

## ABSTRACT

Title of dissertation:      The Effect of Behavioral Biases  
                                  on Supply Chain Decisions

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Traditional work in operations management has focused on topics such as supply chain contracts and pricing, studying design of efficient contracts and optimal pricing policies. After these optimal solutions and recommendations are derived, they must be implemented properly by managers in practice. Because this process is subject to behavioral decision biases, work in behavioral operations management has begun to connect theories of decision biases to behavior in classical operations management. My dissertation focuses in this area by studying how decisions are made by suppliers and retailers in B2B settings.

In essay one, I investigate the effect of effort-dependent demand on supply chain contracts. It is found that the actual cost of effort affects the retailers optimal level of effort and subsequently determines when a supplier should prefer a wholesale price contract to a buyback contract. As the retailers cost of effort increases, the retailers optimal level of effort decreases, leading the supplier to prefer the wholesale price contract. It is verified experimentally that retailer and supplier decisions are driven by cost of retailer effort. Furthermore, I demonstrate that suppliers' contract

preferences are influenced by effort cost, not expected profit.

In essay two, I look at the link between two supply chain decisions that have previously not been connected before. In this this essay, I study how the contract type (wholesale price or buyback) offered to the retailer affects his decision about which product to stock, particularly when one product is obviously riskier than another. I find, experimentally, that while contract type should make no difference in preferences between a safe and risky product, the retailer displays markedly different preferences across contract type. I propose that this difference in preference structure can be explained by a model that incorporates a Prospect Theory weighting function. Finally, I demonstrate experimentally that this behavioral model of choice explains retailer product choice both when making the isolated product choice decision and the joint product/quantity decision.

# The Effect of Behavioral Biases on Supply Chain Decisions

by

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## Chapter 1: Understanding the Appeal of Suboptimal Contracts

### 1.1 Introduction

The typical supply chain is plagued with the problem of coordinating disparate incentives between retailers and suppliers. Research in supply chain management has generated recommendations for coordinating contracts promising improved performance and profits (see Cachon 2003 for a review). Contracts such as the buyback contract theoretically achieve supply chain coordination by allowing the supplier to share the retailer's risk. When using a buyback contract, the supplier offers to buy back leftover inventory from a retailer at some price less than the initial price. This reduces the retailer's risk, encouraging a larger order quantity and creating higher expected profits for both parties. Despite the academically appealing properties of these shared risk contracts, they have failed to gain significant traction in the field. Instead, the literature suggests that most professionals cling to the simple, yet supposedly economically flawed, wholesale price contract (Cachon 2003, Keser and Paleologo 2004). In this paper, we examine one of the reasons why suppliers may prefer the wholesale price contract.

One industry that could especially benefit from the use of buyback contracts is fashion retail. Fashion goods are perishable and there is a significant degree of

uncertainty about consumer demand. Yet, even in this industry, wholesale price contracts are the most prevalent contracts used (Cachon 2003, Keser and Paleologo 2004). In our own interviews conducted with 14 fashion retailers and suppliers, only three firms we interviewed reported using any type of buyback contract, and their use seemed to be accompanied by increased scrutiny of retailer business practices. For example, a purchasing manager from a large athletic clothing company reported traveling to retailer stores with low sales to check placement of the product and salesperson behavior.

Notably, the business press suggests that although suppliers are hesitant to enter into buyback contracts, retailers seem to welcome them. Writing in the *Wall Street Journal*, Byron (2005) suggests that suppliers view buyback contracts as unfair because they are held liable for the retailer's inability to sell inventory. In contrast, wholesale price contracts eliminate this concern by making the retailer the sole residual claimant of the inventory. Consistently, when we coded online content ( $N = 146$  between 2005 and 2012) from a Google search of "buyback contracts"/"markdown money"/"markdown allowance" for perspective (supplier vs. retailer) and tone (negative vs. positive), we found that 35% of the content discussed negative supplier perceptions while 20% of the content discussed positive retailer perceptions of these contracts. This evidence suggests that negative perceptions of suppliers, rather than retailers, may be limiting the use of buyback contracts (and theoretically equivalent markdown money contracts; see Tsay 2002) in practice.

Why do we see this discrepancy between supplier and retailer perceptions of buyback contracts? Retailers can increase demand by exerting costly effort.

For example, retailers can invest in targeted advertising (Lewis and Reiley 2011), training salespeople (Martin and Collins 1991) or carefully designing store layout (Design Council of the UK 2008) to increase demand. Although higher retailer effort may increase revenues for both the retailer and supplier, effort is costly only to the retailer and is not perfectly verifiable by the supplier. A few papers have theoretically studied the implications of costly retailer effort on shared risk contracts [Taylor (2002), Krishnan et al. (2004), Cachon and Lariviere (2005)]. Krishnan et al. (2004) study how retailer effort is influenced by the presence of a buyback, and they find that although the presence of a buyback increases the retailer's order quantity, it may disincentivize the retailer's effort.

In line with these results, work within operations studying optimal salesforce compensation in a multi-task setting finds that some incentives are inefficient in the sense that they incentivize effort for one task while disincentivizing it for another when inventory considerations are present [Chen (2000), Plambeck and Zenios (2003), Chen (2005), Jerath et al. (2010), Saghafian and Chao (2011), Dai and Jerath (2013)]. We propose that a buyback contract creates a similar trade-off in retailer's actions: while a buyback aims to incentivize higher order quantities, it may decrease the retailers unobservable effort to increase demand, potentially creating a situation in which the supplier is worse off with the buyback contract. Moreover, retailers may be heterogeneous in that some retailers may incur low costs when they engage in demand-stimulating activities and others may incur high costs. Thus, a buyback contract might work well to properly incentivize retailers with low costs of effort, but might backfire and make a supplier worse off when facing a retailer

with high costs of effort. Previous theoretical work has not considered the effects of effort-dependent demand on contract performance in the context of heterogeneous retailers.

These streams of literature and anecdotal evidence from practice motivate our analytical model that describes how both cost of retailer effort and contract type impact retailer decisions and ultimately expected profit. This model provides the basis for a set of hypotheses that can be empirically tested in a laboratory setting. After a brief review of relevant literature in Section 1.2, we present our model in Section 1.3 that characterizes the retailer's equilibrium effort and supplier's profits as a function of retailer's cost of effort and contract. Our analytical model predicts that retailer effort will decrease as cost of effort increases and in the presence of a buyback. This creates changes in supplier expected profits that may shift their relative preferences for the wholesale price and buyback contract. We translate these results into predictions about rational, risk-neutral retailer decisions and supplier preferences between buyback and wholesale price contracts.

In Section 1.4, we test our hypotheses regarding retailer effort in a lab setting where retailers interact with a computerized supplier. The results of the experiment show that participants acting as retailers (1) exert lower effort under higher costs of effort and (2) exert less effort when offered the buyback contract than the wholesale price contract, supporting both our theoretical model and observed supplier aversion to buyback contracts. In Section 1.5, we test our predictions regarding supplier preferences experimentally by manipulating retailer cost of effort and the relative profitability of the two contracts. Results suggest that participants acting as suppli-

ers do not behave in a profit maximizing manner. However, their preferences can be linked to their suboptimal predictions of retailer effort under the buyback contract. In Section 1.6, we explore supplier preferences in a more realistic setting where no information about effort cost is available or only retailer business practices can be observed. We find a pattern of results consistent with our previous study in which suppliers were provided with explicit cost information. Notably, *we demonstrate that in the absence of cost information, participants behave as if the retailer has a high cost of effort and exhibit a strong preference for the wholesale price contract.* This suggests that suppliers are pessimistic, assuming a high cost of effort when no information is available. We conclude in Section 1.7 with a discussion of our results and their managerial implications.

## 1.2 Literature Review

This research draws on two main bodies of literature: (1) Supply chain contracts and (2) Principal agent theory. Below, we briefly review the relevant aspects of these literature streams in relation to our current research question.

### 1.2.1 Supply Chain Contracts

Within a supply chain context, a main goal of contract theory has been to design contracts that align the incentives of suppliers and retailers with those of the centralized supply chain. This stream of literature has provided dozens of recommendations for improving supply chain efficiency assuming that decision makers

choose parameters that maximize expected profits (Cachon 2003). A majority of this work, as well as the current work, focuses on contracts that alleviate the retailer's risk of overstocking perishable items (e.g., buyback contracts). Although buyback contracts have been proven to coordinate the supply chain in a general setting (see Tsay (2002) and Cachon (2003)), most of this work assumes that demand is exogenous and cannot be influenced by the retailer's actions.

A few papers study the effects of effort dependent demand on coordinating contracts. Cachon (2003) demonstrates that when demand can be influenced by costly, unverifiable retailer effort, buyback, revenue sharing, and sales rebate contracts fail to coordinate the supply chain. If the supplier cannot contract on retailer effort, then these coordinating contracts will distort the retailer's incentive for exerting effort. Both Taylor (2002) and Krishnan and colleagues (2004) expand upon these results. Taylor (2002) reaffirms that buyback and sales rebate contracts cause a distortion of retailer effort when demand is influenced by effort, with the former inducing too low an effort level and the latter inducing too high an effort level. Exploiting this difference in distortion, Taylor proves that a combination of the two contracts, although complex, can achieve coordination. Krishnan and colleagues (2004) extend the results of Cachon (2003) by showing that effort dependent demand distorts retailer effort even when the retailer can observe a signal of demand prior to specifying an effort level. In addition, the authors establish conditions under which constrained buyback contracts can achieve supply chain coordination. However, while these works rigorously study the adverse effects of costly effort on the efficiency of shared risk contracts in a theoretical sense, it is unclear whether this

potential inefficiency affects supplier preferences among contracts. Our work adds to this stream of literature by providing a clear link between these models of effort dependent demand and behavioral issues in practice.

