



How can we improve the performance of supply chain contracts? An experimental study

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ABSTRACT

Although optimal forms of supply chain contracts have been widely studied in the literature, it has also been observed that decision makers fail to make optimal decisions in these contract setups. In this research, we propose different approaches to improve the performance of supply chain contracts in practice. We consider revenue sharing and buyback contracts between a rational supplier and a retailer who, unlike the supplier, is susceptible to decision errors. We propose five approaches to improve the retailer's decisions which are in response to contract terms offered by the supplier. Through laboratory experiments, we examine the effectiveness of each approach. Among the proposed approaches, we observe that offering free items can bring the retailer's effective order quantity close to the optimal level. We also observe that the retailer's learning trend can be improved by providing him with collective feedbacks on the profits associated with his decisions.

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1. Introduction

Supply chain contracts have been extensively studied by researchers. A large stream of research in this field considers a two echelon supply chain consisting of a supplier (seller) and a retailer (buyer) who sells a seasonal (fashion) product to a market with random demand. Due to usually lengthy production and distribution lead times (Fisher and Raman, 1996), the retailer has to decide about the order quantity (initial inventory level) long before the start of the selling season. Under this setup, the retailer faces a classical Newsvendor inventory problem. That is, if the retailer's order quantity is less than the realized demand, the retailer faces with inventory shortage (unmet demand), while if the order quantity is more than the realized demand the retailer is left with unsold inventory, which should be discarded or salvaged with a very low price. The classical Newsvendor solution identifies the optimal order quantity which maximizes the retailer's expected profit.

In a simple wholesale price contract, the retailer faces all the risk and the wholesale price that maximizes the supplier's profit causes the retailer to order a quantity less than the value that maximizes the channel profit (Spengler, 1950). To avoid this situation, the supplier can offer a contract in which she provides the retailer with proper economic incentives to order the quantity that maximizes the supply chain profit (a coordinating contract).

In this research, we consider two types of coordinating contracts: revenue sharing and buyback. In a revenue sharing contract, the supplier offers a relatively low wholesale price but asks the retailer to share part of the revenue of every item sold. Revenue sharing contracts have been used successfully (among other industries) in the video-rental industry (Cachon and Lariviere, 2005). In a buyback contract, the supplier buys back any unsold item from the retailer with a price lower than the wholesale price. Buyback contracts are common practice in the publishing, software, and pharmaceutical industries (Padmanabhan and Png, 1995). In both contracts, the supplier shares part of the retailer's risk of facing a random demand.

Although the theoretical benefits of optimal Newsvendor solutions and coordinating contracts have been widely studied, it is also known that retailers fail to place the optimal order quantities in practice. Fisher and Raman (1996) and Corbett and Fransoo (2007) show industry evidence that managers' inventory decisions systematically deviate from the optimal quantities. Fisher and Raman (1996) show that managers' less-than-optimal production quantity, at a ski apparel manufacturer, resulted in a profit which was 60% less than their calculated optimal profit. Corbett and Fransoo (2007) study inventory decisions of 51 small businesses. They show that the inventory decisions deviates from the optimal decisions calculated by a Newsvendor model. They show that the deviations are consistent with the prospect theory predictions.

Almost all the research papers in this field have focused on finding how and why decision makers' order quantities deviate from the optimal values (we will briefly review these papers in Section 2). The more important question of how this deviation

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could be avoided, however, has received little attention in the existing literature. As an attempt to fill this gap, we explore possible ways through which we can improve the performance of a supply chain by inducing the retailer to choose order quantities close to the channel's optimal order quantity.

Here, we consider an ideal supplier whose decisions are rational and sets the parameters of the contract according to their theoretical optimal values. The retailer, however, is assumed to be prone to behavioral misjudgments and errors. Therefore, the order quantities chosen by the retailer can systematically deviate from the optimal values. The retailer's suboptimal decision has a negative impact on his profitability as well as the supplier's and the channel's profitability. Hence, the supplier tries to design the contract terms or offer additional information to address the inefficiency in the retailer's decision and increase her (and consequently channel's) profit.

