

Design and Implement of a Web-based E-Procurement System Platform for Shipping Line

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Abstract: - To establish an e-procurement system platform for the global shipping line can not only solve the problems of purchase and delivery difficulties, but also help the enterprises improve the efficiency of procurement.

The goal of this research is to develop a web-based e-procurement platform, which can be actually initiated in the multinational shipping companies. The implementation of e-procurement system with W. Shipping Corporation about one year showed that the average procurement time decreased 80%, the number of full-time procurement personnel went down 50%, annual telephone and stationery expenditures were reduced 66%, the time for document processing of procurement personnel went down 89%, and value analysis time went up 25%. Moreover, it can solve the unnecessary contacts of negotiation dealings and documentation between purchasers and suppliers. For the required supplements of ships, suppliers can be informed in advance to deliver and supply the goods before the ships berth at any of the worldwide operation points or ports. This service design can improve the competition of enterprises.

Key-Words: E-procurement platform, Enterprise Resource Planning (ERP), Shipping line.

1 Introduction

It is time and manpower consuming in manual labor used to follow up the procedure of procurement for a company. The traditional procurement procedure in a company's operational departments includes reviewing the budget, filling in a procurement request form and waiting for approval. All the deals depend on faxes and telephone calls to communicate back and forth. As the scope of E-Business expands, the procurement function of a company has made the transition from a supporting role to the decisive factor in competitiveness of an enterprise. According to a the report from the Aberdeen Group, a company may save more than 70% in terms of costs and time by conducting its procurement on the Internet. Through the use of electronic procurement system under E-Business framework, companies may initiate their procurement procedures with saving time and money [1].

In the case of shipping industry, the global operational management and the ships moving and docking at the world's various harbors makes it evident that the traditional procurement methods are unable to meet the customers' needs. Moreover,

the following problems may occur continuously:

1. The procurement personnel, no matter where they are located at head offices or the various business units all over the world, all have to wait for the review and approval of procurement behavior, which is a waste of time.
2. The tools of the trade in shipping industry are inefficient. For example, any spare parts or consumed oils procured need to be made available immediately from the docked ship of the supplier. The traditional procurement method is unable to do this because it cannot control the delivery time.
3. The procurement personnel of head office or business units worldwide may not be able to buy the products at the same time.
4. The procurement behavior or modes of trading on the part of procurement personnel from head office or worldwide business units cannot be audited. The transactions are not transparent, which easily leads to kickbacks and other corrupt practices.
5. As the internal product coding principles and product categories of a company lack a set of standards, people are unable to find the needed

products in a timely manner, which is another form of procurement inefficiency.

However, the building of a rapid response and successful e-procurement platform hinges on one crucial factor – the categorization of products and the formulation of a sound material coding principles. The spare parts and consumed oils needed in the shipping industry are both complicated and ever-changing. Each ship has a different set of spare parts and required types of consumed oils. That makes it quite difficult for the procurement personnel to make the procurement fast. Consequently, this study focused on gathering in a platform with categorizing and analyzing the currently procured products, as well as coming up with the coding principles. It also tried to establish coding principles that would be applicable to various types of products. By connecting to the complicated and ever-changing sets of required spare parts and consumed oils in the shipping industry, this study set out to create an e-procurement platform and integrated it with the procurement system of the company's backend ERP system, as well as with the disbursement system and the warehouse inventory system. The study hopes to solve the problems of traditional procurement method, to lower procurement costs, and to shorten delivery time.

Taking into account time, manpower, and costs, the study submitted solutions that would assist the shipping industry in improving the following situations:

1. The procurement personnel from head office or various business units all over the world are allowed to transmit electronic forms and documents of any procurement behavior rapidly through this platform on the Internet.
2. After the purchase of spare parts or consumed oils, the supplier would be immediately notified to provide the supply from its ship at the harbor.
3. The procurement personnel from head office or various business units all over the world would buy the products at the same time to lower costs and have these goods delivered to specified locations.
4. More economically viable suppliers or potential suppliers worldwide are attracted to come and work together.
5. The top-level managers would be allowed to readily look into the procurement behavior of procurement personnel and modes of trading.
6. A set of material coding principle is established to allow of rapid searching of needed products and the procurement personnel would therefore do the effective procurement management.
7. The related procurement platforms in the

country would be analyzed and compared with each other, so that sound recommendations would be provided to the procurement managers.

2 Related Literature

The focus of the study is to come up with a fast and effective way to categorize products. Taking the shipping industry as an example, an e-procurement platform was established from the company's viewpoint. Therefore, the literatures includes product categorization principles, coding principles, existing corporate e-procurement platform functions, the internal ERP system of the company as well as the characteristics of the shipping industry.

2.1 Trading platform of electronic procurement

The existing trading platform of electronic procurement are introduced as follows.

2.1.1 Definition of electronic purchasing trading platform

E-procurement platform uses electronic means to integrate corporations and suppliers, allowing revisions on needs/supply to be made through the Internet. It helps companies lower their procurement overheads as well as to save time in procurement. It also enables suppliers to acquire procurement via the platform within the shortest time as well as to get an immediate reply of procurement. The establishment of electronic procurement provides corporations with a safer and more convenient channel for platform information exchange [4]. The imminent dawning of the electronic procurement age proposed not only electronic trading, shipping, warehousing, and payment collection, but also accurate prediction of customer needs through the analysis of customers in the platform [13, 14, 15]. At the same time it can further achieve low inventory level and rapid response to customers' needs.

2.1.2 Design of electronic purchasing trading platform

1. Comprehensiveness of application functions: If a company chooses to use the current products in the market, it should consider if the functions of the applied system could meet its current needs.
2. Capability of platform information exchange: The B2B system prioritizes the automation of

platform between companies. This is why the method of transmission and the communication mode supported by the system should include current standards such as: HTTP, SMTP, FTP, EDI/XML.

3. Flexibility of systems integration: Because the e-commerce applications extend a company's internal in platform system to its trading partners, it is necessary to consider the integration with the ERP system existing within the company. The consistency of the platform is usually an issue that needs to be resolved during the integration of procurement system.
4. Support of public standards: Current software development or software engineering is concerned with categorization of documents. The standards of components determine the development of system platform.
5. Stability and expandability of the system: The stability requirements of the e-procurement platform should be supported to reach a certain standard [16].

