

Explaining Retailer and Manufacturer Behavior in Supply Chain Experiments

Ümmühan Akbay – Murat Kaya

*Manufacturing Systems and Industrial Engineering, Sabancı University, Orhanlı,
Tuzla 34956 Istanbul, TR*

ummuhana@sabanciuniv.edu – mkaya@sabanciuniv.edu

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1. Introduction

Laboratory experiments as well as case studies from various sectors have uncovered that existing operations management theory, which assumes expected utility maximizing rational individuals who interact according to game theoretic strategies, is not sufficient in predicting actual behavior of the decision makers.

Since the first experimental study on the newsvendor problem conducted by Schweitzer and Cachon in 2000, researchers have been studying both retailer's and manufacturer's decision making behavior. These studies have shown that both the retailer and the manufacturer systematically deviate from their respective optimal decisions.

Some studies in literature aim to explain these systematic deviations through different behavioral models or decision heuristics. Pavlov & Katok (2011) study a fairness concerned retailer's behavior in a linear demand environment. Cui et al. (2007), Katok et al. (2011), Wu (2006), and Loch & Wu (2008) also study fairness concerns in supply chain contracting in a linear demand setting. Wang & Webster (2007) model a simple supply chain with a loss-averse retailer facing the newsvendor problem. Pranato (2005) studies both risk and loss aversion in the retailer. Ho & Zhang (2008) consider loss averse and boundedly rational retailer behavior. Zhang et al. (2011) study loss averse supplier behavior.

In addition to these studies, one of the most pronounced explanations for retailer's suboptimal behavior is the use of anchor-and-adjust-type decision heuristics, namely the mean anchor and demand chasing heuristics.

In this study, we conduct human-to-human experiments on a simple manufacturer-retailer supply chain where the manufacturer determines the contract parameters, and the retailer faces the standard newsvendor problem. Similar to previously reported experiments in literature, we observe both decision-makers' decisions to systematically deviate from the theoretically predicted values.

The focus of this paper is to extend the existing theory by developing behavioral models that will be better at predicting the actual decisions. The factors we consider include risk preferences, inventory error aversion and social preferences.

We develop theoretical models to explain the manufacturer's contract decision, retailer's stock quantity decision, as well as retailer's contract rejections based on these factors. We do so under wholesale price, buyback and revenue sharing contracts separately.

These theoretical models are tested on experiment data by estimating the behavioral parameters for each individual subject. Some of the models are found to fit significantly well to data, and thus have the power to explain subject deviations from the theoretical predictions to a large degree.

Next, in order to predict subject behavior based on measurable personal factors, we try to find connections between our behavioral model estimations, and subjects' answers to pre-experiment personal traits surveys. The surveys include a self-esteem scale, regret scale, risk and loss aversion scale and a fairness survey adapted from the dictator and ultimatum games.

We also introduce new anchor-and-adjust-type heuristics. Our contracting experiments reveal these heuristics to be more successful in explaining the retailers' behavior than the well-known demand chasing and mean anchor heuristics. Finally, we show these heuristics to be effective in retailer-only experiments as well, using data from separate newsvendor experiments.

2. Experimental Design

In this study we consider a simple manufacturer-retailer supply chain where the manufacturer produces a certain product and sells it to the retailer, and the retailer faces a newsvendor setting. Each role is played by human subjects. Experiments are conducted under the wholesale price contract, buyback contract and revenue sharing contract. The manufacturer determines the pricing decisions and offers the contract to the retailer. Upon receiving the contract offer the retailer can decide either to reject the contract or to accept it. To reject the contract he or she just places an order of zero and both parties receive zero profit for that period. If the retailer decides to accept the contract, he or she will place an order between 51 and 150.

We use the same parameters and demand stream as an earlier study conducted by Katok and Wu (2009). The production cost of the manufacturer is \$3 and the selling price of the retailer is \$12. The consumer demand that the retailer faces, is discrete uniformly distributed between 51 and 150. The roles and pairs are randomly assigned by the experiment software. Subjects play the same role with the same partner throughout the experiment for 40 periods.

The only motivation for the subjects is cash payment of an average 30 TL (\$14) based on their total profit earned in the experiment. For each contract type 44 students participated in the experiments making a total of 132.

3. Behavioral Models

In this study, we aim to extend the standard theory to address the regularities in our experiment data. We study several behavioral models including

- Risk aversion, loss aversion
- Waste aversion, stock-out aversion and minimizing ex-post inventory error
- Fairness concerns, status seeking and group identity.

