



# The impact of repeated interactions on supply chain contracts: A laboratory study

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## ABSTRACT

In this laboratory study, we investigate the interactive behaviors that develop over a perceived long-term contractual relationship. Specifically, three types of contracts are examined under a two-echelon supply chain setting with stochastic demand: wholesale price contracts, buyback contracts and revenue-sharing contracts. The supply chain contracting theory has demonstrated that the simple linear price contract is inefficient; whereas the latter two contracts can coordinate the channel through risk-sharing, and they are mathematically equivalent. We propose an experimental design that controls for individual decision biases to isolate the behavioral impact of repeated negotiations. Our experimental results indicate that participants systematically deviate from predictions by the normative model that assumes a one-shot interaction between self-interested players. We find that when future opportunities to punish are available, social preferences for fairness and reciprocity are reinforced; and reputation-building behaviors are motivated to achieve long-term economic benefits. As a result, the performance of the overall supply chain is enhanced. Moreover, we observe that buyback contracts behave differently from revenue-sharing contracts by inducing higher order quantities over time.

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## 1. Introduction

Contractual relationships among supply chain partners have attracted considerable interest from both practitioners and academicians. In any channel that consists of individual firms, inefficiency may arise due to decentralized decisions motivated by local interests. Particular research efforts have been devoted to the analytical design of contracting mechanisms to align the economic incentives of multiple parties in a supply chain. Cachon (2003) provides a comprehensive review of the theoretical literature on *coordinating contracts* and concludes that future empirical research should “challenge the assumptions and analysis of the theory” (Cachon, 2003, pp. 330–331).

Most supply chain contracting models assume that decision makers behave in a way that maximizes their *own* expected payoffs. In other words, agents are (1) fully rational, and (2) have no social preferences for fairness or reciprocity. However, behavioral studies from various fields have provided counter-evidence. For example, a recent experimental study by Katok and Wu (2009) shows the effectiveness of coordinating contracts are reduced by persistent individual decision biases. Kahneman et al. (1986) argue that willingness to enforce fairness is common,

and that even profit-maximizing firms can be motivated by preferences for equitable payoffs. Empirical research in marketing has documented cases where fairness plays an important role in the manufacturer–retailer relationships in many industries, including automobiles, consumer packaged goods, semiconductors, computers, and telecommunications (Kumar et al., 1995; Kumar, 1996; Scheer et al., 2003).

In the basic contracting model, a supplier initially proposes a contract, and a retailer then responds by determining an order quantity as a newsvendor. Most analyses focus on a one-shot interaction between these two players, thereby excluding the possible social and economic impact from repeated exchanges. In practice, however, even if a retailer is selling a perishable product, there may be multiple opportunities to negotiate the contract arrangement with the same supplier. Past research has suggested that the perceived long-term relationship helps foster trust and reinforce reciprocity. For instance, Dyer (1997) conducts surveys and interviews to analyze automotive channel relationships in the U.S. and Japan. The study reports that Japanese auto companies maintain longer transaction relationships with a smaller group of suppliers compared to their counterparts in the U.S. Because of these “repeated games”, Japanese suppliers indicate that they are more likely to trust Japanese auto-makers to treat them fairly. And due to the anticipation of future opportunities to reward and punish, the incentives to behave opportunistically are largely reduced for Japanese automotive partners.

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The current study experimentally investigates how decision makers interact through various supply chain contracts when repeated negotiations are possible. We choose to study, under a stochastic demand environment, three types of contracts: the wholesale price contract, the buyback contract, and the revenue-sharing contract. These contracts represent distinct characteristics in general: non-risk-sharing versus risk-sharing, and non-coordinating versus coordinating. Although buyback contracts and revenue-sharing contracts have been demonstrated to be mathematically equivalent (Cachon and Lariviere, 2005), we would also like to examine whether there exists any behavioral difference between these two contracts.

The focus of our research is on the *strategic behaviors* developed over a perceived long-term relationship. In our experiments, pairs of human subjects interact with the same anonymous partner repeatedly via computer. The supplier is asked to determine the parameters for a given type of contract. The retailer, on the other hand, can choose to reject the contract, order the minimum possible demand, or place the order quantity that maximizes her own expected profit ( $q^*$ ). Our computer program automatically calculates this optimal order given each offer proposed by the supplier. This information is provided to both players before they make any final decisions. Unlike most newsvendor experiments in the literature, in which the decision maker can choose from a wide range of nonnegative integers as the order quantity, we constrain the retailer's options and offer decision analysis tools to compute  $q^*$  for all players. The purpose of this design is to control for the impact of possible individual decision biases.

