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A Roadmap to Green Supply Chain System Through Enterprise Resource Planning (ERP) Implementation

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Abstract

Green supply chain is a supply chain system focusing on environmental impacts and the efficiency of energy used. A green supply chain will be achieved if a system is able to track down all information regarding the environmental influence. However, a green supply chain will not be possible without enterprise resource planning (ERP) implementation in organizations. ERP is the integrated information system overlooking manufacturing processes from raw materials to finished products. However, the successful implementation of ERP depends on four critical factors: defining business cases, prepare system and users, stabilizing to obtain normal operations and maintaining and upgrading. Moreover, learning organization (learning from own experience and learning from others) is another key ingredient for the successful implementation. Last but not least, process mapping from "As-Is" to "To-Be" models is also a powerful technique which facilitates the implementation by identifying the process models of current and future ones. Moreover, the featured functions of ERP for a green supply chain should include the capability to keep and track the environmental data of raw materials from suppliers, to prepare an environmental report for each product from raw materials to finished products, to keep the environmental data regarding logistics and transportation and to comply with the ERP software used by third-party manufacturers.

1. Introduction

Enterprise resource planning (ERP) is an integrated system, which is designed to automate and integrate business processes and operations together. This is a desired function which paves the way for the organizations to have the

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operation, especially the supply chain, which is environmental friendly. However, the implementation of ERP requires a lot of organizational efforts and many enterprises end up with failures or do not achieve the benefit as expected before the implementation. For this reason, there are a lot of research works conducted in order to identify potential factors and approaches, which have helped to guide the enterprise through the implementation successfully. In this research, the roadmap to a green supply chain with the assistance from ERP is clearly illustrated. Critical success factors, which are significant to the success of the implementation, are addressed and described while its relationship with ERP is also clarified by following the chronological order of the implementation. Moreover, the role of process mapping as well as the organizational characteristic of how to learn from failures was presented and discussed on how they influenced the success of the implementation. Finally, the desired characteristics of the ERP system leading to green supply chain are listed and explained while the integrated model for implementing ERP is also proposed.

2. Literature review

Al-Mashari and Zairi [1] pointed out that a supply chain system can be re-engineered within and beyond the organizational scope by applying the ERP scheme to the existing system. Hervani, Helms and Sarkis [2] created a framework for studying, designing and evaluating a green supply chain. Their studies were based on experiences, case studies and literature reviews. The integration of supply chain management and ERP was shown in the research work of Koh, Saad and Arunachalam [3] since these two approaches were known to fulfill each other. Their study indicated that the close relationship with suppliers and the centralized system would lead to a successful integration. For a model-oriented study, the moderated hierarchical regression analysis was utilized by Zhu and Sarkis [4] to explore the relationship among the green supply chain implementation, the environmental and economic performance in Chinese firms which now face high pressure from lawmakers to adopt a green supply chain system. The critical factor to achieve a green supply chain system is studied by Zhu, Sarkis, Cordeiro and Lai [5]. The correlation between the organization learning and the management support and its influence on the green supply chain were also investigated.

3. Green supply chain and ERP

There is a lot of effort trying to combat pollution issues, especially from the European Union (EU). Among these initiatives are the restrictions of hazardous substances directive (RoHS) (adopted in 2003) and European Union emission trading scheme (EU ETS) (launched in 2005). Under RoHS, six hazardous materials (Lead, Mercury, Cadmium, Hexavalent chromium, Polybrominated biphenyls and Polybrominated diphenyl ether) are restricted in the manufacturing processes of electronic and electrical equipment. On the other hand, EU ETS focuses on the reduction of greenhouse gas emission based on the cap and trade scheme. Cap is the limited amount of emission from each country and it can be traded in the form of emission permits (carbon credits). Installations are able to hold credits but it will not be allowed to exceed the cap. However, if the installations would like to emit more gas, they have to pay in order to obtain credits. Therefore, not only carbon footprint or hazardous substances but also environmental footprint has to be closely monitored by manufacturers. The supply chain system of each installation has to comply with the above constraints and this can be considered as the responsibility to the environment and customers. As a result, manufacturers have to establish their green supply chain systems which have the capability to document all the environmental information in every stage of supply chain. In order to fulfill this objective, an integrated information system is required to track every detail due to the environmental impacts of supply chain system. The answer to this question is the implementation of ERP system since ERP has integrated every aspect of the production system together and overlooks the transactions of data throughout the system by following the master production schedule (MPS). Basically, ERP focuses on the following categories (Table 1):

However, there are many factors affecting the successful implementation of ERP system. Therefore, the in-depth understanding of these factors will pave the road to the green supply chain system.

