated by examining the VIF values for formative indicators.

VALIDITY AND RELIABILITY ANALYSIS RESULTS

ERP value is a second-order formative construct. It is formed by four first-order formative constructs: Internal Business Oriented ERP value, Customer Oriented ERP value, Learning and Growth Oriented ERP value, and Strategic and Financial Oriented ERP Value. Before assessing the validity and reliability of the ERP value construct, the validity and reliability of each of the four first-order formative constructs that constitute ERP value construct were assessed. To examine the validity and reliability of each first-order formative construct related to ERP value, a principal component analysis (PCA) was carried out using the respective indicator items of the formative construct. The item weights were checked for statistical significance at the $\alpha = 0.05$ level to establish the construct validity. Subsequently, multi-collinearity among the construct indicators was analyzed using VIF value for each indicator item. As with previous tests, a VIF value of less than 3.3 was assumed to indicate no major problem of multi-collinearity among construct indicators. The results of the PCA test and VIF scores for each of the indicator items for all four first-order formative constructs for ERP value and second-order formative constructs of ERP value are presented in Table 5.

Items	Item Weights	t-statistic	VIF
Internal Business Oriented ERP Value			
IBO1	0.3378	5.3188*	1.76
IBO2	0.3092	4.1260*	1.83
IBO3	0.5178	8.2257*	1.78
Customer Oriented ERP Value			
CO1	0.0978	0.9194	2.36
CO2	1.0733	9.2979*	2.35
Learning and Growth Oriented ERP Value			
LGO1	0.5653	8.4878*	1.58
LGO2	0.5444	9.0436*	1.59
Strategic and Financial Oriented ERP Value			
SFO1	0.3990	7.3803*	1.76
SFO2	0.2701	3.8251*	1.77
SFO3	0.4883	6.9052*	1.99
ERP Value			
Internal business oriented ERP Value	0.4810	5.0537*	2.00
Customer oriented ERP value	0.2065	2.1531*	1.11
Learning and growth oriented ERP value	0.1175	1.2137	2.05
Strategic and financial oriented ERP value	0.4493	4.3043*	1.81
Table 5: PCA Analysis for ERP Value			

*p < 0.05

The item weights are statistically significant for all indicator items for each formative construct, except for item CO1 for customer-oriented ERP value construct and item learning, and the growth-oriented ERP value related to the ERP value construct. However, the corresponding VIF values for these items indicate values less than 3.3. This shows that these items do not pose any multi-collinearity issue. Therefore, it was decided to retain these items for respective formative constructs to preserve content validity. The VIF values for other item indicators are also less than 3.3, demonstrating no major issues of multi-collinearity among construct indictors. The results of PCA and analysis of VIF scores for each indicator establish more than satisfactory validity and reliability of all four first-order formative constructs (Internal Business Oriented ERP value, Customer Oriented ERP value, Learning and Growth Oriented ERP value, Strategic and Financial Oriented ERP Value) and second-order formative construct (ERP value).

DISCUSSION AND CONCLUSIONS

Based on the results of reliability and validity analysis of ERP value construct, the measures developed in this study provide a robust measurement framework for assessing ERP value. For formative constructs, items weights and VIF scores for each construct indicator were examined to establish construct validity and reliability. Except for one item, all other construct indicators were found to have significant item weights. The VIF scores for all construct indicators were less than the recommended 3.3 (Petter et al., 2007), indicating high formative construct reliability.

The approach presented in this paper differs from existing approaches in that it not only assess ERP value more comprehensively using BSC approach but also provides measures to assess ERP value quantitatively using formative construct approach. We could not come across any study in IS literature that focuses on assessing ERP value quantitatively using formative constructs approach. The use of formative construct approach is more relevant because BSC dimensions are not interchangeable and the items used to measure the respective dimensions are not necessarily interchangeable.

This study contributes to ERP value literature in two ways. First, it provides the measures for assessing ERP value using BSC approach. Second, using data collected from the field, it provides evidence about the robustness of the measures for assessing ERP value. We hope that further research can use these measures in a nomological net to further test the validity of the measures.

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