We first solve the relevant theoretical models and derive the retailer's optimal decision as a function of the behavioral factors in affect. Then estimate these factors for each individual subject using linear regression models. The results show that experiment subjects are highly heterogeneous, suggesting that an individual-level analysis would be more appropriate than an aggregate-level one. Among the models we consider, minimizing ex-post inventory error model is the strongest one that fits almost all individual's decisions significantly.

For the manufacturer, the wholesale price contract has a concave profit function yielding a closed form expression for the optimal wholesale price. For this contract type, we estimate the behavioral factors similar to the retailer's behavioral factor estimation. For the buyback and revenue sharing contracts, the manufacturer's expected profit is not jointly concave in the two contract parameters, therefore an analytical solution cannot be derived. For these contracts, we estimate the behavioral factors numerically. We compute the optimal pricing decisions for different values of these behavioral factors. Then we select the factor which gives the pricing decisions closest to the experiment results. This part of the study is currently in progress.

4. Personal Trait Surveys

We observe significant heterogeneity in subject behavior. It would be valuable to predict an individual subjects' behavior (such as the strength of certain biases) based on data obtained outside the experiment. For instance a negative relationship between self-esteem and risk aversion has been shown in various studies. (Josephs et al. 1992, Landau & Greenberg 2006) Hence measuring the decision maker's self-esteem may provide information about his risk preferences and that may in turn provide information about his likely stock quantity or pricing decisions.

To this end, we asked each subject to complete a personal traits survey consisting of a self-esteem scale (Rosenberg 1965), a regret scale (Schwartz et al. 2002), a risk and loss aversion scale (Hartog et al. 2000, Gachter et al. 2010), and a fairness survey adapted from the dictator and ultimatum games (Forsythe et al. 1994). The answers to this survey are converted to self-esteem, regret, risk aversion, risk-and-loss-aversion and fairness scores. We are currently trying to bridge these scores with the decisions made during the experiment. For instance, we have already observed strong differences in experimental interaction when two individuals with significantly different survey scores are matched.

5. Decision Heuristics

According to anchoring and adjustments theory, decision makers base their decisions on the first piece of information they receive and make adjustments from there. Adjustments are usually insufficient and the anchor point has dominant impact on the decisions to be made. Anchoring and adjustments theory was first developed by Kahneman and Tversky (1974). Schweitzer and Cachon (2000) theorized that an anchoring-and-adjustment heuristic might be able to explain the pull-to-center effect (the behavior causing the stock quantity decisions to lie significantly between the demand mean and the optimal quantity). In their experimental study they found some evidence of

a heuristic which anchors at the mean demand and adjusts towards the optimal order quantity over periods. They referred to this heuristic as “the mean anchoring and insufficient adjustments heuristic”.

Theory suggests that decision maker’s previous decisions may also create an anchoring point for the current decision. In Schweitzer and Cachon (2000), 64.3% of all decisions were same as the prior order and when the orders deviated from the prior one, the change was 69% of the time toward the previous demand realization. Schweitzer and Cachon explained this with the “demand chasing” heuristic. In this heuristic, the subject anchors decisions at the most recent stock quantity decision and adjusts towards the most recent realization of the demand.

Considering the pieces of information available to the retailer at each period, we develop new anchor and adjust type decision heuristics. Out of these heuristics the ones that anchor at the most recent demand realization and adjust towards one of the remaining pieces of information are the strongest ones. They are also significant for almost all retailer in all contract types. In this respect, even though the demand chasing heuristic, as defined by Schweitzer & Cachon, is significant for most of the retailers, is not as strong. This suggests that the demand realization has a significant role in stock quantity decisions as a decision anchor.

In addition to the contracting experiment, we test these heuristics on a separate newsvendor experiment data and observe paralleled results with the contracting experiment.

6. Contract Rejections

Upon receiving the manufacturer’s contract offer, the retailer can decide to either accept or reject the contract. In order to understand the factors lead to contract rejections by retailers, we analyze each retailer subject’s rejection decisions separately. Retailers make most rejections following a price increase (specifically increase in the wholesale price and revenue share and decrease in the buyback price) or repetition of prices by manufacturers. They might be using the rejection as a signal to request a cut in the prices. However, not all price increases or repetitions lead to a contract rejection. Therefore, we are developing logit/probit models to better understand the causes of retailers’ rejection decisions.

7. Conclusions

The purpose of this study is to extend the frontiers of the current theory by developing better behavioral models in to predict the retailer’s and manufacturer’s decisions. We study several behavioral models and introduce new anchor-and-adjust type heuristics. Our findings show that some of these behavioral models and decision heuristics are quite powerful in predicting the decision maker’s actions.

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