

**EFFECTS OF REGRET IN SUPPLY CHAIN DECISIONS:
AN EXPERIMENTAL STUDY**

by
SEYYED SABER MOUSAVI GARGARI

Submitted to the Graduate School of Engineering and Natural Sciences
in partial fulfilment of
the requirements for the degree of Master of Science

Sabanci University
July 2021

**EFFECTS OF REGRET IN SUPPLY CHAIN DECISIONS:
AN EXPERIMENTAL STUDY**

Approved by:

[Redacted signature]

[Redacted signature]

[Redacted signature]

Date of Approval: July 13, 2021

SEYYED SABER MOUSAVI GARGARI 2021 ©

All Rights Reserved

ABSTRACT

EFFECTS OF REGRET IN SUPPLY CHAIN DECISIONS: AN EXPERIMENTAL STUDY

SEYYED SABER MOUSAVI GARGARI

Industrial Engineering M.Sc. Thesis, July 2021

Thesis Supervisor: Assist. Prof. Murat Kaya

Keywords: Behavioral operations management, Supply chain contracts, Regret tendency, Supply chain experiments, The newsvendor model

In this thesis, effects of regret tendency on supply chain decisions are investigated. To this end, data from a previously conducted laboratory experiment where human subjects play the roles of manufacturer and retailer are used. The subjects make contracting and order quantity decisions under wholesale price, buyback and revenue sharing contract scenarios. Subjects are classified into high-regret and low-regret categories based on their responses to the questionnaire of Schwartz et al. (2002). We analyze the extent of the Pull-to-Center behavior in retailers' order quantity decisions who face the newsvendor problem. We find high-regret retailers to be more prone to exhibit the preference to minimize ex-post inventory error and demand chasing heuristic under some of the contracts we study. In the wholesale price contract scenario, we observe high-regret manufacturers to offer more attractive contracts to the retailers compared to low-regret manufacturers. We also observe manufacturers to increase the retailer's predicted profit and profit share in their contract offer following a contract rejection; however, this behavior does not depend on the level of regret tendency.

ÖZET

PIŞMANLIK EĞİLİMİNİN TEDARİK ZİNCİRİ KARARLARINA ETKİSİ: DENEYSEL BİR ÇALIŞMA

SEYYED SABER MOUSAVI GARGARI

ENDÜSTRİ MÜHENDİSLİĞİ YÜKSEK LİSANS TEZİ, Temmuz 2021

Tez Danışmanı: Dr. Öğr. Üyesi Murat Kaya

Anahtar Kelimeler: Davranışsal operasyon yönetimi, Tedarik zinciri sözleşmeleri, Pişmanlık eğilimi, Tedarik zinciri deneyleri, Gazeteci çocuk modeli

Bu tezde, pişmanlık eğiliminin tedarik zinciri kararlarına etkisi incelenmiştir. Buna yönelik olarak insan karar vericilerin üretici ve perakendeci rolleri oynadıkları, önceden yürütülmüş karar verme deneylerinin verisi kullanılmıştır. Deneyde katılımcılar, toptan satış fiyatına dayalı sözleşme, geri alıma dayalı sözleşme ve gelir paylaşımına dayalı sözleşme senaryoları altında sözleşme parametresi ve sipariş miktarı kararları verirler. Katılımcılar, Schwartz v.d. (2002)'nin anketine verdikleri cevaplara göre yüksek pişmanlık eğilimli ve düşük pişmanlık eğilimli olarak kategorize edilmiştir. Gazeteci çocuk problemi ile karşı karşıya kalan perakendecilerin kararlarındaki Merkeze Çekim etkisi incelemiştir. Yüksek pişmanlık eğilimli perakendecilerin, bazı sözleşme tipleri kullanıldığında stok hatasını en aza indirme davranışı ve talep kovalama sezgiseli kullanımının daha yoğun olduğu bulunmuştur. Toptan satış fiyatına dayalı sözleşme senaryosunda, yüksek pişmanlık eğilimli üreticilerin, düşük pişmanlık eğilimli üreticilere kıyasla perakendecilere daha çekici sözleşmeler önerdikleri gözlemlenmiştir. Bir sözleşme reddi sonrasında, üreticilerin sözleşmedeki perakendeci karını ve kar payını arttırmaya yatın oldukları bulunmuş; ancak bu davranışın pişmanlık eğilim düzeyi ile ilişkisi kurulamamıştır.

ACKNOWLEDGEMENTS

I would like to express my sincere gratitude to my thesis advisor Asst. Prof. Murat Kaya, for his guidance, patience, and support throughout my master studies. Also I want to thank him for introducing me to the field of behavioral operations management. I feel fortunate to have him as my supervisor.

My family deserve endless gratitude for all their support over every moment of my life.

This research was based on data that was generated by a TÜBİTAK-funded project (TÜBİTAK Grant 111K454).

To my beloved, Bahareh

TABLE OF CONTENTS

LIST OF TABLES	x
LIST OF FIGURES	xi
1. INTRODUCTION	1
2. LITERATURE REVIEW	4
2.1. Behavioral Studies on the Newsvendor Model	4
2.1.1. Preference to Minimize Ex-Post Inventory Error	5
2.1.2. Anchoring and Insufficient Adjustment Heuristic	6
2.1.3. Other Behavioral Studies on the Newsvendor Model	7
2.2. Behavioral Studies on Supply Chain Contracting	8
2.3. Decision Regret	11
2.4. Regret in Business Literature	12
3. THE ANALYTICAL MODEL	15
4. EXPERIMENTAL STUDY	18
4.1. Experiment Procedure	18
4.2. Categorization of Data and Analyses	19
4.3. Measuring Regret	21
4.4. Methodology	24
5. EFFECT OF REGRET ON RETAILER BEHAVIOR	25
5.1. Effect of Regret on Pull to Center Behavior	25
5.1.1. Preference to Minimize Ex-post Inventory Error.....	28
5.1.2. Demand Chasing	32
5.2. Effect of Regret on Overordering and Underordering Behavior	34
6. EFFECT OF REGRET ON MANUFACTURER BEHAVIOR	38
6.1. Effect of Regret on Contract Offers	38

6.2. Effect of Regret on Manufacturer Behavior Following a Contract Rejection	39
7. CONCLUSION	42
7.1. Relationship Between Risk and Regret	42
7.2. Conclusion	43
BIBLIOGRAPHY	45

LIST OF TABLES

Table 3.1. Decision Variable(s) of Each Firm	16
Table 3.2. The Optimal Order Quantity Under Each Contract	16
Table 3.3. Manufacturer’s Theoretical Optimum Solution Under Each Contract	17
Table 4.1. Evaluation of the Regret Questionnaire	21
Table 4.2. Regret Data Statistics	22
Table 4.3. Number of Subjects with Respect to Regret Label and Contract Type	23
Table 5.1. Percentage of Orders in the PTC Zone	27
Table 5.2. Median Distance of the Order Quantities from the Demand Mean	31
Table 5.3. Percentage of Orders in the PTC Zone (Medians)	32
Table 5.4. Estimation of the Coefficients in Equation 5.2	34
Table 5.5. Estimation of Coefficients in Equation 5.2 for subjects who chase the demand	34
Table 5.6. Comparing Retailer’s Over/Under Ordering Behavior	36
Table 6.1. Comparing Retailer’s Predicted Profit Share (Medians)	39
Table 6.2. Percentage of Change in Retailer’s Predicted Profit After a Rejection (Medians)	41
Table 6.3. Percentage of Change in Retailer’s Predicted Profit Share After a Rejection (Medians)	41
Table 7.1. Risk and Loss Aversion Survey Questions	43

LIST OF FIGURES

Figure 4.1. Time Series Data of the WSP Outlier Retailer.....	19
Figure 4.2. Regret Data Box Plot	22
Figure 4.3. Distribution of Subjects' Regret Tendency Scores.....	22
Figure 4.4. Regret Label Thresholds	23
Figure 5.1. Individual Subjects' Orders in the PTC Zone.....	26
Figure 5.2. Distribution of Q^* and Q in Aggregate Data	27
Figure 5.3. Percentage of Orders in the PTC Zone for High-regret and Low-regret Retailers	28
Figure 5.4. Distribution of $ Q - \mu $ in Pooled Data	30
Figure 5.5. Distribution of $ Q - \mu $ and $ Q^* - \mu $ under the Wholesale Price Contract	31
Figure 5.6. Predicted Profits with Respect to Q^* under the Wholesale Price Contract	36
Figure 6.1. Change in the Retailer's Predicted Profit Following a Contract Rejection.....	40
Figure 6.2. Change in the Retailer's Predicted Profit Share Following a Contract Rejection.....	40

1. INTRODUCTION

One of the base assumptions in traditional operations management is considering decision makers as fully rational expected profit maximizers. However, empirical evidence supports that most decision makers are boundedly rational. The term bounded rationality refers to the decision maker's behavior that she searches among the alternatives and finally chooses a satisfactory alternative which is not necessarily optimal (Simon, 1957).

The traditional newsvendor problem is among the most studied ones in the Behavioral Operations Management literature (see, for example, Bendoly et al., 2006). Starting with seminal work of Schweitzer and Cachon (2000), empirical studies show that decision makers systematically deviate from what the theory predicts in the newsvendor solution. In a laboratory experiment, Schweitzer and Cachon observe, on average, a too low order quantity for high profit margin products and conversely a too high order quantity for low profit margin ones, referred to as the *pull-to-center* (PTC) effect. The authors argue that the PTC behavior can be explained with three concepts: preference to minimize ex-post inventory error, mean anchoring, and demand chasing. Following Schweitzer and Cachon, further research is conducted to investigate other factors influencing decisions in a newsvendor setting, such as effect of learning, feedback, and also individual differences of the human subjects.

A number of papers in the Behavioral Operations literature investigate supply chain contracting decisions (see, for example, Loch and Wu, 2008; Pavlov and Katok, 2011). Typically, these supply chains involve a manufacturer that offers a contract and a retailer that needs to make a quantity decision facing probabilistic demand, hence the newsvendor problem. This stream of research aims at understanding the empirical performance of the different supply chain contracts, as well as the effect of interaction between the subjects who act as the retailer and manufacturer.

In this thesis we investigate the effect of regret emotion, as one of the individual and cognitive factors, on the ordering and contracting decisions in a supply chain setting. Landman (1993) defines the regret as "a more or less painful cognitive and emotional

state of feeling sorry for misfortunes, limitations, losses, transgressions, shortcomings or mistakes”. Regret affects the decisions from two perspectives: experienced regret and anticipated regret. The former one arises after a decision is made and the outcome turns out to be unpleasant. A person who experiences regret tries to undo the effect of his decision, more likely by selecting the reverse alternative in the future similar situations. Anticipated regret arises before a decision is made; a decision maker anticipates the regret he might feel in the future and makes his decision accordingly.

We use the data of an experiment conducted by Akbay and Kaya (2016), in which two human subjects interacted as retailer and manufacturer under one of the three different contract types, namely the wholesale price contract, buyback contract, and the revenue sharing contract. Each retailer-manufacturer pair repeated a three-stage interaction for 40 periods. In each interaction, first the manufacturer offered a contract by setting the contract parameters, and then the retailer had the option to accept the contract and decide on her order quantity or reject it, in which case the outcome of both players would be zero. At the third stage, the demand realized and the two firms’ profits are calculated. To measure each subject’s tendency to experience regret, each subject was asked to respond to a questionnaire proposed by Schwartz et al. (2002).

In particular, we consider the following research questions:

1. Does regret influence the retailer subjects’ pull-to-center behavior and the drivers of this behavior?
2. What is the relationship between regret and over/under ordering behavior of the retailer subjects?
3. Does regret affect the manufacturer subjects’ contract offerings?
4. How does experiencing regret influence manufacturer subjects’ behavior in their future decisions?

To the best of our knowledge, no prior research has studied the effect of regret on contracting and stocking decisions in a supply chain scenario in which both the manufacturer and the retailer are human decision makers. Our results show that both anticipating and experiencing regret influences subjects’ behavior.

The rest of the thesis is organized as follows. In Chapter 2, we provide a review of the studies related to our thesis. In Chapter 3, the theoretical solution to our analytical model is calculated. Chapter 4 describes the experiment procedure and the data used. Effect of regret on retailer’s and manufacturer’s behavior are discussed in

Chapters 5 and 6, respectively. We conclude the thesis in Chapter 7.

2. LITERATURE REVIEW

2.1 Behavioral Studies on the Newsvendor Model

The newsvendor problem is a single period problem in which a decision maker should decide about the number of products to order and stock to meet uncertain demand. The objective in this problem is to maximize the expected profit by ordering the optimal quantity. The ordering process takes place before each selling period and there is only a single ordering chance. The newsvendor knows the probabilistic distribution of demand. In case realized demand is lower than the the ordered quantity, overage costs are incurred. These costs may include cost of holding excess inventory and cost of salvaging remained inventory with a lower price than the purchase price. On the contrary, when realized demand is higher than the ordered quantity, the seller may incur underage costs such as loss of goodwill.