In the past decade, there has been a developing interest in experimentally studying the impact of behavioral issues on the use of supply chain contracts in the newsvendor setting. This growing stream of literature has exposed consistent, sub-optimal behavior in contract usage due to a variety of behavioral biases. For example, research has examined why retailers tend to select sub-optimal order quantities (i.e. pull to center bias, anchoring, loss aversion, anticipated regret) and how these biases change across different types of contracts [Schweitzer and Cachon (2000), Bolton and Katok (2008), Becker-Peth et al. (2010), Davis (2011), Wu and Chen (2013)]. Other work within behavioral operations has tried to understand both retailer order quantities and supplier parameter selections by having each player interact with a computerized counterpart or in random pairs. These works reaffirm previous results regarding retailer behavior and add to the literature by showing that suppliers also make sub-optimal decisions (e.g., suppliers seek a more equitable distribution of profits than theoretically predicted; Keser and Paleologo (2004), Lim and Ho (2007), Ho and Zhang (2008), Katok and Wu (2009), Kalkanici et al. (2011)). Although this research sheds light on how human decision makers may misuse contracts, these papers quantify and characterize sub-optimal parameter setting provided that the contract type is fixed (i.e., choice of contract is exogenous).

In contrast to this earlier work that has examined retailer and supplier use of

contracts, we focus on an earlier stage in the decision process: contract selection. We highlight the fact that low retailer effort can have a deleterious effect on supplier profits for buyback contracts, potentially explaining why suppliers often choose a suboptimal wholesale price contract. Because retailers and suppliers often choose among contract types prior to implementing a contract, we believe it is important to understand which contracts suppliers prefer prior to seeing how the contract performs. One working paper exists that begins to address this question. Zhang et al. (2012) study supplier preferences between two, equivalent, coordinating contracts (buyback and revenue sharing). They show that loss aversion plays an important role in the choice between these two contracts. However, their paper makes the assumption that the supplier has already decided to use a coordinating contract. *Our work contributes to this stream of literature by going one step back in the decision process to understand why suppliers may prefer a wholesale price contract over a coordinating contract.* Controlling for behavioral biases such as loss aversion and anticipated regret that affect use of contracts, we demonstrate that concerns about effort dependent demand drive suppliers away from shared risk contracts.

### 1.2.2 Principal Agent Theory

The study of principal agent theory (early work includes Ross (1973)) and related challenges such as moral hazard (early work includes Arrow (1970) and Holmstrom (1979)) has existed for decades. Research on this topic is vast, spanning multiple disciplines, extensions, and research questions. Two extensions of this

problem that have begun to receive attention within the operations context are relevant to our work: (1) multitask principal agent models and (2) designing contracts for heterogeneous agents.

Holmstrom and Milgrim (1991) were the first to address the multitask principal agent model. Their work formalizes the problem and studies the interplay between incentives and multiple agent tasks that require effort. A series of papers within operations have studied a version of this model by examining incentives for salesforce compensation when inventory considerations are present [Chen (2000), Plambeck and Zenios (2003), Jerath et al. (2010), Saghafian and Chao (2011), Dai and Jerath (2013)].

One general commonality in the results of this stream of literature is that often, multiple types of incentives are needed to properly coordinate both effort decisions and quantity decisions. Research in this area has focused on understanding the tradeoff between effort and quantity decisions in order to design a set of incentives that adequately incentivizes both decisions simultaneously. Various combinations of incentives have been studied that coordinate both decisions including sales quotas, performance rates, inventory penalties, and contract renegotiation [Zenios (2003), Jerath et al. (2010), Saghafian and Chao (2011), and Dai and Jerath (2013)]. Given that the buyback contract is a single mechanism that incentivizes higher order quantity, neglecting the impact on retailer effort, these works suggest that the buyback contract requires further attention.

The second extension of a principal agent model that informs our work considers how to design incentives when facing heterogeneous agents. Within salesforce

compensation literature, Rao (1990) has studied how to design optimal incentives when a firm employs a salesforce with varying degrees of skill. The findings of this work show that a firm should offer a menu of options that specify sales quotas, bonuses for reaching sales quotas and commission rates above and below the quota, allowing agents to self-select into different incentive schemes. One paper in operations literature has extended this viewpoint to designing optimal contracts between suppliers and retailers assuming that retailers are heterogeneous (Koch and Peryache 2008). Koch and Peryache (2008) find that a one-size-fits-all contract can be optimal for a supplier to offer, however, this is contingent on current incentives impacting future labor markets. Just as salesperson skills may vary, so may a retailer's cost of exerting effort, which may impact which contract a supplier prefers to offer.

Our work draws on aspects of principal agent theory to explain supplier preferences between wholesale price and buyback contracts by considering that (1) a buyback is not a sufficient incentive when both quantity and effort decisions are considered and (2) retailers may vary in their cost of exerting effort. We contribute to this stream of literature by creating another link between principal agent theory and operations management to explain infrequent use of buyback contracts among suppliers.

### 1.3 Model and Hypotheses

Our goal is to understand whether the presence of costly retailer effort helps explain a supplier's choice between wholesale price and buyback contracts. Although

earlier work has incorporated effort dependent demand into a supply chain setting, [Taylor (2002), Krishnan et al. (2004), Cachon and Lariviere (2005)], research has yet to demonstrate how optimal retailer effort changes as a function of cost of effort potentially impacting which contract generates higher expected profits for the supplier. Therefore, we build a model that depends on the level of costly effort exerted by the retailer. We use this model to, first, analyze how retailer effort is impacted by both cost of effort and the presence of a buyback (Section 1.3.2). Then, we draw on previous results from Krishnan et al. (2004; referred to as KKB 2004 for the remainder of the paper) to demonstrate how retailer effort can affect supplier profits, thus defining when a risk-neutral, profit-maximizing supplier should be selecting the wholesale price contract as opposed to the buyback contract (Section 1.3.3).

The basic model studies a single, risk-neutral supplier who supplies a product to a single, risk-neutral retailer. The supplier incurs a per unit production cost of  $c > 0$  and is assumed to have sufficient capacity to meet demand. The retailer faces a fixed retail price  $r > c$  and salvage value  $v \leq c$ . He also faces, pre-effort, stochastic demand,  $\xi$ , that has distribution  $F(\xi)$  and density  $f(\xi)$ . As in KKB 2004,  $f(\xi) > 0$  for all  $\xi > 0$  which allows for the claim of strict concavity, strict monotonicity, and uniqueness of solutions. If inventories are not sufficient to fulfill demand, neither the retailer nor the supplier suffers any penalty aside from lost revenue.

With knowledge of  $\xi$ , the retailer may exert costly effort,  $\rho \geq 0$ , during the season in order to increase demand. As noted in KKB 2004, we assume demand is additively influenced by effort. Therefore effort dependent demand is  $\xi + \rho\kappa \geq \xi$

where  $\rho$  is the level of effort exerted and  $\kappa$  is the resulting additive increase in demand per unit of effort. The cost of effort for the retailer is  $C(\rho)$ , a convex, increasing function that is continuously differentiable with  $C(0) = 0$  and this cost function is known to both the retailer and the supplier. Furthermore, we assume that the cost of exerting effort varies by retailer and will denote the retailer's cost of effort with  $C^i(\rho)$ .

The sequence of events is as follows. First, the supplier sets a per unit wholesale price,  $w$ , to offer the retailer. Additionally, the supplier may choose to offer the retailer a per-unit end-of-season payment for left over items in the form of a buyback,  $b$ , where  $w > b > v$ . The retailer then places an order for  $q$  units and the supplier receives revenues  $(w - c)q$ . In the same manner as KKB 2004, we assume that both players know the retailer's cost of effort at the time the order quantity is placed. Therefore, the quantity and effort choice are simultaneous. The retailer considers his individual cost of effort ( $C^i$ ) and determines his order quantity ( $q$ ) based on the expected, effort dependent, regular season demand ( $\xi + \rho\kappa$ ). The retailer then sells  $S(q, \rho) = q - \int_0^q f(y)dy$  units in expectation, earning expected revenues  $rS(q, \rho) - wq - C_\rho^i$ .

After regular season demand,  $\xi + \rho\kappa$ , has occurred, the retailer has expected leftover inventory  $q - S(q, \rho)^+$ . This leftover inventory generates an expected end-of-season payment,  $v(q - S(q, \rho)^+)$  under the wholesale price contract and  $b(q - S(q, \rho)^+)$  under the buyback contract. As a result, the supplier incurs an expected end-of-season payment under the buyback contract.

