

# Impact of Stockout Compensation in E-Commerce

## Drop-Shipping Supply Chain

**Raj Kamalapur**

Norris-Vincent College of Business  
Angelo State University, Texas Tech University System, TX, USA  
E-mail: raj.kamalapur@angelo.edu (*Corresponding Author*)

**David Lyth**

College of Engineering and Applied Sciences  
Western Michigan University, MI, USA  
E-mail: david.lyth@wmich.edu

### ABSTRACT

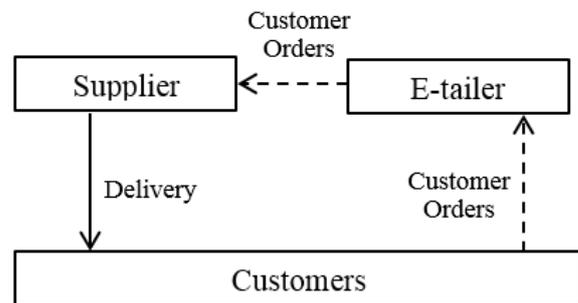
Using simulation modeling, our research is the first study to investigate impact of two different stockout compensation strategies (E-SC and S-SC) compared to no-stockout compensation strategy (N-SC) on supplier's profits and etailer's profits in e-commerce drop-shipping supply chain. The conceptual model is a two-echelon production-inventory system with a make-to-stock supplier and an etailer. The results from this study suggests that on average, the profit difference is less than 4.0 percent in E-SC compared to N-SC for both the supplier and etailer. However, when demand variability is high, production capacity is low and service level is low, the profit difference for both the supplier and etailer is significantly higher in E-SC compared to N-SC. Also, if both the supplier and etailer pursue S-SC strategy, then on average, an increase in wholesale price by around 1.0 percent compared to wholesale price in N-SC is sufficient to offset the stockout compensation cost for the supplier.

**Keywords:** e-commerce, drop-shipping, inventory management, stockout compensation, simulation

### 1. INTRODUCTION

In recent years, due to ease of online shopping, there is significant increase in online sales and continues to increase. Market research firm eMarketer estimates online sales of \$1.91 trillion in 2016 and projects to exceed \$4.00 trillion by 2020 (eMarketer, 2016). However, many online retailers have realized that the integration of front-end order taking process with back-end order fulfillment process is challenging, with order fulfillment process being regarded as the weakest link. To overcome this challenge, many online retailers have adopted drop-shipping strategy, solely or in combination with their in-house order fulfillment strategy (Khouja, 2001; Netessine *et al.*, 2002; Ayanso *et al.*, 2006; Gan *et al.*, 2010; Chen *et al.*, 2011; Cheong *et al.*, 2015). In drop-shipping order fulfillment strategy, as shown in **Figure 1**, the online retailer (here on referred to as etailer) takes online orders from their customers and requests their supplier (manufacturer or distributor) to ship these orders directly to customers. For example, eBags.com carries very little inventory and use drop-shipping extensively to sell more than 12,000 different bags online which are shipped directly

by their suppliers to their customers. Large online retailers like Amazon and eBay also use drop-shipping to fulfill some of their customer orders (Cheng *et al.*, 2015). In drop-shipping strategy, etailer benefits by transferring inventory management and shipping responsibilities to the supplier, while the supplier benefits with increased demand and the ability to charge higher wholesale prices to the etailer.



**Figure 1** Drop-shipping supply chain

However, in a variable demand environment with production (and/or supply) capacity constraints, there are risks to this zero-inventory order fulfillment strategy for the etailer. They are usually vulnerable, especially when the dropship supplier is unable to fulfill customer orders due to stockout situations. As etailers are in direct contact with their customers, they are ultimately held responsible for any unfulfilled customer orders. If orders are not fulfilled on time, customers may cancel their orders or leave negative reviews that will impact the etailer's current and future business. (Kim and Lennon, 2011). In a recent study, using 14 months of empirical sales data for an online retailer selling non-perishable items, Jing and Lewis (2011) found that approximately 25.4% of all online orders were imperfectly filled due to stockouts. Similarly, another study by Accenture found that despite best efforts to improve online order fulfillment during the busy season, more than 12% of the orders were not delivered on time (Enos, 2010). When online retailer Value America declared bankruptcy, it cited the inability of its dropship suppliers to fulfill their customer orders on time. Similarly, in its early days, online

retailer Zappos.com carried very little inventory and used drop-shipping extensively to fulfill their customer orders. However, they soon stopped using drop-shipping due to poor order fulfillment by their suppliers (Hsieh, 2010). As most dropship suppliers do not pay any penalty for late orders, there is less incentive for them to improve their inventory management and order fulfillment rates (Yao *et al.*, 2008; Gan *et al.*, 2010).

So, in a drop-shipping supply chain, unfulfilled customer orders during stockout can be a huge obstacle for etailers to pursue drop-shipping strategy. In an online retailer setting (without drop-shipping), Bhargava *et al.* (2006) analyze stockout compensation policy during inventory stockouts and conclude that it helps to increase customer retention, improve demand rate and decrease average inventory costs. However, to the best of our knowledge, there are no research studies that investigate the impact of stockout compensation on supplier's profits and etailer's profits in a drop-shipping supply chain. In our research study, we propose that both the supplier and etailer share the risk of stockout and equally pay stockout compensation in a drop-shipping supply chain. The etailer generates continuous demand for the supplier, and therefore the supplier should consider sharing the risk of stockout to avoid losing future business with this etailer. However, if only the supplier needs to pay stockout compensation, then it is important to understand the wholesale price they can charge under different supply chain parameters to help offset their stockout compensation cost. So, if stockout compensation is to be considered in a drop-shipping supply chain, some of these questions arise. What will be the impact on the supplier's profits and etailer's profits when both equally share stockout compensation (E-SC)? What will be the impact on supplier's profits and etailer's profits when only the supplier pays stockout compensation (S-SC)? In E-SC and S-SC stockout compensation strategies, what will be impact on supplier's profits and etailer's profits under different supply chain parameters? In S-SC strategy, what is the appropriate wholesale price the supplier can charge to offset stockout compensation cost under different supply chain parameters? Using simulation modeling, our research aims to answer these questions by investigating impact of E-SC and S-SC compared to no stockout compensation (N-SC) on supplier's profits and etailer's profits in a drop-shipping supply chain.

## 2. LITERATURE REVIEW

Academic research in online retailing has largely focused on the marketing aspect, and is mostly qualitative in nature (Gulati *et al.*, 2000; De Koster 2003; Jiang *et al.*, 2005; Anderson *et al.*, 2007; Baier *et al.*, 2010; and Rafiq *et al.*, 2013). Academic research in online retailing with operations consideration (production, inventory, drop-shipping, etc.) is relatively new and growing in importance. Many online retailers have realized that the integration of front-end order taking process with back-end order fulfillment process is quite challenging, where order fulfillment is regarded as the weakest link.

