An organization-wide analysis of ERP and information systems interrelationship for logistics support

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Abstract: Enterprise resource planning (ERP) system is a popular information technology application for enhancing competitive advantage, efficiency, and performance of modern organization's business process. Information systems, on the other hand, are applied to manage and monitor such a technology. This paper explores the existence of connection and interrelationship between ERP system and information systems based on the perceptions of 70 ERP system adopters. In addition, the study also examines correlation analysis to find what factors that have influence on satisfaction to adopt and use IT applications. The results describe current activities in usage and future implementation of IT applications, internal and external barriers and support. Some research implications and further exploration are also discussed.

Keywords: Enterprise Resource Planning System, Information Systems, Information Technology, Influence Factors

1. Introduction

Information Technology (IT) applications offer many benefits to company and become an indispensable tool for organization. According to Pavia (1997), IT applications serve as strategic tools for organization to obtain competitive advantages in the market. As information needs to integrate effectively into management and operational processes (Bruque & Moyano, 2007), fast,

accurate and on-line access to data can be accomplished with the help of IT applications such as enterprise resource planning (ERP) system to manage routine business processes (Morabito et al., 2005). Su and Yang (2010) suggest that ERP, together with supply chain management (SCM), has a good potential to improve business performance in organization. As supply chain inherently requires efficient logistic information to improve its business process, the need for both internally and externally integrated information managed by ERP increases and exerts impact on the overall integrated information for decision support to management (Rutner et al., 2003). Bayraktar et al. (2009) suggest that both SCM and information systems (IS) practices positively and significantly influent business operational performance.

Although many organizations recognize the potential value of information as a strategic resource (Karim & Hussein, 2008), usage and implementation of ERP system in companies have concentrate more on daily transactions recording than decision support benefits (Holaspple & Sena, 2005). A number of factors can affect IT investment decision such as environmental context, strategic direction, and potential competitive advantages (Li & Richard Ye, 1999; Chang et al., 2008). Such investment renders a positive edge to business performance (Loukis et al., 2009). Therefore the influence factors to adoption of IT applications can be viewed by three perspectives, namely, perceived benefit, perceived support, and perceived barriers (Ngai et al., 2008). Thus, the research questions addressed in this study are as follows: (1) what are the influential factors to incorporate IT applications in business processes? (2) what are the barriers of implementing IT applications in business processes? and (3) how is the satisfaction level to adoption of IT applications?

The organization of this paper is as follows. Section 2 provides some influential prior works to this study. Section 3 describes the objectives and research methodology. Data analysis and findings are elucidated in Section 4. Section 5 illustrates an actual industrial case study of IS support. Results interpretations and discussions are given in Section 5. Section 6 describes some final thoughts and future work.

2. Literature Review and Hypotheses

Many researches (Palvia, 1997; Loukis et al., 2009) have indicated that IT applications play an important role in supporting business processes because they have a significant influence on the competence of organization. Penstock et al.(2008)expand model of logistics service quality (LSQ) by means of technology acceptance model (TAM) to assess utility and acceptance of

logistics information technology. The information systems literature has developed a number of theoretical frameworks for explaining the influence factors in individual's decision to adopt and use information technology. ERP system is an example application in the form of a software package that consolidates all functions of a company to arrive at efficient and effective IT solutions (Motwani et al., 2005). There are substantial connections between ERP and decision support, whose benefits perceived to have been realized by ERP adopters (Holsapple & Sena, 2005). In addition, the influence factors that have a positive impact on ERP implementation are change management, network relationships, and cultural readiness (Motwani, et al., 2005), while Bayraktar et al. (2009) assert that both SCM and IS have positively and significantly influences to performance of organizations.

Penstock et al. (2008) employed technology acceptance model (TAM) to assess logistics IT use and acceptance with respect to the relationship of perceived ease of use (PEOU) and perceived usefulness (PU) of IT applications. The results provided equal relationships between PEOU and PU that are influence factors in individuals' decision to adopt and use IT applications. The connection between ERP and decision support enables ERP adopters to realize such a benefit (Holsapple & Sena, 2005). Operating managers need comprehensive information to manage the organization's operations and set strategy (Kaplan & Norton, 1996). These are evidences for the role played by IS in modern organizations.
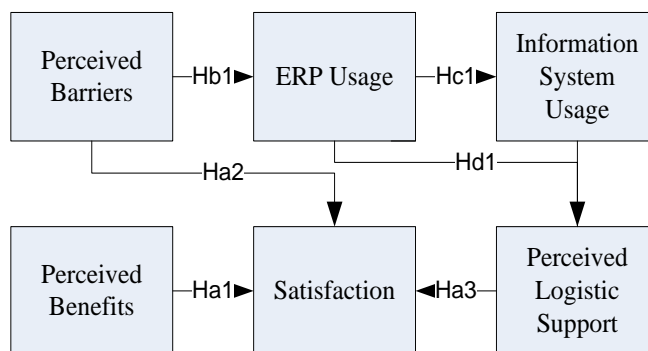

Fig. 1: Research framework of the study.