Many extensions to this classical problem are addressed in the literature. These extensions are different from the classical model in many aspects, such as the objective of the problem. Perakis and Roels (2008) use minimax regret as the objective of newsvendor in a model with partial information about demand. Other papers with different objectives include Lau (1980), and Ismail and Louderback (1979). Other extensions include differences in supplier pricing policy (Kabak and Weinberg, 1972), newsvendor pricing policy (Khouja, 1995), and information about demand (Moon and Choi, 1995). A review about the newsvendor model and its extensions can be found in Khouja (1999) and Qin et al. (2011).

From a behavioral point of view, Schweitzer and Cachon (2000) are the first to study the decision making biases in a newsvendor setting through a controlled laboratory experiment. Their experiments show that subject order too much of a low-profit product compared to the profit maximizing order quantity, and too low of a high-

profit one. Here, low-profit refers to a product in which the critical fractile is less than 0.5, and a product is referred to as high-profit otherwise. The authors refer to this behavior as the *pull to center* (PTC) effect and examine some well-known behavioral explanations to find the underlying reason for this observation. They show that PTC behavior of the newsvendor subjects cannot be explained by risk-aversion or risk-seeking preferences, prospect theory preferences, loss aversion, waste aversion, stock-out aversion, or undervaluing opportunity costs. The authors find support for two explanations for the PTC behavior: preference to minimize ex-post inventory error and anchoring heuristics. Following Schweitzer and Cachon, many researchers have investigated the PTC phenomena, and have examined the role of other factors in subjects' behavior in a newsvendor model.

In Sections 2.1.1 and 2.1.2 we discuss the two main explanations for the PTC effect, and in Section 2.1.3 we review the other extensions to the behavioral newsvendor studies.

2.1.1 Preference to Minimize Ex-Post Inventory Error

Minimizing ex-post inventory error is one of the main explanations for PTC effect. Ex-post inventory error is referred to as the deviation between the order quantity and the realized demand. The main idea is that, subjects anticipate the potential future regret about not ordering an amount equal, or at least close, to the realized demand when they are determining their order quantity, and the anticipation of this regret pushes them toward ordering a quantity that is close to demand mean. In fact, because the ex-post inventory error is minimized when the order quantity is equal to the mean demand, this order quantity minimizes the experienced regret ex-ante (Schweitzer and Cachon, 2000).

Chen and Davis (2014) conduct experiments that make it possible to compare and separate three common explanations (bounded rationality, mean anchoring, and minimizing ex-post inventory error) for the PTC behavior. The authors utilize an asymmetric demand function to remove the effect of the symmetry on subject's decisions and conclude that preference to minimize ex-post inventory error is the best explanation for the PTC effect. This claim is based on the observation that subjects try to minimize their error in predicting the demand by ordering quantities equal to the most probable outcome of the demand distribution. Minimizing the error of demand prediction is equivalent to minimizing the ex-post inventory error.

Certain other studies also confirm the strength of preference to minimize ex-post inventory error in explaining the newsvendor behavior. Kremer et al. (2014), for example, observe that subjects are willing to overpay for the demand information. The authors show that this observation cannot be explained by risk aversion and it is consistent with preference to avoid ex-post inventory error.

2.1.2 Anchoring and Insufficient Adjustment Heuristic

When people want to make an estimation about something, most often they start from an initial value and try to adjust it to find the desired estimation. In this regard, the initial value, which is referred to as the *anchor*, can be suggested by the formulation of the problem or it can be the result of a partial computation (Tversky and Kahneman, 1974). In a newsvendor setting, the anchoring point can be the ordered quantity in the last selling season, or it can be the demand mean. Also, the adjustments can be made toward the theoretical optimal order quantity, or toward the realized demand in the last period.

Schweitzer and Cachon (2000)'s PTC phenomena shows that the average order size falls between the mean demand and the profit maximizing order quantity. The authors show that this behavior can be explained by two separate anchoring and insufficient adjustment type heuristics: mean anchoring and demand chasing. In the mean anchoring heuristic, the demand mean works as the anchoring value and some adjustments are made toward the theoretical optimal order quantity. In the demand chasing heuristic, the individual anchors at her most recent order quantity and makes some adjustments towards the most recent realized demand.

After the seminal work of Schweitzer and Cachon, many other studies have also reported the existence of demand chasing and mean anchoring behavior in their experiment data. Benzion et al. (2008) argue that subjects tend to change their order quantity toward the most recent realized demand. They also find that demand mean affects the subjects' ordering decision, as well. Bolton and Katok (2008) posit that anchoring behavior exists even when the experiment periods are extended. The authors argue that although learning mitigates the anchoring effect a little, it cannot fully eliminate the anchoring effect. Many other studies, such as Bostian et al. (2008), Lurie and Swaminathan (2009), Moritz et al. (2009) and Kremer et al. (2010) also observe the existence of demand chasing behavior in their experiments. Gavirneni and Xia (2009) by providing different information for subjects, show that the anchor is not always the demand mean and it can change according to the experi-

ment setting. D’Urso et al. (2017) show that the anchoring and adjustment heuristic that a subject adopts depends on the information that is available. Using the data from previous experiments, Gavirneni and Robinson (2017) mathematically show that anchoring behavior of newsvendor subjects can be explained by risk aversion and shortage aversion.

2.1.3 Other Behavioral Studies on the Newsvendor Model

To study the effect of learning, experience and feedback, Bolton and Katok (2008) design experiments to examine whether enhancement to experiences and feedback results in better newsvendor performance or not. They extend experiment rounds to 100 in order to eliminate the effect of *law of small numbers*. Although the authors observe improvement in newsvendor performance in longer periods, the subjects’ behavior strongly exhibit the PTC effect. Benzion et al. (2008) show that tendency to move towards the demand mean declines over time, while the subjects move closer towards the optimal solution of the newsboy problem. These authors posit that participants are affected by the surplus demand or supply in the past round; however, over time they learn to control this bias. Lurie and Swaminathan (2009) investigate the effect of feedback frequency on the performance of newsvendors and observe that when demand has high variance, subjects that receive less frequent feedback perform better than the ones that receive more frequent feedback.

Most newsvendor experimental studies have assumed a uniform distribution for demand. Different from these, Benzion et al. (2008) use both normal and uniform distributions in their experiments and observe the PTC under both distributions. Chen and Davis (2014) use an asymmetric demand function to remove the effect of demand symmetry on newsvendor behavior, which allows them to distinguish between the different explanations for the PTC effect. The authors find the preference to minimize ex-post inventory error to be the best explanation for the PTC behavior. Benzion et al. (2010) and Bolton et al. (2012) show that being aware of the demand distribution does not improve the performance of newsvendor subjects.

Most of the studies in this context ignore individual differences as one of the factors that may explain some proportion of deviation from the optimal order quantity. Conversely, Lau et al. (2014) state that PTC effect is the result of averaged group data and is not a good representative of individual behavior. The authors use the data in Bolton and Katok (2008) and also data derived from their own experiment to examine whether individual subject behaviors are consistent with the PTC effect.

They conclude that subjects' behavior are very heterogeneous and only a few percent of them show PTC behavior.

A number of studies seek to capture the effect of individual and cognitive differences of subjects on their ordering behavior in a newsvendor setting. Bolton et al. (2012) design an experiment with subjects consisting of managers and students. They find that both groups show the same bias of PTC, and the managers do not utilize the information better than the students. De Vericourt et al. (2013) study the effect of gender and financial risk attitude on subjects' behavior. The authors observe that in the high margin setting, males order more and hence gain higher profits, which is due to their higher risk preference. They conclude that gender affects ordering behavior and risk attitude acts as a mediator. In a similar experiment, Becker-Peth et al. (2018) reach at a different conclusion. Observing that females order less than males, the authors conclude that gender directly affects the ordering behavior independent of the risk attitude. Feng et al. (2011) conduct a cross-national experiment and find Chinese subjects to order closer to the demand mean than American subjects. Moritz et al. (2013) take some individual characteristics such as cognitive reflection, college major, years of experience and managerial position into consideration. They conclude that cognitive reflection is a better predictor of the subject's performance compared to the other characteristics.

2.2 Behavioral Studies on Supply Chain Contracting

Supply chain members are individual self-interested firms that are interconnected with financial, information, and service/product flows. In order to achieve the optimal supply chain performance, members should take some specific actions; however, each member is an individual entity who is concerned only about maximizing his own objectives, and there might be conflicts between a member's individual objectives and the overall supply chain objectives. This decentralized decision making scheme usually results in an inefficiency in the supply chain performance, known as *double marginalization* problem (Spengler, 1950). Many studies address this issue in the literature of the supply chain management, referred to as *supply chain coordination* studies. Studies on supply chain coordination deal with the effort made to manage the incentive conflicts among different members and align their decisions with the supply chain objectives (Fugate et al., 2006). Arshinder et al. (2011) classify the means and mechanisms of supply chain coordination in three main groups: supply

chain contracts, information sharing, and other collaborative initiatives.

Several different contracts, such as buyback, revenue sharing, quantity-flexibility, sales-rebate, and quantity-discount contracts are proposed to coordinate the supply chain. In a *buyback* contract the manufacturer charges w per unit of product at the beginning of the selling season but commits to refund the retailer b per unit for the unsold products at the end of the selling season, where $b \leq w$ (see, e.g., Pasternack, 1985). In a *revenue sharing* contract the manufacturer charges w per unit, but also receives some share of the retailer's revenue for every unit sold. See Cachon and Lariviere (2005), for an analysis of different settings in revenue sharing contracts. Other purposes of using contracts include sharing the risk and facilitating long-term relationship among the members (Tsay et al., 1999). Interested readers are referred to Cachon (2003) and Höhn (2010) for a review of different supply chain contracts.

Research on supply chain coordination assumes rational and self-interested players who are only concerned about their own economic benefits; however, behavioral studies in this context show that other incentives, such as social preferences, also affect individuals' behavior in a supply chain setting. This is in addition to decision makers being constrained by bounded rationality.

In Section 2.1 we discussed the studies that investigate the behavior of a retailer in a newsvendor setting, and try to explain why order quantities deviate from the theoretical predictions. This research concentrates on the individual decision biases to explain the observations. However, focus of the studies surveyed in the current section is mainly on the empirical power of different contracts to coordinate the supply chain channel. In addition, the key to explain the behaviour of the manufacturer and retailer subjects is the interaction between them and their social preferences.

Some authors compare the experimental performance of several supply chain contracts with theoretical predictions and develop models to explain the deviations. A large body of literature focuses on the performance of supply chain in laboratory experiments and compare them with theoretical predictions and try to explain the reasons for these differences. These studies show that even though coordinating contracts are able to persuade the retailer to order more, their efficiency is not as high as the theoretical predictions. Katok and Wu (2009) compare the performance of three supply chain contracts, namely buyback, revenue-sharing and wholesale price in a laboratory experiment. In their setting human retailers play against computerized suppliers and human suppliers play against computerized retailers that are programmed to act as predicted by theory. The authors choose this setting in order to eliminate the effects of potential social interaction between human players. The authors observe an over ordering behavior in retailers under the wholesale

price contract which causes the coordination performance of this contract to be better than the theoretical prediction. The other two contracts are successful in inducing retailer to order higher, but they do not perform as good as expected in theory. Moreover, the performance of two mathematically equivalent buyback and revenue-sharing contracts are not identical in practice.

Davis (2015) evaluates the wholesale price and two coordinating pull contracts, namely the payback contract and the service-level agreement, in a laboratory setting. Pull contracts are the contracts where the supplier holds the whole inventory and takes the risk and cost of unsold units. The author uses an experiment where the human retailer plays against an automated supplier. The coordinating contracts are observed to perform better relative to the wholesale price contract, even though they do not perform as good as what is predicted in theory. Based on an experiment with human suppliers, Niederhoff and Kouvelis (2019) conclude that the wholesale price contract offered by a risk averse supplier that is concerned about fairness can be as efficient as a revenue sharing contract; hence it may not be necessary to use a complicated mechanism for coordination. Becker-Peth et al. (2013) argue that in addition to the critical fractile implied by the offered contract, the ordering decision of a retailer depends also on the individual parameters of the contract. In other words, different buyback contracts that have the same expected profit maximizing order quantities but different contract parameters result in different order quantity choices in retailers. The authors develop a model to predict the decision behavior of the subjects, and tested their proposed model by designing a separate experiment. The authors also perform some out of sample validation tests showing that contracts designed based on behavioral models are more efficient than those that are based only on the theoretical studies.

Social preferences, such as concerns about the fairness, are one of the underlying incentives for subjects' behavior in a supply chain setting. Loch and Wu (2008) investigate how social preferences influence supplier-retailer relationship under a wholesale price contract. The authors divided their supplier-retailer pairs into two groups. Pairs in the first group do not have any relationship with their peers and play with an anonymous peer. Subjects in the second group meet face to face with their peer before the experiment and are told to assume their peers as a friend. The experiments find the deviation from the profit-maximizing decisions to differ between the two groups. The first group show more competitive behavior which is deteriorating both individual and overall supply chain performance. The second group however, show more mutually beneficial behavior.

