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The optimal approach for parameter settings based on adjustable contracting capacity for the hospital supply chain logistics system

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ABSTRACT

This paper establishes a simulation model for the supply chain of the hospital logistic system (SCHLS) based on the dynamic Taguchi method. The model derives optimal factor level combinations in the SCHLS setting when establishing adjustable contracting capacity between SCHLS and the pharmaceutical company. To attempt the goal, this study adopts the SCHLS case in the North Alliance of the Department of Health of Taiwan. The data collection uses a simulation based on Taguchi's L_{18} orthogonal table for SCHLS. This work also proposes an optimal approach, including the neural network (NN) and genetic algorithm (GA), to obtain an optimal robust design in achieving optimal SCHLS multi-performance. The research results show that the predicted response of multi-performance in the optimal approach is better than that in Taguchi.

1. Introduction

Over the past two decades, various industries have explored the supply chain (SC) to save on total system cost. Mabert and Venkataramanan (1998) defined SC as the "relationship" in buyer–seller activities, including all "upstream" suppliers, every "downstream" customer, and a "value chain" approach. In other words, its process includes all control activities spanning raw materials procurement and production/manufacturing to distribution of end-products to customers. Thus, to decrease SC's total system cost, the eliminating inaccurate information in the inventory record is the most crucial job. Several bodies of research (Chen, Drezner, Ryan, & Simchi-Levi, 2000; Joshi, 2001; Simchi-Levi, Kaminsky, & Simchi-Levi, 2000) have shown that the information shared between suppliers' provision supply and end-customers' demand may significantly reduce total system cost of the bullwhip effect. Ganeshan, Boone, and Stenger (2001) and Brown, Inman, and Calloway (2001) also pointed out that an inaccurate inventory record significantly impacts SC performance.

To understand SC's dynamic behavior, a widely used approach to study its dynamics has been adopted based on the dynamic systematic simulation methodology. Wang, Pokharel, and Wang (2004) built a mathematical model to simulate manufacturers for the purpose of improving SC's positioning strategies. Meanwhile, Reddy and Rajendran (2005) considered a simulation study of the dynamic order-up-to policies in an SC through non-stationary customer demand and information sharing. Chan and Chan (2005) defined five common SC models, tested with simulation for comparative evaluation of SC management strategies. Zhang and Zhang (2007) developed a simulation approach that quantifies firms' business operations and performances in a multi-tier SC. In general, the results show that with high demand variance, low demand correlation, and/or high demand covariance, the supply chain without intermediate tiers performs better than the one with an intermediary.

However, most SC's simulation behavior belongs to the industrial field, while only a few studies are in the hospital research field. They believe that hospitals' cost reduction and quality control measurement is a competitive strategic issue that influences all facets of the healthcare medical market. Nylander, Suominen, Nenonen, Rintanen, and Pelanteri (2002) analyzed the hospital's total system cost and showed that improving the hospital SC system's affecting factors increases overall efficiency and effectiveness. Gilbert (2001) emphasized that establishing an e-health system helps hospitals to decrease procurement cost. However, buyers and suppliers must work together toward standardization, and agree on a universal product numbering system. Essentially, e-health is an information communication tool to assist in decision-making and contains existing register data about suppliers, hospitals, and customers that can be used as a reference (More & McGrath, 2002).

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Based on the above literature study, this paper sets up a SC simulation model of the hospital logistics system (SCHLS) to obtain optimal factor level combinations in a SCHLS setting when establishing an adjustable contracting capacity between the SCHLS and the pharmaceutical company. The SCHLS' research case is based on the SCHLS of the North Alliance of the Department of Health of Taiwan. Owing to the SCHLS' dissimilar situation with the manufacturing industry, most medicines have patent right limitations and market monopolies. Hence, the SCHLS must pay attention to medical capacity when asking pharmaceutical companies to contract a supply quantity to the SCHLS. In turn, the pharmaceutical company must also reserve medical capacity for other hospitals since it is quite impossible to reserve all of it for a certain SCHLS. Otherwise, a medicine shortage may occur and eventually cause a medicine scarcity with other hospital demands, resulting in a very serious problem and threat to patient safety. This paper considers medical capacity as adjustable from the SCHLS contracting with the pharmaceutical company. Moreover, the current study uses the dynamic Taguchi research method to seek optimal factor level combinations in the SCHLS setting for treating adjustable contracting capacity. The next section discusses SCHLS and the relationship of experimental factors within the simulation. Section 3 describes the research methodology. Section 4 analyzes the development of optimal approach and collected data. Lastly, Section 5 presents the summary of findings, followed by a presentation of research limitations and contributions.