First, we will review the studies related to drop-shipping in online retailing. Next, we will review the studies related to stockout compensation in online retailing. The following studies are related to our research in online

retailing using drop-shipping. Using a single period model framework, Khouja (2001) formulate a model to identify the optimal mix of in-house inventory and drop-shipping to meet customer demand, where capacity of drop-shipping option is unlimited. Using empirical data, Netessine *et al.* (2002) discuss the advantages and disadvantages of drop-shipping for the etailers (they use the term virtual order fulfillment for drop-shipping). Netessine and Rudi (2004) develop a model to analyze the interaction between a wholesaler and an online retailer in a drop-shipping supply chain. They propose a profit-sharing contract where both the wholesaler and online retailer should share the profits and expenses of acquiring customers and fulfilling customer orders. Bailey and Rabinovich (2005) develop an analytical model for an internet book retailing, where both in-house inventory and drop-shipping option can be used to fulfill customer orders. They discuss how the product's popularity or frequency of ordering affects the decision of either using in-house inventory or drop-shipping option. Netessine and Rudi (2006) model a supply chain with multiple retailers and wholesaler with drop-shipping contract. They provide recommendations where drop-shipping or a traditional channel should be preferred from the perspective of inventory risk pooling. Using Monte Carlo simulation, Ayanso *et al.* (2006) determine a threshold level of inventory for online retailers to switch from internal inventory stocking to drop-shipping option for different demand priorities and different lead times. Using a Stackelberg game, Yao *et al.* (2008) explore how an online retailer (leader) can give the supplier (follower) appropriate incentive to improve the level of delivery reliability in a drop-shipping supply chain. Khouja and Stylianoua (2009) develop two (Q, R) inventory models for an online retailer with both in-house inventory and drop-shipping option. Their results suggest that drop-shipping should be used in case of inventory shortage during the lead time. Chiang and Feng (2010) consider an EOQ game model with pricing and lot-sizing decisions to investigate the advantages of drop-shipping over traditional shipping channel. They identify conditions under which drop-shipping channel produces more profit than traditional shipping channel. Gan *et al.* (2010) propose a commitment penalty contract in a drop-shipping supply chain with three different parameters under asymmetric demand information. They propose that the supplier should receive demand information from online retailer to maximize the expected profit. Chen *et al.* (2011) study the optimal inventory and dynamic admission policies for two physical retailers (R1 and R2) who also act as drop-shipper for an online retailer. They assume that R1 shares inventory and admission policy information with R2 and compare two heuristic admission policies with optimal policy and show that if R2 implements a simple FCFS policy, their potential loss in revenue could be substantial. Cheong *et al.* (2015) develop an analytical model for a two-level supply chain to study the impact of information discrepancies on both the drop-shipper and online retailer. Their study concludes that both parties can achieve substantial cost reductions if information discrepancy is eliminated. Using mathematical models, Cheng *et al.* (2016) investigate different order fulfillment strategies for an e-tailer and show that drop-shipping model and hybrid channel with inventory rationing model are optimal choices for the e-tailer. Yu *et al.* (2017) consider a dual-channel supply chain with a manufacturer selling a

product through a traditional retailer and also through an online retailer using drop-shipping. Their study shows that drop-shipping benefits both the manufacturer and online retailer, when the online retailer has relatively low market power compared to the traditional retailer. Ma *et al.* (2017) consider a news-vendor model with two sales channels (physical store and online store, where online orders are filled by drop-shipping) with the option of reselling products that are returned by the consumers during the selling season. Using mathematical modeling, they identify the optimal mix of drop-shipping quantity and in-store inventory, by considering different rates of returns for different types of flows to help increase the overall profits. Park (2017) consider an online retailer with in-house inventory to fulfill the customer orders, where unmet demand is partially lost and partially backordered. Partially backordered demand is fulfilled by using the drop-shipping option. Using computational analyses, this study shows that more profit can be generated by utilizing a drop-shipping option for the partially backordered demand. Chen *et al.* (2018) develop a continuous review inventory model for an online retailer to solve the product placement and inventory control problem by allowing the online retailer to use drop-shipping option when shortage occurs during the lead time. They show that the total profits can be maximized by using the drop-shipping option for any inventory shortage during the lead time. Ma and Jemai (2019) consider a single-period inventory model for a traditional retailer and an online retailer. The in-store demand is fulfilled with retail store inventory, and the online demand is fulfilled with retail store inventory along with drop-shipping option. They analyze two rationing policies (fixed and threshold) to determine the optimal order quantity for in-store inventory and drop-shipping inventory. Using numerical examples, they show that the threshold-rationing policy is more profitable than the fixed-proportion policy.

There are some studies in online retailer setting that consider consumer behavior during stockouts. However, there are limited studies in online retailing that consider some form of financial compensation during stockouts. Using EOQ type inventory modeling framework with deterministic demand in an online retailer setting, Bhargava *et al.* (2006) analyze profit difference between stockout-compensation backorder policy and no-stockout-compensation backorder policy. They conclude that stockout compensation policy results in more efficient operation which helps to increase customer retention, increase demand rate and lower average inventory costs. Breugelmans *et al.* (2006) investigate the impact of an online retailer's stock-out policy on the consumer's category purchase and choice decisions. Their results from an online grocery shopping experiment reveal that suggesting a replacement item during stockout helps to substantially increase consumer's probability of purchasing the suggested item. Jinzhong and Jian (2007) analyze characteristics of optimal inventory, pricing and stockout period in an online retailer setting. They determine that the firm obtains maximum profits, only when customer's valuation for product in stockout period is the same as in stock-in period. Kim and Lennon (2011) investigate how consumers respond to online apparel stockouts and found that negative emotions evoked by stockouts create a depressed perception of store image, lowered decision satisfaction, and reduced behavioral intent of buying. They show that financial compensation was most

effective in mitigating the negative impact of stockouts.

Previous studies in online retailing using drop-shipping have identified some factors that help the supplier and etailer to pursue drop-shipping strategy, where most studies consider unlimited capacity for dropship supplier. However, the literature related to stockout compensation in online retailing is relatively small and to the best of our knowledge, there are no studies that consider impact of stockout compensation on supplier's profits and etailer's profits in a drop-shipping supply chain. Using simulation modeling, our study is the first paper to consider the impact of two different stockout compensation strategies (E-SC and S-SC) on supplier's profits and etailer's profits compared to no-stockout compensation strategy (N-SC) in a drop-shipping supply chain.

Our research will expand the existing literature (Netessine and Rudi, 2004; Bhargava *et al.*, 2006; Yao *et al.*, 2008; Gan *et al.*, 2010; Chen *et al.*, 2018) in the area of online retailing and drop-shipping by investigating the impact of stockout compensation in a drop-shipping supply chain. The contributions of our research to the literature are three-fold. First, our research is the first study to consider impact of stockout compensation on the supplier's profits and etailer's profits in a drop-shipping supply chain. Second, using simulation modeling we consider the impact of two different stockout compensation strategies (E-SC and S-SC) compared to N-SC on supplier's profits and etailer's profits in a drop-shipping supply chain under different supply chain parameters. Third, our study aims to provide managerial insights on the appropriate wholesale price in S-SC, so it is fair for both the supplier and etailer under different supply chain parameters.

