RANKING THE BARRIERS OF INFORMATION TECHNOLOGY ADOPTION IN SUPPLY CHAIN MANAGEMENT BY ANALYTIC HIERARCHY PROCESS

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Abstract- Information technology (IT) has an important role to increase supply chain capability. The barriers of IT adoption in supply chain management (SCM) are identified as a part of the right guideline development for IT adoption.The objective of this research is to rank the barriers of IT adoption in SCMby Analytic Hierarchy Process (AHP).The samples are companies,which participate in a promotion of applying information technology projectof logistics unit, the Bureau of Logistics Department. The result of this research showsthe ranking ofIT adoption's barriers in SCM.Orders of themain criteriafrom the most to the least are project barriers, individual barriers, technological barriers, supply chain barriers and strategic barriers.Inadequate knowledge and training are the most criticalsub-criteria. Poor project management and poor vendor/consultants are the following important sub-criteria. These resultscan used to set the guideline for barrier prevention and solution to the problems, which might occur.

Keywords- Supply Chain Information Technology, Barriers, Analytic Hierarchy Process.

I. INTRODUCTION

Presently, supply chain management (SCM)must deal with uncertainties, which may cause by increasing customer demand and more rivals in organizational level and supply chain level. Manufacturers have to enhance supply chain flexibility in the global competition and market fluctuation[1], [2],[3].Information Technology (IT) will increase supply chain capability in the market change response by improving the quality of information, data accuracy, accessibility and timeliness to provide supply chain flexibility[4].IT capability and information sharing effect to the integration of information flow and raw material flow. IT adoption such as Electronic Data Interchange (EDI), Barcode system, Enterprise Resource Planning (ERP), Customer Relationship Management (CRM) and Decision Support System (DSS)can provide better supply chain integration [5].An organization can use IT to create competitive advantage such as inventory information sharing, production plan sharing, sale forecast sharing, which can help in decreasing the bullwhip effect and accelerating time to market of the product [6].

Industrial sector in Thailand has to develop capability and create competitive advantage by making a differentiation, in which the customers can see their better products and services. Cost leadership and quick response are also the ways to create differentiation.Logistics and supply chain management are used as akey tool to drive an industry in achieving business goals. Especially, IT is adopted as a major tool for logistics management and enhanced operational performances. Appropriate IT adoption to the organization is essential and crucial for industrial development in Thailand [7].

In order to reach the successful IT adoption, organizations have to find major barriers. One of the major barriers is changing in individual and organization. In addition, inadequate knowledge, business process change, poor project management and lack of top management support are the factors which effect to the failure of IT adoption. To avoid the failure, organizations have to realize key success factors such as changing in management, training and education, top management support, planning and vision. These factors effect to the competitive advantage[8], [9].However, the barriers of IT adoption in SCM have not been ranked yet especially for Thai industry. The barriers of IT are identified as a part of the right guideline development for IT adoption. This guideline can use to set the barrier prevention and solution[10].

Analytic Hierarchy Process (AHP) is used to prioritize barriers in this research. It has been widely used in many literatures[11],[12],[13],[14].AHP can assess both quantitative and qualitative factors. Pair wise comparison is employed to rank the major barriers of IT adoption in SCM of organizations in Thailand. Obtained results can be used to set as the guideline for barrier prevention and solution to the problems which might occur.

Table1: Initial hierarchy model of barriers of IT adoption in SC and its criteria.

Main criteria	Code	Sub-criteria	References
Strategic barriers	SB 1	Lack of strategic direction and planning	[15]
	SB 2	Lack of a performance measurement system	[16]
	SB 3	Lack of IT awareness	[17], [18]
Supply chain barriers	SCB 1	Lack of top management support & involvement and lack of a project champion	[15], [17]
	SCB 2	Lack of financial support	[19],[20], [21], [22]
	SCB 3	Misfit between supply chain structure and technology system	[17], [23]
	SCB 4	Poor business reengineering	[22], [25]
Technological barriers	TB 1	Lack of technical expert	[10], [22]
	TB 2	Lack of adequate technical/IT infrastructure	[17]
	TB 3	Privacy and security concerns	[10],[18], [19], [22],[26]
	TB 4	Lack of interoperability and standards	[18]
Individual barriers	HB 1	Employees' resistance to change	[19], [24], [27]
	HB 2	Inadequate knowledge and training	[17], [28], [29]
Project barriers	PB 1	Poor vendor/consultants	[17], [20]
	PB 2	Poor project management	[15]

II. BARRIERS OF INFORMATION TECHNOLOGY ADOPTION IN SUPPLY CHAIN MANAGEMENT

2.1. Information Technology Adoption in Supply Chain Management

IT tools in logistics and SCM are gathered from literature review and summarized as follows:

1. Material Requirement Planning: MRP
2. Enterprise Resource Planning: ERP
3. Warehouse Management System: WMS
4. Distribution Requirement Planning: DRP
5. Transportation Management System: TMS
6. Electronic Data Interchange: EDI
7. Electronic Business Extensible Markup Language: e XML
8. Electronic Commerce: E-commerce
9. Point Of Sale: POS
10. Barcode System
11. Radio Frequency Identification: RFID
12. GPS Tracking

2.2. Barriers

The barriers of IT adoption in SCM are identified as a part of the right guideline development for IT adoption. The barriers from literature reviews can be concluded as shown in Table1.