Fairness is another social preference that has been considered in a large number of

studies as the underlying reason for inefficiency in behavioral supply chain contracting literature. In a supply chain setting, players often compare their profit with the profit of the other supply chain member. This can lead to a fairness concern known as the *distributional fairness* (Ho et al., 2014). Cui et al. (2007) are the first to theoretically consider the effect of fairness in supply chain contracting. They find that if the players are concerned about fairness, even a simple contract like the wholesale price can coordinate the channel. Pavlov and Katok (2011) argue that contract rejections in laboratory settings are one of the reasons for the low efficiency of the channel. They propose a model including fairness preferences with incomplete information that can explain rejection behavior. Moreover, they design an experiment to test the proposed model and show that the experiment results support the model predictions. Katok and Pavlov (2013) design an experiment to separate the possible cause of rejections, including inequality aversion, bounded rationality, and incomplete information, and find that inequality aversion has the most important explanatory power for the retailer’s rejection behavior. Katok and Pavlov also posit that incomplete information about retailer’s degree of inequality aversion is the most important cause of supplier’s behavior.

Ho et al. (2014) perform an experiment with one manufacturer and two retailers that interact under a wholesale price contract. The authors conclude that the manufacturer offers prices that are lower than prices predicted in theory due to the existence of distributional fairness concerns. Zhao et al. (2019) conduct an experiment where one retailer and one supplier interact under a revenue sharing contract and the inventory is managed by the supplier. The authors observe deviations in subject decisions from theory and explain deviations with suppliers’ fairness concerns and retailers’ preference for equity.

2.3 Decision Regret

The term *decision regret* is introduced by Bell (1982). After making a decision under uncertainty and learning the outcome, a decision maker may feel regret if he discovers that his outcome would have been better had he chosen the other alternative. Bell believes that the decision maker might tradeoff financial outcome to avoid feeling regret. The same year Loomes and Sugden (1982) also mention the anticipatory aspects of regret. The authors propose a model, called regret theory, which they believe provides a basis for an alternative theory of rational choice under uncertainty.

Bleichrodt et al. (2010) are the first to introduce the quantitative measurement of utility based on regret theory.

Experiencing regret about a decision that is made in the past is not just an unpleasant feeling; it is also a powerful motivation to act against the regretted outcome. Experiencing regret has direct behavioral consequences. A regretted person will act in such a way that he wants to undo the outcome, most probably by taking the reverse decision in future similar situations. Regret is experienced when someone compares an achieved outcome unfavorably with another outcome that could have been achieved if a different option had been chosen. Therefore, the decision maker thinks that he could prevent the unfavorable outcome from occurring or change it. This feeling of self-blame motivates the person to choose the alternative option in the subsequent decisions (Zeelenberg et al., 2001).

2.4 Regret in Business Literature

Regret theory is widely used in many context including business studies. In this section we review the role of regret in business literature and try to capture the effect of regret on subject's behavior in different circumstances. Some of the observations here can apply to behavior of the players in a supply chain contracting setting that we study.

Ultimatum games (Thaler, 1988) resemble the manufacturer-retailer strategic interaction that we study. In an ultimatum game two players, a proposer and a responder, possess a fixed sum of money. The proposer offers a specific share of the money to the responder, and the responder has two options; she can either accept the share or reject it. If the offer is accepted, the proposed share will be given to the responder and the rest of the money will be proposer's share. If the offer is rejected, each player's payoff is zero. Zeelenberg and Beattie (1997) argue that in a normal ultimatum game, where there is no feedback on the minimum offer that would be accepted, the proposer may feel regret about both offering a too high share and offering a too low share. In the former case, after the offer is accepted, the proposer feels regret because he might think that even with offering a lower share the responder would accept the offer. In the latter case when the offer is rejected, the proposer feels regret since he wishes he had offered a higher share to the responder. The authors believe that regret about offering too high a share

is less painful for the proposer. Hence, the proposer will anticipate the regret and take the regret-minimizing decision, which is offering a relatively higher share to the responder.

Regret also has gained so much attention in the context of auctions. In an experiment, Engelbrecht-Wiggans and Katok (2008) investigate whether the bidding behavior in the first-price auction is affected by regret. The authors posit that both the winner and the losers of the auction will feel regret; the winner will feel regret about bidding too much relative to the second highest bid, referred to as *winner's regret*, and the losers may feel regret regarding bidding too low and losing the opportunity (*loser's regret*). The authors observe that when the bidders are being informed about the fact that the second highest bid will be revealed, the average bids decreases due to winner's regret. On the contrary, informing the bidders about revealing the highest bid increases the average bids due to loser's regret. The authors also observe the weight of loser's regret to be larger than the weight of winner's regret. Filiz-Ozbay and Ozbay (2007) show that although subjects suffer from the anticipated loser regret, they do not anticipate the winner regret and that is why overbidding takes place in auctions. Subjects still show this overbidding behavior even in the case where there is no information about the winning bid or the second highest bid.

Some studies investigate the relationship between regret aversion and risk aversion, such as whether regret anticipation leads to risk aversion. As an example, Josephs et al. (1992) claim that anticipating regret is one of the basis for risk aversion. However, Larrick and Boles (1995) empirically show that regret anticipation can result in selecting a riskier option as well. Larrick and Boles find out that in negotiation decisions when subjects do not expect feedback on a more risky forgone alternative, they exhibit higher risk aversion compared to the case where they expected feedback. As a result, negotiators that do not expect feedback are more likely to reach to an agreement. Zeelenberg et al. (1996) also argues that in some circumstances regret anticipation leads to risk seeking. The authors hypothesize that people are regret averse rather than risk averse, that is, they try to minimize regret instead of risk in their decisions. Their results support this idea, showing that regret aversion can promote both risk averse and risk seeking options by manipulating the feedback. These results are further supported with the authors' next work, Zeelenberg and Beattie (1997), in which they conduct experiments on investing decisions and ultimatum games.

Relation between social comparison and regret has been investigated by Avcı et al. (2014). The authors believe that since it is difficult to assess what might have been

achievable, managers mostly compare their achieved results not with respect to an internal frame of references, but with the performance of a peer. The authors refer to the case where the subject is inferior to a peer as social regret, which has a negative contribution to utility.

Barberis et al. (2006) try to solve the stock market puzzle; the fact that although the mean return of stock market is relatively high, most people do not invest in it. The authors posit that regret can offer a valid explanation. People anticipate the regret of losing money if the stock price falls and try to prevent feeling that probable regret by not participating in the market.

3. THE ANALYTICAL MODEL

In this chapter we describe our analytical model and provide the theoretical solution to this model under three different contract types, namely the wholesale price contract, buyback contract, and revenue sharing contract.

We consider a two-echelon supply chain consisting of one manufacturer and one retailer. The consumer demand for the product at the retailer has a discrete uniform distribution between 51 and 150, and the sales price to consumers is $p = \$12$ per unit.

Stage 1. The manufacturer offers the contract by determining the contract parameters.

Stage 2. The retailer can either accept the contract and decide on the order quantity (Q), or reject the contract by ordering zero units. The manufacturer produces this order quantity at a unit price of $c = \$3$, and delivers to the retailer.

Stage 3. Consumer demand is realized and the two firms' profits are revealed.

Depending on the contract, the manufacturer decides on different parameters. In the wholesale price contract the only parameter is the wholesale price (w) for which a unit of product is sold to the retailer. In the buyback contract, in addition to the wholesale price, the manufacturer should also decide on the buyback price (b) at which the manufacturer buys back unsold items from retailer at the end of selling season. In the revenue sharing contract, the manufacturer decides on both wholesale price and revenue share (r) that the retailer pays to the manufacturer for each sold product. Table 3.1 shows the decision parameter(s) of the two firm under each contract.

We can find the subgame-perfect equilibrium of this sequential game-theoretical model using backward induction. We assume that the firms are self-interested, risk neutral firms who aim only at maximizing their own expected profits. In stage 2 of

Table 3.1 Decision Variable(s) of Each Firm

	Wholesale Price	Buyback	Revenue-Sharing
Manufacturer	w	w, b	w, r
Retailer	Q	Q	Q

the game, the retailer faces a newsvendor model. The profit-maximizing order quantity is calculated by the well-known critical fractile solution. Table 3.2 summarizes these optimal ordering quantities (Q^*) under each of the contracts.

Table 3.2 The Optimal Order Quantity Under Each Contract

Wholesale Price Contract	$F^{-1}\left(\frac{p-w}{p}\right) = 50 + \frac{12-w}{12}100$
Buyback Contract	$F^{-1}\left(\frac{p-w}{p-b}\right) = 50 + \frac{12-w}{12-b}100$
Revenue-Sharing Contract	$F^{-1}\left(\frac{p-w-r}{p-r}\right) = 50 + \frac{12-r-w}{12-r}100$

Being aware of this fact, in stage 1 the manufacturer can set the contract parameters in a way that his own expected profit is maximized. The manufacturer knows that any contract offered to the retailer will be responded by ordering Q^* , where Q^* depends on the contract parameters. Therefore, he can find the optimal contract parameters which maximizes his expected profit. These expected profit functions under each of the contracts are given in the following equations.

$$(3.1) \quad \pi_w^m = (w-3)Q^* = (w-3)\left(50 + \frac{12-w}{12}100\right)$$

$$(3.2) \quad \pi_{w,b}^m = (w-3)Q^* - bE[\textit{leftovers}]$$

$$(3.3) \quad \pi_{w,r}^m = (w-3)Q^* + rE[\textit{sales}]$$

The profit functions under the buyback and revenue sharing contracts are not jointly concave on the decision parameters, so we use numerical search to determine the optimal parameter values. Table 3.3 summarizes the theoretically optimal (the

subgame-perfect equilibrium) results under all three contracts.

Table 3.3 Manufacturer's Theoretical Optimum Solution Under Each Contract

Contract	Q^*	w^*	b^*	r^*	Retailer's Profit	Manufacturer's Profit
Wholesale Price	67	10	-	-	117.7	469.0
Buyback	100	11	10	-	75.5	677.5
Revenue Sharing	100	1	-	10	75.5	677.5

4. EXPERIMENTAL STUDY

In this chapter we first describe the conducted experiment and then explain different data categories that we use in our analyses. Next, we explain the measure for subjects' regret tendency and provide some general statistics about the regret data. Finally, we explain our methodology.

4.1 Experiment Procedure

In this research we use the data from an experimental study that was conducted at the CAFE (Center for Applied Finance Education) laboratory in Sabanci University by Akbay and Kaya in 2016 (Akbay and Kaya, 2016). 176 subjects voluntarily participated in this study who were recruited through an online registration system. Before the experiment, instructions were provided to subjects. To ensure that subjects knew the rules of experiment and how to use computer interface, three pilot periods of experiment were conducted. To provide incentives to subjects, they were given monetary payments depending on their total profit in the experiment session.

Each of the 176 subjects were assigned to one of the roles of manufacturer or retailer randomly by the server computer in the lab, and the retailer-manufacturer pairs were also formed randomly. Each of these pairs interacted for forty periods under one of the three contracts: wholesale price contract (WSP), buyback contract (BB) and revenue sharing contract (RS). The subjects' role, pairings and the contract type were fixed throughout their experiment session. In each period of the experiment, the three-stage supply chain contracting game that was explained in Section 3 was played. Briefly, the manufacturer offers a contract by setting the contract parameters and then the retailer observes this offer on her computer screen. The retailer can either reject the contract by ordering zero units or accept it and order an integer quantity in the $[51, 150]$ interval. At the end, the consumer demand is realized and

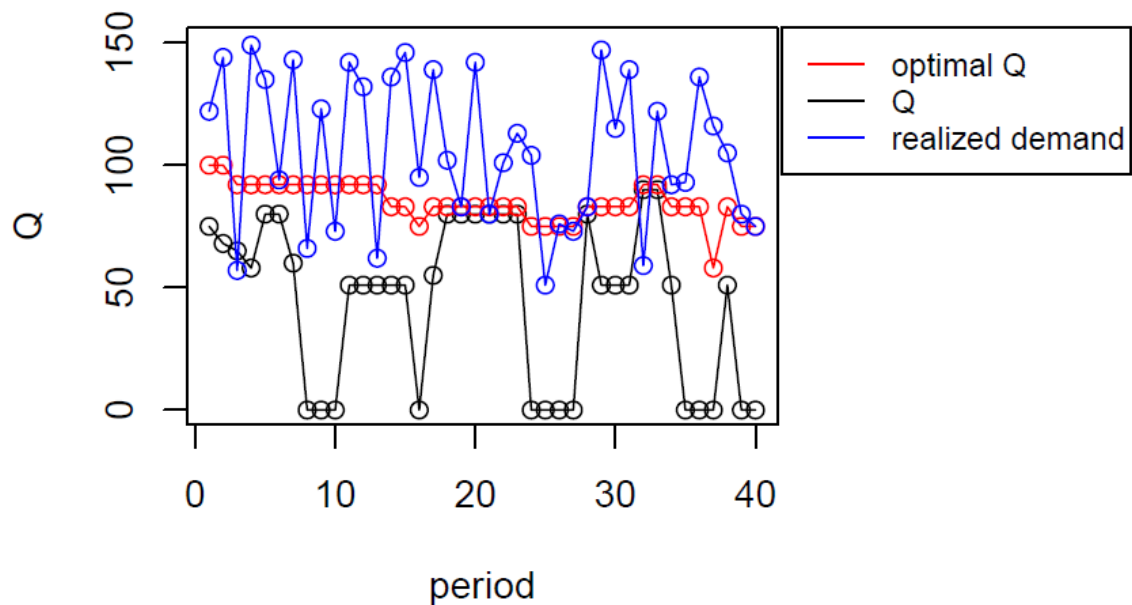
the resulting sales quantity, leftover quantity and player profits are calculated and displayed to both players.