### 3. RESEARCH METHODOLOGY

Discrete event simulation (Arena software from Rockwell automation) is used to develop the simulation model for drop-shipping supply chain. Simulation method is appropriate to study the dynamic and time varying behavior of a drop-shipping supply chain in a variable demand environment with production capacity constraints. Simulation helps to provide insight into the cause and effects of different supply chain parameters on the performance measures. Simulation approach has been used in many studies for analyzing supply chain systems, including drop-shipping and online retailing (Ayanso *et al.*, 2006; Becerril-Arreola *et al.*, 2013; Mathien and Suresh, 2015). In our study, simulation is used to investigate the impact of different supply chain parameters and different stockout compensation strategies on both the supplier's profits and etailer's profits in a drop-shipping supply chain. These are the different scenarios considered in our research study.

**Scenario 0 (N-SC):** This is the Base Scenario. During stockout, the customer orders are backordered with 'no stockout' compensation. Customers are willing to wait for their orders to be delivered.

**Scenario 1 (E-SC):** During stockout, the customer orders are backordered with a stockout compensation. Both the supplier and etailer 'equally share' stockout compensation, and the wholesale price is the same as in the Base Scenario (N-SC).

**Scenario 2 (S-SC1):** During stockout, the customer orders are backordered with a stockout compensation. Only the ‘supplier pays’ stockout compensation, and the wholesale price is increased by 1% of retail price compared to the wholesale price in N-SC.

**Scenario 3 (S-SC2):** During stockout, the customer orders are backordered with a stockout compensation. Only the ‘supplier pays’ stockout compensation, and the wholesale price is increased by 2% of retail price compared to the wholesale price in N-SC. We investigate the following research questions in this study.

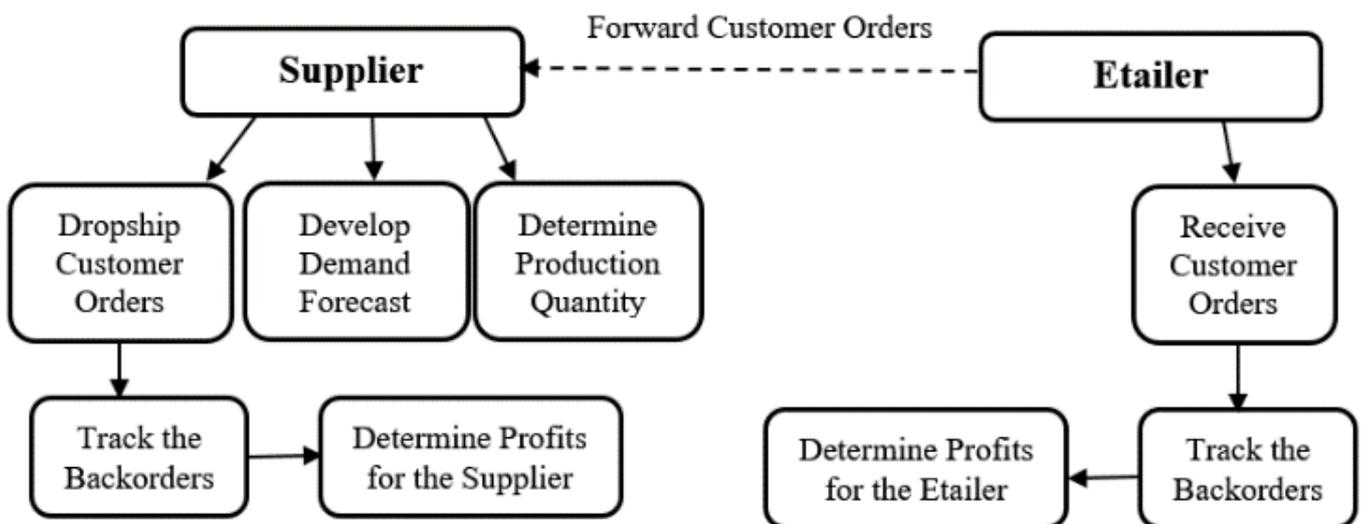
1. On average, what is the impact of E-SC and S-SC (S-SC1 and S-SC2) compared to N-SC on the supplier’s profits and etailer’s profits?
2. What is the impact of E-SC and S-SC (S-SC1 and S-SC2) compared to N-SC on the supplier’s profits and etailer’s profits under different supply chain parameters?
3. What is the appropriate wholesale price in S-SC, to help offset stockout compensation cost for supplier under different supply chain parameters (i.e. profits for both partners are same as in E-SC)?

### 3.1 Simulation Modelling

The conceptual model used to develop simulation model for drop-shipping supply chain is a two-echelon production-inventory system with a make-to-stock manufacturer (i.e. supplier) and an online retailer (i.e. etailer). Periodic review policy is used where all decisions by the supplier and etailer are made at the end of each period, where review period is one week. Demand forecast for the supplier is developed using exponential smoothing forecast

technique and smoothing parameter is selected based on minimizing the forecast error. Periodic review order-up-to policy is used to determine the production quantity during each period. The safety stock for the supplier is determined using service factor (based on service level) and standard deviation of demand. The supplier uses lot-for-lot production policy with a lead time of one week and has production capacity constraints. If the production quantity needed is more than the available production capacity, only the maximum available production quantity is produced during that period.

During each period, the customers place their orders online and the etailer forwards these orders to supplier at the end of each period. The supplier’s warehouse receives shipment from their production plant at end of each period and their inventory level is updated. From this available inventory, the supplier dropships the customer orders received from etailer, and any demand not met is backordered. In N-SC, the customer orders are backordered without a stockout compensation, and in E-SC and S-SC, they are backordered with a stockout compensation. Next, the supplier forecasts demand for next period, calculates order up-to inventory level to determine production quantity. The production quantity during each period is the difference between order-up-to inventory level and current inventory position. The production starts at the beginning of next period and the production quantity along with current inventory is available for drop-shipping at the end of next period. Finally, the revenues and expenses are calculated to determine the supplier’s profits and etailer’s profits during each period. The decisions made by the supplier and etailer during each period in the drop-shipping supply chain are shown in **Figure 2**.