The barriers of IT adoption in SCM are classified into 5 main criteria, including15 sub-criteria.

1. Strategic barriers: Lack of strategic direction and planning is one of the strategic barriers, which are significant for IT investment [15].Moreover, lack of an effective performance measurement system and inconsistent of performance measurement and objective with partners affect to IT adoption and IT performance measurement because the importance of performance factors differs between partners [16]. Lack of IT awareness is another strategic barrier, which leads to unwillingness in innovative investment, because of lack of understanding about IT process and its benefit[17], [18].

2. Supply chain barriers: Lack of top management support is one of key supply chain barriers. Top management should be involved and allocated the necessary resources to IT implementation project[15], [17].Lack of financial support and the high investment cost are other supply chain barriers, which IT adoption need to restructure/business process reengineering, training and educating staff[19],[20], [21],[22].Misfit between supply chain structure and information system are caused by lack of organization's readiness assessment and feasibility study before IT adoption[17], [23].Thus the existing business process is incompatible with the new IT system. Poor business reengineering is one of supply chain barriers, because lack of IT integration between organizations within the supply chain. The organization has to change the existing business process to compatible with the new technology [19], [24].

3. Technological barriers: Lack of technical experts and IT experts affect to the spread and penetration about IT[22],[25].Lack of adequate technical/IT infrastructure is one of the technical problems, which makes IT system incompatible with organizational structure and process[17].Privacy and security concerns for electronic system implementation are another technological barriers [10].Data access is one of privacy and security concerns for partners, who work together in supply chain. Partners worry about information leakage and data hacking. They will not share their information, which leads to the difference in information[18], [19], [23], [26].The next technological barriers are lack of interoperability and international standards for facilitating the information exchange between users. Standards can help to reduce technology cost, which are comprised of hardware design, training and system maintenance [18].

4.Individual barriers: Employees' resistance to change is one of key individual barriers, which cause by lack of the understanding about the role of technology in their daily work. They think that they may replace by technology [19],[26], [27].Inadequate

knowledge and training for users in using new IT and how business processes changes through IT adoption are another individual barriers. Many organizations obstruct training and testing IT. The effect of lack of training makes the employees cannot work with the new system and they lack morale and motivation in their daily work[17], [28], [29].

5.Project barriers**:** Poor vendors/consultants are one of the project barriers. If vendors or consultants are inappropriate or less experience, then they cannot interoperability among supply chain[17], [20].Poor project management is another project's barrier, which refers to the implementation processes from project planning, assignment of responsibilities to various players, scheduling of project tasks, monitoring and controlling activities, and closing the project[15]. It plays important role in implementing IT.

III. RESEARCH METHODOLOGY

3.1. Data Collection

The samples are from 6 experts of companies, which participate in a promotion of applying information technology project of logistics unit, the Bureau of Logistics Department. These companies are implementing IT for their SCM under supervision from logistics unit, the Bureau of Logistics Department. Results are collected from questionnaires. The respondents are: one Logistics Manager, two Warehouse Managers, one Logistics Analysis, one Supervisor and one IT Staff.

3.2. Barriers Ranking by Analytic Hierarchy Process

AHP is a multi-criteria decision making process that has been used for rational diagnosis. It was developed by Thomas L. Saaty in the mid of 1970s. A problem can separate into sub element and structured as a hierarchy. Then, the problem can be determined using pair wise comparison. Next, weight of criteria is calculated and ranked. AHP is simple and rational[30]. Its structure is imitated human thinking process.AHP does not require the special expert to control or instruct the judgment[31].

The AHP method is based on three phases: first, construct the structure of the model; second, comparative judgment of the criteria has to be assigned; third, synthesis the priorities[11].

Step1:A problem is structured as a hierarchy. Overall goal of the problem is in the first level. The main criteria are in the second level, and sub-criteria in the third level. The AHP hierarchy structure of prioritize the barriers of IT adoption in SCM is shown in Fig. 1.