### 1.3.1 Assumptions for Laboratory Implementation

The general setting defined above is studied so that we may empirically test retailer and supplier decisions experimentally. Therefore, we make two additional assumptions before generating our hypotheses that allow us to make direct comparisons between the model and our experiments without compromising the robustness of our results.

First, for both the remainder of this section and our laboratory experiments, we will simplify effort to a discrete choice. This means that the retailer can exert no effort,  $\rho = 0$ , resulting in no cost to the retailer and demand  $\xi$ . Alternatively, the retailer can exert one unit of effort,  $\rho = 1$ , resulting in a cost  $C_1$  to the retailer and demand  $\xi + \kappa$ , or two units of effort,  $\rho = 2$ , resulting in a cost  $C_2$  to the retailer and demand  $\xi + 2\kappa$ . Since cost of effort is assumed to be convex,  $2C_1 \leq C_2$ . We fix  $C_1$  for all retailers and let  $C_2^i$  denote the cost of effort for a retailer with cost  $i$ . This characterization of cost of effort is simple to explain to participants yet, does not change the underlying structure of our defined model.

The second assumption made for the sake of laboratory experiments is that we do not explicitly study supplier-optimal contract parameters  $w$  and  $(w_b, b)$ . Instead, we select a  $w$  and  $(w_b, b)$  in our experiments to satisfy two conditions: (1) the retailer earns a reasonable portion of the supply chain profits and (2) the difference in  $w$  and  $w_b$  is negligible. There are two justifications for our selection of  $w$  and  $(w_b, b)$ .

First, the supplier-optimal contract parameters for both contracts provide the supplier with a large majority of the supply chain profits. The buyback contract

can produce an infinite number of coordinating  $(w_b, b)$  pairs each with a different distribution of profits between the retailer and supplier. The supplier-optimal  $(w_b, b)$  pair gives all of the supply chain profit to the supplier. Under the wholesale price contract, the unique supplier-optimal  $w$  distributes a large portion of the total supply chain profits to the supplier. Previous works have shown that participants prefer a more equitable distribution of profits (Kalkanci et al. 2011) and therefore this may be perceived as unfair in our experiments, creating unwanted effects. In addition, business press suggests that retailers and suppliers in practice set wholesale prices such that retailers achieve a profit of 30% or more (Associated Press, 2005).

Second, the optimal  $(w_b, b)$  and  $w$  for the supplier may be such that  $w_b$  is drastically different than  $w$ . This difference may draw participants' attention to the per unit price charged when selecting a contract type, creating a reference effect in which the contract with the larger per unit price appears unfair. This unwanted effect could complicate the analysis of our results. Additionally, business press and our own interviews with fashion retailers and suppliers would suggest that wholesale prices charged are similar regardless of the presence of a buyback. For example, during our interview with the VP of Financial Planning and Analysis at a large fashion supplier, he stated that wholesale prices are typically set as a fixed fraction of the retail price. In addition, in explaining the negotiation process, an article in Associated Press (2005) provides additional support for this, stating that the wholesale price is determined prior to shipment and set as a percentage of the retail price.

With these assumptions in mind, we explore the impact of a buyback contract

on retailer effort when retailers have different costs of effort. We then examine the effect of retailer effort on supplier expected profits under both the wholesale price and buyback contract. In keeping with our laboratory assumptions, the analysis below assumes discrete retailer effort and  $|w - w_b| < \epsilon$  with  $\epsilon \rightarrow 0$ . We use the analysis to generate four potential outcomes, achieved by manipulating two factors, for which we can make specific predictions regarding supplier preferences (see Table 1.1): (1) high cost of effort and wholesale price contract is more profitable, (2) high cost of effort and buyback contract is more profitable, (3) low cost of effort and wholesale price contract is more profitable, (4) low cost of effort and buyback contract is more profitable. These four cases will allow us to study whether supplier preferences are driven by expected profits or the level of costly retailer effort exerted.

Table 1.1: Potential Comparisons of Supplier Expected Profits

		Greater Supplier Expected Profit	
		Wholesale Price	Buyback
Retailer	High	Case 1: $\pi_S > \pi_S^b, \rho \geq \rho_b$	Case 2: $\pi_S < \pi_S^b, \rho \geq \rho_b$
Effort Cost	Low	Case 3: $\pi_S > \pi_S^b, \rho = \rho_b$	Case 4: $\pi_S < \pi_S^b, \rho = \rho_b$

### 1.3.2 The Retailer Selection of Effort and Quantity

In this setting, the retailer's profit functions, which include effort ( $\rho$ ) and cost of effort ( $C_1$  and  $C_2^i$ ) are given by (where a superscript of  $b$  denotes the buyback

contract):

$$\pi_R = -wq + rS(q, \rho) + v(q - S(q, \rho))^+ - C_\rho^i \quad (1.1)$$

$$\pi_R^b = -wq + rS(q, \rho) + b(q - S(q, \rho))^+ - C_\rho^i \quad (1.2)$$

We establish the retailer's optimal level of effort and order quantity jointly. To do this, we assume that the retailer considers all possible  $\rho$  and  $q$  pairs, and selects the one that maximizes retailer profit. The retailer considers three pairs of decisions when maximizing profit: (1) he can exert no effort ( $\rho = 0$ ) and place the optimal newsvendor order quantity ( $q$  or  $q^b$ ) assuming demand is  $\xi$ ; (2) he can exert one unit of effort ( $\rho = 1$ ) and place the optimal newsvendor order quantity ( $q_1$  or  $q_1^b$ ) assuming demand is  $\xi + \kappa$ ; or, (3) he can exert two units of effort ( $\rho = 2$ ) and place the optimal newsvendor order quantity ( $q_2$  or  $q_2^b$ ) assuming demand is  $\xi + 2\kappa$ . Each level of effort increases the quantity decisions ( $q < q_1 < q_2$ ,  $q^b < q_1^b < q_2^b$ ,  $q < q^b$ ,  $q_1 < q_1^b$ , and  $q_2 < q_2^b$ ) but increases the retailer's cost ( $C_1$  and  $C_2^i$ ).

**Observation 1.1.** *The retailer's optimal level of effort,  $\hat{\rho}$  or  $\hat{\rho}^b$  is weakly decreasing in cost of effort. More specifically:*

- $\hat{\rho} = 2$  when  $C_2^i < \Delta_2$  under the wholesale price contract ( $C_2^i < \Delta_2^b$  under the buyback contract).
- $\hat{\rho} = 1$  when  $C_2^i > \Delta_2$  and  $C_1 < \Delta_1$  under the wholesale price contract ( $C_2^i > \Delta_2^b$  and  $C_1 < \Delta_1^b$  for the buyback contract).
- $\hat{\rho} = 0$  when  $C_2^i > \Delta_2$  and  $C_1 > \Delta_1$  under the wholesale price contract ( $C_2^i > \Delta_2^b$  and  $C_1 > \Delta_1^b$  for the buyback contract).

Where the following expressions describe the breakpoints given in Observation

1.1:

$$\Delta_2 = (v - w)(q_2 - q_1) + (r - v)(S(q_2, 2) - S(q_1, 1)) + C_1$$

$$\Delta_2^b = (b - w)(q_2^b - q_1^b) + (r - b)(S(q_2^b, 2) - S(q_1^b, 1)) + C_1$$

$$\Delta_1 = (v - w)(q_1 - q) + (r - v)(S(q_1, 1) - S(q))$$

$$\Delta_1^b = (b - w)(q_1^b - q^b) + (r - b)(S(q_1^b, 1) - S(q^b))$$

It has been shown that when demand is influenced by effort, the buyback contract is no longer coordinating because retailer decisions are not aligned with the integrated supply chain (Taylor 2002, KKB 2004, Cachon and Lariviere 2005). While a buyback contract is able to achieve a first best solution in the case of random, exogenous demand, this is no longer the case when the retailer can exert costly effort. KKB 2004 explicitly show that by offering an end-of-season payment, the supplier distorts the retailer's incentive to exert effort, therefore decreasing (1) the optimal retailer effort level  $\hat{\rho}(i)$  (denoted  $\hat{\rho}$  for ease of exposition throughout) and (2) the supplier's profit for a given cost of effort ( $i$ ).

We build on KKB 2004 to establish a link between retailer cost of effort ( $i$ ) optimal effort/quantity decision pairs, and subsequently, supplier profits. As the retailer's type ( $i$ ) increases, it becomes more expensive for the retailer to exert effort to stimulate demand. Therefore, as cost of effort increases, the retailer switches from exerting two units of effort,  $\rho = 2$ , to one unit of effort,  $\rho = 1$  (See Figure 1.1).