**Figure 2** Drop-shipping supply chain setting

**3.2 Model Notation**

- P Retail price per unit (paid by customer)
- W Whole sale price per unit (paid by etailer)
- T Drop-shipping cost per unit (paid by etailer)
- E Etailer cost (website, marketing, etc.) per unit
- F Fixed cost of production per period
- C Variable cost of production per unit
- H Inventory holding cost per unit per period
- Ss Supplier stockout compensation cost per unit per period
- Se Etailer stockout compensation cost per unit per period
- d Customer orders per period
- q Production quantity per period
- i Average inventory of supplier per period
- b Backorder quantity (due to stockout) per period
- EP Etailer profits per period
- SP Supplier profits per period

Profits for Supplier and Etailer in N-SC strategy

$$EP = (P - W - T - E) d \tag{1}$$

$$SP = Wd - (F + Cq) - Hi \tag{2}$$

Profits for Supplier and Etailer in E-SC strategy

$$EP = (P - W - T - E) d - S_s b \tag{3}$$

$$SP = Wd - (F + Cq) - Hi - S_s b \tag{4}$$

Profits for Supplier and Etailer in S-SC strategy

$$EP = (P - W - T - E) d \tag{5}$$

$$SP = Wd - (F + Cq) - Hi - S_s b \tag{6}$$

**3.3 Experiment Design**

The purpose of an experimental design is to develop a methodology to track changes in performance measures by varying factors under study during the experimental runs. According to Law and Kelton (2000), “One of the principal goals of experimental design is to estimate how changes in input factors (control variables) affect the performance measures (response variables) in the experiment.” The main motivation for this research is to investigate the impact of E-SC and S-SC stockout compensation strategies compared to no stockout compensation strategy (N-SC) in a drop-shipping supply chain under different supply chain parameters. So, four independent variables (control variables) with three levels each and two dependent variables (response variables) are considered for this study. All factor combinations of these independent variables are used to investigate the impact on dependent variables in N-SC, E-SC and S-SC stockout compensation strategies.

**Table 1** Control variables for this research

Control Variables	Levels
Demand Variability (DV)	Low Demand Variability, $\sigma = 100$ Med Demand Variability, $\sigma = 200$ High Demand Variability, $\sigma = 300$

**Table 1** Control variables for this research (cont’)

Control Variables	Levels
Production Capacity (PC)	Low Production Capacity, 1.10 Med Production Capacity, 1.25 High Production Capacity, 1.40
Service Level (SL)	Low Service Level, 90.0 % Med Service Level, 95.0 % High Service Level, 99.0 %
Inventory Holding Cost (HC)	Low Inventory Holding Cost, \$1 Med Inventory Holding Cost, \$2 High Inventory Holding Cost, \$3

**Table 2** Response variables for this research

Response Variables	Details
Etailer Profits per Period (EP)	Etailer Revenues minus Expenses
Supplier Profits per Period (SP)	Supplier Revenues minus Expenses

As shown in **Table 1** and **Table 2**, four control variables and two response variables are used to investigate the impact of E-SC and S-SC compared to N-SC on supplier’s profits and etailer’s profits in a drop-shipping supply chain. Variable demand, production capacity, service levels, and inventory holding costs are used as control variables, as these are important factors that will impact profits for both the supplier and etailer. In this study, auto-correlated demand pattern with three levels of demand variability is considered. The customer demand during each period of the simulation run is generated as shown  $D_t = d + \rho D_{t-1} + \varepsilon_t$  where  $\rho$  = correlation factor,  $d$  = initial mean, and  $\varepsilon_t$  = error that is normally distributed with mean zero and standard deviation  $\sigma$ . The initial mean is 500 units with a correlation factor of 0.5 to generate an average demand of 1000 units per period. Three levels of demand variability are generated by varying  $\sigma$  in above equation. To investigate the impact of production capacity, three different levels of production capacities are considered for this study. Production capacities of 1.10, 1.25 and 1.40 means a production capacity equal to 10%, 25% and 40% above the average customer demand respectively. Additionally, three levels of service levels to determine the safety stock inventory and three levels of inventory holding costs for supplier are considered. The retail price is assumed to be \$100 per unit and the wholesale price per unit is as follows: When demand is less than 900 units per period, the wholesale price is \$61 per unit; when demand is 900 to 1100 units per period, the wholesale price is \$60 per unit and when demand is more than 1100 units per period, the wholesale price is \$59 per unit. The shipping cost charged by supplier to etailer for drop-shipping the item is as follows: When inventory holding cost is \$1 per unit per period, shipping cost is \$5.00 per unit; when inventory holding cost is \$2 per unit per period, shipping cost is \$5.50 per unit and when inventory holding cost is \$3 per unit per period, shipping cost is \$6.00 per unit. The stockout compensation cost is assumed to be 10% of retail price and no customer order returns are considered in this drop-shipping model.

Most studies in drop-shipping use retail price minus wholesale price as profit measure for etailer and do not consider any expenses incurred by online retailer (Netessine and Rudi, 2006; Chiang and Feng, 2010). However, the etailer incurs some expenses for online retailing such as cost of website, marketing, etc. and so our study considers etailer’s expense as \$3 per unit to generate the customer demand. Generally, the production cost per unit decreases as production capacity increases, so our study considers the production cost details as shown in **Table 3**. Initial inventory of 2000 units (2 times average demand) is used for supplier at start of simulation run. The supplier profit and etailer profit are used as performance measures and calculated based on revenues minus expenses during each period.

To eliminate the impact of random variations of input data, the same random number sequence is utilized in the simulation model to generate the same customer demand data in N-SC, E-SC, and S-SC strategies for all factor combinations. In addition, to reduce variance of output data, a sample size of 60 replications is considered in this study. Generally, stochastic processes for most real systems do not have a steady state distribution, since parameters of the system may continue to change over time. In this research, customer demand for etailer varies from period to period, and therefore the steady state parameters are not well defined or do not exist. In this situation, there will be a fixed amount of data describing how the input parameters can be varied over some time duration. This in effect provides a terminating event for simulation and thus analysis techniques for terminating simulation will be appropriate. (Law and Kelton, 2000). To determine performance measures for a terminating simulation, the initial conditions should be representative of the actual system. In our study, the simulation model for all factor combinations is run for a total of 1144 periods, with the first 104 periods used to initialize the system (warm up period), and remaining 1040 periods (equal to 20 years) is used for analysis. Increasing warm up period will not have a significant impact, as output values from the simulation model are relatively stable for different warm-up periods. Microsoft Excel and statistical software “Minitab 18” are used for results and discussions.

## 4. RESULT AND DISCUSSION

The output data (supplier’s profits and etailer’s profits) from the simulation model is analyzed to determine the impact of E-SC and S-SC compared to N-SC. First, the impact of E-SC and S-SC compared to N-SC on the supplier’s profits and etailer’s profits for all factor combinations is investigated. Next, the impact of E-SC and S-SC compared to N-SC on the supplier’s profits and etailer’s profits under different supply chain parameters is investigated. Some of the main results of this research study are shown below.