Therefore, the following research framework and hypotheses as shown in Figure 1 are established and elucidated in subsequent sections.

- *Ha1: The benefit factors have an effect on satisfaction of adopting IT applications.*

- *Ha2: The barrier factors have an effect on satisfaction of adopting IT applications.*
- *Ha3: The logistic support factors have an effect on satisfaction of adopting IT applications.*
- *Hb1: The barrier factors have an effect on satisfaction of adopting ERP systems.*
- *Hc1: Adopting ERP system has an effect on satisfaction of IS usage.*
- *Hd1: ERP and IS usage have an effect on logistic support factors.*

3. Research Objectives and Methodology

The purpose of this research is to investigate the current status of ERP in conjunction to logistics in Thailand and how IS can be incorporated to support such operations. The objectives are fourfold: (1) to analyze current and future prospect of organization-wide IT applications, logistics in particular, (2) to identify factors that influent the use of IT applications, (3) to assess the level of users' satisfaction, and (4) to find the relationship between ERP and IS usage. The research framework is depicted in Figure 1.

Based on the above issues so identified in the literature review, we derive a set of survey questionnaire, encompassing four topics, namely, (1) use of IT applications to support company's operations, (2) factors that influent the adoption of IT applications in both support side and barrier side, (3) benefits to adoption of IT applications, and (4) satisfaction level of adopting IT applications (Ngai et al., 2008). The perceived benefits of IT applications will also be taken into consideration. The questionnaire uses a 5-point Likert's scale with 1 being "Strongly Disagree" and 5 being "Strongly Agree" to adopting IT applications.

The questionnaire was pilot tested with students in executive management business administration program. Subsequent questionnaire refinement was performed to arrive at appropriate final questionnaire. Thus, content validity of the measure is systematically accounted for in this study.

A preliminary study was conducted to test the viability of the questionnaire with subjects in executive management business administration program. From the preliminary 300 questionnaires, 132 were returned and used in the analysis. The overall response feedback was 44%. Table 1 summarizes the respondents' company profile. The respondents included operation personnel, manages, top executives, and owners. The majority of respondents clearly have considerable experience with IT applications and are well-qualified to inform this research. Table 2 shows the implementation of current IT systems to support organization-wide operations, i.e., already use IT, under planning to pursue, and no plan to use in near future. Although the last two categories seem to be

indistinguishable, their share of IT activities was proportionally equal and significant enough to exert a notable impact on result analyses, hence the separation.

Table 1: Profile of respondent companies (132 totals).

	Freq	Percent
Industry categories		
Non Service Industries:		
Manufacturing for industry	42	31.8
Manufacturing for consumer	12	9.1
Retail	6	4.5
Wholesale	1	0.8
Subtotal	61	46.2
Service Industries:		
Service for consumer	19	14.4
Service for industry	22	16.7
IT Service	25	18.9
Bank	4	3.0
Telecommunications	1	0.8
Subtotal	71	53.8
Operation (Yrs)		
< 1 Yrs	2	1.5
1 – 3 Yrs	9	6.8
4 – 6 Yrs	11	8.3
7 – 9 Yrs	8	6.1
> 10 Yrs	102	77.3
Number of employees		
< 50	20	15.2
51 – 200	23	17.4
201 - 350	13	9.8
> 350	76	57.6
Revenue (Baht)		
< 30,000,000	13	9.8
30,000,001 – 60,000,000	9	6.8
60,000,001 – 100,000,000	11	8.3
100,000,001 - 200,000,000	10	7.6
> 200,000,001	89	67.4
No. of years implementing IT		
< 5 Yrs	24	18.2
5-10 Yrs	30	22.7
> 10 Yrs	78	59.1
No. of products		
1	22	16.7
2	8	6.1
3	16	12.1

	4	86	65.2
Duration of computer usage (days)			
	2	1	.8
	3	2	1.5
	4	1	.8
	5	1	.8
	7	127	96.2

Table 2: Current IT systems and future implementation.