2.1.3 Functions of electronic purchasing trading platform

Ordinarily, a complete e-procurement platform would include the following functions [2, 8-12]:

1. Online database functions of supplier: This includes company online registration, company notification (e-mail, fax), account and password management, basic protection in platform, and integration of suppliers in platform.
2. Online application functions: This includes procurement company applicant search, input of procurement application, revision of procurement application, removal of procurement application, procurement application search (reviewed, not reviewed), online review of procurement application (for managers).
3. Online price inquiry and price quotation functions (procurement): This includes transformation of reviewed procurement application forms into price inquiry, supplier search, supplier notification (e-mail, fax), bargaining and haggling, archive search.
4. Online price inquiry and price quotation functions (business): This includes: quotation and re-quotation, archive search, price inquiry search, and meeting confirmation.
5. Online bidding functions: This includes production of bid form, online quotation bids from suppliers, supplier notification (e-mail, fax), searching for bid quotations (procurement), searching for bid quotations (supplier), and bid voiding operations.
6. Online price comparison functions: This

includes notification of meeting for supplier (e-mail, fax), online price comparison operations, production and entry of price comparison form.

7. Online delivery revision functions: This includes procurement delivery form, online revision of terms of delivery, revision of delivery schedules and terms of delivery by supplier, and online adjustments of terms of delivery by purchasing entity [3].
8. Online notification functions: This includes notifying the supplier (e-mail, fax).
9. Online payment status inquiry functions: This includes online inquiry of payment status for the supplier.

2.2 Shipping industry

The world's economic development has been being closely related to the international shipping industry. Economic development is based upon the international shipping which establishes the form of growth. It is also the basic premise for the development of the industry. Consequently, the worldwide economic development trends have far reaching effects on the shipping industry as a whole [6]. In summary, there are four factors which directly affect the shipping industry [5, 7]:

1. Exchange rate: Shipping companies use the US dollar to purchase oils, ships, cars, and planes. Oil possesses current and future prices which are pegged to the US dollar, so that stable currency becomes a the major currency in market exchanges for the shipping industry.
2. Interest rates: Shipping companies take out bank loans to purchase vehicles, ships, airplanes, and other tools of the trade. Therefore, the interest rate becomes the major consideration in making these purchases for the shipping companies. The bank interest rate is linked to the ship-making costs. The lower it is, the higher desire of buying new boats the shipping companies will have.
3. Price of oil: Oil is the lifeblood of shipping industry. The cost of oil accounts for the largest part of the costs. If the shipping companies do not keep a close eye on the oil prices, they will not be able to take advantage of low shipping costs and therefore high profits.
4. Economic prosperity: The shipping industry is most affected by the economic prosperity. The volume of trading going up or down depends on how prosperous the economy is at the moment.

3 Analysis of Procurement Case in Shipping Industry

3.1 Analysis of old procurement procedures

W. Shipping Corporation has more than 40 branches all over the world geographically distributed in the United States, Japan and Mainland China. Any procurement requests from the branches are submitted to the head office in Taiwan. Currently, the procurement system of W. Corporation is executed in COBOL environment. The operational platform of hardware is HP3000. The procurement procedure is divided into two parts, namely the computerized procurement system and the manual operation. On the manual operation aspect, as the huge comings and goings of with the procurement procedure are manipulated by manual processing, it is prone to mistakes, corruption, and inability to control the delivery time effectively. In addition, it requires the participation of large number of personnel resulting in a burden on HR costs. These people are usually engaged in the petty and ordinary work, resulting in low performance and job satisfaction. On the aspect of computerized procurement system, it does not totally satisfy the needs of electronic procurement. The study figured out the following disadvantages:

1. Procurement time is lengthy: The price inquiry form, quotation form, order form, as well as other trading documents processed in platform will be sent through traditional mail or fax. These manual processes increase not only the procurement time, but also a higher chances of mistakes or losses.
2. Procurement time is not easily controlled: For any procurement requirements submitted from the branch offices, it is usually a long wait without any information about the whole procurement status and when the shipment is going to be delivered. The uncertainties, especially in the purchase of oils, bring on a lot of problems.
3. Manual operation mistakes: A large amount of manpower required in the procurement work leads to many mistakes occurring in some crucial steps of the procedure which include filling in the order form, sending the order's confirmations, inventory, inspection, and acceptance of shipment.
4. High procurement capital: In the course of contact between the procurement personnel and the supplier, the telephone and mail are used to transmit the order form, the order confirmation form, delivery schedule notification, and other processing procedure information. Therefore, a lot of budgets is spent on telephone calls, postage, stationery, and other related office expenses. It is a heavy burden on HR as the larger costs are incurred in terms of manpower.

To get rid of the disadvantages which were resulted from the manual parts of procurement procedure, a new e-procurement system in this research was proposed to take over the manual manipulations. It would automate and simplify the procurement procedure and system operations. This new procurement procedure will improve overall corporate performance.

3.2 Automation Solutions of Procurement Procedures

3.2.1 Development of New Procurement System

1. Functions of integration support: This subsystem integrates the content of the back end ERP database with other procurements in the platform to ensure the entire veracity and consistency. This will benefit the ensuing financial and managing operations by from reducing manpower costs and increasing supply sources.
2. Automated notification system: The subsystem equips an automatic notification function for the procurement procedure. For example, when the procurement personnel requires the a supplier to submit the quotation. The subsystem will automatically send an e-mail to notify the supplier to of submitting a quotation. After a review sent to the platform, the subsystem would notify the reviewing personnel of a pending procurement case for further review. In such way, the company would achieve a stationery-free and environment-friendly operations as well as effectively preserved records reduced future searching costs.
3. Online price negotiation system: This design aims at reducing the amount of time in negotiations between procurement personnel and suppliers. It allows both sides to for initiate initiating price inquiry, price comparison, negotiation, and bidding procedures. It could also provide the revision and confirmation of delivery quantities and schedules after an order has been confirmed.
4. Security control and management system: As the platform includes suppliers' offered prices, reviews from corresponding departments, and other crucial business information, this subsystem provides a flexible and efficient security management mechanism to prevent users from unauthorized searches in the platform.