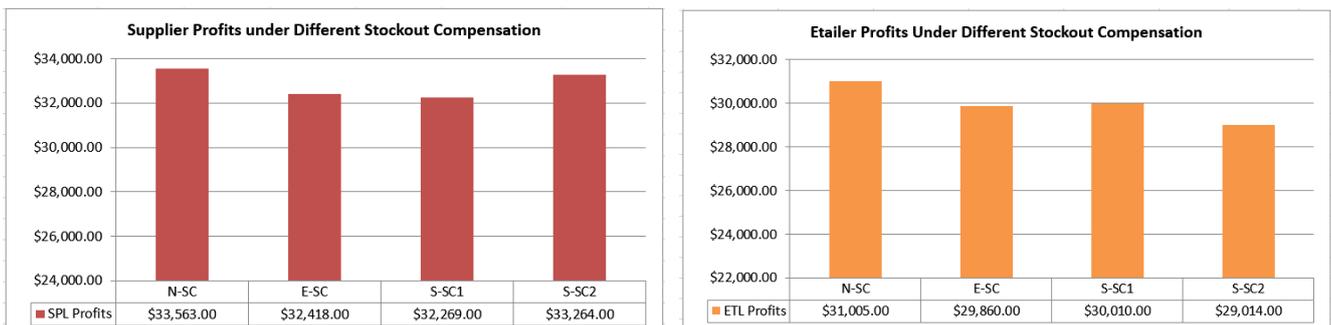
### 4.1 Impact of Different Stockout Compensation (SC) Strategies

To determine impact of E-SC and S-SC (S-SC1 and S-SC2) stockout compensation strategies compared to N-SC on supplier’s profits and etailer’s profits in a drop-shipping supply chain, the output data from simulation model for all factor combinations are plotted as shown in **Figure 3**. When both the supplier and etailer pursue E-SC, on average, the supplier’s profits decrease from \$33,563 to \$32,418 (i.e. by 3.42%) and etailer’s profits decrease from \$31,005 to \$29,860 (i.e. by 3.69%) compared to N-SC. So, based on the drop-shipping supply chain considered in our research study, on average, the profit difference in E-SC compared to N-SC is less than 4.00% for both the supplier and the etailer. This amount of money, which is less than 4.00% of overall profits is surely worth spending to keep the customers happy, which in turn can help in maintaining or even increasing the overall demand and profits for both the supplier and etailer.

However, if only the supplier is required to pay stockout compensation, on average, the supplier’s profits decrease by 3.86% and etailer’s profits decrease by 3.21% in S-SC1 compared to N-SC. Similarly, on average, the supplier’s profits decrease by 0.90% and etailer’s profits decrease by 6.42% in S-SC2 compared to N-SC. So, if both the supplier and etailer pursue S-SC, then on average, they should negotiate to slightly increase wholesale price by little over 1% of retail price compared to wholesale price in N-SC which will help offset the stockout compensation cost for the supplier.

**Table 3** Production capacity and unit production cost

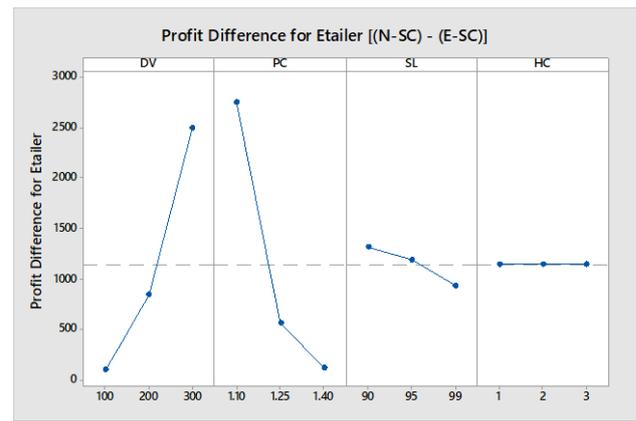
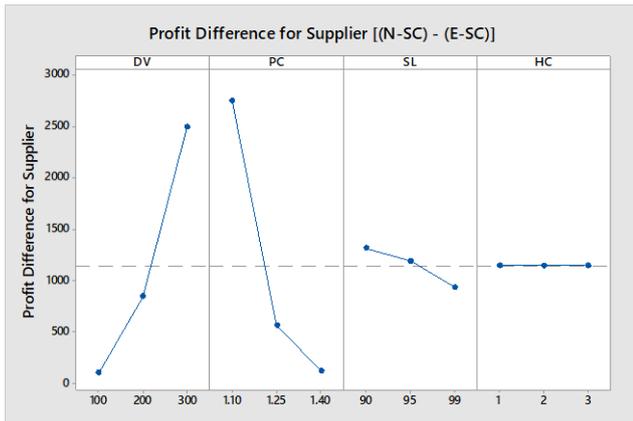
Production Capacity	Fixed Production Cost per Period	Var. Production Cost per Unit	Avg. Production Per Period	Avg. Production Cost Per Unit
1.10	\$4,000	\$22.00	1000	\$26.00
1.25	\$5,000	\$20.00	1000	\$25.00
1.40	\$6,000	\$18.00	1000	\$24.00



**Figure 3** Impact of different stockout compensation strategies

**Table 4** ANOVA of profit difference between N-SC and E-SC

Source	DF	Sum of Squares	Mean Squares	F	P
DV	2	80845559	40422780	2398.78	0.000
PC	2	106221592	53110796	3151.71	0.000
SL	2	2026614	1013307	60.13	0.000
HC	2	0	0	0.00	1.000
DV*PC	4	65954297	16488574	978.47	0.000
DV*SL	4	1172861	293215	17.40	0.000
DV*HC	4	0	0	0.00	1.000
Error	60	1011084	16851		
Total	80	257231736			



**Figure 4** Profit difference for supplier and etailer between N-SC and E-SC

To determine if the difference between means for supplier profits and etailer profits in E-SC and N-SC are statistically significant in a variable demand environment, we use ANOVA to compare p-value to significance level ( $\alpha = 0.05$ ) as shown in **Table 4**. In E-SC, both the supplier and etailer equally pay stockout compensation, and so the profit difference for both the supplier and the etailer between E-SC and N-SC will be the same. In addition, profit difference for the supplier and etailer between E-SC and N-SC for different supply chain factors is shown in **Figure 4**.

From **Table 4**, the p-value is less than the significance level, and so we conclude that there is a statistically significant difference for the supplier profits and etailers profits between N-SC and E-SC for different DV (demand variability), PC (production capacity) and SL (service level). However, it is interesting to see that there is no statistically significant difference in supplier profits and etailer profits between N-SC and E-SC for different HC (inventory holding cost). The likely reason is that same amount of inventory is held by the supplier in both the N-SC and E-SC strategies under different inventory holding costs. Also, only the supplier holds inventory in a drop-shipping supply chain, and so inventory holding cost does not impact the etailer’s profits.

**4.2 Impact of Stockout Compensation (SC) and Demand Variability (DV)**

Demand variability can play an important role on the impact of E-SC and S-SC compared to N-SC on both the supplier profits and etailer profits in a drop shipping supply chain. In this research, the customer demand for etailer is varied during each period of the simulation run. The supplier profits and etailer profits under different demand variabilities

and stockout compensation strategies in a drop-shipping supply chain are shown in **Figure 5**.