The subjects were able to see their result history in a separate window. Also, they had access to a decision support tool which allowed them to perform a what-if analysis before determining their decision parameters. Inventory was not carried over from one period to the next, and in this regard the periods are independent of each other. However, the outcome in former periods might affect the decision behavior of the subjects in the latter periods.

4.2 Categorization of Data and Analyses

In our experimental study, 44 subject pairs interacted under the wholesale price contract, 22 pairs under buyback contract and 22 pairs under revenue sharing contract. We identified two retailers as outliers (a RS retailer with 21 rejections and a WSP retailer with 13 rejections and 10 minimum orders). The data associated with these retailers' pairs are removed from our data set. The ordering behavior of the second outlier retailer is shown in Figure 4.1. We observe a consistently low ordering behavior for this subject.

Figure 4.1 Time Series Data of the WSP Outlier Retailer



Hence, we have an overall number of 172 subjects (86 manufacturers and 86 retail-

ers). Also, in the buyback contract experiments, three data points with mistakes are removed. As a result we have a total number of 3437 data points.

In the next two chapters we analyze the subjects' decision behavior from different aspects. This requires us to prepare our data in different formats depending on the purpose of the analysis. Below we explain different data categories that we use in the study.

a. Analysis levels: In some analyses, we represent each subject with the average of all his or her period values (the *subject average*); whereas in some other analyses we use each period decision separately and pool all data of all subjects of a given type (retailer or manufacturer) together (*pooled data*).

b. Data types: Some analyses use only the data of periods in which the contract was accepted (*AC*) and a positive quantity was ordered. Some analyses focus only on the data of periods where the contract was rejected (*RC*), hence the order quantity and both firms' profits were zero. Some analyses use the data of both accepted and rejected contracts (*ALL*).

c. Predicted/expected/realized values: We compare the performance of subjects in three different levels. In the *predicted level*, we assume that the retailer reacts to a contract by ordering the newsvendor optimal quantity. Thus, the values in this level depend only on the contract parameters that the manufacturer offers and they are independent of the order quantity and the realized demand. That is, the predicted values are the expected values (with respect to demand realization) assuming that the retailer ordered the newsvendor quantity. We utilize the predicted level values to evaluate the attractiveness of offered contracts to the retailer. In the *expected level*, the values depend on both the contract parameters and the order quantity, but they are independent of the demand realization. That is, the "expected values" are the expected values with respect to demand realization given the manufacturer's contract offer and the retailer's order quantity. Finally, the *realized level* depends on the offered contract parameters, retailer's order quantity and the demand realization. This level shows the achieved outcome for each player after the demand is realized. Experiment payments to subjects are based on their total realized profits at the end of the 40 periods.

4.3 Measuring Regret

In order to study the effect of regret on the behavior of subjects in the experiment, we should know the extent to which a subject is affected by regret. We term this as *regret tendency*. For this aim, each subject was asked to respond to a questionnaire that enables us to quantitatively measure his or her regret tendency. The questionnaire, which is proposed by Schwartz et al. (2002), contains 5 statements as follows:

1. Once I make a decision, I don't look back.
2. Whenever I make a choice, I'm curious about what would have happened if I had chosen differently.
3. Whenever I make a choice, I try to get information about how the other alternatives turned out.
4. If I make a choice and it turns out well, I still feel like something of a failure if I find out that another choice would have turned out better.
5. When I think about how I'm doing in life, I often assess opportunities I have passed up.

Each subject responded to each item using a 7-point Likert-type scale (1 = completely disagree, 7 = completely agree). The score of answers for each statement is evaluated according to Table 4.1. Note that the first statement's scoring is directionally different from all other statements. The overall regret tendency score for each individual is calculated by averaging out the scores of the five items. A higher score shows a higher tendency to experience regret.

Table 4.1 Evaluation of the Regret Questionnaire

Question 1	Question 2-5
Completely disagree: 7	Completely disagree: 1
Moderately disagree: 6	Moderately disagree: 2
Somewhat disagree: 5	Somewhat disagree: 3
Not sure: 4	Not sure: 4
Somewhat agree: 3	Somewhat agree: 5
Moderately agree: 2	Moderately agree: 6
Completely agree: 1	Completely agree: 7

Table 4.2 shows the summary statistics of the regret measure. Figures 4.2 and 4.3 show the distribution of subjects' score with respect to their role.

Table 4.2 Regret Data Statistics

data set	n	mean	sd	median	min	max
all subjects	172	4.43	1.14	4.4	1.4	7
manufacturers	86	4.37	1.17	4.4	1.4	6.8
retailers	86	4.48	1.12	4.6	1.6	7

Figure 4.2 Regret Data Box Plot

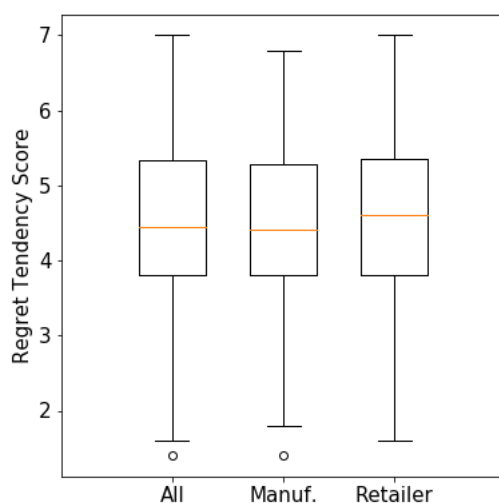
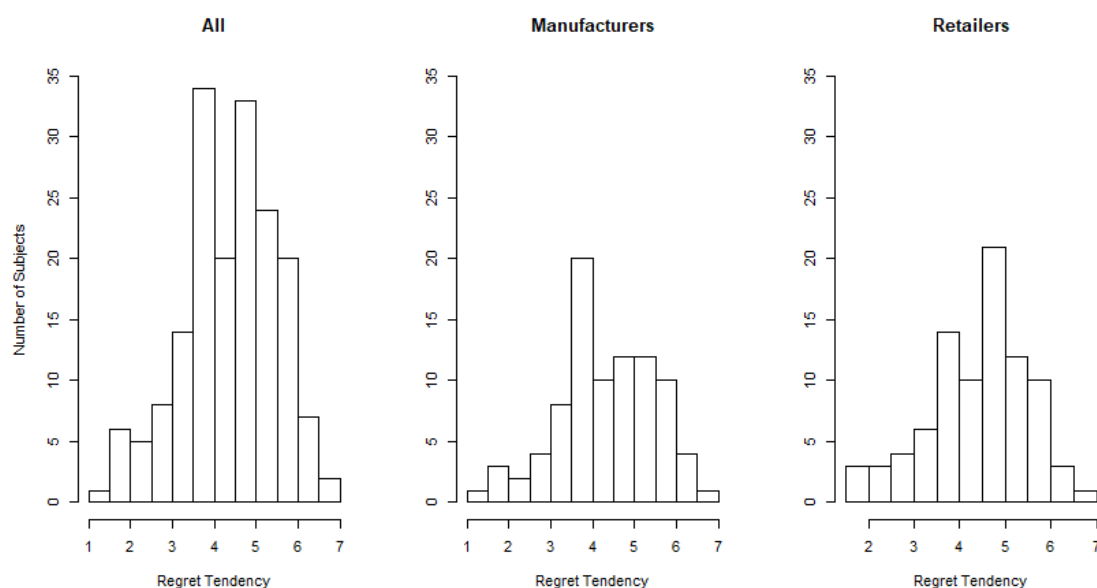


Figure 4.3 Distribution of Subjects' Regret Tendency Scores



In order to study the effect of regret on subjects' behavior, we categorize our subjects according to their regret scores within each contract type and role. Schwartz et al. (2002) do not suggest a threshold for labeling the subjects as high or low regret. To do so, under each contract and role, we label the lowest third of the subjects as low regret (LR), and the highest third as high regret (HR). Notice that, in order to

obtain sharper results, we do not use the middle third of the data (MR) in most of our comparisons. Figure 4.4 illustrates the thresholds that yield the regret labels under each subject group. In some cases assigning all of the subjects with a threshold regret score to one of the regret classes leads to unbalanced number of HR and LR subjects. When this issue arises, we randomly assign some of the subjects to one of its higher or lower regret classes. For instance when labeling WSP manufacturers, we label the subjects with a score in $[4, 5.2]$ as MR, however in order to balance the number of subjects under each label we randomly label one manufacturer with a score of 4 as LR and a subject with a score of 5.2 as HR. Table 4.3 shows the number of subjects with each regret label under each contract.

Figure 4.4 Regret Label Thresholds



Table 4.3 Number of Subjects with Respect to Regret Label and Contract Type

	WSP		BB		RS		All	
	Man	Ret	Man	Ret	Man	Ret	Man	Ret
LR	14	14	7	7	7	7	28	28
MR	15	15	8	8	7	7	30	30
HR	14	14	7	7	7	7	28	28
Total	43	43	22	22	21	21	86	86

4.4 Methodology

In the analyses we do not assume any specific distribution for the data and hence we use non-parametric hypothesis tests. When we deal with data from two independent samples, we use the Mann Whitney U test, and for data coming from dependent samples we use the Wilcoxon signed rank test. The results with $p\text{-value} < 0.10$ are considered as significant. The tests are performed on both R and Python software.

5. EFFECT OF REGRET ON RETAILER BEHAVIOR

Subjects' regret emotion may influence their decisions in terms of both anticipated and experienced regret. In this chapter we motivate and test a number of hypotheses regarding the regret behavior of the retailer subjects. In particular, we aim to investigate how the behavior of retailers from a particular regret class might be different from that of other classes. In Section 5.1 we study the effect of regret on retailer's pull-to-center (PTC) behavior. In Section 5.2 we seek to understand how regret can influence over/under ordering behavior of retailers with respect to the optimal order quantity for the contract that was offered.

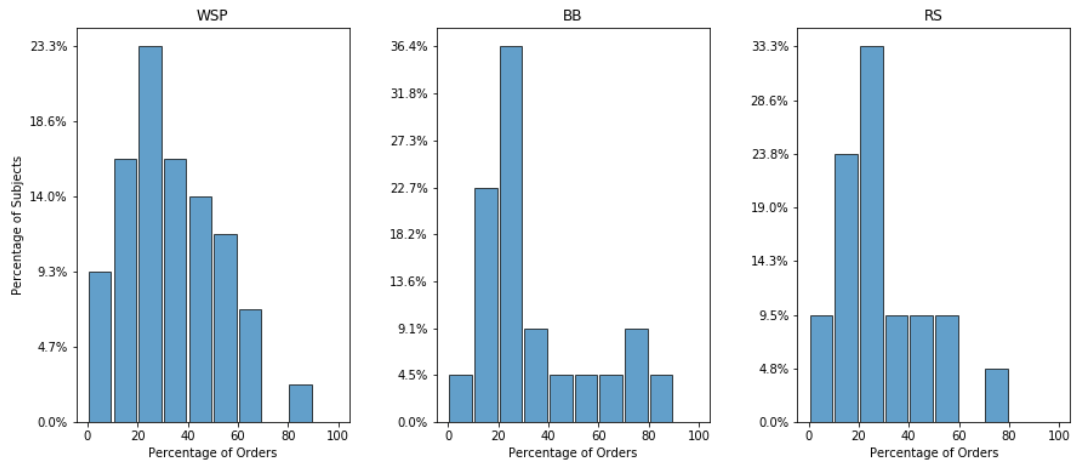
5.1 Effect of Regret on Pull to Center Behavior

Starting with Schweitzer and Cachon (2000) many studies report the existence of the PTC behavior in their experimental data (e.g., Benzion et al., 2008; Bolton and Katok, 2008; Bostian et al., 2008). Nevertheless, Lau et al. (2014) argue that these studies have observed the PTC effect in aggregate data and posit that the PTC effect does not describe the individual behavior properly. Lau et al. use the data from Bolton and Katok (2008) as well as the data from their own experiment to show that the PTC is not a good representative of the individual behavior. The authors utilize different methods, such as counting the percentage of orders in the PTC zone to support their idea. For a low profit product (that is, a product with $Q^* < \mu$), the PTC zone is defined as the interval between the optimal order quantity (Q^*) and the demand mean. Conversely, for a high profit contract (that is, a product with $Q^* > \mu$) the PTC zone is defined as the interval between the demand mean and the optimal order quantity (Q^*). Lau et al. argue that in order to consider the PTC behavior to be the prevalent behavior for a subject, 50% or more of her orders should fall into the PTC zone.

In this section, first we examine the existence of the PTC behavior in individual subject data in our experiments. Following an approach similar to Lau et al. (2014), we calculate the ratio of orders in the PTC zone over the accepted contracts for each subject. Therefore each subject is represented by a single data point. We remove the data points in which the optimal order satisfies $Q^* = \mu = 100$, since in this case we cannot distinguish between optimal ordering and mean ordering behaviors.