3.2.2 Implementation priorities of proposed procurement procedure

The system development implementation points of each core procedure, serving as the major functional items of this study's procurement trading platform:

1. Supplier network database module: The major functions of this module include online registration for suppliers, platform protection, account and password management, as well as identification and review of suppliers.
2. Online application management module: The major functions of this module include online submission of procurement application for the demanding department, online review, and transformation of a procurement application form into a the procurement form after being approved. This would reduce the repetitious input by the personnel.
3. Online price inquiry management module: This module comprises online price inquiry for each purchasing entity, online quotation submission for the suppliers all over the world and online bargaining.
4. Online bidding management module: This module consists of producing a tender form from the purchasing entity and initiating the online bidding procedure for suppliers
5. Online price comparison management module: The major functions include online price comparison procedure and online review of price comparison forms. The former allows interested suppliers to submit quotations and produces a price comparison automatically from the subsystem. The latter provides the online review for price comparison forms
6. Online delivery date revision management module: The major functions of this module's include: (1) confirmation procedure for purchasing entity and supplier delivery schedule, (2) online revision, adjustment, and confirmation procedure for terms of delivery.
7. Online notification management module: This module aims to provide the online notification procedure which is connected from the internal ERP system in the platform.
8. Online payment status inquiry management module: This module integrates the internal ERP system for supply factories to proceed with payment status inquiry.

4 Design and implementation of Procurement Trading Platform for Shipping Line

4.1 System Functions

Based on the proposed procurement procedure implementation and analysis of the ~~old~~ existing procurement system, a list of core process functions were served as the modular functions of the proposed procurement trading platform.

4.2 System design

The system design was built on the J2EE platform with the Thin Client framework. Users could manipulate the system through the Windows operation system and internet browsers. The system website used SSL encryption to ensure the security of information transmissions. The Oracle database and JSP development tool were implemented on the back end. All users were provided with HTML operational front end.

4.3 Design of Procurement Procedure

4.3.1 Procurement operation procedure

After summarizing and analyzing the procurement procedure of W. Corporation and together with the system functions mentioned above, a new procurement procedure defined in 17 steps, as shown in Fig. 1.

Step1: Entity with goods and materials requirement submits a request on the platform to the warehouse management entity. The warehouse management personnel would look into warehouse inventories.

Step2: If there are inventories satisfying the request, then the entity is notified of taking the needs immediately.

Step3: If there is no inventory, then a procurement application shall be submitted to the procurement platform.

Step4: Based on the review system implemented in the procurement platform, if the application does not pass the review, then the procurement application is sent back.

Step 5: If the procurement application passes the review, then the procurement entity is notified of initiating the price inquiry.

Step 6: Suppliers may submit quotations to the platform for the needed products which they are able to supply.

Step 7: Purchasing entity may haggle and bargain with all suppliers online.

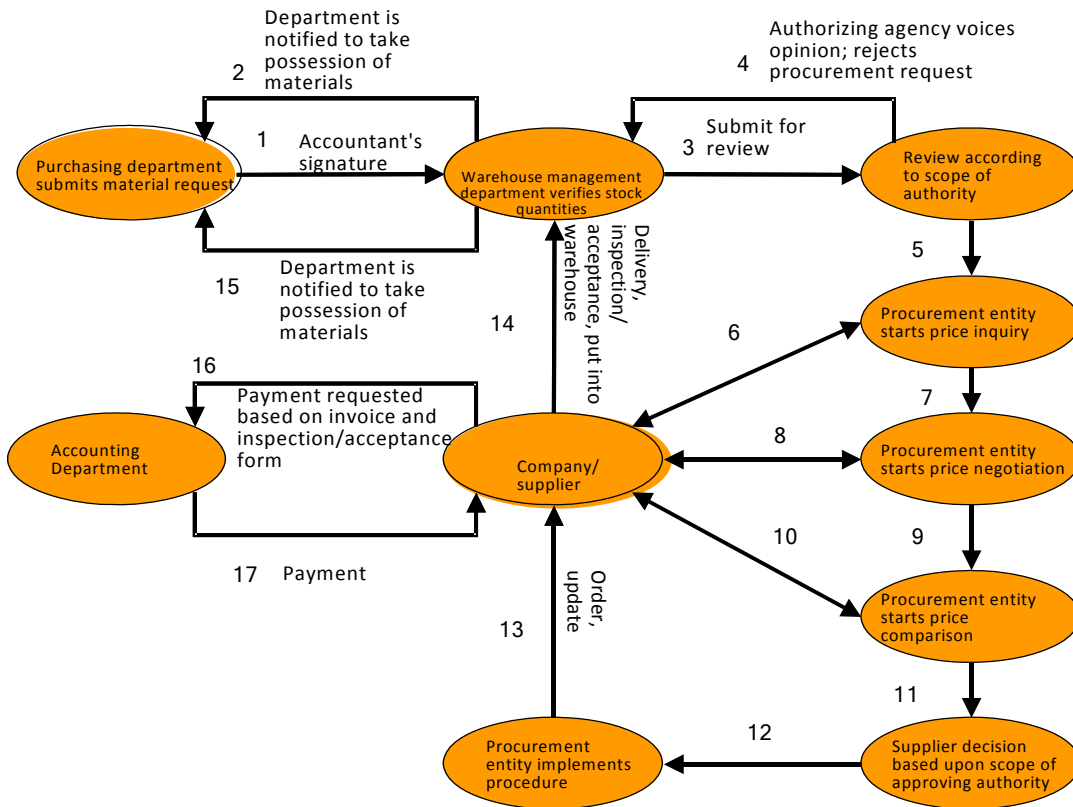


Fig. 1 Complete Procurement Flow Diagram

- Step 8: Suppliers may submit another quotation for the same product based on the price offered by the purchasing entity.
- Step 9: Purchasing entity produces a price comparison form based on the final price of each supplier.
- Step 10: Supplier can know the final price on the platform.
- Step 11: Through the review and approval system in the platform, the top-level manager can make a decision about the supplier.
- Step 12: After the supplier is decided, procurement entity can place the order.
- Step 13: Purchasing entity proceeds with the last stage of negotiation with the bidding winner.
- Step 14: Winning supplier proceeds with inspection, and acceptance procedures based on the terms and quantities of the order.
- Step 15: After the warehouse management personnel the purchasing entity would be notified of taking the purchases.
- Step 16: The winning supplier submits documents to the accounting entity and collects payment after shipments are accepted by

- the purchasing entity.
- Step 17: The accounting entity can disburse payment to the supplier according to the terms of payment and thereby complete the procurement procedure.

4.3.2 Procurement Processing Procedure

For any entity with procurement need, it should submit an application on to the procur have annotation ement platform. The system will first automatically collate if the same procurement need is also requested by any other entities within the procurement database. If so, the system will send a message to the entity that first submitted the application inform it of increasing procurement quantities. Complying with review regulations, the system will automatically send a form to the reviewing manager for proceeding with the procurement price inquiry procedure. The comprehensive procurement application procedure is shown in Fig. 2.