When demand variability is low, the supplier’s profits decrease only by 0.30% and etailer’s profits decrease only by 0.33% in E-SC compared to N-SC. It means that when demand variability is low, the profit difference for E-SC compared to N-SC is less than 0.50% for both the supplier and etailer. This is because when demand variability is low, the supplier may be able to accurately forecast demand and also has enough production capacity to fulfill almost all customer orders with very little stockout. However, it is interesting to see that the supplier’s profits increase by 2.36% and etailer’s profits decrease by 3.23% in S-SC1 compared to N-SC. In this study, wholesale price is increased by 1% of retail price for S-SC1 compared to N-SC, and so with very little stockout, the supplier’s profits increase at the expense of etailer. So, if both the supplier and etailer pursue S-SC strategy in low variable demand environment, then a wholesale price increase of less than 0.50% of retail price compared to wholesale price in N-SC will be sufficient to offset the stockout compensation cost for the supplier.

When demand variability is high, the supplier’s profits decrease by 7.46% and etailer’s profits decrease by 8.01% in E-SC compared to N-SC. When demand variability is high, the supplier may not be able to accurately forecast demand and also may not have sufficient production capacity resulting in higher profit difference in E-SC due to higher stockout. Our results are similar to the study by Bhargava *et al.* (2006) who show that when demand rate increases, the profit difference also increases for an online retailer with stockout compensation (without drop-shipping). When demand variability is high, the supplier’s profits decrease by 11.94% and etailer’s profits decrease by 3.20% in S-SC1

compared to N-SC. Similarly, supplier's profits decrease by 8.97% and etailer's profits decrease by 6.39% in S-SC2 compared to N-SC. So, if both the supplier and etailer pursue S-SC in a high variable demand environment, then a wholesale price increase of more than 2.0% of the retail price compared to wholesale price in N-SC will be needed to offset the stockout compensation cost for supplier. On the other hand, if feasible, the etailer should try to reduce demand variability to help increase profits in E-SC and S-SC for both the supplier and etailer.

#### **4.3 Impact of Stockout Compensation (SC) and Production Capacity (PC)**

Production capacity helps to determine if supplier has enough capacity to produce and meet the customer demand. Most studies in drop-shipping consider unlimited capacity, however, production capacity is generally not unlimited. Our study is one of the first study to consider production capacity constraints in a drop-shipping supply chain. The supplier profits and etailer profits under different production capacities and stockout compensation strategies in a drop-shipping supply chain are shown in **Figure 6**.

When production capacity is high, the supplier's profits decrease only by 0.36% and etailer's profits decrease by 0.39% in E-SC compared to N-SC. It means that when production capacity is high, the profit difference in E-SC is less than 0.50% for both the supplier and etailer. This is because when production capacity is high, the supplier may have enough capacity to produce and fulfill almost all customer orders with very little stockout. However, supplier's profits increase by 2.18% and the etailer's profits decrease by 3.21% in S-SC1 compared to N-SC. So, when production capacity is high and if both the supplier and etailer pursue S-SC strategy, then a wholesale price increase of less than 0.50% of retail price compared to wholesale price in N-SC is sufficient to offset stockout compensation cost for supplier.

When production capacity is low, the supplier's profits decrease by 8.33% and etailer's profits decrease by 8.85% in E-SC compared to N-SC. When production capacity is low, the supplier may not have enough capacity to produce and fulfill customer orders resulting in higher stockout. When production capacity is low, supplier's profits decrease by 13.65% and etailer's profits decrease by 3.21% in S-SC1 compared to N-SC. Similarly, the supplier's profits decrease by 10.62% and etailer's profits decrease by 6.42% in S-SC2 compared to N-SC. So, when production capacity is low and if both the supplier and etailer pursue S-SC strategy, they should negotiate to increase wholesale price by more than 2.0% of retail price compared to wholesale price in N-SC to offset cost of stockout compensation for the supplier. On the other hand, in a variable demand environment, the supplier should increase the production capacity which will significantly reduce cost of stockout and increase profits for both the supplier and etailer.

#### **4.4 Impact of Stockout Compensation (SC) and Service Level (SL)**

Service level used to determine the safety stock for supplier can play an important role on the impact of E-SC and S-SC for both the supplier and etailer in a drop shipping supply chain. The supplier profits and etailer profits under

different service levels and stockout compensation strategies in a drop-shipping supply chain are shown in **Figure 7**.

When service level is high, the supplier's profits decrease by 2.78% and the etailer's profits decrease by 2.98% in E-SC compared to N-SC. It means that when service level is high, the profit difference for E-SC is less than 3.00% for both the supplier and etailer. With higher service level the supplier carries more safety stock inventory which helps to fulfill customer orders with less stockout. Similarly, the supplier's profits decrease by 2.60% and etailer's profits decrease by 3.21% in S-SC1 compared to N-SC. However, the supplier's profits increase by 0.37% and etailer's profits decrease by 6.42% in S-SC2 compared to N-SC. So, if both the supplier and etailer pursue S-SC strategy when service level is high, then a wholesale price increase of little over 1.00% of retail price compared to wholesale price in N-SC will be sufficient to offset the stockout compensation cost for the supplier.

When service level is low, the supplier's profits decrease by 3.91% and the etailer's profits decrease by 4.23% in E-SC compared to N-SC. It means that when service level is low, the profit difference for E-SC is more than 3.90% for both the supplier and etailer. With lower service level the supplier carries comparatively less safety stock inventory which increases the stockout rate. Our results here are in-line with the empirical study done by Kim and Lennon (2011) for an online apparel retailer with in-store inventory (without drop-shipping). Based on their empirical study, they conclude that higher service levels for high-selling items helps reduce the total operating costs and minimize the lost sales due to stockouts. Similarly, the supplier's profits decrease by 4.85% and etailer's profits decrease by 3.21% in S-SC1 compared to N-SC. Also, the supplier's profits decrease by 1.89% and etailer's profits decrease by 6.42% in S-SC2 compared to N-SC. In S-SC strategy, only the supplier pays stockout compensation and holds inventory in a drop-shipping supply chain, and so different service levels only impacts the supplier's profits and does not impact etailer's profits. So, if both the supplier and etailer pursue S-SC strategy when service level is low, then a wholesale price increase of little over 1.00% of retail price compared to wholesale price in N-SC is sufficient to offset the cost of stockout compensation for the supplier. Ideally, the supplier should maintain higher service level in a variable demand environment to help reduce stockout and increase overall profits for both the supplier and etailer.

#### **4.5 Impact of Stockout Compensation (SC) and Inventory Holding Cost (HC)**

Even though the profit difference is same between E-SC and N-SC strategies for different inventory holding costs, however the supplier profits and etailer profits are not the same in E-SC and N-SC under different inventory holding costs. The supplier profits and etailer profits under different inventory holding costs and stockout compensation strategies in a drop-shipping supply chain are shown in **Figure 8**. In this study, for every dollar increase in inventory holding cost per unit per period, an additional cost of \$0.50 per unit is charged to etailer for drop-shipping the customer orders. In a drop-shipping supply chain, only the supplier holds inventory, and so they should be able to charge slightly higher price to etailer due to higher inventory holding cost..

