INVENTORY ALLOCATION BEHAVIOR OF THE DISTRIBUTOR DURING DEMAND SHOCKS AND SUPPLIER DISRUPTIONS

Dilina Kosgoda[1,2], H. Niles Perera[1,2], John Aloysius[3]
[1]*Department of Transport and Logistics Management, University of Moratuwa, Sri Lanka.*
[2]*Center for Supply Chain, Operations & Logistics Optimization, University of Moratuwa, Sri Lanka.*
[3]*Walton College of Business, University of Arkansas, Fayetteville, Arkansas 72701, United States of America.*
dilinak@uom.lk, hniles@uom.lk, Jaloysius@walton.uark.edu

ABSTRACT – Inventory allocation is one of the main operations in any supply chain. Most of the time inventory allocation for the retailer is done by the manager of the distribution center. Literature reports three allocation mechanisms namely; proportional, linear, and uniform which can be used by the distributor when allocating inventory to their retailers. However, the distributor struggles to identify the best allocation mechanism when there is a mismatch between available supply and demand. We investigate the inventory allocation behavior of the distributor under three different scenarios; (i). when there are positive demand shocks, (ii) when there are supply disruptions, and (iii) when there are both scenarios. We used a computerized laboratory experiment to study the allocation behavior. We employed undergraduate students as participants in our laboratory experiment. The participants in all treatments were assumed as distributors and they were asked to allocate the inventory using any inventory allocation mechanism out of the three mechanisms. ANOVA techniques were used to analyze our data. Our results suggest, the proportional allocation mechanism as the best allocation mechanism when there are demand spikes. A liner allocation mechanism is ideal to use when there are supply disruptions. Further, when there are both demand spikes and supply disruptions, we recommend using the liner allocation mechanism.

Keywords: Behavioral Operations; Inventory Allocation Decisions; Laboratory Experiments

1. INTRODUCTION

Manufacturers often pool inventory to serve downstream requirements at their fulfillment or retail locations due to many benefits including lower inventory investment through reduced safety stock levels, lower product acquisition cost and lower distribution cost. However, the main problem of such integrated distribution system arises when allocating pooled inventory across downstream partners [1]. Spiliotopoulou, Donohue and Gürbüz [2] investigate the three well-known allocation mechanisms (i.e., proportional, linear, and uniform) on retailers' ordering. In their study, participants took on the role of a retailer and played the inventory allocation game.

According to the authors, the allocation decision of the manager of the distribution center remains underexplored. In practice, when retailers experience a local market demand, they place orders with their distributor who attempts to allocate inventory accordingly. The distributor struggles to identify what allocation mechanism is best suited when there is a mismatch between available supply and order requests. For example; the distributor has to decide whether he/she is going to allocate proportionally to each retailer's order (proportional allocation), equally split shortages or excess inventory to retailers (liner allocation) or match order quantities for selected retailers while allocating less than what was ordered to other retailers (uniform allocation).

Tokar et al. [3] investigate inventory ordering decisions when decision makers anticipated a demand shock. They show that uncertainty regarding the magnitude and timing of a demand shock induces decision makers

to overstock where decision makers order too much inventory too early. This ordering behavior of the retailer who places orders to the distributor is more likely to affect the behavior of the distributor who aims to allocate the inventory based on inventory availability. To the best of our knowledge, this research gap has not been addressed in literature. Thus, we attempt to investigate the inventory allocation behavior of the distributor under a positive demand shock.

Supply chains face a variety of disruptive events including natural disasters, human-made attacks and common failures [4]. However, during a supply chain disruption suppliers are less likely to deliver the same quantities to their distribution center as they usually do. As a result of the sudden drop in supply, the distributors are compelled to make allocation decisions based on the available inventory when allocating to their retailers. Even though the literature highlights several studies which examine order allocation for suppliers [5],[6] there is a dearth of studies that investigate order allocation for retailers by distributors. According to the literature, these allocation decisions of the distributor have not been examined from a behavioral perspective. Therefore, we take the first steps to fill this research gap by utilizing the behavioral lens.

2. MATERIAL AND METHODS

Perera, Fahimnia et al. [7] report five main experimental methods; Field Experiments, Verbal Protocol Analysis, Vignette-Based Experiments, Laboratory Experiments, and Laboratory Experiments with Neuroimaging studies which can be employed for behavioral research in the domain of inventory ordering decisions. Laboratory experiments are identified as the most appropriate research methodology, due to its appropriateness considering research objectives. A computerized program is designed to implement the laboratory experiment that includes an inventory game that is created using the R shiny web application.

Our laboratory experiment was a computerized experiment composed of 40 rounds. We employed undergraduate students who have knowledge of supply chain management, inventory management, logistics management, and operations management as participants for our experiment. They were assumed as distributors and they had to allocate their inventory to two retailers. They were given a radio button to select their allocation mechanism out of the three allocation mechanisms. They were incentivized up to 1000 LKR based on their performance.

We designed eight treatments as Table 1 considering our research objectives. The first four treatments (T1, T2, T3, T4) were designed as single-period treatments where leftovers cannot be used for the next period. The other four treatments (T5, T6, T7, T8) were multi-period treatments in which additional inventory can be used for the next period. In the supplier disruption treatment (T2, T6), the quantity received from the supplier (Q_t) was reduced during some rounds. In the demand spike treatments (T3, T7), there were demand spikes for retailers in some rounds. Both these effects occur in T4 and T8.

3. RESULTS AND DISCUSSION

We collected experimental data from 170 participants who have knowledge in inventory decisions. We used ANOVA to analyze our data. Our results reveal a significant difference in allocation behavior in each scenario. Participants tend to perform better when they use the proportional allocation mechanism during demand shocks (in both single-period and multi-period situations). However, when participants use the proportional allocation mechanism during supplier disruption (in both single-period and multi-period situations), their performance have deteriorated. We identified that the participants who use the linear allocation mechanism during supplier disruption ended up with better performance. Further, when there were both demand shocks and supplier disruption (in both single-period and multi-period situations), participants who used the liner allocation mechanism performed better than participants who used other allocating mechanisms. We believe these findings would be beneficial for both industry practitioners and academics when dealing with inventory allocation decisions under different circumstances.

Table 1. Design of the laboratory experiment

	Control	Supplier Disruption	Demand spikes	Both
Treatment Number	**T1 & T5**	**T2 & T6**	**T3 & T7**	**T4 & T8**
Type	Single Period (T1,T2,T3,T4) and Multi Period (T5,T6,T7,T8)			
Order Quantity Supplied by the Supplier	constant	reducing	constant	reducing
Demand Experienced by the Retailer	No demand spike	No demand spike	Demand spikes	Demand spikes
Demand Experienced by the Retailer	No demand spike	No demand spike	Demand spikes	Demand spikes

4. CONCLUSION

We developed a computerized laboratory experiment to investigate the inventory allocation behavior of the distributor under three different scenarios; (i). when there are positive demand shocks, (ii) when there are supply disruptions, and (iii) when there are both scenarios. Undergraduates were employed as participants in our laboratory experiment. We identified best inventory allocation mechanisms that can be used under each scenario.

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