4.3.3 Price inquiry operation processing procedure

After the procurement application is reviewed and approved, it will be turned into a price inquiry form. And an inviting e-mail for quotations will automatically be sent to the suppliers who are capable of filling the products specified on the price inquiry. The flow chart of comprehensive price inquiry procedure is shown in Fig. 3. The manager is responsible for reviewing and approving the factory supplier and the procurement content. The flow chart of comprehensive quotation and price comparison process is shown in Fig. 4.

4.3.4 Price comparison operation processing procedure

Suppliers may submit a price quotation according

to the contents of price inquiry. The procurement personnel may negotiate the price based on the the quotations submitted by the suppliers.

4.3.5 Payment inquiry operation processing procedure

The procurement personnel could produce a price comparison form after the winning supplier has confirmed the delivered shipments and negotiated price. As the workflow accepted by the buyer, the procurement platform will link up the ERP system to enable the supplier to trace the payment status and mode of payment from the platform. The comprehensive payment inquiry processing procedure is shown in Fig. 5.

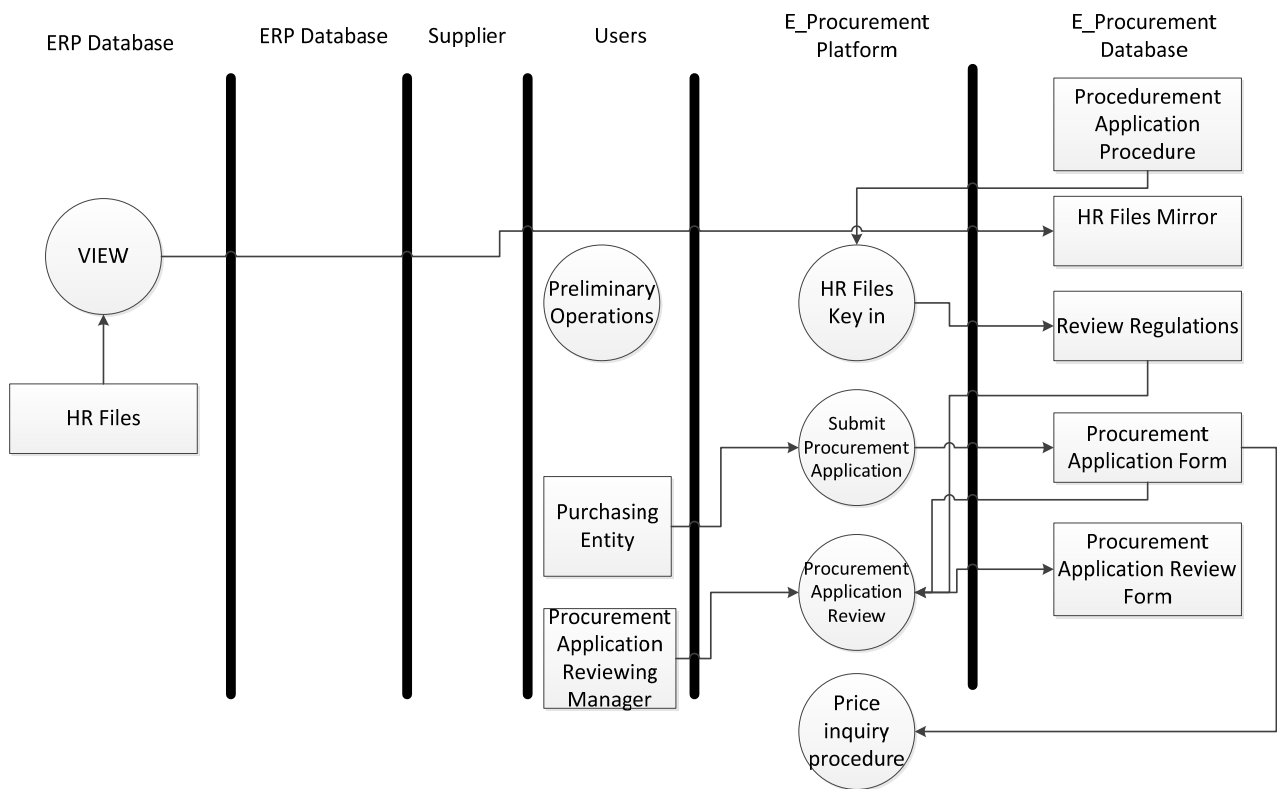


Fig. 2 Flow chart of procurement processing procedure

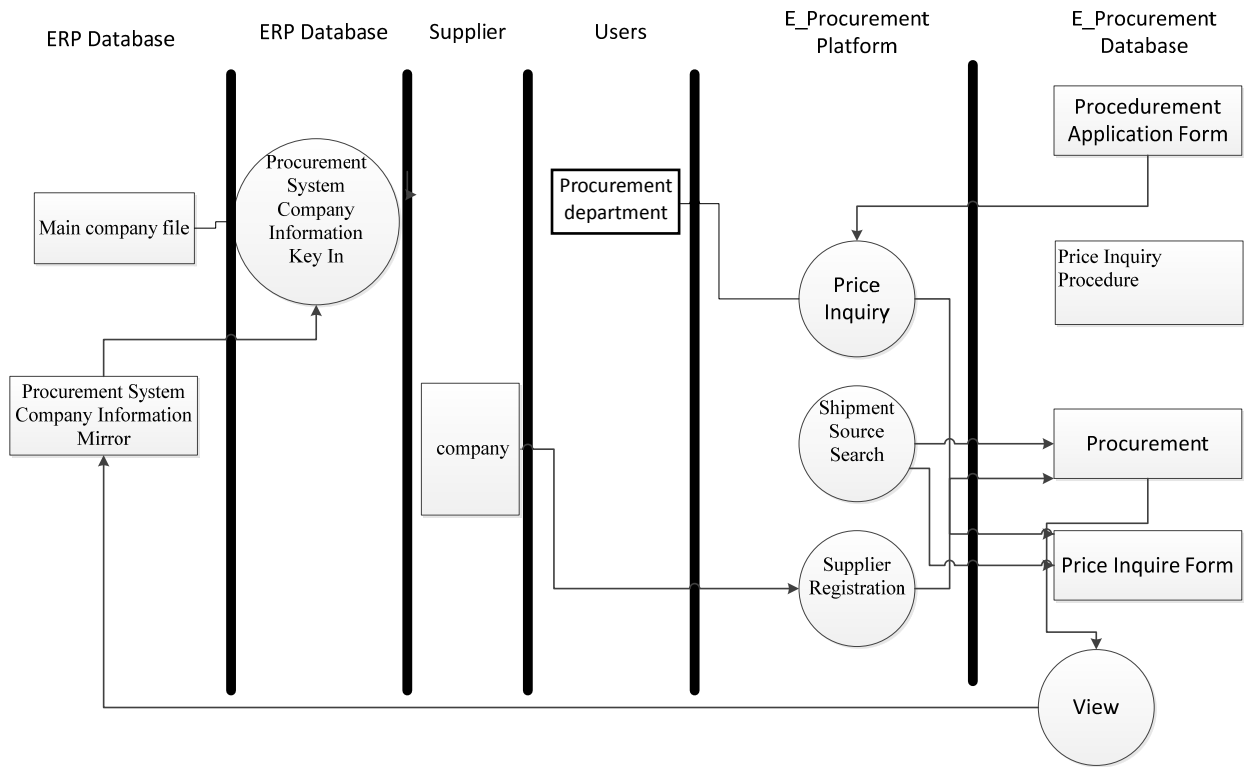


Fig. 3 Flow chart of price Inquiry operation processing procedure.