When considering profits earned under each contract, simple comparison shows that the retailer's profit function is always increasing in  $b$  and, in equilibrium, the

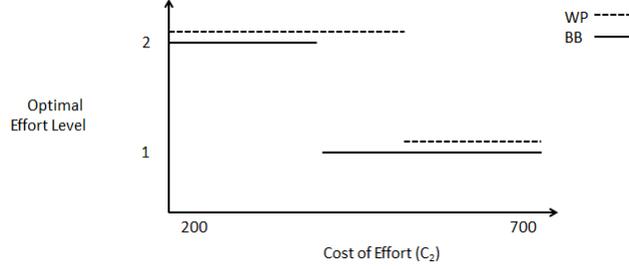


Figure 1.1: **Optimal Retailer effort** ( $\hat{\rho}$  and  $\hat{\rho}^b$ )

For  $C_1=100$ ,  $\xi$  uniformly distributed on  $[110, 510]$ ,  $\kappa = 60$ ,  $w = 40$ ,  $(w^b, b) = (40.5, 38)$

retailer can be better off when a buyback contract is offered (KKB 2004). However, Observation 1.1 shows that the optimal level of effort,  $\hat{\rho}$ , exerted is determined by the tradeoff between expected increase in revenue due to higher demand and order quantity, and the cost of increasing the demand. What is left to consider is which contract induces more retailer effort. KKB (2004) specifically show that for a fixed  $w$ , as  $b$  increases,  $\hat{q}$  increases while  $\hat{\rho}$  decreases. Therefore, by using this single metric of a buyback, we incentivize one retailer decision (quantity) while simultaneously disincentivizing another (effort). For our case of discrete units of effort, we find the same result.

As seen in Observation 1.1, the breakpoint between 0 units of effort, 1 unit of effort, and 2 units of effort is different for each contract. The main difference in breakpoints for contract type is the difference between  $b$  and  $v$ . Given that  $b$  is greater than  $v$ ,  $q_1 < q_1^b$ , and  $q_2 < q_2^b$  we can see that the breakpoint for exerting  $\hat{\rho}$  is smaller with the wholesale price contract. More specifically, the retailer exerts 2 units of effort across a larger range of costs of effort with the wholesale price

contract than with the buyback contract. Similarly, in part (b) of Observation 1.1, the retailer stops exerting one level of effort, reverting to no effort, over a wider range of effort costs with the buyback contract than the wholesale price contract.

**Observation 1.2.** *The retailer exerts a higher level of effort,  $\hat{\rho}$  or  $\hat{\rho}^b$ , for a greater range of effort costs under the wholesale price contract than the buyback contract.*

### 1.3.3 The Supplier's Contract Choice

We will now consider how the presence of costly, retailer effort impacts supplier expected profits and, subsequently, their choice between wholesale price and buyback contracts. Let supplier expected profits under the wholesale price and buyback (denoted with a superscript  $b$ ) contracts, respectively, be given by:

$$\pi_S = (w - c)q \tag{1.3}$$

$$\pi_S^b = (w_b - c)q^b - b(q^b - S(q^b, \rho)^+) \tag{1.4}$$

In this setting (studied in KKB 2004), we observe a major downfall of the buyback contract in a setting where demand is effort-dependent. Although the presence of buyback increases the retailer's optimal order quantity,  $\hat{q}_b$ , it decreases their optimal level of effort,  $\hat{\rho}_b$ . Therefore, in our model with  $|w - w_b| < \epsilon$  and the retailer receiving a reasonable portion of the supply chain profits, the supplier can earn a lower level of expected profit when offering a buyback contract as opposed to a wholesale price contract<sup>1</sup>. Thus, we see that when demand is effort-dependent (1) retailer decisions

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<sup>1</sup>In a more general setting, such as that in KKB 2004, it can be the case that for any  $w$ , all  $b > 0$  result in lower expected profits for the supplier.

are impacted by the cost of effort, subsequently impacting supplier expected profits and (2) the supplier can earn lower expected profit with the buyback contract. In light of this, we study how supplier preferences for contracts are impacted by two factors: (1) retailer cost of effort and (2) expected profit of the contracts. By manipulating two factors independently along two dimensions, we are able to determine whether contract choice is driven by rational expected profit maximizing behavior.

With our model completely defined, we now explain how the four cases described in Table 1.1 are constructed. Consider Case 1 when the retailer has a high cost of effort but the wholesale price contract achieves higher expected profit (i.e.,  $\pi_S > \pi_S^b$ ). Here, we have that  $\rho > \rho_b$  and the retailer orders  $q$  anticipating a higher demand distribution than if placing an order for  $q_b$  producing higher expected profits for the supplier with the wholesale price contract. If we slightly alter only  $C_2$  such that the retailer's cost of effort still remains relatively large but, the retailer now exerts higher effort under the buyback contract than in Case 1 (for the same  $w$  and  $(w_b, b)$ ) and we now have  $\pi_S < \pi_S^b$ , resulting in Case 2. If we keep all parameters the same but significantly decrease  $C_2$  such that the retailer now has a relatively low cost of effort, the buyback contract still outperforms the wholesale price contract producing Case 4. Finally, keeping all else equal, if we increase the salvage value, this increases the retailer's order quantity under the wholesale price contract while leaving  $q_b$  as in Case 4 (since  $b > v$ ). Therefore, while maintaining a low cost of retailer effort, we can again observe a flip in supplier expected profits (i.e.,  $\pi_S > \pi_S^b$ ), producing Case 3.

We can now make clear predictions of retailer and supplier behavior that are

testable experimentally. Below, we formally define our hypotheses.

### 1.3.4 Hypotheses

Below, we present four hypotheses regarding retailer and supplier behavior that can be used to test how the presence of costly retailer effort impacts supplier preferences between contracts.

Observation 1.1 and previous literature (Cachon 2003, KKB 2004) suggest that when retailer effort is a decision variable, the presence of a buyback decreases the amount of equilibrium effort the retailer will exert. Thus, retailers should exert lower levels of effort when presented with a buyback contract as compared to a wholesale price contract.

**Hypothesis 1.1.** *Retailers will exert less effort when offered the buyback contract as compared to the wholesale price contract.*

Although previous work has studied buyback contracts in the presence of costly retailer effort (Cachon 2003, KKB 2004), our work considers heterogeneous retailers, distinguishing between retailers who have low and high effort costs. As demonstrated in the model above, retailer effort is decreasing in cost of effort, regardless of contract type. Therefore, we predict that retailers will exert lower levels of effort when told they have a high cost of effort as compared to a low cost of effort.

**Hypothesis 1.2.** *Retailers will exert less effort when they have a high cost of effort compared to a low cost of effort.*

These predictions of retailer behavior have implications for supplier decisions.

In determining which contract will generate greater expected profit, the supplier must anticipate retailer decisions to accurately determine his own expected profits. It has been theoretically shown that when offering the buyback contract, the retailer will exert lower levels of effort than under the wholesale price contract for both continuous (KKB 2004) and discrete forms of effort. Therefore, the rational supplier will correctly anticipate this.

**Hypothesis 1.3.** *Suppliers will predict a lower level of retailer effort when offering the buyback contract as compared to the wholesale price contract.*

Finally, we consider supplier preferences between the wholesale price and buyback contract. Theoretical results (see KKB 2004) demonstrate that when retailer effort is a decision variable, supplier profits under the buyback contract can be either better or worse than under the wholesale price contract. Therefore a rational, profit-maximizing supplier will offer the wholesale price contract to the retailer when it earns greater expected profit and will offer the buyback contract when it earns greater expected profit. More specifically, we hypothesize that suppliers' preferences may be driven by expected profits.

**Hypothesis 1.4a.** *Profit-maximizing suppliers will select the wholesale price contract when  $\pi_S > \pi_S^b$  and the buyback contract when  $\pi_S < \pi_S^b$ , regardless of the retailer's cost of effort.*

While the assumption of a rational, profit-maximizing decision maker is reasonable, a growing stream of work in behavioral operations suggests that not all decision makers adhere to profit-maximizing decision rules. The use of heuristics

(i.e., mental shortcuts) by human decision makers is well documented (see Tversky and Kahneman (1974) and Tversky and Kahneman (1981) for early work) especially when tasks are complex (see Bettman, Johnson, and Payne 1991 for a review). For example, for complex choices involving multiple attributes, decision makers may employ a lexicographic rule (Hogarth 1990), focusing on a single attribute of the task ignoring other attributes and potentially relevant information.

When evaluating which contract to offer, although suppliers are concerned with expected profits, the interviews and articles discussed in Section 1.1 suggest that suppliers also value high retailer effort. It may be difficult for a decision maker to determine exactly when the switch in profitability occurs between the wholesale price and buyback contract. Therefore, rather than focus on both retailer effort and expected profits (a cognitively difficult task), the supplier may focus solely on the outcome of retailer effort. A supplier, concerned with high retailer effort, can easily employ an effort cost heuristic in which he links a low cost of effort (high cost of effort) with high retailer effort (low retailer effort). Operating under this heuristic, a supplier may choose to offer the buyback contract to the retailer only when he anticipates high effort and the wholesale price contract when he anticipates low effort, disregarding expected profits. Therefore, supplier preferences could be driven by an effort cost heuristic rather than expected profit.

**Hypothesis 1.4b.** *Suppliers relying on an effort cost heuristic will be less likely to choose the buyback contract relative to the wholesale price contract when they know that the retailer has a high cost of effort versus when the retailer has a low cost of*

*effort.*

In the following sections we report three experiments conducted to test our hypotheses.

## 1.4 Study 1: Retailer Effort Decisions

The theoretical results presented in Section 1.3 provide insight on how a retailer makes effort decisions under both the wholesale price and buyback contract. Therefore, in Study 1, we examine experimentally how cost of effort affects retailer effort decisions under both types of contract.

