Supply chain management in health sector in Thailand: a case study

Duangpun Kritchanchai*

Department of Industrial Engineering,
Mahidol University,
Salaya Campus, Nakornprathom 73170, Thailand
Email: egdkc@mahidol.ac.th

Rawee Suwandechochai

Department of Mathematics,
Faculty of Science,
Mahidol University,
272 Rama VI Rd, Bangkok 10400, Thailand
Email: scrsw@mahidol.ac.th

Abstract: Logistics and supply chain management play an important role in Thailand industry. We believed that logistics and supply chain management could be a means to improve competitive performance in service sector. This paper diagnoses the hospital’s internal supply chain and logistics system in Thailand by business process analysis. This paper also investigates the inventory policy. Our results show the unconnected link at the case study’s internal supply chain in the medicine inventory system between medicine storeroom in each ward, central warehouse and the hospital purchasing department. ‘MSale’ is used to represent average monthly demand; however, ‘it does not reflect the end customer. This leads to inaccurate reorder point and order quantity at the central warehouse. The paper illustrates the business process analysis by using Integration Definition (IDEF0). The re-engineering business process will be proposed. Finally a new inventory system and software development for connecting this internal supply chain is presented.

Keywords: logistics and supply chain; inventory management; information system; health sector; business process; hospital’s internal supply chain; service industry.


Biographical notes: Duangpun Kritchanchai is currently an Associate Professor at Industrial Engineering Department, Mahidol University, Nakornprathom, Thailand. She received her PhD in Manufacturing Engineering and Operations from University of Nottingham. Her current research interests include logistics and supply chain management, performance measurement, quick response manufacturing, information technology in logistics and supply chain management.
1 Introduction

Logistics management has become a competitive tool for enhancing system efficiency and customer satisfactions in many businesses and industries in Thailand. However, it is mostly interpreted and applied in the environment of transportation and exports. In previous work, we have adapted logistics concepts together with supply chain management in industries such as textile, rubber and SMEs. It is found that implementing logistics in the order fulfillment process results in lead time reduction and higher customer satisfactions.

Thailand, one of the speedy growing manufacturing countries, also has good reputation in service industry. Having a number of high-standard hospitals, we aim to become a medical hub in the region. In this study, an attempt was made to apply logistics concept to this sector. First of all, we recognise some similarities between industrial sector and service sector. In the industry supply chain, we see the core system as input, process and output. Then material flow and information flow are analysed. Likewise, we attempt to identify the input, process and output in the hospital supply chain. However, unlike the production process in industry, there are a number of chains crossing one another in a hospital. We then need to select one essential chain to study in depth. One of the significant input material flows in the hospital is medicine. It circulates across functions in hospital. Also, the information of this flow also needs to be distributed among functions in the chain.

The study takes place in one of the biggest state-owned hospitals. To understand the current situations in the chain, an interviewing phase is necessary. The purpose of this step is to gather information from an individual who possesses expertise considered important to both order process mapping and technology analytical effort. The primary data gain in this research come from an in-depth semi-structured interview in the medicine storeroom in each hospital ward, medicine central warehouse and the hospital purchasing department. Then, to explicitly illustrate the flow of this supply chain, it is necessary to demonstrate the current situation of business process. This is called the AS-IS model business process mapping. This model describes information exchange and decision making in all processes in supply chain. The business process model consists of material and product flow (Physical Flows) and information for material management (Information Flows). The business process mapping tool used in this study is the Integration Definition (IDEF0) methodology (Feldmann, 1995). It was initially intended for the use in systems engineering. The IDEF methodology provides a disciplined way of graphically describing the detailed structure of processes and how they relate to one another. Then the problems can be found and the proposed system is recommended.

2 Literature review

Healthcare enterprises involve complex processes that span diverse groups and organisations (Anyanwu et al., 2003). Anyanwu et al. (2003) states that the processes involve clinical and
Supply chain management in health sector in Thailand

administrative tasks, large volumes of data and large numbers of patients and personnel. The tasks in the enterprises are supported by a variety of software applications and information systems. The idea is supported by DeScioli (2005). He studies in depth in hospital supply chain. He is convinced that a hospital needs to implement more than one supply chain policy in order to achieve its objective of maximising patient care while avoiding prohibitive costs. Litvak and Long (2000) also propose an idea of system-wide analysis for healthcare business. They indicate that to achieve maximal cost effectiveness in healthcare, we must understand the complete dynamics of patient interaction with all components of the delivery system and their mutual interdependencies. Also, a report from FPMA (2007) believes that key business processes are usually supported by a series of essential system and technology infrastructures. Also inventory and safety stocks are a key factor in healthcare supply chain disruption.