We explore five approaches which could possibly improve the performance of a revenue sharing or buyback contracts. We first identify the concept or logic behind each approach and then verify its effectiveness through laboratory experiments. Three of these approaches concern the contract terms which the supplier offers the retailer. The other two approaches concern providing the retailer with additional information or feedback that might help him to make better decisions. In our first approach we consider a new type of contract which is a combination of revenue sharing and buyback contracts. The second approach examines the possibility that risk-aversion is the source of suboptimal decisions. If this is the case, then a coordinating contract that is designed for a risk-averse (not a risk-neutral) retailer should result in an optimal order quantity. The third approach considers the offering of free items by the supplier. If the number of free items offered increases with the size of the order, the retailer might be encouraged to increase his order quantity. Moreover, these free items increase the number of items in the supply chain. In our fourth approach we examine the impact of providing the retailer with visual information about the nature of demand uncertainty. This could possibly discourage the retailer to follow shortsighted strategies such as demand chasing. In our last approach we provide the retailer, in each decision round, with a new performance measure that shows the collective impact of last decision if the current order quantity were the decision for previous decision rounds as well. This new piece of information should also discourage the retailer to follow a demand chasing strategy.

The remainder of this paper is organized as follows. Section 2 reviews the related literature. Section 3 presents the theoretical background of the problem, explains the general experimental setup, and shows the results of our benchmark experiments. Sections 4–8 present the five studies through which we explain and investigate the effectiveness of each of our approaches to improve the performance of the supply chain. Section 9 concludes the paper with a summary of our results.

2. Related literature

In this research we study a two echelon supply chain consisting of a supplier and a retailer, in which the retailer faces a classical Newsvendor problem. In a Newsvendor problem a decision maker, who faces a random demand for a single selling period, has to decide about the quantity (inventory level) he needs to order/manufacture before the beginning of the period. Optimal order quantity is a trade-off between overage and underage inventory costs (Arrow et al., 1951). In its basic form, the Newsvendor problem has an elegant solution which can be applied to many applications other than single period inventory

problems (e.g., multi-period inventory problems, capacity selection, choice of staffing level, time should be allocated to a given task, etc.). A review of different extensions of this widely studied problem is beyond the scope of this paper. We refer the interested readers to Olivares et al. (2008) and Qin et al. (2011) for reviews of this literature.

Although the elegant structure of the Newsvendor problem has let researchers develop analytical solutions for different variants of this problem, it has been known for a while that decision makers facing this problem deviate from the theoretical optimal solution in practice. Fisher and Raman (1996) and Corbett and Fransoo (2007) provide industry evidence for this deviation. These observations have attracted many researchers' attention as to how and why this deviation occurs. There are many research papers that try to explore this behavior through laboratory experiments.

Schweitzer and Cachon (2000), in a set of laboratory experiments, observe that the subjects' order quantity always fall between the average demand and the optimal value. That is, for a high profit margin product, for which the optimal order quantity is higher than the average demand, the subjects' average order quantity is also higher than the average demand, but lower than the optimal value. For low profit margin products, for which the optimal order quantity is lower than the average demand, the subjects' average order quantity is lower than the average demand, but higher than the optimal value. This behavior is known as "pull to center." The authors attribute this behavior to *ex post* inventory error, anchoring, and insufficient adjustment. Through their experimental analysis, they rule out the influential impacts of other factors like risk aversion, loss aversion, prospect theory preferences, waste aversion, and stock-out aversion. Our research is different from Schweitzer and Cachon (2000) since we study coordinating contracts between a supplier and a retailer, while they study a single Newsvendor decision maker (retailer). Similar to their results, our subjects (retailers) demonstrate the pull to center behavior. We also rule out the influential role of risk aversion in retailers' suboptimal decisions, which is similar to what they conclude (using a completely different method).

Building on Schweitzer and Cachon's (2000) model, Bostian et al. (2008) use an adaptive learning algorithm to justify the pull to center behavior. Unlike Schweitzer and Cachon (2000), Bostian et al. (2008) find that subjects' average order quantity is very close to the mean demand in the first round of decisions. However, order quantities diverge from the mean demand in successive decision rounds. The authors' adaptive learning model explains the pull to center behavior and shows that subjects respond to recent gains and losses. They also show that payoff insensitivity to order quantity in the vicinity of the optimal order quantity could not explain the pull to center behavior. One of the approaches that we propose in this paper (the collective feedback approach) is partly based on Bostian et al. (2008) observation that subjects respond mostly to recent gains and losses.

Using a model based on the quantal choice theory, Kremer et al. (2010) show that decision makers' random errors cannot be the main source of deviation from the optimal order quantity. They show that context dependent decision strategies such as anchoring, chasing, or inventory error minimizing play more influential roles. The conclusion that context dependent and systematic biases play the influential role in subjects' suboptimal decisions (rather than their random errors) suggest that there should be ways to counter these systematic biases. In this research, we propose approaches to work against these systematic biases and bring the supply chain profit close to its optimum level.

Bolton and Katok (2008) study the impact of experience and feedback on the subjects' behavior. The authors show that subjects' decisions improve over the 100 rounds of decisions in their

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