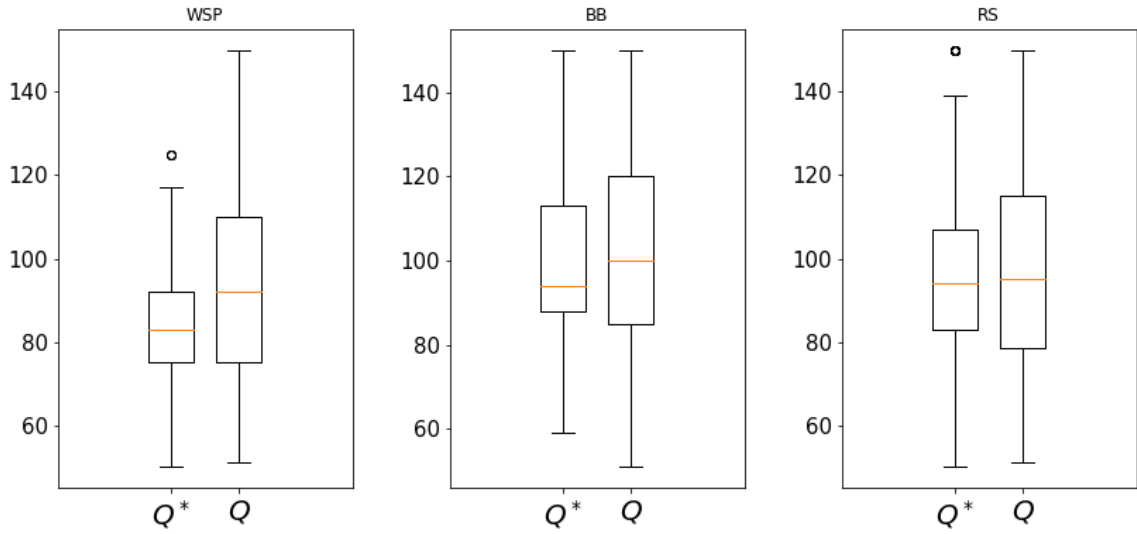
Figure 5.1 shows the distribution of subjects by their percentage of orders in the PTC zone. We observe that under all three contracts the histograms are right-skewed, which means most subjects make less than 50% of their orders in the PTC zone. With this observation, it is safe to conclude that in individual subject level, the existence of the PTC behavior is not supported by our experimental data.

Figure 5.1 Individual Subjects' Orders in the PTC Zone



Next, we investigate the PTC effect in aggregate data. Most studies on PTC show that the average order in a period over all subjects falls into the PTC zone. These studies conduct a newsvendor experiment where there are only retailer subjects and the exogenously determined contract does not change from one period to other. Hence, the optimal order quantity is also fixed for all subjects in all periods. However, in our experiment the optimal order quantity changes in each period based on the contract offered by the manufacturer. Therefore, we cannot use the common approach in the literature to analyze the PTC behavior in aggregate data. Nevertheless, we compare the distribution of Q^* and Q visually in Figure 5.2. The figure shows the distribution of order quantities and optimal order quantities for all accepted contracts under each contract type. Under each contract, we observe the median order quantity to fall between the median optimal order quantity and the demand mean, supporting the idea of the PTC behavior in aggregate data.

Figure 5.2 Distribution of Q^* and Q in Aggregate Data



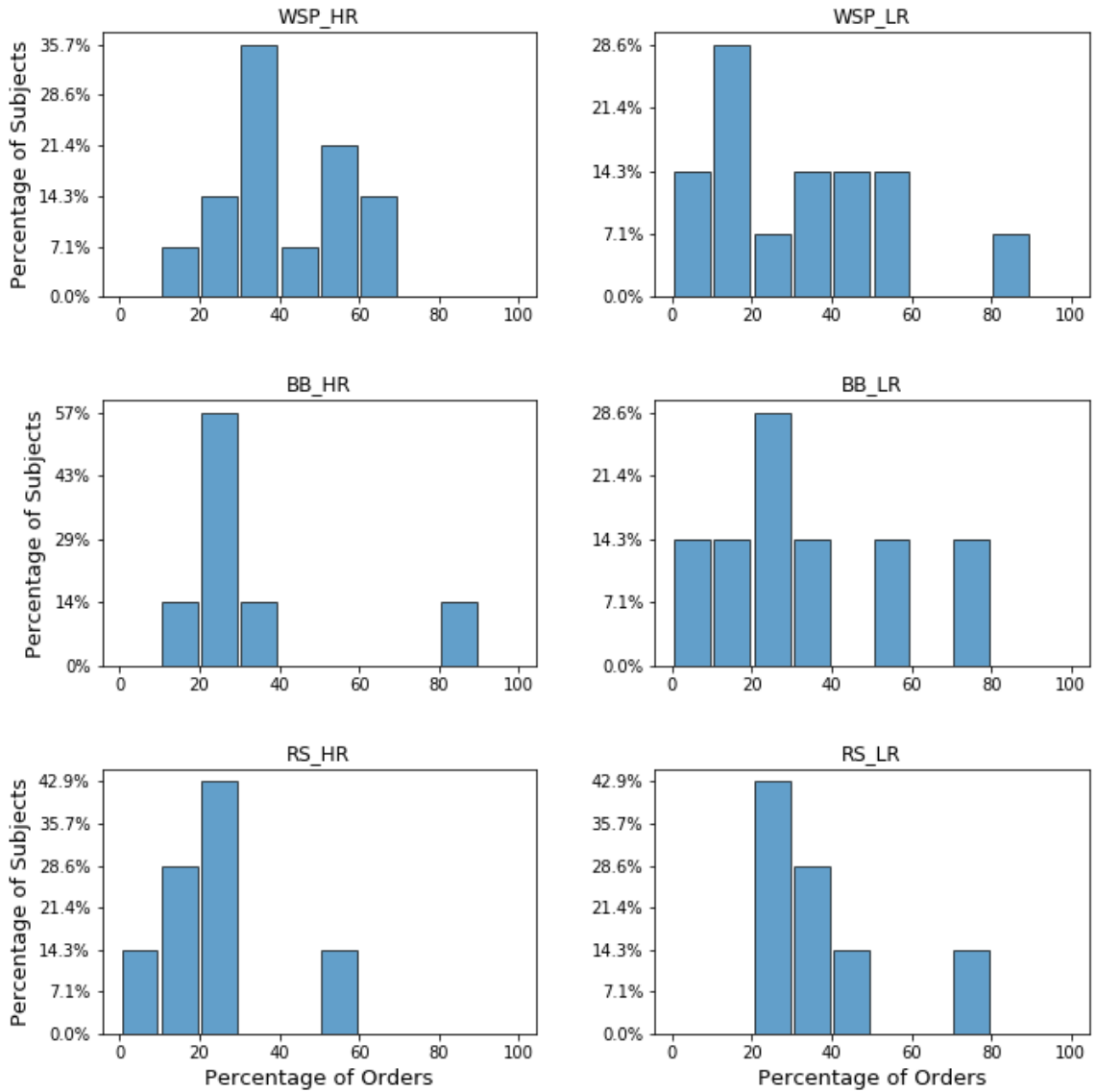
Next, we repeat the same analysis separately for high-regret and low-regret subjects. Figure 5.3 demonstrates the histograms of high-regret and low-regret subjects by contract type. Table 5.1 provides the mean and median percentage of orders in the PTC zone by the regret class of the retailer and contract type. Both the figure and the table suggests that PTC is not supported in either regret category.

Table 5.1 Percentage of Orders in the PTC Zone

Regret Class		WSP	BB	RS
Mean	HR	42.2%	33.1%	22.0%
	LR	31.6%	32.4%	36.4%
Median	HR	38.5%	29.0%	24.0%
	LR	28.0%	27.0%	31.0%

To conclude, we do not observe PTC to be a prevalent behavior in individual subject data under any contract. This observation is in line with the findings of Lau et al. (2014). Although we did not observe PTC as the prevalent behavior among individual subjects' data, Table 5.1 shows a difference between the PTC behavior of high-regret and low-regret retailers. Therefore, in what follows we investigate the differences that regret might cause in the PTC behavior. In particular, we study the relationship between regret and two explanations of the PTC effect as proposed by Schweitzer and Cachon (2000).

Figure 5.3 Percentage of Orders in the PTC Zone for High-regret and Low-regret Retailers



5.1.1 Preference to Minimize Ex-post Inventory Error

Schweitzer and Cachon (2000) argue that one explanation for the PTC behavior is the subjects' preference to minimize ex-post inventory error. The authors model such a preference using the following utility function:

$$(5.1) \quad U(Q, D, W_0) = W_0 + U_n(\pi(Q, D)) - \delta(|Q - D|),$$

where W_0 is the decision maker's initial wealth, $U_n(\cdot)$ is the utility function of a

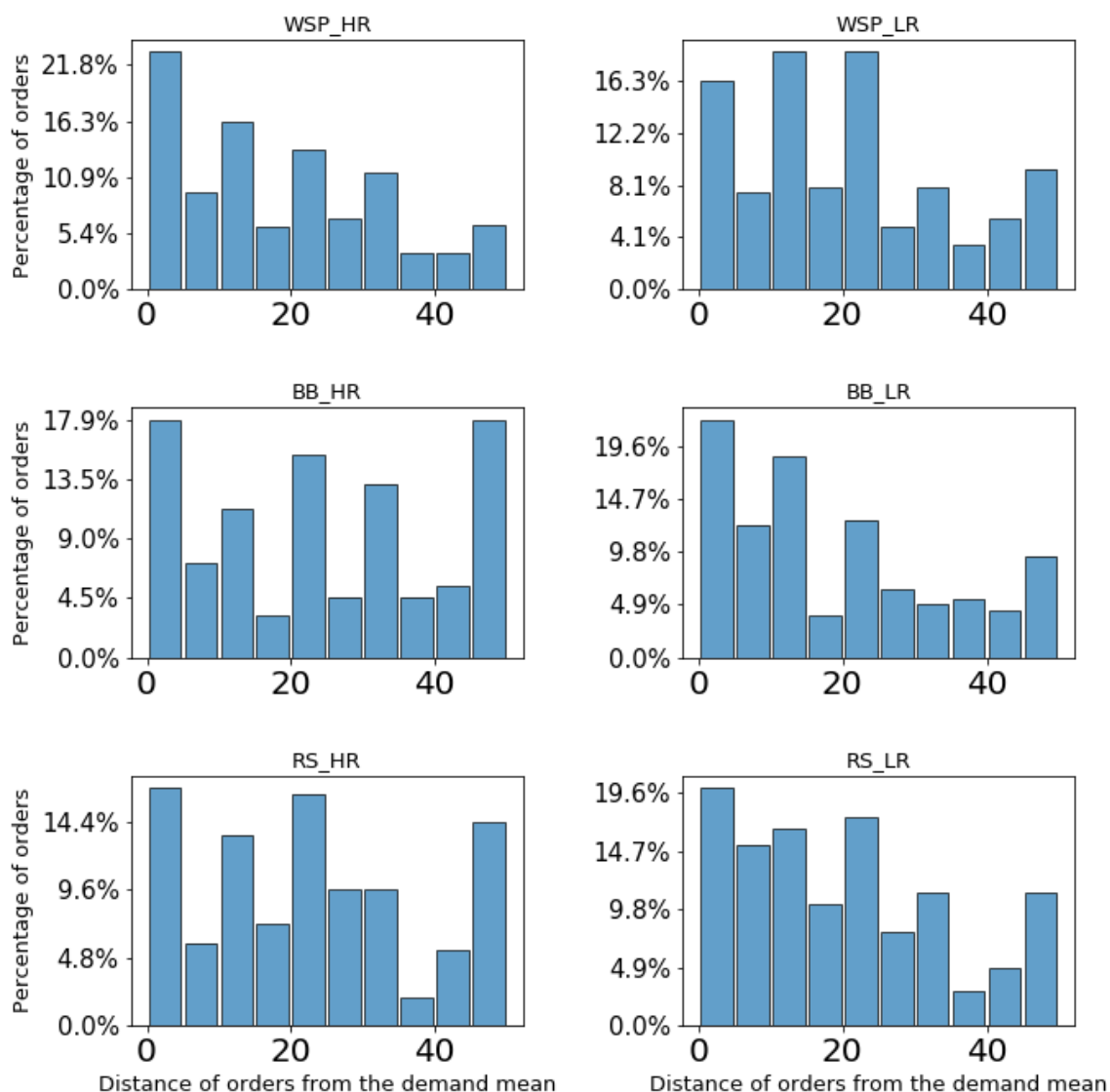
risk neutral newsvendor with $U_n(W) = W$, and the function $\delta(\cdot)$ is the disutility of a mismatch between order quantity and realized demand (that is, the ex-post inventory error $|Q - D|$). According to regret theory, at the stage of making a decision people anticipate that they may feel regret when they learn about their decision outcome, and hence seek to make the regret-minimizing decision (Bell, 1982). Schweitzer and Cachon (2000) believe that a newsvendor may anticipate regret about not ordering a quantity equal to the realized demand and therefore may try to minimize the difference between them. The authors show that a subject with such a preference may order too low from a high profit margin and order a too high from a low profit margin product, hence the PTC effect. Note that our experimental setting is different from that of Schweitzer and Cachon due to the existence of strategic interaction between the players. Due to this interaction, the retailer may feel regret about other issues, such as not having rejected a contract. However, in this section we focus on the retailer's anticipated regret about her ex-post inventory error.