Among those papers convincing the complexity in healthcare supply chain, Jansen-Vullers and Reijers (2005) believe that business process redesign is frequently applied to optimise business processes. Solutions can be found by using coloured Petri net which is another approach based on redesign heuristic. In their paper, case study in a mental healthcare institute has been considered by using CPN to model and simulate business process. However, they conclude that result from CPN model is too complex and is hard for the end-user to understand. Beyond the business process modelling, Litvak and Long (2000) points out that in healthcare industry, one should consider decision-making area. They identify the difficulties in technically measuring the cost and quality consequences of most healthcare management decisions. DeScioli (2005) gives an example of apply s, Q inventory policy to fit product and supply chain policy implemented within the hospital. He finally concludes that ‘one-size-fits-all’ strategies are inappropriate in a hospital supply chain enhancement.

From the literature in supply chain healthcare businesses, we found that applying business process analysis in hospital supply chain is promising. A modelling approach is needed. Also, area for technical decision making must be explored. A management decision support system should be developed. Here in this paper, we then propose a way to explore hospital supply chain by business process modelling using IDEF0. Then a problem is found at a decision-making area – inventory. A new policy for inventory management for this case study is proposed. Also we found that information technology and management is a must after re-engineering the business process.

3 Findings

3.1 Current system

First of all, to understand logistics flow of medicine in the hospital, interviews were conducted. The questions are to investigate how medicine are flown and managed. The study found that medicine and its information are flown across three major functions in the hospital. These are medicine storeroom in each ward, medicine central warehouse and the purchasing department. When medicines are delivered by suppliers, it is sent to the central warehouse. The warehouse checks against purchasing order and store these medicines in its storeroom. Then the warehouse distributed medicines to each ward storeroom according to the requests. Figure 1 shows medicine distribution system in the hospital.

The medicine requisition from each ward to central warehouse is defined by each storeroom’s pharmacist. The pharmacist defines the quantity of each medicine type to replenish the stock in each ward by their own experience. This depends upon level of
stock left in each storeroom and other conditions such as seasonal diseases, emergency request, new government regulations, etc. The pharmacist places this demand order to the warehouse everyday at 9 am. The warehouse collects all this requests and supplies this amount to each ward daily without knowing the stock level in each storeroom. The warehouse also uses this amount placed by the pharmacists to calculate the reorder point level in the central warehouse. The weighted demand average using all historical data is set as 'MSale' value. The MSale is updated each month. When stock is less than 70% of this MSale, the warehouse will place a request to the purchasing department to replenish the stock up to 100–150% of the value.

Figure 1  Medicine distribution system in the hospital

3.1.1 Business process analysis

The current system is then modelled by IDEF0. The IDEF0 (Integration Definition for Function Modelling) is a method designed to model the decisions, actions and activities of an organisation or system. The ‘box and arrow’ graphics of an IDEF0 diagram show the function as a box and the interfaces to or from the function as arrows entering or leaving the box. To express functions, boxes operate simultaneously with other boxes, with the interface arrows ‘constraining’ when and how operations are triggered and controlled (Feldmann, 1995).

The objective of using IDEF0 in this study is to illustrate the flow of material and information of the medicine supply chain. Figure 2 shows the relationship of activities of medicine supply chain in the hospital.

From Figure 2, in A5 activity, the amount of medicine requested come from the amount of patient uses. However, the level of requisition placed to the warehouse is controlled by minimum and maximum level set by pharmacist in each storeroom. This is then sent to the central warehouse daily. The central warehouse in A3 receives the amount requests and updates stock record in A4 by consider amount of total medicine in the warehouse and amount requested together with amount receive from supplier in A2.