### 1.4.1 Procedures

The study was conducted with 52 Master's degree students in Supply Chain Management at a large university in the Eastern United States who were compensated via an incentive compatible lottery. Participants were randomly assigned to a 2 (effort cost: low cost, high cost) x 2 (contract type: wholesale price, buyback) design in which effort cost was manipulated between subjects and contract type was manipulated within subjects. Initially, participants were told that they worked for a fashion retail store (i.e., they were acting as the retailer) and would be purchasing shoes from an automated supplier to sell at their store. Their task was to determine how much effort to exert during the selling season in order to sell the shoes. This decision was made by each participant twice, in two separate selling seasons, facing two separate suppliers. Prior to making this effort decision, participants were given

the following information about product cost/demand, contract type offered by the supplier, and their own cost of effort.

#### 1.4.1.1 Cost/Demand Information

At the beginning of each selling season, participants were presented with per unit production cost (in francs) and demand information. Specifically, they were told that each pair of shoes had a per unit production cost,  $c = 18$ , and could be sold by the retailer for  $r = 48$  with a salvage value of 8 francs. They then learned that they face a base level of random demand,  $\xi$ , uniformly distributed over  $[110,510]$ .

#### 1.4.1.2 Contract Type

In one season, participants were told that the automated supplier offered a wholesale price contract while in the other season the automated supplier offered a buyback contract (order of presentation was randomized). Each contract was presented in diagram form supplemented by text (see Appendix for diagrams). In the wholesale price condition for both high and low cost cells, participants were told that the supplier charged  $w = 40$  francs for wholesale price. In the buyback contract condition, they were told that the supplier charged  $w = 40.5$  per unit with a  $b = 38$ .

Next, we told participants the order quantity for their contract type. This quantity was set to be the optimal order quantity assuming an optimal effort decision. We automated this decision for two reasons: (1) having participants maximize

expected profits over two variables is a much more complicated problem than over one and (2) it would not be possible to isolate the effect of cost type on effort decisions if participants selected both. Under the wholesale price contract, the retailer purchased 310 units, regardless of their cost type. When offered the buyback contract, the retailer ordered 530 units in the low cost condition (where optimally the retailer exerted  $\hat{\rho} = 2$ ) and 470 units in the high cost condition (where optimally the retailer exerted  $\hat{\rho} = 1$ ).

#### 1.4.1.3 Retailer Effort Cost

Finally, participants were informed that during the selling season, they could exert effort to additively increase demand, but this effort came at a monetary cost. In all conditions, the participants faced three options. If he chose to exert no effort ( $\rho = 0$ ), this keeps the demand distributed between [110,510] and cost nothing. The participant could exert either one or two units of effort, with each unit increasing demand by 60 (i.e., one unit of effort results in demand [170,570] and two units of effort results in demand [230,630]). In all conditions, one unit of effort,  $\rho = 1$  resulted in a cost of 200 francs. The cost to exert the second unit of effort,  $\rho = 2$ , varied by cell. In the high cost condition, the cost to exert the second unit of effort was 455 francs (655 francs in total). In the low cost condition, the cost to exert the second unit of effort was an additional 250 francs (450 francs in total).

#### 1.4.1.4 Dependent Measures

Following the presentation of information for each season, participants were asked “what level of effort would you like to exert?” This dependent measure provided a test of both H1.1 and H1.2 which proposes that retailers exert less effort under the buyback contract and retailers exert less effort when they have a higher cost of effort.

In each season, after the participants made their effort decisions, demand was randomly drawn from the appropriate distribution and profits were calculated in terms of francs. Participants were rewarded with an incentive compatible lottery in which the winner received \$100. Each franc of profit earned increased a participant’s probability of winning the lottery. Therefore, higher profits were linked to a greater chance to win the \$100.

#### 1.4.2 Results

Table 2.2 displays the results of Study 1. As predicted by H1.1, participants exerted higher levels of effort under the wholesale price contract than under the buyback contract. While all participants in the wholesale price condition chose to exert at least some effort ( $\rho = 1$  or  $2$ ), 19% of participants in the buyback contract condition chose to exert no effort ( $\rho = 0$ ). We conducted a 2x3x2 log-linear analysis to examine the effects of cost type and contract type on participant effort choice (Table 1.3).

As predicted, the interaction between cost type and effort choice indicates

Table 1.2: Summary of Study 1 Results

	Effort Choice WP			Effort Choice BB			N
	No	Low	High	No	Low	High	
	$\rho = 0$	$\rho = 1$	$\rho = 2$	$\rho = 0$	$\rho = 1$	$\rho = 2$	
High Cost	0%	52%	48%	15%	70%	15%	27
Low Cost	0%	24%	76%	24%	48%	28%	25

that, participants chose to exert more effort when cost was low as opposed to high, confirming H1.2. The significant interaction between contract type and effort choice indicates that as predicted by H1.1, participants chose to exert more effort under the wholesale price contract than under the buyback contract.

Finally, the three-way interaction between cost type, effort choice, and contract type demonstrates that when participants decide how much effort to exert, their choice is significantly impacted by both their cost type and the contract offered to them. More specifically, effort choice was less responsive to cost type when participants were offered the buyback contract than when they were offered the wholesale price contract. In comparing effort choices across condition for each contract, we find that while the difference in effort choice is marginally significant between high and low cost conditions for the wholesale price contract ( $\chi^2 = 5.68$ ,  $p = 0.058$ ), the difference is not significant for the buyback contract ( $\chi^2 = 2.73$ ,  $p = 0.255$ ).

Table 1.3: Retailer Effort Choices: Log Linear Analysis

	$G^2$	DF	P-value
Cost type x Effort Choice	6.62	2	0.036
Cost type x Contract type	0	1	1
Effort Choice x Contract type	26.96	2	<.001
3-way interaction	34.06	7	<.001

### 1.4.3 Discussion

By manipulating both cost type and contract type in Study 1, we have gained interesting insights into how retailer's select effort under wholesale price and buy-back contracts. We draw two conclusions from our results. First, in support of H1.1, in both the low and high cost conditions, participants chose to exert a higher level of effort under the wholesale price contract, with zero participants choosing to exert  $\rho = 0$ . Second, in support of H1.2, participants chose to exert higher levels of effort in the low cost condition, particularly for the wholesale price contract, with a large percentage of participants choosing to exert high effort (76%).

Notably, we observe that regardless of effort cost, retailers choose to exert consistently lower effort than is optimal. Although in the high cost condition the majority of participants exerted the optimal effort of one unit ( $\rho = 1$ ) under the buyback contract (76%), in the low cost condition, the highest weighting was still on one unit of effort (48%) when two units of effort is optimal. This suggests that not only does the buyback contract incentivize a lower optimal level of effort but,

participants exerted suboptimally lower effort levels when offered the buyback contract.

For the supplier, this implies that even when, theoretically, the buyback contract is the superior choice, the retailer may exert less effort than is optimal for the supplier's profits. Our results, therefore, suggest that the buyback contract introduces expectations of lower retailer effort, lending potential support to supplier's revealed preference for wholesale price contracts.

Now that we understand how the presence of costly effort affects retailer decisions, we can examine how the presence of costly effort affects supplier preferences.

## 1.5 Study 2: Supplier Contract Choice

While the majority of previous experimental work in the newsvendor setting has focused on behavioral biases affecting sub-optimal quantity and pricing decisions, one decision that has gained little attention is how suppliers choose which contract to use. In line with the predictions made in Section 1.3, Study 2 was designed to measure suppliers' preferences between contract types as retailer cost of effort varies, affecting which contract produces greater expected profit for the supplier. Therefore, whereas Study 1 is from the retailer's perspective, Study 2 reverses the role of the participant.

### 1.5.1 Procedures

As in our theoretical model, we compare supplier choices between wholesale price and buyback contracts when retailers are known to have low versus high cost and when either the wholesale price or buyback contract generates higher expected profits. Thus, the experimental design was 2 (retailer effort cost: low cost, high cost) x 2 (greater expected profit: wholesale price, buyback), where both effort cost and greater expected profit were manipulated between subjects.

Study 2 was conducted with 95 participants using an online participant pool managed by a large university in the Eastern United States. Initially, participants were told that they worked for a woman's shoe manufacturing company (i.e., they were acting as the supplier) and would be selling boots to an (automated) retailer during a single Fall selling season. Their task was to select a contract type to offer the retailer. Given that the focus of the Study 2 is to gain insight about why suppliers choose not to *adopt* buyback contracts, this single interaction eliminates participant learning. Prior to selecting a contract, participants were given the following information about product cost/demand, retailer effort cost, and contract types <sup>2</sup>.

#### 1.5.1.1 Cost/Demand Information

At the start of the season, participants were presented with per unit production cost (in francs) and demand information. Specifically, they were told that boots had

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<sup>2</sup>See Appendix for screenshots.

a per unit production cost,  $c = 18$ , and could be sold by the retailer for  $r = 48$  with a salvage value of 8 francs in the three conditions that correspond to Case 1, Case 2, and Case 4 from Section 1.3. However, in the low cost cell when the wholesale price contract has greater expected profit (Case 3), the salvage value was listed as 21 francs. They then learned that the retailer faces random demand,  $\xi$ , uniformly distributed over [110,510].