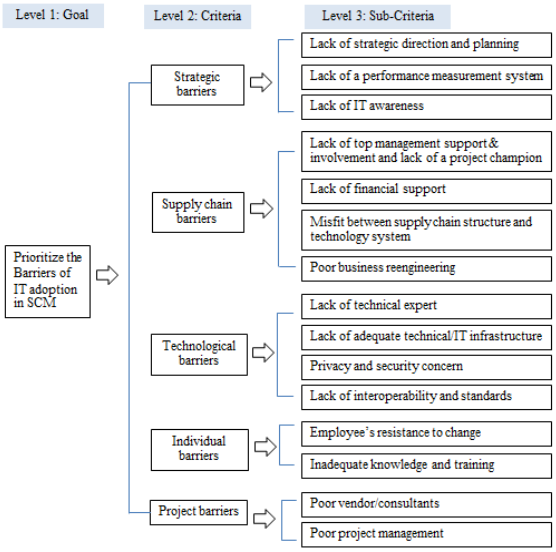


Fig. 1. Decision hierarchy for prioritizing the barriers of IT adoption in SCM.

Step 2: Comparative judgment of the criteria is based on three phases. Firstly, uses use the fundamental scale that provides in Table 2 to compare criteria based on pair wise comparison. Secondly, weight calculation. Thirdly, consistency check is done.

Table2: The fundamental scale.

Verbal Judgments	Intensity of importance
Equal Importance.	1
Moderate Importance.	3
Strong Importance.	5
Very Strong Importance.	7
Extreme Importance.	9
For compromise between the above values.	2, 4, 6, 8
For tied activities.	1.1-1.9

Comparison matrix is used for the pair wise judgment. If the matrix is consistent, the priority can be calculated by

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\left\{\frac{\sum_{j=1}^{n} a_{ij} \times w_j}{w_i}\right\} \quad (1)$$

Where λ_{max} is core axis of eigenvector, n is matrix size, a_{ij} is the element of pair wise comparison and w_i and w_j are eigenvector of elements I and j respectively. Consistency Ratio (CR) is the ratio between Consistency Index (CI) and Random Consistency Index (RI), which can be calculated in (3), Consistency Index can be calculated in (2),

$$\text{Consistency Index } (CI) = \frac{\lambda_{max} - n}{n-1}, \quad (2)$$

$$\text{And} \quad CR = CI/RI \quad (3)$$

Random Consistency Index (RI), which is shown in Table 3. CR does not exceed 0.5 and 0.8 for n = 3 and4 respectively, and it does not exceed 0.10 for n> 5, the data are consistent and can be used to conclude.

Step3: Synthesis to prioritize the overall importance.

Table3:The random consistency index (RI).

Size (n)	1	2	3	4	5	6	7	8
RI	0	0	0.52	0.89	1.11	1.25	1.35	1.40

Table 4: Pair wise comparison matrix of the main criteria

Main Criterion	Strategic Barriers	Supply Chain Barriers	Technological Barriers	Individual Barriers	Project Barriers	Weight
Strategic Barriers	0.08	0.06	0.06	0.07	0.11	0.08
Supply Chain Barriers	0.16	0.11	0.09	0.08	0.15	0.12
Technological Barriers	0.20	0.19	0.15	0.10	0.17	0.16
Individual Barriers	0.31	0.37	0.39	0.28	0.21	0.31
Project Barriers	0.26	0.27	0.32	0.47	0.36	0.33
Sum	1	1	1	1	1	1

IV. RESULTS AND DISCUSSION

4.1. Priority of main criteria

Pair wise comparison matrix of the main criteria includes strategic barriers, supply chain barriers, technological barriers, individual barriers, and project barriers. Results from 6 experts and the weight of the main criteria are shown in Table 4.Order of weights of barriers of IT adoption in SCM Is project barriers (0.33), individual barriers(0.31), technological barriers(0.16), supply chain barriers (0.12)and strategic barriers(0.08). The consistency ratio (CR) is0.03< 0.1. So, consistency of the experts' judgment is acceptable.

Results show that project barriers are the most important barriers of IT adoption in SCM for Thailand industries. These could be from lack of expertise in project management and poor vendor/consultants. This result is similar to Amin, et al. (2012)[17]. Amin has concluded that poor project management is the major failure factor for ERP implementation in Iran industries. Poor project management refers to lack of full time and balance project team. The project team should be balanced and the key person should work in full time for an ERP implementation project. However, these results differ from Lenny, et al (2011) [16], who found that the important barrier to ERPII implementation is an organizational barrier or individual barrier in our research. The employees do not accept the change that is the difficulty in maintaining and improving business processes.

Individual barriers are the second barriers, which compose of lack of training and educating and employees' resistance to change. The result of this work is consistent with the work by Amin, et al. (2012) [17].Amin found that poor human resource management is the second failure factor for ERP implementation. The organizations focus on technical management and project finance, but human management is abandoned. ERP implementation requires the ability to recruit, select, place, evaluate and develop appropriate employees.