3.1.2 Information management

From the IDEF0 in Figure 2, it can be seen that the information flow in this medicine supply chain is obviously one-way communication. It is evidenced that the only information that the warehouse receives is the request form from each ward. The central warehouse has no chance to see the patients’ end demand and each ward’s stock level. As a result, the stock updating information is not the supply chain stock in the whole system. It is merely the stock in the central warehouse. This results in mislead calculation of the stock reorder point. This again affects the accurate order amount supply to patients’ demand.
Supply chain management in health sector in Thailand

Figure 2: IDEF0 of medicine supply chain in the hospital (see online version for colours)
3.1.3 Inventory system

In the current system, only one policy is used to control the hospital’s inventory. That is if the stock of any item at the central warehouse is below 70% of the MSale, the order will be placed to replenish its stock up to 100–150% of the MSale. Thus the reorder point and amount of ordering depends only on MSale. In addition, only information from each ward request is used to calculate this MSale. It can be easily seen that using the request from each ward is not reflected the real demand. Thus, this may not be an appropriate way to manage the hospital’s inventory. We have conducted ABC and VEN analyses on 2106 items and the result is shown in Table 1.

Table 1 Number of items from ABC/VEN analyses

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>19</td>
<td>26</td>
<td>169</td>
</tr>
<tr>
<td>E</td>
<td>186</td>
<td>279</td>
<td>1206</td>
</tr>
<tr>
<td>N</td>
<td>7</td>
<td>16</td>
<td>198</td>
</tr>
</tbody>
</table>

Pharmacist should pay closely attention to items in Category ‘V’. A policy should be developed individually depending on item’s characteristic. In this paper, we would like propose a new system to manage inventory in the hospital’s central warehouse, thus items in category ‘E’ are studied since it contains approximately 80% of all items in the central warehouse. We analysed a one-year data starting from October 2005 to September 2006. Our findings show that the demand pattern can be divided into three major categories: no trend with low variance, no trend with large variance and trend with large variance. As a result, we develop formula to calculate reorder point and amount of ordering for each type of demand pattern.

Let $r$ be a reorder point, $Q$ be an order quantity, $L$ be lead-time, $N$ be number of days to cover, $y$ be inventory position (on hand + on order inventory), $\mu$ be average daily demand, and $\sigma^2$ be variance of daily demand.

**Type I: Demand with no trend and low variance:**

Since Type I demand has low variance and no trend, the mean can be used to represent future demand. $r$ and $Q$ can be calculated from the following equation.

$$ r = \mu(L+1), \quad Q = \mu N - \mu(L+1) - y $$

**Type II: Demand with no trend and high variance:**

Beside mean demand, its variance should be considered to determine reorder point and order quantity. In this case $r$ and $Q$ can be obtained as

$$ \Pr(D_i \leq r) \leq 1 - \alpha \quad Q = \text{Max} \left\{ \frac{\mu N - y}{\text{units per box}}, \text{min. order} \right\} - r. $$

(2)
where $1 - \alpha$ is a service-level and $D_L$ is total demand during lead-time with mean $\mu(L + 1)$ and variance $(L + 1)\sigma^2$.

**Type III: Demand with trend and high variance:**

For Type III, linear regression is used to estimate future demand. Let $f(x)$ be the predicted demand on day $x$ which is in the form of $ax + b$. The following equation can be used to calculate $r$ and $Q$.

$$
\Pr(D_L \leq r) \leq 1 - \alpha \quad Q = \text{Max} \left\{ \left[ \frac{Y - y}{\text{units per box}} \right], \text{min. order} \right\} - r
$$

(3)

where $Y$ is calculated from $\Pr(D_N \leq Y) \leq 1 - \alpha$. $D_L$ is future demand during lead-time with mean $\sum_{x=1}^{L} f(x)$ and variance $L \times MSE$ obtained from linear regression result and $D_N$ is future demand of $N$ days $\sum_{x=1}^{N} f(x)$ and variance $N \times MSE$.

3.2 Proposed system

3.2.1 Information management

The current system illustrates the unconnected link between end demand at each ward and the reorder point calculating at the warehouse. The customer real demand is not reflected to the central warehouse and then to the purchasing department. Here we propose a linkage from the ward storeroom to the warehouse. The end-patient usage is reflected to the warehouse. Instead of using the pharmacist’s experience in setting minimum stock level for reordering point, the central warehouse can monitor the supply chain stock and set the reorder point more accurately to the end-patient demand. The patients’ medicine dispensed quantity per day is then sent directly from each ward’s storeroom (A6) to reorder point calculation (A1). Also stock is updated at the same time as medicine is dispensed from the warehouse. This can be seen that A4 has been put in the A3 function. The proposed system is shown in Figure 3.