### 1.5.1.2 Retailer Effort Cost

After the cost/demand information were presented, participants were informed that during the selling season, the automated retailer could exert effort to additively increase demand, but this effort came at a monetary cost to the retailer. If the automated retailer exerted no effort ( $\rho = 0$ ), this kept the demand distributed between [110,510] and cost the retailer nothing. Participants were then informed that the automated retailer could exert either one or two units of effort, with each unit increasing demand by 60 (i.e., one unit of effort resulted in demand [170,570] and two units of effort resulted in demand [230,630]). In each of the four cells, one unit of effort,  $\rho = 1$  resulted in a cost of 200 francs. The cost of exerting the second unit of effort,  $\rho = 2$ , varied by cell.

In Case 1, when cost of effort is high and the wholesale price contract generates greater expected profit, the cost of exerting the second unit of effort is 455 francs (655 francs in total). In Case 2, when the cost of effort is still high but the buyback contract generates greater expected profit, the cost of exerting the second unit of

effort is 445 francs (645 francs in total). When cost of effort is low, for either contract generating higher expected profit (Cases 3 and 4), the cost of exerting the second unit of effort was an additional 250 francs (450 francs in total). These parameters were selected so that, under the wholesale price contract, the optimal retailer effort is high ( $\hat{\rho} = 2$ ) in both the low and high cost conditions. However, when offered the buyback contract, the automated retailer optimally exerts high effort ( $\hat{\rho}^b = 2$ ) when cost is low but only one unit of effort ( $\hat{\rho}^b = 1$ ) when the cost is high. Given this set of parameters, the automated retailer was programmed to select the optimal level of effort for the given condition as described in Table 1.4. Although participants were not provided with this table, they were informed that the automated retailer would behave as a risk-neutral profit maximizing agent.

Table 1.4: Summary of Optimal Retailer Decisions in Experiment

	Wholesale price Greater $\pi_S > \pi_S^b$		Buyback Greater $\pi_S < \pi_S^b$	
	WP	BB	WP	BB
High	$\hat{\rho} = 2$	$\hat{\rho}^b = 1$	$\hat{\rho} = 2$	$\hat{\rho}^b = 2$
Cost	$\hat{q} = 310$	$\hat{q}^b = 470$	$\hat{q} = 310$	$\hat{q}^b = 530$
Low	$\hat{\rho} = 2$	$\hat{\rho}^b = 2$	$\hat{\rho} = 2$	$\hat{\rho}^b = 2$
Cost	$\hat{q} = 349$	$\hat{q}^b = 530$	$\hat{q} = 310$	$\hat{q}^b = 530$

### 1.5.1.3 Contract Types

Finally, participants were presented with the two contract types they could choose to use, a wholesale price contract or a buyback contract. Each contract was presented in diagram form<sup>3</sup> supplemented by text and their order of presentation was randomized. Examples were provided for each contract to ensure familiarity. Because our focus was contract preference rather than parameter setting, the participants were given contract parameters for each contract ( $w = 40$  francs for wholesale price and  $w = 40.5, b = 38$  for the buyback contract) as well as the optimal resulting retailer order quantities (as summarized in Table 1.4). These contract parameters were selected so that we could observe a flip in which contract type produced greater expected profits in both the high and low cost conditions. If the participant offered the retailer the wholesale price contract, the automated retailer purchases 310 units in Case 1, Case 2, and Case 4 and 349 units in Case 3. If the participant offered the buyback contract, the automated retailer orders 530 units when the retailer is a low cost type (exerts  $\hat{\rho} = 2$ ) and 470 units when the retailer is a high cost type (exerts  $\hat{\rho} = 1$ ).

### 1.5.1.4 Dependent Measures

After these pieces of information were presented, two dependent measures were collected. First, to test H1.3, participants were asked, for *both* contracts, “what level of effort do you expect the retailer to exert?” We expected suppliers to predict that

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<sup>3</sup>The same diagrams from Study 1 were used in Study 2 to explain the contract types.

retailers would exert less effort under the buyback contract than under the wholesale price contract. Then, to test H1.4a and H1.4b, participants were asked “which contract would you like to offer the retailer?” H1.4a predicts that suppliers display a stronger preference for the contract with the greater expected profit. H1.4b predicts that suppliers would exhibit a stronger preference for the buyback contract when the retailer has a low cost of effort as compared to a high cost of effort, regardless of which contract produced greater profits.

At the end of the study, subjects completed four scales measuring individual differences in (1) numeracy (Fagerlin et al. 2007), (2) anticipated regret (Kugler et al. 2009), (3) loss aversion (Zhang et al. 2012), and (4) risk aversion (Weber et al. 2002). Previous work in experimental supply chain contracts has shown that complexity, anticipated regret, risk aversion and loss aversion can affect a participants’ performance in correctly using contracts. These measures were used to control for the effects of these individual differences on contract choice.

Once the participants responded to the dependent measures, demand was randomly generated (from the appropriate distribution) and profits in terms of francs were displayed.

### 1.5.2 Results

Table 1.5 and Table 1.9 present the results of Study 2 for supplier predictions of retailer effort and supplier preferences between contracts, respectively. We will first discuss the effects of retailer cost type and contract type on effort predictions.

Following this, we test for significant differences in supplier contract preferences across cost type and greater expected profit conditions.

Table 1.5: Summary of Study 2 Effort Prediction Results

	Effort	Predictions for WP Contract			Predictions for BB Contract		
		No	Low	High	Not	Low	High
		$\rho = 0$	$\rho = 1$	$\rho = 2$	$\rho = 0$	$\rho = 1$	$\rho = 2$
High Cost	WP Greater	12%	56%	32%	64%	24%	12%
	BB Greater	17.4%	65.2%	17.4%	52.2%	30.4%	17.4%
Low Cost	WP Greater	8%	44%	48%	32%	52%	16%
	BB Greater	9%	45.5%	45.5%	18.2%	63.6%	18.2%

### 1.5.2.1 Supplier Predictions of Retailer Effort

To test H1.3, participants were asked to predict the level of effort they thought the retailer would exert if offered the wholesale price and buyback contract. As expected, participants predicted higher levels of effort for the wholesale price contract. When cost of effort was high, 41 out of 48 participants predicted higher effort under the wholesale price contract (85.4%) and when cost of effort was low, 41 out of 47 participants predicted higher effort under the wholesale price contract (85.1%). To study this effect more rigorously, we conducted two log-linear analyses, one for the condition when the wholesale price contract has greater expected profit and one for the condition when the buyback contract has greater expected profit. Each log-linear analysis is 2x2x3 (Cost of Effort x Contract Type x Effort Prediction) and

will be used to examine the effect of contract type and cost of effort on participant effort predictions (see Table 1.6 and 1.7).

Table 1.6: Supplier Predictions of Effort for WP Greater Condition: Log Linear Analysis

	$G^2$	DF	P-value
Cost Type x Effort Prediction	5.14	2	0.076
Cost Type x Contract Type	0.02	1	0.887
Effort Prediction x Contract Type	20.9	2	<0.0001
3-way interaction	27.78	7	0.0002

Table 1.7: Supplier Predictions of Effort for BB Greater Condition: Log Linear Analysis

	$G^2$	DF	P-value
Cost Type x Effort Prediction	6.42	2	0.04
Cost Type x Contract Type	0	1	1
Effort Prediction x Contract Type	6.72	2	0.034
3-way interaction	17.58	7	0.014

As predicted by H1.3, participants believed that retailers would exert less effort when offered the buyback contract than when offered the wholesale price contract, resulting in a 2-way interaction between contract type and effort prediction for both the case when the wholesale price contract produced greater expected profit and the buyback contract produced greater expected profit. As expected, participants believed that effort cost would significantly affect the level of effort

Table 1.8: Supplier Predictions of Effort Collapsing Across Expected Profit Condition: Log Linear Analysis

	$G^2$	DF	P-value
Cost Type x Effort Prediction	9.14	2	0.010
Cost Type x Contract Type	0.64	1	0.424
Effort Prediction x Contract Type	29.6	2	<0.0001
3-way interaction	41.06	7	< 0.0001

exerted by retailers, resulting in a significant 2-way interaction between cost of effort and effort prediction when the buyback contract has greater expected profit. Although this result is only marginally significant when we limit the analysis to those conditions in which the WP contract was more profitable, we observe the same pattern of means regardless of which contract was more profitable. Finally, as shown by the significant 3-way interaction among the factors in both log-linear analyses, participants predicted larger differences between high and low cost retailers under the wholesale price contract than under the buyback contract. No other effects were significant. Collapsing across the expected profit condition we find similar results (see Table 1.8).

### 1.5.2.2 Supplier Choice

In Table 1.9, we observe a stronger preference for the buyback contract relative to the wholesale price contract in the low cost conditions than in the high cost conditions. A chi-squared analysis shows that when either the wholesale price contract or

Table 1.9: Summary of Study 2 Contract Choice Results

		Contract Yielding Higher Expected Profit	
		WP	BB
Effort	High	84%WP	82.6% WP
		16%BB	17.4% BB
Cost	Low	28% WP	27.3% WP
		72% BB	72.7% BB

the buyback contract has greater expected profit, participants exhibited a stronger preference for the buyback contract in the low cost condition than in the high cost condition ( $\chi^2(1) = 13.72$ ,  $p=0.0002$ ) for WP greater,  $\chi^2(1) = 11.79$ ,  $p=0.0006$  for BB greater. Additionally, we see that the contract with greater expected profit had no significant impact on participant contract choices ( $\chi^2(1) = 0.07$ ,  $p=0.7913$ ) for high cost and ( $\chi^2(1) = 0.07$ ,  $p=0.7913$ ) for low cost). Again, we conducted a 2x2x2 (Contract Choice x Effort Cost x Greater Expected Profit) to examine these effects more closely (see Table 1.10 for results).