Baring in mind the above discussion, we anticipate a subject with a greater tendency to regret to be more influenced by the PTC effect. We use two metrics to measure the extent of the PTC behavior: distance of order quantities from the demand mean and percentage of the orders in the PTC zone. We propose the first metric due to the fact that expected inventory mismatch will be minimized when the subject orders the mean demand quantity. Hence, a subject with preference to minimize ex-post inventory error may order quantities that are closer to the demand mean. The second metric is utilized by Lau et al. (2014) and was discussed earlier in the current section. Thus, we test two hypotheses.

Hypothesis 1 *High-regret (HR) retailers will order quantities that are closer to the demand mean compared to low-regret (LR) retailers.*

Since Hypothesis 1 deals with the order quantities, we only use the data of accepted contracts. We also remove the data points with $Q^* = 100$. This hypothesis is tested under both pooled data and subject averages. Under pooled data, data from each period of each manufacturer-retailer interaction is considered as a single data point, whereas under the subject averages each subject is represented by a single data point showing her average order quantity over all accepted contracts. The metric is the absolute distance of the order quantity from the demand mean. Figure 5.4 shows the distribution of the absolute distances from the demand mean under pooled data.

Figure 5.4 Distribution of $|Q - \mu|$ in Pooled Data



The test results are summarized in Table 5.2. In the pooled data we observe a significant difference under the wholesale price contract, supporting our hypothesis. Under the other two contracts, we observe the opposite behavior to the hypothesis, that is, the order quantities of the low-regret retailers are significantly closer to the demand mean compared to high-regret retailers (p-values are < 0.001 and 0.024 , respectively). Under subject averages, none of the differences between medians are significant.

One may claim that under the wholesale price contract closer orders to the demand mean in high-regret retailers can arise from the contracts that are offered to these retailers. In other words, the profit-maximizing order quantities of the contracts offered to the high-regret retailers may be closer to the demand mean, causing the

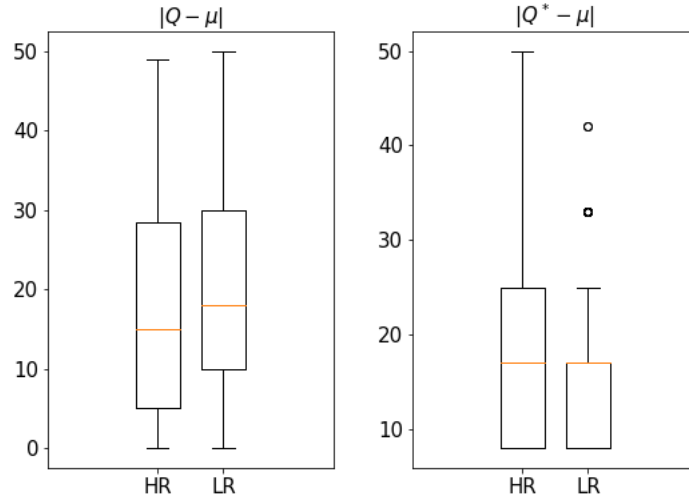
Table 5.2 Median Distance of the Order Quantities from the Demand Mean

	Wholesale Price			Buyback			Revenue Sharing		
	HR	LR	p-value	HR	LR	p-value	HR	LR	p-value
pooled data	15 n=459	18 m=491	0.018	20 n=223	12 m=204	0.999	20 n=209	15 m=241	0.976
subject avg	18.49 n=14	18.37 m=14	0.253	21.80 n=7	18.50 m=7	0.899	21.83 n=7	15.76 m=7	0.739

high-regret retailers to show more prevalent PTC behavior. Surprisingly, we observe the profit-maximizing order quantities of the contracts offered to the high-regret retailers to have a larger distance from the demand mean compared to those offered to the low-regret retailers ($p - value < 0.001$). Figure 5.5 visualizes the absolute distances from demand mean for both the order quantity (Q) and the optimal order quantity (Q^*) under the wholesale price contract, for both the high and low-regret retailers.

To conclude, in the wholesale price contract's pooled data, high-regret retailers order quantities that are closer to the demand mean compared to the low-regret retailers, although for high-regret retailers the optimal quantity is further away from the demand mean. Thus, Hypothesis 1 is supported under the wholesale price contract, but not under the other two contracts.

Figure 5.5 Distribution of $|Q - \mu|$ and $|Q^* - \mu|$ under the Wholesale Price Contract



Hypothesis 2 *Percentage of the orders in the PTC zone will be higher for the high-regret (HR) retailers than it is for the low-regret (LR) retailers.*

To test Hypothesis 2 we calculate the ratio of orders in the PTC zone over the accepted contracts for each subject, after removing the data points with $Q^* = 100$. The results of Hypothesis 2 are summarized in Table 5.3. Under the wholesale price contract, percentage of the orders in the PTC zone is higher for high-regret retailers

than that for the low-regret retailers, supporting Hypothesis 2. We observe that under the revenue-sharing contract the reverse difference is significant, that is the low-regret retailers order more in the PTC zone.

Table 5.3 Percentage of Orders in the PTC Zone (Medians)

	WSP	BB	RS
HR	38.5% (n=14)	29.0% (n=7)	24.0% (n=7)
LR	28.0% (m=14)	27.0% (m=7)	31.0% (m=7)
p-value	0.067	0.500	0.937

5.1.2 Demand Chasing

Schweitzer and Cachon introduce demand chasing as one of the explanations for the PTC behavior. According to this heuristic, retailer subjects anchor to their most recent order quantity decision and make some adjustments towards the most recent realized demand in their next order quantity decision.

We believe that the demand chasing behavior can be the result of regret emotion as well. As discussed before, regret may affect decisions from two different aspects: anticipated regret, which arises before a decision is made, and experienced regret, which the decision maker may feel after the decision results are revealed (Zeelenberg and Pieters, 2007). In our experimental setting, the subjects are prone to feel both types of regret; hence, their decisions may be influenced by either type. From the perspective of experienced regret, result from one period may influence the decisions in the subsequent periods. For a retailer, experienced regret may arouse when there is a difference between the order quantity and the realized demand. If the realized demand is lower than the order quantity, then the subject may wish she had ordered less, and conversely if the realized demand exceeds the ordered quantity, she may wish she had ordered more. In the former case, the subject's reaction in the subsequent period may be decreasing her order quantity relative to her most recent order quantity. In the latter case, she may increase her order quantity in the subsequent period.

We expect a high-regret retailer to be more influenced by the experienced regret, and hence exhibit a more severe demand chasing behavior compared to a low-regret retailer. Thus, we propose the following hypothesis:

Hypothesis 3 *High-regret (HR) retailers will be more influenced by the inventory mismatch of the most recent period, compared to the low-regret (LR) retailers.*

Lau and Bearden (2013) categorize the metrics to measure demand chasing in four groups: changes towards versus away from previous demand, adjustment score, regression model, and correlation. We use the regression model given in Equation 5.2 to test Hypothesis 3. We construct a random effects regression model as the data points generated by each retailer-manufacturer pair are not independent. Using a random effect regression model allows us to consider this heterogeneity in the data.

Equation 5.2 explains the changes in order quantities between two subsequent periods in response to the most recent inventory mismatch. It is the same as the model used in Bostian et al. (2008), where the parameter β shows the extent of demand chasing. The model has two error terms: one error term is independent over all of the observations (ϵ_t) and the other error term is individual-specific (η_i). See, e.g., Katok and Wu (2009) for a similar approach.

$$(5.2) \quad Q_{i,t} - Q_{i,t-1} = \beta_0 + \beta_1(D_{i,t-1} - Q_{i,t-1}) + \eta_i + \epsilon_t.$$

Recall that in each period the retailers are allowed to reject the offered contract by setting $Q = 0$, which causes some breaks in the time series data. To overcome this issue, we remove the data of periods in which a contract is rejected, as well as the data of the subsequent period. Moreover, data for the first periods are also removed because there is no predictor for them.

Table 5.4 shows the estimated coefficients for Equation 5.2. We observe the estimated β_1 values to be significant under all of the contract types and regret classes, meaning that subjects are chasing the demand in all of the contracts. Also, under both wholesale price and buyback contracts, the absolute value of the coefficient is greater for high-regret retailers; i.e., these retailers react more severely to the inventory mismatch observed in the most recent period. This finding is in line with our expectation, and hence Hypothesis 3 is supported for the wholesale price and buyback contracts.

The issue with the above-mentioned random effect regression model is that some subjects may not have chased the demand. However, we fitted the regression on the data from all subjects without considering whether they are chasing the demand or not. To overcome this problem, we fit a regression on each subject individually

Table 5.4 Estimation of the Coefficients in Equation 5.2

	WSP		BB		RS	
	HR	LR	HR	LR	HR	LR
β_0	-3.19** (1.29)	-2.43* (1.26)	-1.82 (1.98)	-1.75 (1.71)	-4.29** (2.00)	-5.29*** (1.59)
β_1	0.32*** (0.03)	0.20*** (0.03)	0.28*** (0.05)	0.21*** (0.05)	0.30*** (0.05)	0.31*** (0.04)
n	481	500	218	223	223	251

Notes: Standard deviations are given in parentheses.
p-value: * p<0.1, ** p<0.05, *** p<0.01

and identify the subjects who chase demand; that is, those who have a significant β_1 coefficient. Then, we fit the random effect regression model in 5.2 with the data of only these subjects. As shown in Table 5.5, the results do not change with the new approach. Similar to our previous observations, under both wholesale price and buyback contracts high-regret retailers chase the demand more compared to low-regret retailers.

Table 5.5 Estimation of Coefficients in Equation 5.2 for subjects who chase the demand

	WSP		BB		RS	
	HR	LR	HR	LR	HR	LR
β_0	-4.90*** (1.63)	-6.14*** (2.27)	-3.93 (2.61)	-1.80 (1.92)	-5.09** (2.39)	-5.42*** (1.75)
β_1	0.42*** (0.04)	0.40*** (0.06)	0.34*** (0.06)	0.24*** (0.05)	0.35*** (0.06)	0.35*** (0.04)
n	320	171	152	170	184	214

Notes: Standard deviations are given in parentheses.
p-value: * p<0.1, ** p<0.05, *** p<0.01

5.2 Effect of Regret on Overordering and Underordering Behavior

In this section we investigate whether regret can explain retailer's over/under ordering behavior with respect to the optimal order quantity (Q^*) implied by the offered contract. To this end, we compare the over/under ordering behavior of the retailers from different regret classes.

Over/under ordering behavior is a means that a retailer might use to express her level of satisfaction for the offered contract. We use the real distance of an order quantity from the optimal order quantity as the metric to measure the extent of over/under ordering. A positive number shows overordering and the absolute value of the distance shows the extent of overordering. An underorder may be caused by different reasons. A retailer may underorder because, for instance, she cannot calculate Q^* (bounded rationality), because she is risk averse or because she wants to punish the manufacturer.

Avci et al. (2014) posit that there is a direct relationship between social comparison and regret aversion. Since it is difficult for the decision maker to evaluate what would be the outcome if she had chosen another alternative, decision makers usually compare their outcomes with their peers' performance. While being superior makes a positive contribution to the utility (*social rejoice*), being inferior impacts the utility negatively (*social regret*).

In our experimental setting, we can define a retailer's superiority and inferiority according to her profit share in a contract. A retailer might compare her outcome with the manufacturer's outcome and might feel social regret if her outcome is inferior to his pair's outcome. In the phase of making the ordering decision, a retailer may compare her expected profit share with the manufacturer's and react to a contract with low expected profit share by underordering. Since this behavior is related to regret, we expect high-regret retailers to react more harshly to inequity in the profit shares. Therefore, we propose the following hypothesis.

Hypothesis 4 *High-regret retailers will make larger overorders in response to a contract with high predicted retailer profit share, and they will make larger underorders in response to a contract that has low predicted retailer profit share compared to low-regret retailers.*

We only use the data of accepted contracts to test this hypothesis. We divide the offered contracts into high-profit-share (HPS) and low-profit-share (LPS) contracts based on their predicted profit share for the retailer. To this end, we use the average predicted retailer profit share as the threshold which is calculated separately for each contract type.