Systems	In use		under planning		no plan	
	fre	%	fre	%	fre	%
Operational Systems						
Internet	129	97.7	1	0.8	2	1.5
Emailing & messaging	121	91.7	4	3	7	5.3
Intranet	114	86.4	9	6.8	9	6.8
Purchasing	95	72	15	11.4	22	16.7
Delivery sched plan	90	68.2	20	15.2	22	16.7
Customer DBM	89	67.4	22	16.7	21	15.9
WH Mgmt	80	60.6	8	6.1	44	33.3
Customer order proc	80	60.6	23	17.4	29	22
Inventory Mgmt	77	58.3	12	9.1	43	32.6
ERP	70	53	29	22	33	25
Barcode & RFID	67	50.8	19	14.4	46	34.8
CRM	67	50.8	32	24.2	33	25
Extranet	67	50.8	31	23.5	34	25.8
EFT	61	46.2	23	17.4	48	36.4
Supplier DBM	53	40.2	30	22.7	49	37.1
Product Catalogue	50	37.9	34	25.8	48	36.4
EC	45	34.1	31	23.5	56	42.4
Information Systems						
BI	52	39.4	41	31.1	39	29.5
DM	51	38.6	41	31.1	40	30.3
DSS	49	37.1	41	31.1	42	31.8

4. Data Analysis and Findings

Exploratory factor analysis (EFA) was applied to examine the underlying dimension that grouped the items of benefits, the barriers, and the support to adoption of IT applications. Principal component analysis (PCA) was used to extract the factors loading with varimax rotation method for factor interpretation. For any factor to be retained, the eigenvalue should be greater than one (Hair et

al., 1998). The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy, which ranges between 0 and 1, was used to detect whether or not the data were properly factored. The KMO measure over the minimum acceptable value of 0.5 (Kaiser, 1974) satisfies the prerequisite of a good factor analysis. Factor validation is accomplished using convention advocated by Nunnally (1967) on items having factor loadings of exceeding 0.4. Data reliability and validity are carried out by Cronbach's alpha that measures the internal consistency of multi-item scales as low as 0.6 (Nunnally, 1967) for each construct.

The results of EFA can be summarized as shown in Table 3. Correlation analysis from all factors, i.e., benefit, barrier, influence, and satisfaction using Pearson Correlation Coefficient, found that barrier to IT realization came mostly from insufficient resources, while changing had no correlation with satisfaction factor at the significant value of 0.05.

Table 3: Results of EFA for all items.

Factors	Eigen	Cronbach
Benefits items:		
KMO= 0.906, Cumulative of Variance = 69.603%	11.066	0.89
Business supplier/partner relation benefits	2.417	0.860
Operational efficiency benefits	1.126	0.878
Organizational benefit	1.086	0.795
Internal process effy benefits	1.010	0.719
Human Resource benefits		
Barrier items:		
KMO= 0.865, Cumulative of Variance = 66.387%	6.829	0.905
Insufficient resources	1.827	0.864
Integration with other systems	1.302	0.697
Changing		
Support items:		
KMO= 0.907, Cumulative of Variance = 71.543%	8.207	0.916
Efficiency	1.432	0.841
Support	1.092	0.852
Competitive advantage		
Satisfaction items:		
KMO= 0.830, Cumulative of Variance = 72.063 %	2.883	0.871
Satisfaction		

Table 4: ERP and IS usage (132 totals).

ERP	Groups of IS usage				Percentage		
	In use	Under planning	No plan	Total	In use	Under planning	No plan
In use	51	10	9	66	77.3	15.2	7.6
Under planning	10	14	5	26	38.5	53.8	7.7
No plan	5	2	26	40	22.5	12.5	65
Total	70	29	33	132	53	22	25

Table 5: IT application usage and industry categories (70 totals)

IS	Industry Categories (% of 70)	Non-service			Service		
		In-use	Under planning	No plan	In-use	Under planning	No plan
Business Intelligence	No.	20	10	3	26	7	4
	%	29	14	4	37	10	6
DSS	No.	17	11	5	20	9	8
	%	24	16	7	29	13	11
Data Mining	No.	17	14	2	21	8	8
	%	24	20	3	30	11	11

The predominant inferences are the existence of relationship between service and non-service segments. Table 4 depicts the relationship between ERP and IS usage from all respondents. The in-use group represents companies that use at least one IS application such as business intelligence (BI), decision support systems (DSS), or data mining (DM). Further investigation by industrial categories as shown in Table 5 reveals that significant numbers of ERP usage are prevalent. This confirms that companies have adopted IT in most of their operational systems. Yet they still fully exploit the potential benefits due to a couple of key barriers, namely, insufficient executive support and integration with suppliers. The associations among these factors in accordance with the model framework hypotheses established earlier are given in Table 6.

Table 6: Summary of association.

Association with ERP Usage	Result
Group of usage IS	Associated
Industry categories	No Associated
Barrier in Insufficient executive support	Associated
Integration with supplier's systems	Associated
Others Barriers	No Associated

Table 7: Factors that yield different multiple comparative results of ERP and IS adoption.