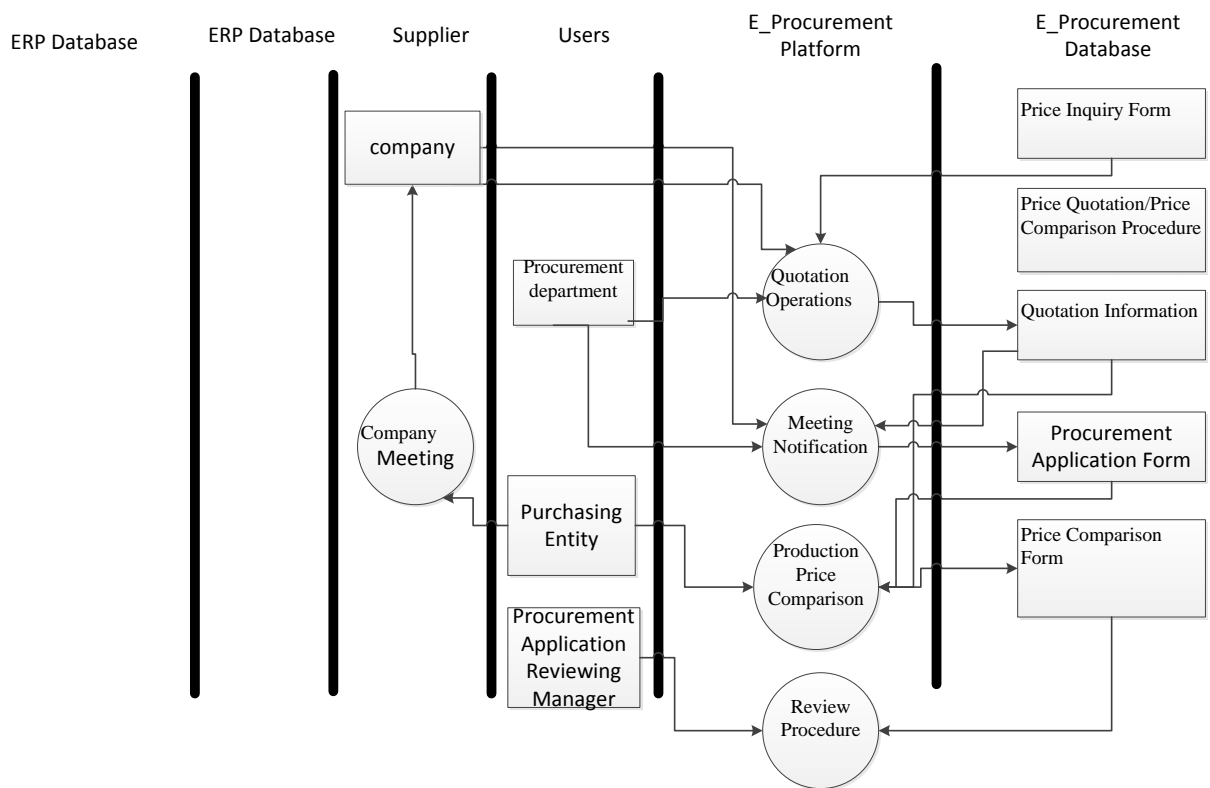


Fig. 4 Price comparison operation processing procedure

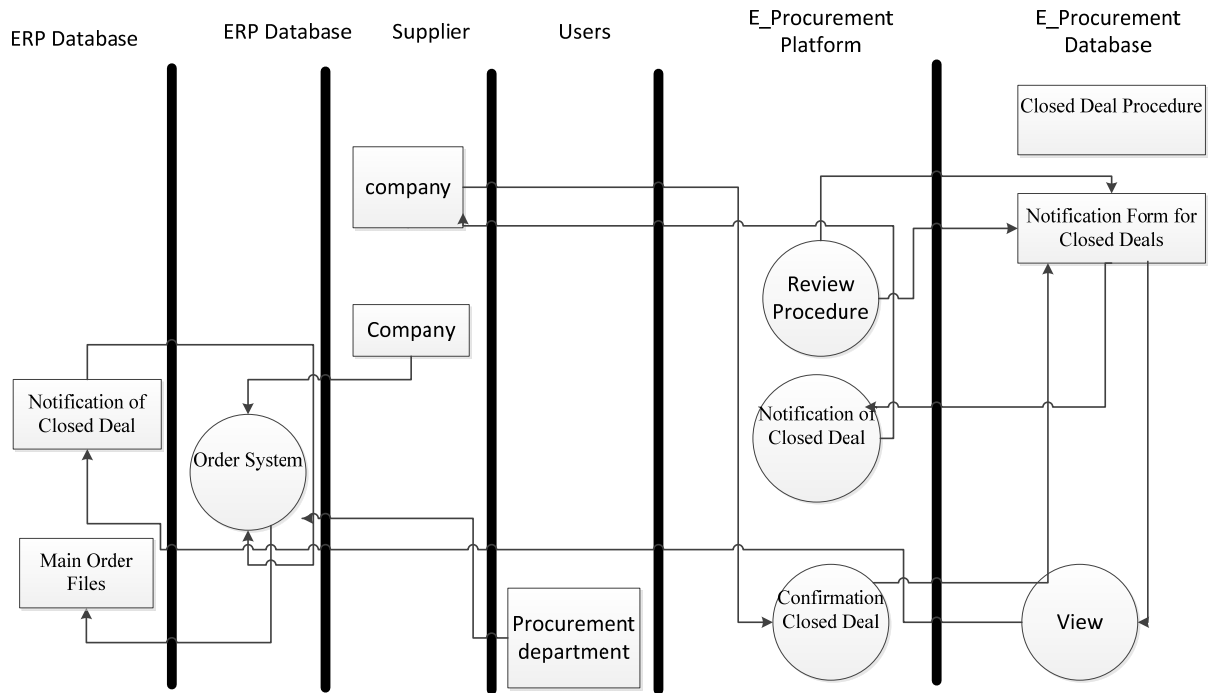


Fig. 5 Payment inquiry operation processing procedure

5 Implementation and Comparative Analysis

5.1 Framework of hardware and software systems

5.1.1 System's environment planning

The study's e-procurement trading platform uses an open J2EE framework to fully satisfy the

5.1.2 Hardware framework

The hardware implementation of the e-procurement trading platform is shown in Fig. 7. This network structure enables suppliers worldwide to quote prices through the Internet, a firewall is used to guarantee the trading security. In

requirement of cross-platform. The core technology for the system includes Java Server Page, HTML, XML, Java Servlet, Java Bean, and Java Script. By making use of the open framework, problems arising from the integration with the ERP system can be avoided. The framework of the system is shown in Fig. 6.

addition, the platform also needs basic supplier information, order information, and payment related information from the company's internal ERP system. Company personnel only requires a web browser to handle all the procedures.

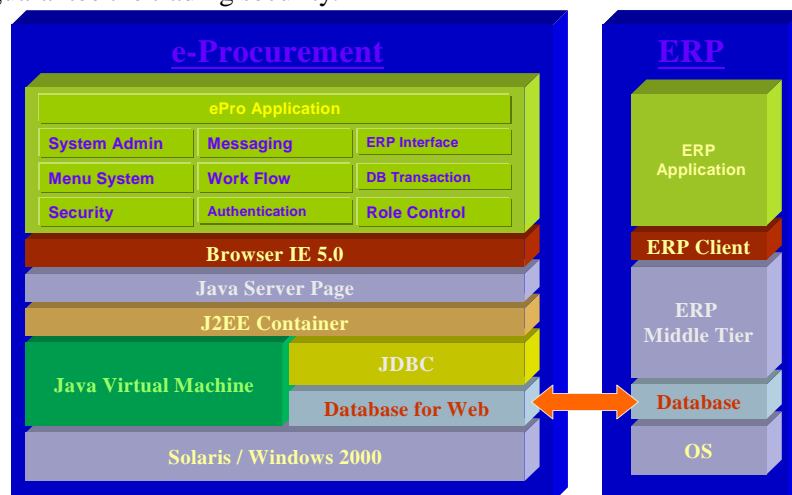


Fig. 6 Framework of web-based e-procurement system platform

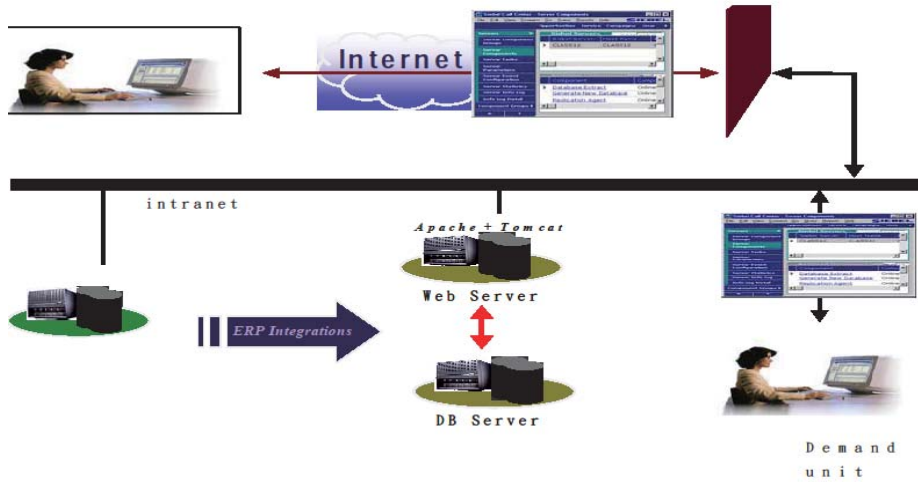


Fig. 7 Hardware framework of the e-procurement platform

5.2 Result Analysis and Benefit Evaluation

5.2.1 Compared analysis

After actually implementing the new e-procurement system for a year, the procurement personnel of W Corporation were interviewed in

the details of the operation-related key performance indicators. The results showed that the procurement procedure and business operation performance had already achieved the following benefits:

1. Benefits in assessment of non-quantitative
Table1 Comparative analysis

	Old procurement	Proposed procurement trading platform