Table 1. Functions and Activities of ERP System.

Function	Activities
Demand	-Demand forecasts
Production	-Planning and control
Tracking	-Data Transaction
	-Tracking material movement
	-Quality control
	-Inventory
	-Environmental impact data

4. Methodology

The methodologies used in this research are the in-depth interviews and the surveys conducted on the designated organizations which have already implemented ERP system in their organizations for the purpose of achieving the green supply chain system.

5. Results

5.1. Critical factors

Critical factor for successful implementation of ERP systems, eleven factors, which are critical to ERP implementation, have been identified and explained by following four different phases of the project [6]: chartering (defining business cases, solutions and constrains), project (prepare system and users), shakedown (stabilizing to obtain normal operations) and onward-upward (maintaining and upgrading). For the whole life cycle of ERP, critical success factors (CSF) like ERP teamwork and decomposition (ERP team should be cross-functional and working full time on the implementation), top management support (top management has to provide resources for ERP teams), effective communication (objectives, scope and progress have to be clarified for the ERP teams and employees), project management (milestones of the project as well as deadlines will be set in order to keep the project on the schedule and budget), project champion (project leader for ERP implementation) and appropriate business and information technology (IT) legacy systems (IT systems and stable business processes) have a significant effect on the implementation. However, change of management program and culture (the corporate culture to accept the change), business process reengineering (BPR) and minimum customization (ERP system should be chosen after the reengineering and it has to be consistent with business processes) and software development and testing (ERP structure is required before the implementation of any ERP software) are critical factors for the second half of the implementation (shakedown and onward-upward phase) while business plans (strategies, measurable benefits, costs and schedule has to be clarified and included in the business plan) and the evaluation of performance (milestones and tangible objectives have to be established in order to keep project on the right track) are considered in chartering phase and onward-upward respectively.

5.2. Process mapping

Process mapping is a powerful tool to investigate business processes before the implementation of ERP since the result of the implementation depends on how thoroughly the mapping has been done to the current supply chain system. Moreover, it can be considered as a tool to guide the organization to go through the implementation of ERP as well. As a result, the activities of the organization regarding the environmental issues have to be clearly identified. Afterwards, the administration should have a clear picture of how the activities of the future supply chain system will be added in order to fit "To-Be" green supply chain system. Process mapping can be categorized into

three phases: "As-Is", "To-Be" and "Bridging the Chasm". In the "As-Is" phase, all critical processes will be identified by key participants for the purpose of separating non-value added activities from value-added ones. The second phase of process mapping with ERP is "To-Be" phase, which will focus on creating the idealized process and their constraints as well as eliminating the non-value added activities specified in the first phase. ERP software will play an important role in this phase since it has to be run by basing on these idealized processes so the benchmarking of each package is required in order to choose the software that is best fitted with enterprise processes. Before implementing ERP software in "To-Be" phase, the conversion from "As-Is" to "To-Be" processes or "Bridging the Chasm" phase is required. In this phase, change management program will be addressed to identify human barriers in the conversion as well as the communication, which is critical to keep employees aligned with "As-Is" and "To-Be" processes. Teams, which are responsible for customizing ERP software, testing and analyzing, will be established in this phase as well.

5.3. Learning organization

Generally, how to implement ERP successfully is still a question for many supply chain administrations. Even some systems, which have a similar structure, implement the same ERP software at the same time, the result may come up in different ways. The organizational learning, which is unique for each enterprise, has a great effect on the outcome of the implementation since it will control the ability to learn from failures, which is important in order to be successful in the implementation [8]. Organizational learning is a discipline that can be categorized into two main issues: learning from individual experience (experiential learning) and learning from other enterprises (vicarious learning). For the experiential learning, an enterprise can gain the experience of ERP implementation via organizational experiments by identifying cause and effect of its own failures or success while the imitation of other enterprise's success or using the second-hand knowledge from consultants can be determined as the vicarious learning. Experiments or exploration have some risks but may lead the enterprise to the breakthrough learning of ERP implementation on their supply chain system since it is considered as a creative way of learning from failure. However, an enterprise has to be a smart learner in order to capture the knowledge from failures effectively. By focusing on processes rather than outcomes of the implementation, the enterprise should have "to be" processes associated with the selected ERP package so errors or failures from the tactical level of the implementation will be configured with the assistance of prototyping and extensive testing. Another characteristic that supports the intelligent failure is the organizational culture itself since an enterprise should support employees to gain experience from failures. A set of well-planned action for an enterprise is also important because it can be used to recognize the cause of failure and allow the organization to respond to a failure rapidly. However, no matter whether the organization chooses to explore or exploit, the bottom line is both approaches have to be supported by the information technology. The extended benefit of implementing ERP in the context of IT is that enterprise personnel can also gain knowledge from learning to replace the existing system by the new system (learning by doing) and learning to adapt themselves by following the implementation. For the environmental impact, people in the organization will realize the consequence of their activities on the environment only if they are aware of this information (those who produce pollution are responsible for paying the damage price). ERP software will play an important role on this aspect since it can show the data regarding the environmental impact from a whole supply chain.