Comparison		Factors
No plan to use ERP	In-use or under planning to use ERP	Barrier: Integration with other systems
Use both ERP and IS	Not use both ERP and IS	Benefits: Business supplier relation
Use both ERP and IS	Use ERP but not use IS	Support: Competitive advantage
Use only ERP	Not use both ERP and IS	Barrier: Insufficient resources

Table 7 shows the significance of correlating factors between ERP and IS adoption. Only four implementation categories are compared since they exhibit significant interrelationship, while other combinations are irrelevant, e.g., use only IS-use only ERP, use only ERP-user only IS, etc. We employed one-way analysis of variance (One-Way ANOVA) and least significant difference (LSD) for multiple comparisons to unveil factors that yield different comparative results in each group.

5. Case Study

The case study is taken from a retail business in ceramic tile and sanitary ware. The business began 32 years ago from an old-fashioned retail shop to become the largest national ceramic chain. They have over the years evolved from manual operation to ERP then IS supported "vendor online" system that links all parties involved in the SCM via intranet to administer three vital information bases, namely, product master and product knowledge base, online purchasing, and vendor manage inventory. Information breakdowns are categorized at the general application level to preserve confidentiality of trade secrets and company's anonymity. All IT and business applications are listed in Table 8.

Table 8: IT Application usage of XYZ Co., Ltd.

| Year	Application	Description
1997	Oracle ERP	Start usage ERP
1999	Customized ERP	Customized Applications
2001	Intranet	Code name Xnet
2002	Product knowledge base	Manage product data in intranet
	BI	Oracle BI: Client server
2003	Vendor Online I	Online Purchasing
2004	Vendor Online II	Manage product data by vendors
	VMI	Replenishment, Request System, Min-Max
2005	BI	Oracle BI: Web based
2007	WMS	Mobile device, Handheld
2007	Delivery System	Trips and Routing
2008	GPS System	Track delivery system
	Member System	reward/redeem point
2010	SAP ERP	Start usage SAP
	BI	Business Object, Dashboard
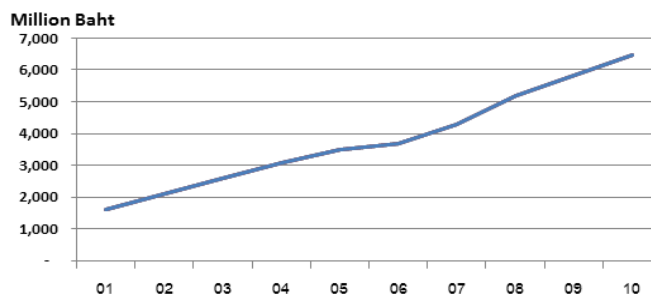
Fig. 2: Graph of annual sales volume.

The above graph provides information on sales trends of XYZ Co., Ltd. It is apparent that such integrated IT applications have transformed many manual and stand-alone applications, ranging from logistics, inventory, and sales, to serve the growing customer's needs. The net results are consecutive annual sale increase for the past 10 years.

6. Discussion

Analysis of the model framework and hypotheses encompass profound implications on company's decision to adopting ERP and IS. In general, barriers factors have no relationship with users' satisfaction for skilled and knowledgeable IS users, thereby no additional needs for IS to support current ERP. On the other hand, barriers of integrating IS with other systems, in one example comparison, are the main hindrance for companies that have no plan to adopt ERP. One important inference drawn from all analyses is the interrelationship between ERP and IS usage. Companies that use both ERP and IS attain different perceived benefits of business supplier relations and better perceived competitive advantages over companies that have not use both ERP and IS, whose barrier came primarily from insufficient resources to adopting IS. The sizable 66% of 70 respondents that adopt ERP and IS underpins SCM as an integrated component of ERP which in turn becomes the core competency of the organization. However, implementing ERP system calls for considerable investment and risk that IT managers must handle with care, not to mention the barriers on adoption as resulted from this study. The effect could ripple down to logistic operation, lack of IS adoption, and organization performance (Chang et al., 2008).

7. Conclusion and Future Work

The contribution of this paper is an interrelationship analysis of ERP and IS in logistics support of many modern organizations, where pockets of IS usage spread over different departments. The missing link so identified is the interrelationship between ERP and IS to support various operations. We have investigated factors that influent users' satisfaction with IT applications by selecting ERP and IS. The results of association encompass BI, DSS, and DM. Moreover, recognition of barrier factors that affect company's decision on their adoption is also attained.

There are ample opportunities for future research exploration that involve the extension to SME segment. The interrelating factors between ERP and IS will warrant further examination on finer grained components that fit their the low budgeted applications of IS for logistics support in SCM, wherein extensive qualitative observation on additional factors and proper quantitative assessment methods can be applied toward the adoption decision for many local SMEs.

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