When inventory holding cost is low, the supplier's profits decrease by 3.35% and etailer's profits decrease by 3.63% in E-SC compared to N-SC. It means that when inventory holding cost is low, the profit difference for E-SC compared to N-SC is less than 4.00% for both the supplier and etailer. In S-SC1, the supplier's profits decrease by 3.78% and etailer's profits decrease by 3.16% compared to N-SC. Similarly, in S-SC2, the supplier's profits decrease by 0.87% and etailer's profits decrease by 6.32% compared to N-SC. So, if both the supplier and etailer pursue S-SC strategy when inventory holding cost is low, then a wholesale price increase of little over 1.00% of the retail price compared to wholesale price in N-SC will be sufficient to offset the cost of stockout compensation for the supplier.

When inventory holding cost is high, the supplier's profits decrease by 3.48% and etailer's profits decrease by

3.75% in E-SC compared to N-SC. It means that when inventory holding cost is high or low, the profit difference for E-SC is less than 4.00% for both the supplier and etailer. This is because, when inventory holding cost is high, the supplier is able to charge higher drop-shipping cost to etailer which will help to offset the higher inventory holding cost. The supplier's profits decrease by 3.93% and etailer's profits decrease by 3.26% in S-SC1 compared to N-SC. However, the supplier's profits decrease only by 0.91% and etailer's profits decrease by 6.53% in S-SC2 compared to N-SC. So, the results suggest that if both the supplier and etailer pursue S-SC strategy when inventory holding cost is high or low, a wholesale price increase of little over 1.00% of retail price compared to wholesale price in N-SC will be sufficient to offset the stockout compensation cost for the supplier.

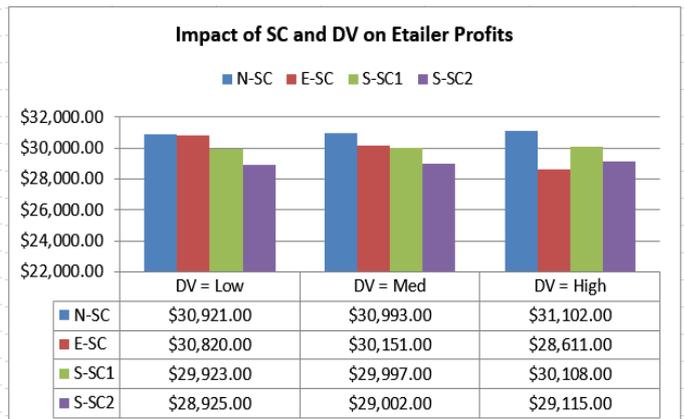
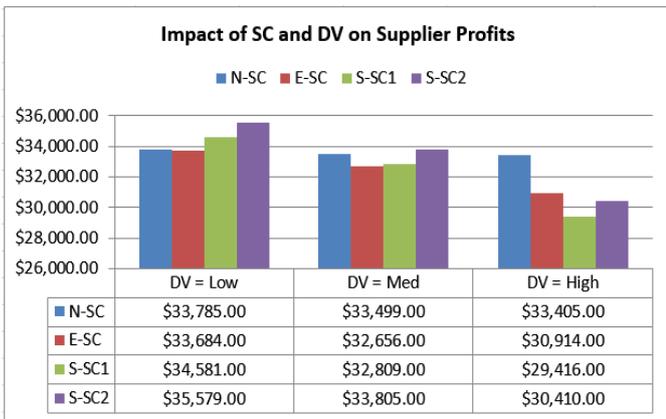


Figure 5 Impact of stockout compensation (SC) and demand variability (DV)

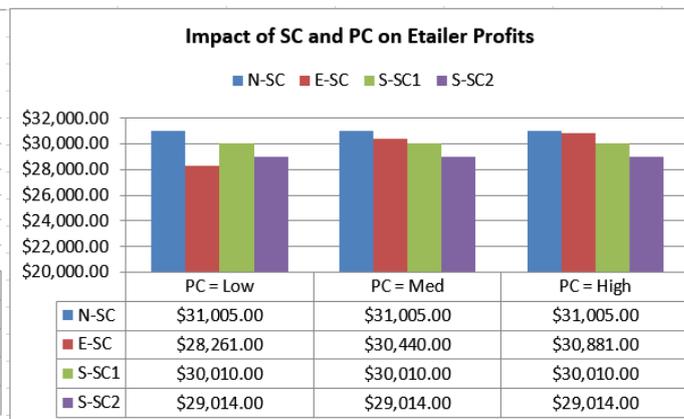
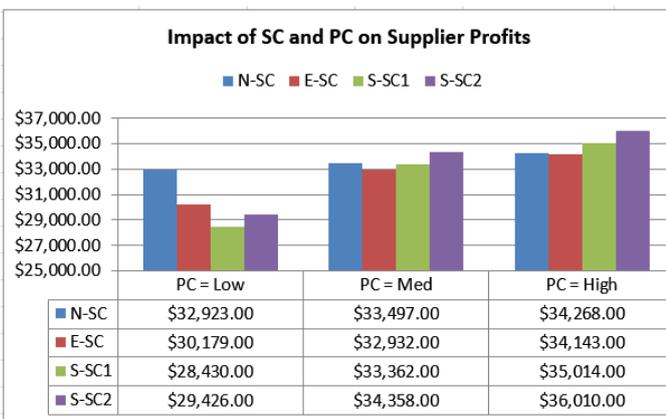


Figure 6 Impact of stockout compensation (SC) and production capacity (PC)

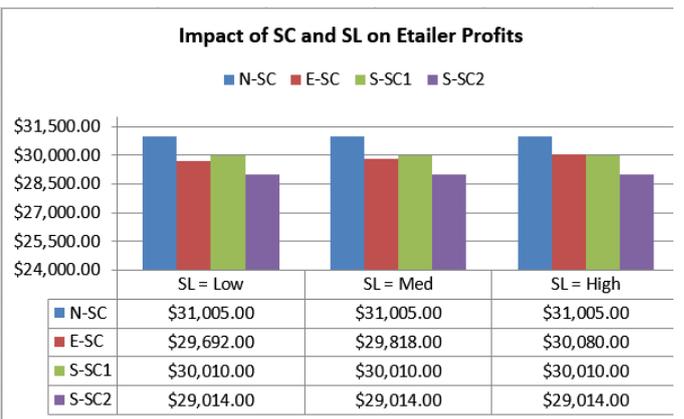
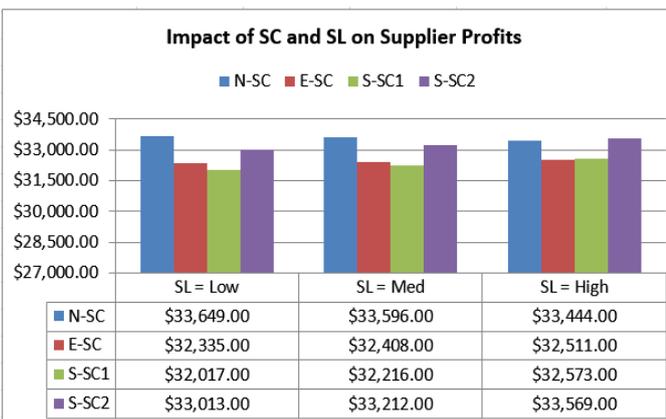