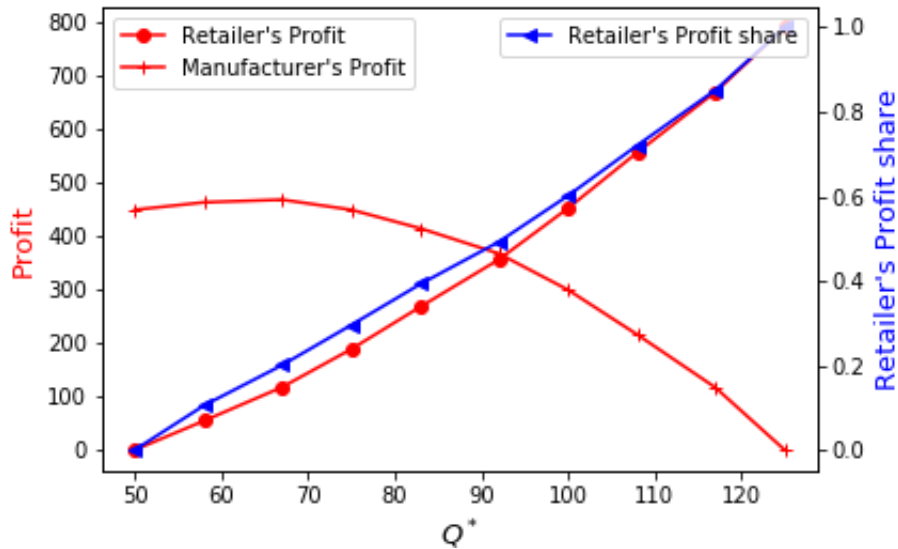
As summarized in Table 5.6, under the wholesale price contract high-regret retailers make smaller overorders in response to HPS contracts; whereas, they make larger overorders in response to LPS contracts compared to low-regret retailers. Both of these results are in contradiction to our expectation in Hypothesis 4. In addition,

Table 5.6 Comparing Retailer's Over/Under Ordering Behavior

		WSP		BB		RS	
		HPS	LPS	HPS	LPS	HPS	LPS
High-Regret (HR)	median	8.0	15.0	-10.0	4.0	-5.0	-5.0
	N	210	309	110	116	189	61
Low-Regret (LR)	median	13.0	3.5	-6.5	10.0	0.5	7.0
	N	253	280	92	151	126	142
p-value (HR>LR)		0.936	<0.001	0.779	0.659	0.993	1.000
p-value (HR<LR)		0.064	1.000	0.221	0.342	0.007	<0.001

high-regret retailers make larger overorders for LPS contracts than for HPS contracts. One potential explanation for these results can be the difference between the risk preference of the retailers from different regret classes. As visualized in Figure 5.6, in the wholesale price contract, higher profit share for retailer means higher Q^* . This, in turn, means increased risk as higher Q values lead to higher variation in retailer's realized profit. Hence, a risk averse retailer may make smaller overorders for HPS contracts than for LPS contracts. High-regret retailers might be concerned more about risk compared to low-regret retailers.

Figure 5.6 Predicted Profits with Respect to Q^* under the Wholesale Price Contract



From Table 5.6, under the buyback contract we do not observe any significant difference between the over/under ordering behavior of the high-regret and low-regret retailers. However, under the revenue sharing contract, similar to the wholesale price contract, high-regret retailers make smaller overorders (larger underorders) in response to the HPS contracts compared to low-regret retailers. The difference in LPS contracts under the revenue sharing contracts is the only significant result in

line with our expectation in Hypothesis 4. In conclusion, our results do not support Hypothesis 4.

6. EFFECT OF REGRET ON MANUFACTURER BEHAVIOR

In this chapter we study the effect of regret on manufacturers' behavior. In Section 6.1 we study the effects of anticipated regret on the parameters of contracts that a manufacturer offers. In Section 6.2 we examine the effects of experienced regret on manufacturer decisions in subsequent periods.

6.1 Effect of Regret on Contract Offers

In this section we explore the effect of regret on parameters of the contracts offered by the manufacturers. To this end, we study the differences between profit shares of contracts offered by the high-regret and the low-regret manufacturers, as a measure of the contract's attractiveness to retailer.

Each period of the interaction in our experiments resembles the well-known ultimatum game. Zeelenberg and Beattie (1997) argue that in a normal ultimatum game, where there is no feedback on the minimum offer that would be accepted, feeling regret about offering high share to the responder is less painful than the regret about offering a low share and being rejected.

In our experimental setting, the total predicted supply chain profit resembles the total money in the ultimatum game, even though it is not a fixed quantity, and the predicted profit of each player resembles the profit shares in the ultimatum game. Bearing in mind the above discussion, high-regret manufacturers are likely to be more concerned about their contract offers being rejected; hence, these manufacturers may offer contracts that have higher predicted retailer profit share. Therefore, we propose the following hypothesis.

Hypothesis 5 *Contracts offered by high-regret manufacturers will have higher retailer predicted profit share than those offered by low-regret manufacturers.*

To test this hypothesis we use the data of all contract offers; accepted and rejected together. Table 6.1 summarizes the results. Under the wholesale price contract, contracts offered by high-regret manufacturers have higher retailer predicted profit share; whereas, under both buyback and revenue sharing contracts profit shares offered by the low-regret manufacturers are higher. Hence, Hypothesis 5 is supported only for the wholesale price contract.

Table 6.1 Comparing Retailer’s Predicted Profit Share (Medians)

	WSP	BB	RS
HR	39% (n=560)	30% (n=280)	30% (n=280)
LR	39% (m=560)	31% (m=280)	39% (m=280)
p-value (HR > LR)	0.067	0.998	0.999

These results may be explained by the subjects’ attitude towards risk, and the risk sharing nature of the buyback and revenue sharing contracts. While in the wholesale price contract all of the inventory risk is undertaken by the retailer, in both buyback and revenue sharing contracts the manufacturer bears some share of the inventory risk. High-regret manufacturers might have taken risk into account more than low-regret manufacturers. When these manufacturers do not bear risk, they offer better contracts compared to the low-regret manufacturers. However, when high-regret manufacturer needs to undertake a share of the inventory risk they offer less attractive contracts compared to low-regret manufacturers. It is noteworthy that, studies about the relationship between regret and risk preference posit that based on the situation regret can result in both risk aversion and risk seeking behavior (see, e.g., Zeelenberg et al., 1996).

6.2 Effect of Regret on Manufacturer Behavior Following a Contract

Rejection

In this section we study the effect of regret on manufacturer behavior following a contract rejection.

In Section 2.3 we discussed how experiencing regret can affect a subject’s futures decisions. In our experimental setting, a manufacturer might experience regret when an offered contract is rejected by the retailer. The reason is that the worst outcome,

which is gaining zero profit, has realized for the manufacturer and he may think that he could have obtained a better outcome had he offered a better contract. This feeling will affect manufacturer's decision in the following period; he will choose different contract parameters to change the outcome. Thus, the manufacturer might offer a more attractive contract for the retailer in the subsequent period. The contract's attractiveness for the retailer might be based on its predicted retailer profit or predicted retailer profit share.

In what follows, we first check whether our expectation about the manufacturer's behavior after a rejection is observed or not. Figures 6.1 and 6.2 demonstrate the percentages of the change direction in the retailer's predicted profit and profit share after a rejection. We observe that under each contract type, both the predicted profit and profit share for the retailer increase following a contract rejection for most cases.

Figure 6.1 Change in the Retailer's Predicted Profit Following a Contract Rejection

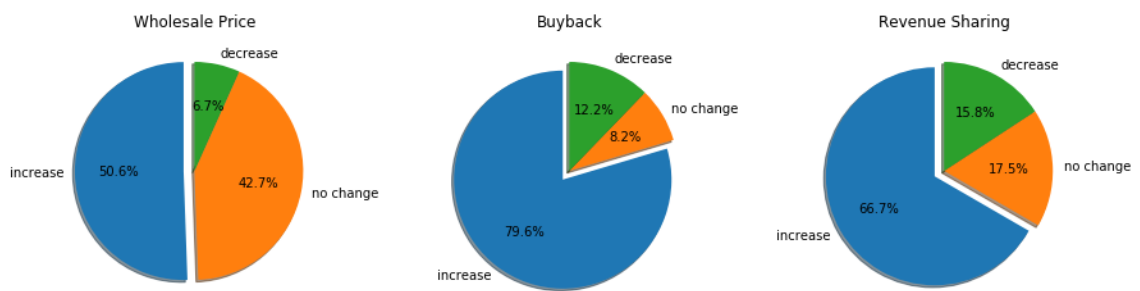
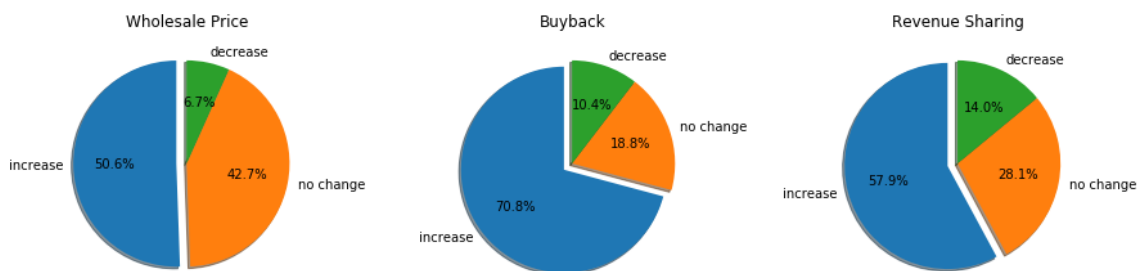


Figure 6.2 Change in the Retailer's Predicted Profit Share Following a Contract Rejection



Next, in the following hypotheses we test if the reaction of the high-regret manufacturers will be more severe.

Hypothesis 6 *High-regret manufacturers will increase retailer's predicted profit in the subsequent period after a rejection more compared to low-regret manufacturers.*

Hypothesis 7 *High-regret manufacturers will increase retailer's predicted profit share in the subsequent period after a rejection more compared to low-regret manufacturers.*

To test Hypotheses 6 and 7 we use the data of all contract offers in the subsequent periods following a rejection. Results are summarized in Tables 6.2 and 6.3. Change in the retailer’s predicted profit and profit share is larger only for high-regret manufacturers under the revenue sharing contract; however, this difference is not statistically significant. Low-regret retailers increase the retailer’s predicted profit and profit share more than high-regret retailers under both wholesale price and buy-back contracts. These results show that any of our expectations in Hypotheses 6 and 7 are not supported.

Table 6.2 Percentage of Change in Retailer’s Predicted Profit After a Rejection (Medians)

	WSP	BB	RS
HR	0% (n=49)	29% (n=21)	39% (n=36)
LR	33% (m=40)	69% (m=28)	29% (m=21)
p-value (HR > LR)	0.848	0.964	0.823

Table 6.3 Percentage of Change in Retailer’s Predicted Profit Share After a Rejection (Medians)

	WSP	BB	RS
HR	0% (n=49)	43% (n=21)	33% (n=36)
LR	26% (m=40)	51% (m=28)	27% (m=21)
p-value (HR > LR)	0.848	0.954	0.871

7. CONCLUSION

7.1 Relationship Between Risk and Regret

In a number of our analyses we propose risk aversion as a potential explanation for the differences in the behavior of subjects from different regret classes. We find high-regret subjects to show more risk averse behavior compared to low-regret subjects. In this section we study the relationship between regret and risk.

Our experimental data includes three surveys regarding risk and loss aversion of the subjects, which enables us to compare the differences in the risk attitude of the subjects from different regret classes. These surveys consist of questions about risky lotteries and are based on the studies by Hartog et al. (2000) and Gächter et al. (2007). The survey questions are provided in Table 7.1. Risk and loss aversion degree of a subject is measured according to his or her answers to these questions. A lower answer to the first and second questions shows more risk and loss aversion; whereas, a higher answer means more risk seeking behavior. In question 3, up to game 4 the expected value of the lotteries are positive, the fifth game has zero expected value, and the last two games have negative expected values. The higher the number of accepted games, the higher the degree of risk and loss aversion.

We calculate the subjects' degree of risk and loss aversion with each survey and seek for a relationship between risk and regret. Although we observe heterogeneity in the risk preference of the subjects, we could not identify a consistent relationship between regret and risk tendencies.

Table 7.1 Risk and Loss Aversion Survey Questions

Question 1: There is a lottery draw in which only 10 people will participate and the prize is 1000TL. How much would you be willing to pay for a ticket to the lottery?

Question 2: You are given as a gift a ticket to this lottery, i.e., you didn't pay anything for the ticket. There is someone who is interested in buying the ticket from you, and this person is very talented at negotiation. What is the minimum price you would be willing to sell the ticket?

Question 3: In each of the below situations, there is a tossing the coin game, in which if the coin turns up HEADS, you will win 6 TL. How much you will lose if the coin turns up TAILS is indicated in each situation. If you don't accept the game, nothing will happen. Please indicate if you would accept the game or not.

Game 1: TAILS: you will lose 2 TL, HEADS: you will win 6 TL

Game 2: TAILS: you will lose 3 TL, HEADS: you will win 6 TL

Game 3: TAILS: you will lose 4 TL, HEADS: you will win 6 TL

Game 4: TAILS: you will lose 5 TL, HEADS: you will win 6 TL

Game 5: TAILS: you will lose 6 TL, HEADS: you will win 6 TL

Game 6: TAILS: you will lose 7 TL, HEADS: you will win 6 TL

Game 7: TAILS: you will lose 8 TL, HEADS: you will win 6 TL

7.2 Conclusion

In this study we investigate the effect of regret on the decisions made by the retailer and manufacturer in a newsvendor setting under three type of contracts, namely the wholesale price, buyback, and the revenue sharing contracts. In each case we analyze the effects of both anticipated and experienced regret on the decisions.