Other important barriers focus on technological barriers. This result is in the same direction with the work by Peral, et al. (2014) [22]. This work has shown that poor supplier/partner infrastructure is a major barrier of e-procurement adoption in the book and the stationery sector in Turkey. These barriers lead to another barrier such as lack of technological /technology infrastructure and lack of e-procurement knowledge and skill.

However, there are also other researches which have different results from this study. The difference depends on industrial sectors that they study and the way they categorized barriers.

4.2. Priority of sub-criteria.

A pair wise comparison matrix of sub-criteria from the experts and the weight of sub-criteria are shown in Table 5-9.

Assessing the importance of sub-criteria barriers of IT adoption in SCM, we have found that there are three critical sub-criteriabarriers. These sub-criteria have weight more than 10% of the overall weight. They are inadequate knowledge and training, poor project management and poor vendor/consultant.

From the results of this study, the guideline management can be prepared as follows:

Table 5: Pair wise comparison matrix for the strategic barriers sub-criteria

Criterion	Lack of strategic direction and planning	Lack of a performance measurement system	Lack of IT awareness	Weight	Finalized weight
Lack of strategic direction and planning	0.11	0.07	0.13	0.10	0.008
Lack of a performance measurement system	0.35	0.23	0.22	0.27	0.021
Lack of IT awareness	0.54	0.69	0.65	0.63	0.050
Sum	1	1	1	1	0.08

Table 6: Pair wise comparison matrix for the supply chain barriers sub-criteria

Criterion	Lack of top management support & involvement and lack of a project champion	Lack of financial support	Misfit between supply chain structure and technology system	Poor business reengineering	Weight	Finalized weight
Lack of top management support & involvement and lack of a project champion	0.08	0.06	0.06	0.07	0.12	0.014
Lack of financial support	0.16	0.11	0.09	0.08	0.29	0.035
Misfit between supply chain structure and technology system	0.20	0.19	0.15	0.10	0.26	0.032
Poor business reengineering	0.31	0.37	0.39	0.28	0.33	0.039
Sum	1	1	1	1	1	0.12

Table 7: Pair wise comparison matrix for the technological barriers sub-criteria

Criterion	Lack of technical expert	Lack of adequate technical/IT infrastructure	Privacy and security concern	Lack of interoperability and standards	Weight	Finalized weight
Lack of technical expert	0.12	0.12	0.09	0.16	0.12	0.020
Lack of adequate technical/IT infrastructure	0.19	0.18	0.14	0.20	0.18	0.029
Privacy and security concern	0.38	0.34	0.27	0.22	0.30	0.048
Lack of interoperability and standards	0.31	0.37	0.50	0.41	0.40	0.063
Sum	1	1	1	1	1	0.16

Table 8: Pairwise comparison matrix for the individual barriers sub-criteria

Criterion	Employee's resistance to change	Inadequate knowledge and training	Weight	Finalized weight
Employee's resistance to change	0.34	0.34	0.34	0.104
Inadequate knowledge and training	0.66	0.66	0.66	0.206
Sum	1	1	1	0.31

Table 9: Pairwise comparison matrix for the project barriers sub-criteria

Criterion	Poor vendor/ consultants	Poor project management	Weight	Finalized weight
Poor vendor/consultants	0.41	0.41	0.41	0.135
Poor project management	0.59	0.59	0.59	0.195
Sum	1	1	1	0.33

1. Training and educating users. Users should be trained on how the system works and how to get the benefit from the system [26]. Employees and parties who use the system of both direct and indirect ways should acquire knowledge and skill that related to the new IT. Moreover, IT should make them gain comfort ability in their operations[32].

2. The effective project management. An organization should set the project management strategy that covers the following topics:

Firstly, good project management should have project schedule and plans, which links to the project goals and includes a clear objective, the development of both a work plan and a resource plan. Secondly, realistic project schedule should be identified. Then, meeting and monitoring show the progress of the project. Next, the project champion is selected. Finally, top management supports control the IT implementation process, avoiding overrun of budget and ensuring implementation on schedule [9].

Moreover, the effective project manager should be able to select the appropriate software vendor, who comprised of the past experiences. Trust between software vendors and organizations should be created. Vendors should monitor the system after technology implementation until success [10]. Software vendors should be involved in all project phases. Vendors' knowledge and experience in software and technology use are necessary for IT implementation [33].

CONCLUSIONS

This research aims to rank the barriers of information technology (IT) adoption in supply chain management (SCM) by analytic hierarchy process (AHP).Data are collected from the experts who expertise in IT. Then, the priority of barriers is ranked. Order of main barrier in descending order is project barriers, individual barriers, technological barriers, supply chain barriers and strategic barriers. From the sub-criteriabarriers, we have found that inadequate knowledge and training are the most importance sub-criteria. Nextcritical sub-criteria are poor project management and poor vendors/consultants. These results can used to set the guideline for barrier prevention and solution for the problem that might occur. Future research will study about the solution for IT adoption for success.

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