2. Experimental factors and SCHLS simulation

To solve the dynamic SCHLS problem, this study uses a simulation method to obtain data and further obtain the optimal setting of experimental factor level combinations based on multi-performance when the adjustable contracting capacity between SCHLS and the pharmaceutical company is established while considering flexible terms. Within this SCHLS, the experimental factors may be classified as signal, noise and control factors. Signal factors are set by the SCHLS operator to express the intended SCHLS response value. The signal factor is an adjustable design after obtaining the optimal level combination of parameters. Noise factors are parameters that cannot be controlled by the decision-maker. Hence, these factors are difficult and expensive to control and could also cause the response to deviate from the target specified by the signal factor. Finally, control factors are parameters that the decision-maker can freely specify to determine the best levels' setting. This enables the experimental system the least sensitivity to the effect of noise factors (Phadke, 1989).

2.1. Experimental factors for SCHLS

The following illustrates the significance of experimental factors, including control, noise and signal factors:

2.1.1. Control factor

1. *Quantity discount*: Much of the production management literature states that quantity discounts will result in unit price decrease. Furthermore, quantity discounts optimize the joint costs of suppliers and buyers to develop price schemes in the SCHLS. In this regard, some researchers studied a SC and explored the benefits of using quantity discounts to decrease the SC's total system cost (Chen & Chen, 2005; Tsai, 2007). Li and Xiao (2004) and Sarmah et al. (2006) analyzed the SC's coordination mechanisms to coordinate the part lot splitting decision in achieving a total system cost to widen the optimum. Meanwhile, Abad and Aggarwal (2005) formulated an SC model in treating freight breakpoints akin to the price breakpoint in a quantity discount schedule.
2. *Safety stock*: The SCHLS' safety stock guards against purchase or manufacturing process uncertainties, ensure on-time-delivery ratios, and provide better customer service. Wijngaard (2004) considered reducing incorrect safety stock to further reduce the SC's bullwhip effect. This creates the model effect of foreknowledge demand in the case of restricted capacity. Iyer (2002) considered safety stock's impact on inventory cost and proposed to develop its heuristic settings to process priorities based on demand uncertainty in the SC.
3. *Lead time*: Production and transportation issues that control SCHLS-selected lead times are important. This is because variability in lead times between successive stages often greatly effects SC coordination. Kamath-B and Bhattacharya (2007) explored ways to minimize lead-time with the goal of improving SC and demand chain performance. Accordingly, Mohebbi (2003) presented an analytical SC model with variable lead times to address the supply interruption problem. So and Zheng (2003) considered the supplier's variable lead times and forecasted demand updating to amplify SC variability downstream from members' order quantities.
4. *Transportation capacity*: Transportation capacity's role in the SCHLS is to find unutilized vehicles' capacity to compute decreasing transportation cost. The selection process for different vehicles with varying transported quantity is an integration of a SC's planning method. Rajeshkumar and RameshBabu (2006) discussed a logistics related policy that optimized total shifting and minimized transportation cost by considering the dynamic SC problem. Gen, Altiparmsk, and Lin (2006) considered the extended version of the SC's transportation problem to minimize total logistic cost.
5. *The reliability of SC*: SC reliability estimates by the need time T whether the medicine delivery to customers is delayed or not. Reliability with regard to fulfilling the order's due date is critical in customer service. Wlendahl, Cleminskf, and Begemann (2003) presented an approach to analyze SC process reliability, to meet the logistics performance expectations of customers. Meyer (2004) discussed that manufacturers should exert efforts in increasing high delivery reliability and developing quick responses to customers. Nieuwenhuyse and Vandaele (2006) optimized reliability of an order's due date to prove the SC model analytically.

2.1.2. Noise factor

Demand variability: Balancing demand variability is difficult since it seriously effects the SC's total system cost. van der Vorst, Beulens, de Wit, and van Beek (1998) studied real-time information systems by decreasing demand uncertainty in obtaining an efficient and effective SC. Goncalves, Hines, and Sterman (2005) investigated feedback between SC performance and demand variability in the SC model used by a major semiconductor manufacturer. On the other hand, Boute, Disney, Lambrecht, and Houdt (2007) integrated the production and inventory model to dampen a SC's upstream demand variability.

2.1.3. Signal factor

The medicine's contracting capacity: Due to medical patents, a supplier (pharmaceutical company) must consider the medical capacity problem when supplying for SCHLS. The supplier cannot supply all capacities for a certain SCHLS because it must consider other hospitals' needs. However, SCHLS can still negotiate and contract for the supplier's production capacity rate to fit demand variability. Korpela, Kylaheiko, Lehmusvaara, and Tuominen (2002) proposed a framework that includes production capacity allocation