5.4. Life cycle impact assessment functions of ERP

The desired ERP software should have the capability to track the environmental impact on supply chain system for the whole life cycle of a product which can be categorized into

1. Midpoint impact: This is the direct impact to environment which includes global warming, ozone depletion, carcinogens, acidification, eutrophication, heavy metal, mineral and fuel used.

2. Endpoint impact: This type of impact is the consequence of midpoint impact, e.g., human health, ecosystem quality and the depletion of natural resources.

As a result, the environmental impact from each stage of product life cycle should be recorded as follows:

1. Resource extraction: The quantity and environmental data of raw materials from suppliers must be recorded

and these data should be retrieved immediately when there is a request. The information should be demonstrated in the form equivalent to the bill of materials.

2. Manufacturing: The available system should be able to track the amount of energy and resources used to manufacture a functional unit of product.

3. Transportation: The environment impact of this stage is mostly the greenhouse gas emitted from the engine combustion due to the shipping process of products from manufacturers to customers. For this reason, the information regarding the mode of transportation (land, air or sea freight) should be kept and recorded since each type of transportation has different impact on the environment. The distance from factory to warehouse should be collected as well.

4. Use: There should be the environmental information according to the daily used of the designated product.

5. Waste disposal: Since not every part of product will be recycled, the percentage of recycling should be clearly identified so the impact will be calculated for only the portion of product that is disposed, e.g., burning or landfill.

Another piece of information that most people always ignore is the resource used for the purpose of quality control process. Moreover, defects (scraps and reworks) from quality control process are needed to be addressed since they require a follow-up process which always comes up with the environmental impact. Additionally, the ERP software should be capable of preparing the environmental report for the activities of the supply chain system regarding all aspects mentioned above.

6. Incorporation

The implementation of ERP in any enterprises is required in order to increase the ability to manage resources and energies effectively. For this reason, the top management support should not be a problem but the concern is the culture of the organization and lack of good management. According to study, the effort to transform many supply chain systems by implementing the ERP had been proposed many times before but it always ended up with failures because of the resistance to change from employees. As a result, setting up clear business plans and vision, establishing clear communication between the management and employees, identifying teamwork with leaders and allowing employees to participate in ERP teams will help guide the enterprise to be on the right direction at the beginning or chartering phase. At the same time, everyone dealing with the implementation (especially the ones in ERP teams) should have a solid background on the theory of the implementation techniques before they have to do it themselves so they need to be well trained or educated. In the next step, process mapping will be used to identify non-value added activities in each department in order to develop "As-Is" model for the whole enterprise. Non value-added activities will be eliminated for the purpose of converting supply chain processes from "As-Is" to "To-Be". This is considered as the hardest part of the implementation since some employees may resist to cooperate. After this, the implementation of ERP packaged software can be done in the "To-Be" phase (after the reengineering). However, the enterprise may learn that the implementation of ERP on their supply chain system is complicated and it may come up with short term failures. Thus, the organizational learning will help the enterprise to achieve the long term success in the implementation by capturing knowledge and experience from failures. For environmental issues, creating awareness and social responsibility is a driven force encouraging employees in the organization to abolish the change resistance. Therefore, they are ready to implement ERP so that a green supply chain is really achieved.

7. Conclusion

How to implement ERP successfully for having a green supply chain system is still a trouble for many enterprises. Although some enterprises have followed all suggested approaches, the success of the implementation is not guaranteed. However, a lot of research works show that most enterprises are likely to implement ERP successfully if they carefully apply all approaches and techniques. In this article, different aspects of ERP implementation have been introduced and it ranges from critical success factors to the practical tool, i.e., process mapping, which helps the enterprise to identify and evaluate processes before implementing ERP. Finally, the

implementation may not come up with a success immediately so the learning process of the organization is needed in order to learn from short term failures and achieve the long-term success.

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