Our manipulation is motivated by Katok and Wu (2009), who propose a design to eliminate human interactions. In their experiments, human retailers or suppliers deal with computerized partners. Decision makers do not have any incentive to treat a computer fairly or act strategically if the computer is not programmed to respond. Therefore, any deviations from theoretical predictions can only be attributed to an individual's bounded rationality. In this study, we intend to isolate the effect of repeated interpersonal interactions by the current design. If a subject knows what would be the "optimal" decision beforehand and still chooses to behave differently, it must be due to strategic concerns, not cognitive limitations. Since Katok and Wu (2009) have removed social considerations, their results are more in line with theories that assume self-interest, and thus will serve as a benchmark for our study.

We observe that the behaviors of both the retailer and the supplier differ systematically from what the normative theory predicts. Repeated interactions improve the supply chain performance in general. Namely, the linear price contract performs better than suggested, even when the efficiency loss from negotiation failure is considered. The channel coordination is approximated under the two risk-sharing contracts, but at the cost of the supplier. Buyback contracts induce higher order quantity than revenue-sharing contracts, and the differences become more apparent over time.

The rest of this paper is organized as follows. Section 2 reviews relevant literature. Section 3 provides the analytical background and establishes the research hypotheses for the study. Section 4 describes our experimental design and implementations. Observational results are reported in Section 5. Section 6 concludes the study and discusses our research limitations and opportunities for future work.

## 2. Literature review

In the supply chain contracting literature, the retailer is usually modeled as the newsvendor who determines the order quantity before a random demand is realized. Schweitzer and Cachon (2000)

were the first to use experiments to study newsvendor decisions. They observe that decision makers tend to place orders close to the average demand. Bolton and Katok (2008) show that such decision biases persist even after subjects have gained extensive learning experience. Katok and Wu (2009) find that the "pull-to-center" behavior by the retailer reduces the performance of both the buyback contract and the revenue-sharing contract.

Note that in the above studies, the economic parameters (i.e., the purchase cost or wholesale price) simulated in the laboratory are static. Under a contracting setting with recurrent human interactions, the supplier's offer can be dynamic. The retailer may need to frequently adjust her ordering decisions in response to changes in the contract. Thus, learning opportunities for the retailers are not as salient as before. Since the literature has already identified the impact of individual decision biases on contract performance and its persistence when learning is relatively easy, we feel there is a need to design our experiments so that behavioral effects driven by strategic considerations can be directly examined. Katok and Wu (2009) also look at the supplier's decisions regarding contract parameters. In their study, a human supplier plays with an automated retailer who is programmed to accept  $q^*$  according to the normative theory, a scenario which is referred to hereafter as the *Supplier Game* (SG). And suppliers are found to not offer contracts to fully coordinate the channel. In the current study, we replace the automated retailer in the SG with a human player. In addition to the option to choose  $q^*$ , our human retailer can choose to reject the offer or order the minimum demand.

Several recent behavioral studies look at decision-making under various types of contracts, including the wholesale price contract (Loch and Wu, 2008), tariff-based contracts (Ho and Zhang, 2008), quantity discounts (Lim and Ho, 2007) and minimum order quantity contracts (Katok and Pavlov, 2009). These experiments all consider a *deterministic* demand condition. Many of them allow only one-shot interactions between pairs of players to avoid reputation-building behavior. Loch and Wu (2008) look at the impact of social considerations such as status seeking and reciprocity on the performance of a wholesale price contract. In their experiments, the same pairs of decision makers are asked to play repeatedly for 15 rounds. They find that when participants are *cued* to perceive a good relationship, more cooperation is promoted; however, when the profit "winner" is indicated in the game, more competition is induced. Our manipulation of the player interactions is similar to their control condition: two randomly matched participants play the game without seeing each other or having any other additional social contact. Yet our players have 100 opportunities to negotiate in the experiments. Moreover, we use a stochastic demand environment so that risk-sharing contracts, like buybacks and revenue-sharing, can be investigated.

Another study closely related to the current research is Keser and Paleologo (2004), in which fixed pairs of human players interact over 30 periods, under a wholesale price contract with demand uncertainty. They find that the supplier tends to choose a wholesale price close to the middle point between the retail price and the production cost; whereas the retailer orders a quantity significantly less than the best response to the proposed wholesale price. These behaviors result in a more equitable profit allocation between the two parties. However, due to the limitation of their experimental design, it is not clear whether these behaviors are the result of interactive considerations, such as fairness and reciprocity; or individual preferences for anchoring and/or risk-aversion.

The experimental economic literature has challenged the self-interested behavioral assumption with empirical evidence from the *Ultimatum Game* (UG). In this bargaining experiment, a

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