Table 1.10: Supplier Contract Choice: Log Linear Analysis

	$G^2$	DF	P-value
Contract Choice x Effort Cost	31.74	1	<0.0001
Contract Choice x Greater Expected Profit	0	1	1
Effort Cost x Greater Expected Profit	0.02	1	0.8875
3-way interaction	31.78	4	<0.0001

As predicted by H1.4b cost of effort has a significant effect on contract selec-

tion, as demonstrated by the significant two way interaction. Thus, participants were significantly more likely to select the buyback contract when the retailer was known to have low cost of effort. In contrast, participants preferred the wholesale price contract when cost of effort was high. There is however, no significant interaction between contract choice and which contract generates greater expected profit, indicating that expected profit did not drive choices. Rather, we see evidence that effort cost drove choices, leading us to reject H1.4a which states expected profits drive preferences.

### 1.5.3 Discussion

Study 2 manipulated effort cost and expected profit of contracts between subjects and contract type within subjects allowing us to test H1.3 and H1.4a/b. Participants acting as suppliers displayed a stronger preference for the buyback contract only when they knew the retailer's cost of effort was low. This effect persists regardless of whether or not the buyback contract produced greater profits than the wholesale price contract. Participants predicted a lower level of retailer effort under the buyback contract than under the wholesale price contract, suggesting that suppliers fear how buyback contracts will affect retailer effort.

Most interestingly, we observe that while participants did not predict theoretically optimal levels of retailer effort, their predictions are in line with actual effort levels exerted by participants acting as retailers in Study 1. Furthermore, they se-

lect the contract that would be more profitable assuming their effort predictions are correct. It is possible that participants were not selecting contracts in a profit-maximizing manner, but as demonstrated above, their estimates of retailer effort are inaccurate. This raises the question of whether the computation of expected profit is too difficult for participants or if they truly are using effort cost as a proxy. To answer this question, we studied supplier contract choices as a function of their effort predictions. We found that 65 out of the 95 participants (68.4%) selected the contract with greater expected profit based on their own predictions of effort which is significantly more than chance ( $\chi^2(1)=12.16$ ,  $p=0.0005$ ). These results imply that participants are linking low cost of effort with high retailer effort and high cost of effort with low retailer effort (even more so for the buyback contract), leading to suboptimal contract selection. Therefore, it appears that effort drives contract choice rather than expected profit under optimal levels of retailer effort<sup>4</sup>.

This controlled experiment with well-defined parameters provides insight but its informational assumption is removed from many practice settings. In practice, it may be difficult for a supplier to assess the retailer's true cost function. Therefore, it is not clear that we can draw parallels between our experiment and practice if we have provided explicit cost functions. In Study 3, we examine supplier preferences between contracts when retailer effort cost is not explicitly provided but can be inferred indirectly by observing retailer business practices. In addition, we study

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<sup>4</sup>A logistic regression was conducted to test whether contract choice was affected by numeracy, anticipated regret, loss aversion, or risk aversion. These variables were not found to be significant predictors of contract choice when controlling for effort cost.

supplier preferences when no effort cost information is available at all.

## 1.6 Study 3: The Effect of Retailer Business Practices on Supplier Contract Choice

Our theoretical results provide us with clear predictions regarding supplier contract preferences when the retailer cost type is known. However, in practice, suppliers are unlikely to have explicit information about retailer cost types when they engage in costly effort. Earlier research has provided examples clearly indicating that many retailers have an incentive to invest in costly promotional activities (Martin and Collins 1991, Klein 1997). Although retailers engage in these activities, suppliers do not typically receive explicit information about the retailer's true cost function and it may be difficult in practice for the supplier to assess this. In the absence of cost type information, the supplier may be able to gather market intelligence about the retailer's past business practices to infer a retailer cost type.

Studies in marketing have shown that consumers are able to infer the cost of firm advertising efforts based on identifiable elements of ad campaigns (Kirmani and Wright 1989, Kirmani 1990). For example, Kirmani and Wright (1989) show that consumers associate the use of "celebrities, large audience media, high frequency, and elaborate staging" with greater advertising expenses. Rationality and profit maximization objectives imply that retailers who engage in costly business practices are low-cost, while those who do not are high cost. In this experiment, rather than being given cost type explicitly, participants are presented only with evidence of the

retailer engaging or not engaging in a series of *costly retailer business practices* to stimulate demand.

### 1.6.1 Pretest

In order to determine whether participants infer appropriate cost types when presented with costly retailer business practices, we conducted an empirical test with 40 participants via an online participant pool managed by a large university in the Eastern United States. Participants were told that Retailer 1 engaged in the following four business practices while Retailer 2 did not: (1) sending emails and targeted ads to customers, (2) carefully planning store layouts to maximize foot traffic, (3) employing a sufficient staff, (4) properly training an effective and helpful sales staff. Furthermore, subjects were instructed to view the retailers as establishments of equal size, in the same geographic region, targeting the same clientele. After receiving this information, participants were asked for which retailer the promotional activities were more costly and then rated how time consuming and expensive they believed each activity would be for the retailer on a scale of 1 to 7.

Participants were significantly more likely to infer that these business practices were more expensive for Retailer 2 (78%) than for Retailer 1 (22%;  $\chi^2(1) = 11.02$ ,  $p < 0.005$ ). Sending ads/emails, training employees and designing an effective store layout were judged to be significantly more time consuming than the scale midpoint ( $t(38) = 10.89$ ,  $p \leq 0.001$ ). Staffing a sufficient number of employees and training employees were deemed to be significantly more expensive than the scale

midpoint ( $t(38) = 8.76, p \leq 0.01$ ) while designing an effective store layout was rated as marginally more expensive ( $t(38) = 1.54, p \leq 0.10$ ). The results of this pretest clearly show that subjects viewed these business practices as costly to the retailer. Based on these results, we conclude that participants are capable of distinguishing between high and low cost types when presented only with a description of costly retailer business practices.

### 1.6.2 Procedures

Study 3 was conducted via an online participant pool managed by a large university in the Eastern United States with 94 participants who were compensated with a show-up fee. Participants were randomly assigned to cost types using a 3-cell (cost type: low, control, high) between-subjects design. We compared suppliers' contract choices when retailers employ more or less costly business practices with a *control* condition in which *no information* was provided about the retailer's business practices.

The procedures of the experiment are similar to those of Study 2 with two main differences. The description of retailer effort cost was replaced with a description of retailer business practices and predictions of retailer effort levels were replaced by predictions of retailer selling success. Below, we present the information that we provided to the participants.

### 1.6.2.1 Retailer Information

In the high and low effort cost conditions, participants were presented with information regarding four pretested business practices of the retailer: (a) Sending emails and targeted ads to customers, (b) Planning store layouts to maximize foot traffic, (c) Employing a sufficient staff size, and (d) Properly training an effective and helpful sales staff. Participants in the low cost condition were told that the retailer engaged in all of these business practices, while participants in the high cost condition were told that the retailer did not. In the *control* condition, it was stated that no information was known regarding retailer business practices.

### 1.6.2.2 Cost and Demand Information

Participants were presented with per unit production cost (in francs) and demand information. Parameters were chosen such that the critical ratio was 0.75, consistent with previous research (Schweitzer and Cachon 2000). Suppliers were selling boots with a  $c = 12$  to a retailer with  $r = 48$  who was facing random demand,  $\xi$ , uniformly distributed over  $[200,500]$ . This demand distribution was fixed and could not be altered by the retailer exerting effort.

The purpose of this experiment is to study supplier preferences for wholesale price and buyback contracts when explicit effort cost is not present. Because the supplier does not know the retailer's cost of engaging in these activities, it would not be possible for the supplier to determine if the retailer should optimally be engaging in the activities. Therefore, we did not explicitly model costly retail effort and,

more importantly, no statement was made to participants suggesting a link between business practices and demand. This also allowed us to observe whether suppliers assumed an underlying link between business practices and demand level even when there was no actual link between the two.

### 1.6.2.3 Contract Types

After being informed of retailer business practices, participants were then presented with a description of the two contract types, either wholesale price or buy-back. Each contract was presented in diagram form supplemented by text and their order of presentation was randomized. This was followed by five hypothetical scenarios during which participants could opt to have demand randomly drawn and see a comparison of the overall profits for each contract.

### 1.6.2.4 Dependent Measures

Participants answered dependent measures at two points in the experiment. First, after cost/demand and retailer information was provided, participants were asked “how many units do you expect the retailer to sell during the season?” and “on a scale of 1 (not successful at all) to 7 (very successful) how successful do you think the retailer will be in selling the product?”. Given that effort does not influence demand in this experiment, the goal of these questions was to assess whether or not participants linked business practices with increased demand. With the same uniformly distributed demand in each of the cells, any difference in responses to

these questions by condition would indicate an underlying assumption that effort influences demand.