Processing timing and scope	Processing timing is usually limited to the office hours. The procurement behavior is also limited to dealing with local suppliers.	All trading procedure could proceed real time. And the suppliers are no longer limited to local suppliers. This increases the company’s competitiveness.
Manual processing errors	Manual process in the old system is easily prone to mistake.	Instead of manual process, the system processing is automated. All quotations and price inquiries are computerized to reduce the human errors.
Just-in-time Procurement	It is very difficult to follow up the procurement procedure after the procurement requirements have been requested.	Each branch office or business unit may use the platform to access procurement status anytime. The platform can manage the estimated delivery time to enable the entire procurement schedule under control.
Rapid response and supply	As the delivery time from supplier cannot be controlled, company raises the inventory levels and increases the procurement costs.	For the procurement of any spare parts or consumed oil products, supplier can immediately notify its ship docked on the harbor of supplying the order.

2. Benefits in assessment of quantitative

1. The average procurement time was shorten :
The comparison of the average procurement time: old system and mode of procurement: manager would need at least 10 working days to review the order before making a decision. The proposed procurement

trading platform: as the procurement proceeds in the e-procurement platform, an order would only need an average of 2 working days. The procurement time is reduced by 80%. 2. The number of personnel reduced 50%. 3. Annual

telephone and stationery expenditures were 66% down as figure 9. With the traditional procurement method, the procured products procurement overhead. 4. Time allocation of procurement personnel: as figure 8, 10, 11, about choose supplier, search substitute,

may not be bought at lower price. And there are also significant increased manpower and administrative costs. interview, telephone contact, interview, telephone contact, documentation work are all reduce.