Figure 7 Impact of stockout compensation (SC) and service level (SL)

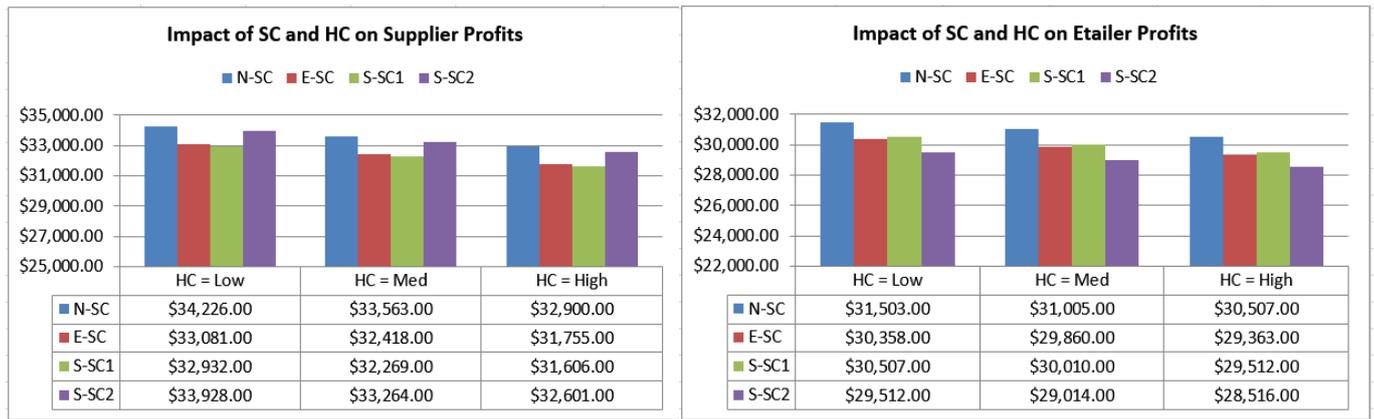


Figure 8 Impact of stockout compensation (SC) and inventory holding cost (HC)

## 5. CONCLUSION

In a drop-shipping supply chain, unfulfilled customer orders during inventory stockout can be a huge obstacle for online retailers (i.e. etailers) to pursue drop-shipping strategy. Using simulation modeling, our research is the first study to investigate impact of two different stockout compensation strategies (E-SC and S-SC) compared to no-stockout compensation strategy (N-SC) on the supplier's profits and etailer's profits in a drop-shipping supply chain. The conceptual model is a two-echelon production-inventory system with a make-to-stock supplier and an etailer. In E-SC, both the supplier and etailer equally pay stockout compensation, and in S-SC, only the supplier pays stockout compensation. In addition, we also investigate the appropriate wholesale price to be charged in S-SC under different supply chain parameters, to help offset stockout compensation cost paid by the supplier (i.e. profits for both partners to be same as in E-SC). The results from this study suggests that on average, the supplier's profits decrease by 3.42% and etailer's profits decrease by 3.69% in E-SC compared to N-SC. So, based on the drop-shipping supply chain considered in our research study, on average, the profit difference for both the supplier and etailer is less than 4.00% in E-SC compared to N-SC. This amount of money, which is less than 4.00% of overall profits, is worth spending to keep the customers happy which in turn can help in maintaining or even increasing the overall demand and profits for both the supplier and etailer in a drop-shipping supply chain. Also, the results from this study suggests that if both the supplier and etailer decide to pursue S-SC strategy, then on average, the wholesale price needs to be increased by around 1% (of retail price) compared to wholesale price in N-SC to help offset the stockout compensation cost paid by supplier. Demand variability, production capacity, and service level have a significant impact on both the supplier's profits and etailer's profits in E-SC compared to N-SC. When demand variability is high, production capacity is low, service level is low and inventory holding cost is high, the impact on the supplier's profits and etailer's profits in E-SC compared to N-SC is higher (i.e. decrease in profits is higher in E-SC compared to N-SC). However, when demand variability is low, production capacity is high, service level is high and inventory holding cost is low, impact on supplier's profits and etailer's profits in E-SC compared to N-SC is comparatively lower.

### 5.1 Limitations and Future Research

Although valuable insights can be gained from this research study to understand the impact of two different stockout compensation strategies (E-SC and S-SC) compared to no-stockout compensation strategy (N-SC) on the supplier's profits and etailer's profits in a drop-shipping supply chain, however, it is recognized that the conclusions provided here is limited to the drop-shipping supply chain setting considered in this study. In this research, a single supplier and a single etailer with periodic review policy (R, S) is considered for the drop-shipping supply chain. Demand variability, production capacity, customer service level and inventory holding costs are used as control variables. A fixed retail price and one set of stockout compensation cost is considered in this study. So, there are many opportunities to evaluate and strengthen these insights by investigating other parameters to determine the impact of E-SC and S-SC compared to N-SC on the supplier profits and etailer profits in a drop-shipping supply chain. Future studies can investigate how different sets of stockout compensation costs, retail price and profit margins will impact supplier profits and etailer profits in E-SC and S-SC compared to N-SC. Another area of future research is to consider the impact of E-SC and S-SC on supplier profits and etailer profits with multiple suppliers and/or multiple etailers. In addition, it would be valuable to extend this study to investigate the impact of E-SC and S-SC on the supplier profits and the etailer profits by considering other inventory management policies like (s, S) and (R, Q) policies in a drop-shipping supply chain.

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**Raj Kamalapur** is an Associate Professor of Operations and Supply Chain Management in the Norris-Vincent College of Business at Angelo State University, Texas Tech University System. His research interests are in area of supply chain collaborations (VMI and CPFR), inventory management in traditional and e-commerce supply chains, and sustainable supply chains. His research has been published in the *Journal of Operations and Supply Chain Management*, *International Journal of Business and Management*, *American Journal of Industrial and Business Management* and he has also presented his research at many DSI conferences.

**David Lyth** is a Professor of Industrial and Manufacturing Engineering in the College of Engineering and Applied Sciences at Western Michigan University. His research has focused on the relationship of service quality to a variety of issues, including organizational culture and system design, ISO-9000 implementation, and supply chain management. He is the co-founder and co-director of WMU's Engineering Management research laboratory and the editor-in-chief of *Quality Engineering*, one of the top journals in the quality field. He has published widely in journals such as *Engineering Management Journal*, *Managing*

Service Quality, Journal of Operations and Supply Chain Management, International Journal of Quality and Reliability Management and others.