Furthermore the information flow can be designed by Data Flow Diagram (DFD). DFDs show the flow of data from external entities into the system. There are only four symbols: the first is squares representing external entities, which are sources or destinations of data, the second is rounded rectangles representing processes, which take data as input, do something to it, and output it, the third is arrows representing the data flows, which can either be electronic data or physical items, and the last is open-ended rectangles representing data stores, including electronic stores such as databases or XML files and physical stores such as or filing cabinets or stacks of paper (4). The context diagram of DFD and its detail are shown in Figures 4 and 5.
Figure 3  The proposed system for medicine information management
(see online version for colours)
Figure 4  The proposed system’s context diagram (see online version for colours)
Figure 5  The proposed system’s Data Flow Diagram Level 0
(see online version for colours)
Figures 4 and 5 show that, in this proposed system, each ward’s storeroom records the patients’ medicine usage in a database. The central warehouse could then query data from this database. This information can be used for filling each ward’s stock as well as setting the reorder point accurately to the real demand. Also, when the medicine is dispensed from the warehouse or supplied by the suppliers, the data is then recorded and stock is updated.

After the information flow is designed, a software for connecting these functions is developed. The main functions of this software are firstly to enable the warehouse to see the stock in each ward’s storeroom, as seen in Figure 6.

**Figure 6**  The warehouse stock monitoring (see online version for colours)

The warehouse could log into the system database to check the stock level of each ward storeroom. Also the patients end demand on that day is displayed. Secondly, the warehouse could record the information of medicine such as name, supplier, cost, etc. Essentially after the patient demand is recorded and the database is shared between the storeroom and the warehouse, the system can show pattern of medicine usage and calculate the reorder point based on the real demand. This is shown in Figures 7 and 8.

In Figure 7, the warehouse could key in the medicine name and its condition such as lead time, on hand quantity and unit price. The system will take all conditions together with historical usage of that medicine and display the pattern fit to data in Figure 8. Then the system enables the warehouse to calculate the reorder point and quantity for that medicine. Then this information is sent to the purchasing department.
Figure 7  Detail of medicine display (see online version for colours)

Figure 8  Pattern of medicine usage (see online version for colours)
4 Discussions and conclusions

In this paper, we apply the concept of supply chain and logistics management in service industry – hospital. The missing link in the chain is found between each ward’s storeroom and the central warehouse. The IDEF0 model evidences the problem in calculating the MSale. This value comes from the medicine requisition form from the pharmacist in each ward, rather than patients’ end demand. The reorder point and order quantity in the current policy are based on moving average value and are updated every month. We propose a new policy for managing inventory at the central warehouse. Our findings suggest that end-demand information should be used to forecast future demand. In addition, reorder point and order quantity should not only depend on mean demand but also its variance, lead-time delivery and demand pattern. We use ABC and VEN analyses and found that items in category ‘E’ are approximately 80% of all items in the central warehouse. Our results show that demand patterns can be divided into three major categories. Thus, we developed formula for each type of demand pattern.

The paper also presents a new design for information system in a hospital supply chain, particularly in medicine stock management. Instead of using pharmacist’s experience in setting stock reorder point, the central warehouse can now monitor the stock usage and stock left in the supply chain. All functions in this medicine supply chain must share the same database in recording and updating stock level. This enables the supply chain members to visualise the stock level from anywhere in the chain. The paper highlights the use of IDEF0 for business process redesign. It shows the need of business process analysis prior to the redesign of any information system and software implementation. This is even more essential for the future Enterprise Resource Planning (ERP) implementation in the business. The business process analysis and reengineering of information system must be a well-prepared platform for any ERP launch. This enterprise’s information flow must be well understood and clearly architected prior to the implementation.

Further research can be explored in inventory management and supply chain management. For the inventory, items are assumed to be independent to each others in this model. It would be interesting to consider substitutable items and its effect on the inventory level. Another challenge research in the hospital’s inventory management is to consider cost analysis. In the supply chain area, there are rooms for linking this internal supply chain to the supplier. Having known the medicine stock and demand in the hospital operations, it can then initiate the vendor manage inventory programme with suppliers. Also reverse logistics for the expired medicine is of our interest.

Acknowledgements

The authors are grateful for the finance supported by Commission on Higher Education (CHE) and the Thailand Research Fund in the research project.
References