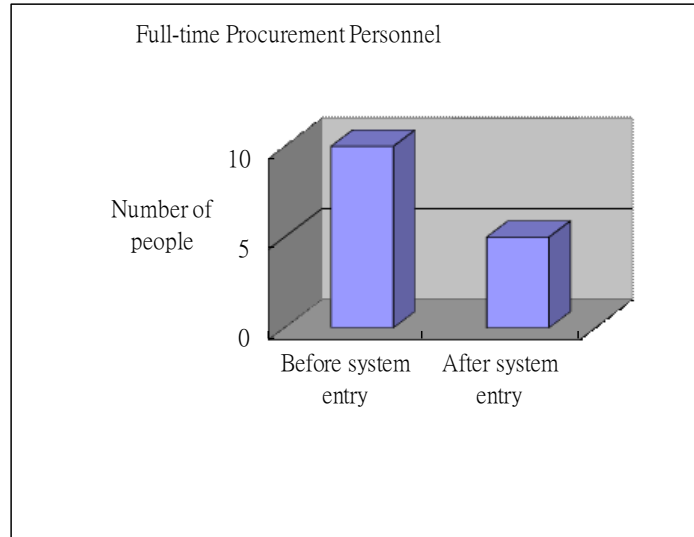


Fig. 8 Number of full-time procurement personnel.

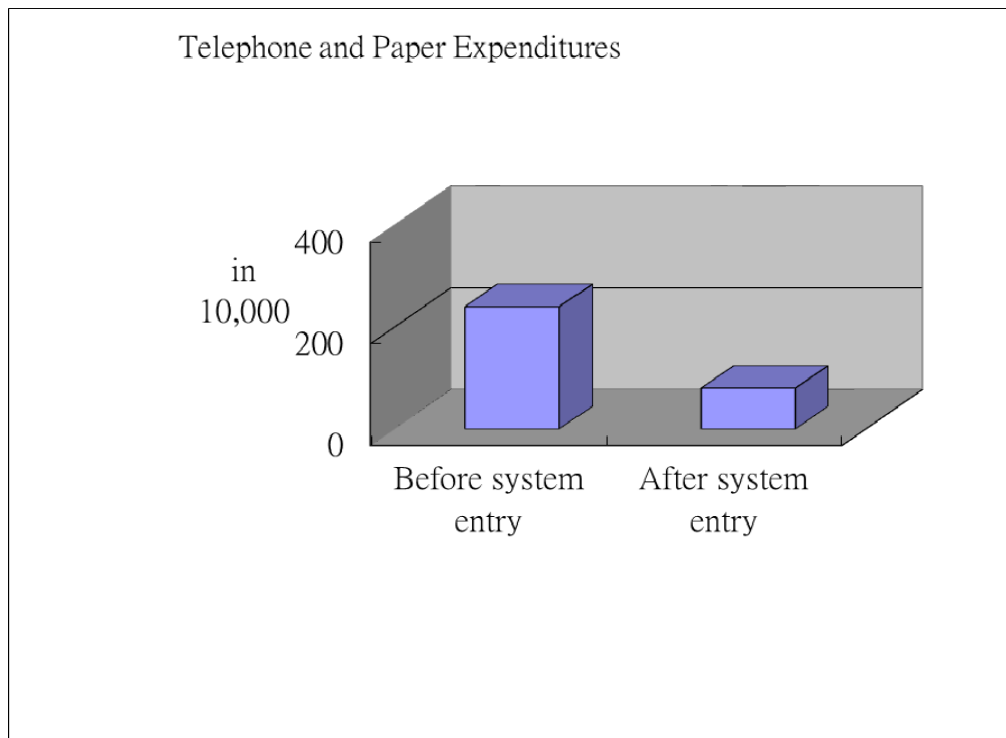


Fig.9 Annual telephone and stationery expenditures before and after system entry.