We characterize if and how regret can account for preference to minimize ex-post inventory error and demand chasing, two potential explanations of the pull-to-center (PTC) effect as proposed by Schweitzer and Cachon (2000). We find high-regret retailers to be more concerned about the ex-post inventory error and hence exhibit more pull-to-center behavior under the wholesale price contract. We develop a random effect regression model to compare the demand chasing behavior of the retailers and find high-regret retailers to be more influenced by the realized demand in the previous period under both wholesale price and buyback contracts. Our investigation of over/under ordering behavior of the retailers suggests that high-regret retailers might be more concerned about the riskiness of an offered contract compared to low-regret retailers, which can be a good direction for future research.

We analyze the effect of anticipated regret on manufacturer's behavior by comparing the predicted profit share of the contracts offered by the manufacturers from

different regret classes. We find high-regret manufacturers to offer contracts with higher predicted profit share for their retailers under the wholesale price contract. However, under both buyback and revenue sharing contracts the opposite is observed. This can be explained by the risk sharing nature of the latter contracts and high-regret manufacturers' concerns about risk. Effect of experienced regret on manufacturer's behavior is studied by analyzing how the attractiveness of the offered contract changes following a rejection. Manufacturers under the revenue sharing contract offer a better contract, in terms of predicted profit share for the retailer, after facing a rejection. However, under both wholesale price and buyback contracts, manufacturers decrease the predicted profit and profit share for the retailer after being rejected.

Research on the relationship between regret and risk posit that regret aversion can result in both risk aversion and risk seeking behavior depending on the circumstances. In a number of our analyses we find subjects from a specific regret class to show a reverse behavior under different contract types. We believe that high-regret subjects show more risk averse behavior compared to low-regret subjects. This idea can be studied as future research.

BIBLIOGRAPHY

- Akbay, U. and Kaya, M. (2016). *Behavioral Experiments on Supply Chain Contracting*. PhD thesis.
- Arshinder, K., Kanda, A., and Deshmukh, S. (2011). A review on supply chain coordination: coordination mechanisms, managing uncertainty and research directions. In *Supply chain coordination under uncertainty*, pages 39–82. Springer.
- Avci, B., Loutfi, Z., Mihm, J., Belavina, E., and Keck, S. (2014). Comparison as incentive: Newsvendor decisions in a social context. *Production and operations management*, 23(2):303–313.
- Barberis, N., Huang, M., and Thaler, R. H. (2006). Individual preferences, monetary gambles, and stock market participation: A case for narrow framing. *American economic review*, 96(4):1069–1090.
- Becker-Peth, M., Katok, E., and Thonemann, U. W. (2013). Designing buyback contracts for irrational but predictable newsvendors. *Management Science*, 59(8):1800–1816.
- Becker-Peth, M., Thonemann, U. W., and Gully, T. (2018). A note on the risk aversion of informed newsvendors. *Journal of the Operational Research Society*, 69(7):1135–1145.
- Bell, D. E. (1982). Regret in decision making under uncertainty. *Operations research*, 30(5):961–981.
- Bendoly, E., Donohue, K., and Schultz, K. L. (2006). Behavior in operations management: Assessing recent findings and revisiting old assumptions. *Journal of operations management*, 24(6):737–752.
- Benzion, U., Cohen, Y., Peled, R., and Shavit, T. (2008). Decision-making and the newsvendor problem: an experimental study. *Journal of the Operational Research Society*, 59(9):1281–1287.
- Benzion, U., Cohen, Y., and Shavit, T. (2010). The newsvendor problem with unknown distribution. *Journal of the Operational Research Society*, 61(6):1022–1031.
- Bleichrodt, H., Cillo, A., and Diecidue, E. (2010). A quantitative measurement of regret theory. *Management Science*, 56(1):161–175.
- Bolton, G. E. and Katok, E. (2008). Learning by doing in the newsvendor problem: A laboratory investigation of the role of experience and feedback. *Manufacturing & Service Operations Management*, 10(3):519–538.
- Bolton, G. E., Ockenfels, A., and Thonemann, U. W. (2012). Managers and students as newsvendors. *Management Science*, 58(12):2225–2233.
- Bostian, A. A., Holt, C. A., and Smith, A. M. (2008). Newsvendor “pull-to-center” effect: Adaptive learning in a laboratory experiment. *Manufacturing & Service Operations Management*, 10(4):590–608.
- Cachon, G. P. (2003). Supply chain coordination with contracts. *Handbooks in operations research and management science*, 11:227–339.
- Cachon, G. P. and Lariviere, M. A. (2005). Supply chain coordination with revenue-sharing contracts: strengths and limitations. *Management science*, 51(1):30–44.
- Chen, L. and Davis, A. M. (2014). Validating models for bounded rationality and

- decision biases in a newsvendor experiment. Technical report, Working Paper.
- Cui, H. T., Raju, J. S., and Zhang, Z. J. (2007). Fairness and channel coordination. *Management science*, 53(8):1303–1314.
- Davis, A. M. (2015). An experimental investigation of pull contracts in supply chains. *Production and Operations Management*, 24(2):325–340.
- De Vericourt, F., Jain, K., Bearden, J. N., and Filipowicz, A. (2013). Sex, risk and the newsvendor. *Journal of Operations Management*, 31(1-2):86–92.
- D’Urso, D., Di Mauro, C., Chiacchio, F., and Compagno, L. (2017). A behavioural analysis of the newsvendor game: Anchoring and adjustment with and without demand information. *Computers & Industrial Engineering*, 111:552–562.
- Engelbrecht-Wiggans, R. and Katok, E. (2008). Regret and feedback information in first-price sealed-bid auctions. *Management Science*, 54(4):808–819.
- Feng, T., Keller, L. R., and Zheng, X. (2011). Decision making in the newsvendor problem: A cross-national laboratory study. *Omega*, 39(1):41–50.
- Filiz-Ozbay, E. and Ozbay, E. Y. (2007). Auctions with anticipated regret: Theory and experiment. *American Economic Review*, 97(4):1407–1418.
- Fugate, B., Sahin, F., and Mentzer, J. T. (2006). Supply chain management coordination mechanisms. *Journal of business logistics*, 27(2):129–161.
- Gächter, S., Johnson, E. J., and Herrmann, A. (2007). Individual-level loss aversion in riskless and risky choices.
- Gavirneni, S. and Robinson, L. W. (2017). Risk aversion and implicit shortage cost explain the anchoring and insufficient adjustment bias in human newsvendors. *Operations Research Letters*, 45(3):191–198.
- Gavirneni, S. and Xia, Y. (2009). Anchor selection and group dynamics in newsvendor decisions—a note. *Decision Analysis*, 6(2):87–97.
- Hartog, J., Ferrer-i Carbonell, A., and Jonker, N. (2000). On a simple survey measure of individual risk aversion. Available at SSRN 260938.
- Ho, T.-H., Su, X., and Wu, Y. (2014). Distributional and peer-induced fairness in supply chain contract design. *Production and Operations Management*, 23(2):161–175.
- Höhn, M. I. (2010). Literature review on supply chain contracts. *Relational supply contracts*, pages 19–34.
- Ismail, B. E. and Louderback, J. G. (1979). Optimizing and satisficing in stochastic cost-volume-profit analysis. *Decision Sciences*, 10(2):205–217.
- Josephs, R. A., Larrick, R. P., Steele, C. M., and Nisbett, R. E. (1992). Protecting the self from the negative consequences of risky decisions. *Journal of personality and social psychology*, 62(1):26.
- Kabak, I. W. and Weinberg, C. B. (1972). The generalized newsboy problem, contract negotiations and secondary vendors. *AIIE Transactions*, 4(2):154–156.
- Katok, E. and Pavlov, V. (2013). Fairness in supply chain contracts: A laboratory study. *Journal of Operations Management*, 31(3):129–137.
- Katok, E. and Wu, D. Y. (2009). Contracting in supply chains: A laboratory investigation. *Management Science*, 55(12):1953–1968.
- Khouja, M. (1995). The newsboy problem under progressive multiple discounts. *European Journal of Operational Research*, 84(2):458–466.
- Khouja, M. (1999). The single-period (news-vendor) problem: literature review and suggestions for future research. *omega*, 27(5):537–553.
- Kremer, M., Minner, S., and Van Wassenhove, L. N. (2010). Do random errors

- explain newsvendor behavior? *Manufacturing & Service Operations Management*, 12(4):673–681.
- Kremer, M., Minner, S., and Van Wassenhove, L. N. (2014). On the preference to avoid ex post inventory errors. *Production and Operations Management*, 23(5):773–787.
- Landman, J. (1993). *Regret: The persistence of the possible*. Oxford University Press.
- Larrick, R. P. and Boles, T. L. (1995). Avoiding regret in decisions with feedback: A negotiation example. *Organizational Behavior and Human Decision Processes*, 63(1):87–97.
- Lau, H.-S. (1980). The newsboy problem under alternative optimization objectives. *Journal of the Operational Research Society*, 31(6):525–535.
- Lau, N. and Bearden, J. N. (2013). Newsvendor demand chasing revisited. *Management Science*, 59(5):1245–1249.
- Lau, N., Hasija, S., and Bearden, J. N. (2014). Newsvendor pull-to-center reconsidered. *Decision Support Systems*, 58:68–73.
- Loch, C. H. and Wu, Y. (2008). Social preferences and supply chain performance: An experimental study. *Management Science*, 54(11):1835–1849.
- Loomes, G. and Sugden, R. (1982). Regret theory: An alternative theory of rational choice under uncertainty. *The economic journal*, 92(368):805–824.
- Lurie, N. H. and Swaminathan, J. M. (2009). Is timely information always better? the effect of feedback frequency on decision making. *Organizational Behavior and Human decision processes*, 108(2):315–329.
- Moon, I. and Choi, S. (1995). The distribution free newsboy problem with balking. *Journal of the Operational Research Society*, 46(4):537–542.
- Moritz, B. B., Hill, A. V., and Donohue, K. (2009). Cognition and individual differences in the newsvendor problem: Behavior under dual process theory. *Unpublished manuscript*. Retrieved from <http://citeseerx.ist.psu.edu/viewdoc/download>.
- Moritz, B. B., Hill, A. V., and Donohue, K. L. (2013). Individual differences in the newsvendor problem: Behavior and cognitive reflection. *Journal of Operations Management*, 31(1-2):72–85.
- Niederhoff, J. A. and Kouvelis, P. (2019). Effective and necessary: Individual supplier behavior in revenue sharing and wholesale contracts. *European Journal of Operational Research*, 277(3):1060–1071.
- Pasternack, B. A. (1985). Optimal pricing and return policies for perishable commodities. *Marketing science*, 4(2):166–176.
- Pavlov, V. and Katok, E. (2011). Fairness and coordination failures in supply chain contracts. *Available at SSRN 2623821*.
- Perakis, G. and Roels, G. (2008). Regret in the newsvendor model with partial information. *Operations Research*, 56(1):188–203.
- Qin, Y., Wang, R., Vakharia, A. J., Chen, Y., and Seref, M. M. (2011). The newsvendor problem: Review and directions for future research. *European Journal of Operational Research*, 213(2):361–374.
- Schwartz, B., Ward, A., Monterosso, J., Lyubomirsky, S., White, K., and Lehman, D. R. (2002). Maximizing versus satisficing: Happiness is a matter of choice. *Journal of personality and social psychology*, 83(5):1178.
- Schweitzer, M. E. and Cachon, G. P. (2000). Decision bias in the newsvendor prob-

- lem with a known demand distribution: Experimental evidence. *Management Science*, 46(3):404–420.
- Simon, H. A. (1957). *Models of man: social and rational; mathematical essays on rational human behavior in society setting*. New York: Wiley.
- Spengler, J. J. (1950). Vertical integration and antitrust policy. *Journal of political economy*, 58(4):347–352.
- Thaler, R. H. (1988). Anomalies: The ultimatum game. *Journal of economic perspectives*, 2(4):195–206.
- Tsay, A. A., Nahmias, S., and Agrawal, N. (1999). Modeling supply chain contracts: A review. *Quantitative models for supply chain management*, pages 299–336.
- Tversky, A. and Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *science*, 185(4157):1124–1131.
- Zeelenberg, M. and Beattie, J. (1997). Consequences of regret aversion 2: Additional evidence for effects of feedback on decision making. *Organizational Behavior and Human Decision Processes*, 72(1):63–78.
- Zeelenberg, M., Beattie, J., Van der Pligt, J., and De Vries, N. K. (1996). Consequences of regret aversion: Effects of expected feedback on risky decision making. *Organizational behavior and human decision processes*, 65(2):148–158.
- Zeelenberg, M., Inman, J. J., and Pieters, R. G. (2001). What we do when decisions go awry: Behavioral consequences of experienced regret. *Conflict and tradeoffs in decision making*, pages 136–155.
- Zeelenberg, M. and Pieters, R. (2007). A theory of regret regulation 1.0. *Journal of Consumer psychology*, 17(1):3–18.
- Zhao, X., Si, D., Zhu, W., Xie, J., and Shen, Z.-J. (2019). Behaviors and performance improvement in a vendor-managed inventory program: An experimental study. *Production and Operations Management*, 28(7):1818–1836.