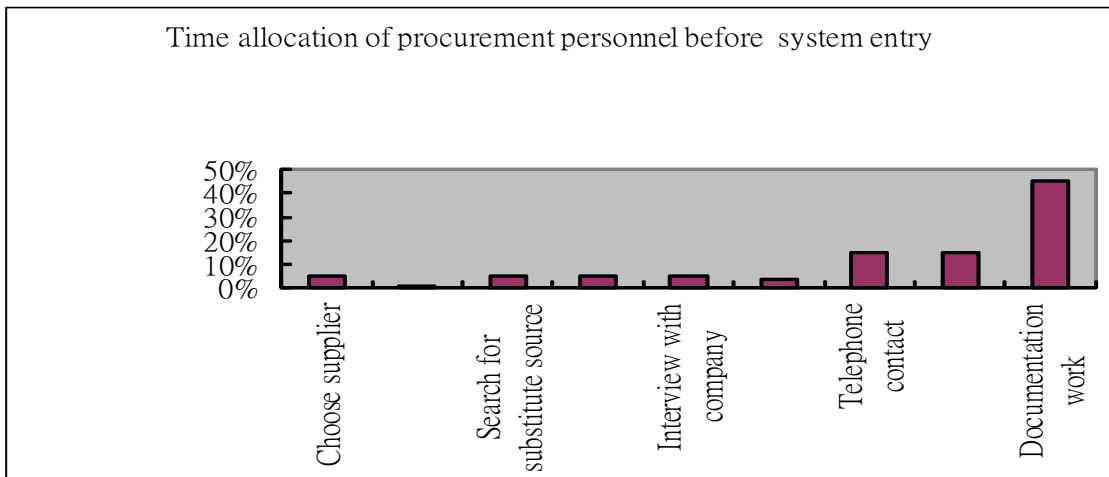


Fig. 10 Time allocation of procurement personnel before system entry

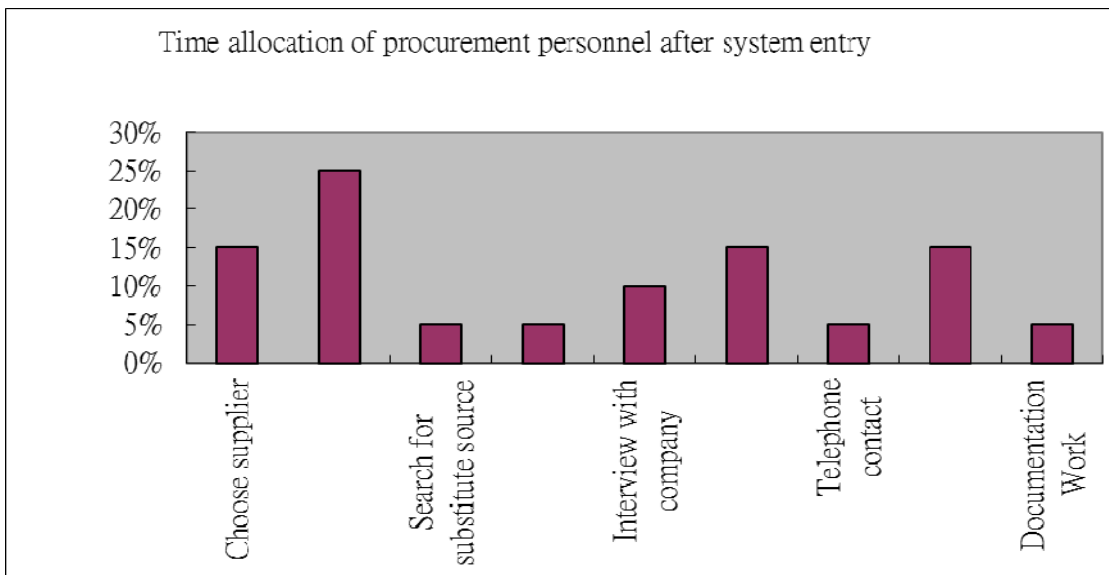


Fig.11 Time Allocation of Procurement Personnel after System Entry

The research results showed the job specifications of the procurement personnel have been changed into strategic work. With this shift in job attribute, not only has it enhanced the performance of procurement personnel, but it also has provided efficiency for decision makers within the company. The implementation of e-procurement system platform contributes to the overall efficiency of the company.

6 Conclusion

Currently, it is still not common for local corporations to make use of electronic procurement system. The main reasons include high setup costs, benefits unexploited by the corporations, rejection from the purchasing entity, and so on. As the emerging technology is applied to rebuild the internal operational procedures of the corporations.

This is considered as a very good way to raise the corporate competitiveness.

This study has the following contributions:

1. Establishing a web-based e-procurement platform: The designed web-based e-procurement platform is able to not only process each procurement case through electronic verification and approval, but also inspect and audit procurement behavior to prevent procurement personnel from indulging in corrupt practices and to improve their performances.-The implementation showed that the average procurement time decreased 80%, the number of full-time procurement personnel went down 50%, annual telephone and stationery expenditures were reduced 66%, the time for document processing of procurement personnel went down 89%, and value analysis time went up 25%.

2. Establishing a good product categorization and coding principles: The product coding principles designed in this research can be applied to all product categorizations and coding. It may also be used for huge quantities of spare parts and oil products in the shipping industry.
3. Establishing a comprehensive procurement model for the shipping industry: The redefined and redesigned procurement system could work for the cross country and cross time zone natures of shipping industry. It has been verified and proven to be feasible.

Acknowledgements

We thank the National Science Council for funding this research (NSC 102-2221-E-163-003).

References

- [1] Ho, Shih-Chiang, "Overhead Costs for Purchases Over the Internet May Exceed 70%," *Aberdeen Group*, 2010.
- [2] Jha, V.: Impact of Cloud Computing on Supply Chain Management. IIM Indore Mgmt Canvas ,2013.
- [3] Toka, A., Aivazidou, E., Antoniou, A., Arvanitopoulos-Darginis, K.: E-Logistics and E-Supply Chain Management: Applications for Evolving Business. IGI Global, Hershey , 2013.
- [4] Nair, P.R., Balasubramaniam, O.A.: IT Enabled Supply Chain Management using Decision Support Systems. *CSI Comm.* 34(2), 2010, PP. 34–40.
- [5] Yuan, Yi-Li, "The Development and Current Status of the Shipping Industry," *Foreign Exchange Monthly*, 1997, PP.25 – 28.
- [6] Wang, Chuan-Shu, "The Effects of World Economic Development Trends and Other International Shipping Industries," *Shipping Monthly*, 2008, PP. 21 – 26.
- [7] Wang, Yi, "Analysis of Taiwan's Shipping Industry," *Cross-Straits Industry and Investment Journal*, 2009, PP. 9 – 13.
- [8] Falagario, M., Sciancalepore, F., Costantino, N., Pietroforte, R.: Using a DEA-cross efficiency approach in public procurement tenders. *European Journal of Operational Research* 218, 2012, PP. 523–529.
- [9] Li, Chuan-Ping, "Corporate Electronification, Plan A: 100% Performance of Online Procurement at IBM," *United Daily News Network*, 2001.
- [10] Liao, Guo-Pao, "Formosa Plastics Saves NT\$41.2Billion on Overhead Costs Through E-Procurement," *Digital Age*, Issue #27, 2001, PP. 23 – 28.
- [11] Manas Ranjan Pani, Amit Agrahari, S. K. De, and G. Sahoo," Critical factors that influence e-procurement implementation success in the public sector", *Management and Labour Studies*, vol. 36, 3: 2011. pp. 225-246.
- [12] Chatterjee, P., Athawale, V.M., Shankar, C.: Materials selection using complex proportional assessment and evaluation of mixed data methods. *Materials and Design* 32, 2011, PP. 851–860.
- [13] Wang, Y.-M., Chin, K.-S., Luo, Y.: Cross-efficiency evaluation based on ideal and anti-ideal decision making units. *Expert Systems with Applications* 38, 2011, PP.10312–10319.
- [14] Amponsah, C.T.: Application of multi-criteria decision making process to determine critical success factors for procurement of capital projects under public-private partnerships. *International Journal of the Analytic Hierarchy Process* 3, 2011, PP. 107–129.
- [15] Guide, V., Harrison, T., Wassenhove, L.V.: The Challenge of Closedloop Supply Chains. *Interfaces: The INFORMS. J. of Oper. Res.* 33(6), 2007. PP. 3–6
- [16] William H. DeLone and Ephraim R. McLean,"Measuring e-Commerce Success: Applying the DeLone & McLean Information Systems Success Model,"*International Journal of Electronic Commerce*, Issue: Volume 9, Number 1, 2004, PP. 31 – 47