Following the description of contract types, each participant was asked “which contract would you prefer to use?” After participants selected either the wholesale price or buyback contract, they were asked to provide an open-ended description to “explain why you chose this contract.” Following the contract choice, actual demand was randomly generated and participants were shown a calculation of their overall season profits, given their contract choice.

#### 1.6.2.5 Scales

At the end of the study, subjects completed four scales that gauged individual differences in (1) numeracy (Fagerlin et al. 2007), (2) anticipated regret (Kugler et al. 2009), (3) loss aversion (Zhang et al. 2012), and (4) risk aversion (Weber et al. 2002). Previous work in experimental supply chain contracts has shown that complexity, anticipated regret, risk aversion and loss aversion can affect a subject’s performance in correctly using contracts. These measures were used to control for the effects of these individual factors on contract choice.

#### 1.6.3 Results

The results of Study 3 are presented in Table 1.11 below. Confirming that participants did associate higher levels of demand with costly retailer business practices, participants estimated that the number of units each retailer would sell (see

the column labeled “Sales Estimate”) are significantly different. We find that the high cost condition generates significantly lower sales estimates than the control ( $t(60) = 2.12, p=0.037$ ) and the control condition is significantly lower than the low cost condition ( $t(63) = 3.45, p=0.001$ ). This gives the following ordering: high cost estimate  $\leq$  control estimate  $\leq$  low cost estimate. Similarly, participants predicted that the retailer would be more successful (see the column labeled “Success Rating”) when the retailer was described as having low costs than when the retailer was described as having high costs or no business practice information was provided.

### 1.6.3.1 Choice

Preferences were significantly higher for the buyback contract when the retailer was described as engaging in costly business practices as compared to not engaging in them ( $\chi^2(1) = 4.67, p=0.031$ ), supporting the results of Study 2. *Interestingly, we find that preferences in control condition do not significantly differ from the high cost condition* ( $\chi^2(1) = 0.03, p=0.863$ ) indicating that providing no information about business practices results in the same contract preferences as explicitly stating that the retailer does not engage in any business practices to stimulate demand. Contract choices in the control condition are marginally different from the low cost condition ( $\chi^2(1) = 3.12, p=0.07$ ) suggesting that participants are slightly more likely to offer the buyback contract when explicitly told that retailers engage in costly business practices.

Finally, we find no evidence of contract choices systematically differing by the

individual factors we collected (loss aversion, risk aversion, anticipated regret, and numeracy). We ran logistic regression on the likelihood of choosing a buyback contract as a function of loss aversion, risk aversion, anticipated regret, and numeracy. Controlling for the effects of condition, none of these variables significantly predicted contract choice.

Table 1.11: Summary of Study 3 Results

	Prediction of Retailer Performance		Contract Choice		N
	Sales Estimate	Success Rating	Chose WP	Chose BB	
Low Cost	383.17 (67.69)	5.41 (0.95)	64%	36%	32
Control	329.18 (54.13)	4.32 (1.02)	85%	15%	33
High Cost	294.77 (75.89)	3.79 (1.11)	89%	11%	29

### 1.6.3.2 Open-Ended Responses

In addition to our quantitative dependent measures, we collected open-ended responses from participants to better understand the reasoning behind their choices.

These responses were found to contain four distinct justifications for contract choice: (1) risk aversion, (2) retailer motivation/business practices, (3) greater profits, (4) contract was better/easier/more familiar. Please see Table 1.12 for examples of responses coded in each category.

Table 1.12: Sample Open Ended Responses

	Selected WP	Selected BB
Risk Aversion	A sure thing is far more safe than an unknown. Although you might be able to make more money with the other choice they key word here is MIGHT or MIGHT NOT	Seemed to be the safer option.
Retailer Motivation/Business Practices	As stated earlier, the retailer does not market, is understaffed, and has poor customer service. I wouldn't expect the demand to be strong, so there would be more leftover. In that case, a Wholesale Price contract would be more beneficial.	I would expect that highland fashions is able to sell the majority of boots. Demand does not have to be too high to make more money this way. Since Highland Fashions has a reputation for marketing its products, they should have no problem selling the majority of the boots.
Greater Profits	It is more likely I will get the most profit.	I chose this contract because the chance of having higher profit is available.
Contract was better/More familiar	I don't want to deal with what actual demand is. This is easier.	Seems better for both companies given conditions shown.

All open ended responses were coded by three independent coders (Fleiss's  $\kappa=0.83$ <sup>5</sup>, see Table 1.13). Each response was assigned to one of the four categories and disagreements were resolved by majority rule. We observe that while context specific risk aversion<sup>6</sup> was the top reason for selecting the wholesale price contract, retailer motivation/business practices was a greater concern in the control and high cost type conditions than in the low cost type condition. Additionally, we see that the top reason for selecting the buyback contract in the high effort condition was retailer motivation/business practices. This evidence further supports our prediction that suppliers are averse to entering into buyback contracts when the retailer does not engage in costly business practices to stimulate demand.

### 1.6.3.3 Discussion

Study 3 used retailer business practices as a proxy for retailer cost of effort to create a setting more closely linked to practice. When we manipulate perceived effort cost by describing retailer business practices, we see similar patterns in contract preferences to that of Study 2. Most notably, when suppliers had no information about retailer effort costs (in the control condition), they seemed to assume the worst. They predicted lower levels of retailer success when provided with no information regarding retailer business practices than when told the retailer engaged in costly business practices to increase demand. This prediction of lower retailer

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<sup>5</sup>See Fleiss 1971 for a description of Fleiss'  $\kappa$ .

<sup>6</sup>Although the measure for individual level of risk aversion is not significant in predicting contract choice, context specific aversion to immediate profit risk appeared to be a concern.

Table 1.13: Summary of Study 3 Open Ended Responses

		Risk Aversion	Retailer Motivation Business Practices	Greater Profit	Better/ Easier/ Familiar
Preference for WP	Low Cost	51%	8%	20%	21%
	Control	54%	22%	9%	15%
	High Cost	19%	34%	36%	11%
Preference for BB	Low Cost	6%	59%	29%	6%
	Control	0%	11%	56%	33%
	High Cost	0%	12%	50%	38%

success translated into similar contract preferences in the control condition and the condition in which the retailer did *not* engage in costly business practices (i.e., a stronger preference for the buyback contract). Thus, lack of information may result in an unwillingness to engage in risk sharing with the retailer. If effort was not a concern for suppliers, they should have preferred the buyback contract when no mention of retailer effort was made (as predicted by Cachon 2003).

This finding has significant implications for suppliers in practice. Because preferences in the control conditions favored wholesale price contracts, we can conclude that effort is an inherent concern when there is uncertainty surrounding cost of effort. Therefore, retailers who *do* exert costly effort to sell items will be well served by being forthcoming about their business practices; open communication

between retailers and suppliers can be beneficial to both parties.

## 1.7 Conclusion

The primary goal of this research is to provide insight into why wholesale price contracts dominate the practitioner's landscape, as opposed to coordinating contracts such as buyback contracts. We propose that despite their theoretical superiority, suppliers are reluctant to use buyback contracts because they are concerned that retailers will exert less effort when operating under a buyback contract than under a wholesale price contract. When retailers are able to influence demand by investing in costly effort, our analytical model shows that retailers will exert less effort when faced with a buyback contract than a wholesale price contract. Moreover, study 1 demonstrates that retailers choose to exert systematically less effort under a buyback contract than under a wholesale price contract. Thus, we find empirical support for our predictions about retailer reactions to different contract types.

Our analytical model suggests that profit-maximizing suppliers should consider retailers' effort decisions when choosing among contracts to offer retailers. Studies 2 and 3 test our predictions regarding supplier preferences between contracts, demonstrating that retailer cost of effort has the predicted impact on supplier preferences. Our empirical results show that suppliers prefer the buyback contract only when the retailer is known to have a low cost of effort. Furthermore, we find that regardless of whether the cost of effort is known to be high or is unknown, suppliers predict lower retailer effort and we observe a decrease in supplier preferences for the buy-

back contract. These effects persist whether cost of effort is provided explicitly or inferred through retailer business practices.

One potential question raised is whether or not there is something unique about the buyback contract that is producing these results. As a follow-up to Study 3, we conducted an experiment in which we presented participants with a choice between the wholesale price contract and another form of contract with similar supplier risk-sharing: the markdown money contract. When using a markdown money contract, the supplier agrees to subsidize the retailer's profit margin on items sold at a discount. While this type of contract has been shown to be theoretically equivalent to the buyback contract (Tsay 2002), the framing is different. Similar to Study 3, the retailer's business practices were described as either low cost, high cost, or unknown (control). In this study (N=90), we find the same pattern of supplier contract preferences. There is a significantly stronger preference for the markdown money contract when the retailer's description of business practices is consistent with a low cost retailer (40% selected markdown money) versus high cost (10% selected markdown money,  $\chi^2(1)=5.69$ ,  $p=0.02$ ) or control (13% selected markdown,  $\chi^2(1)=4.18$ ,  $p=0.04$ ). As in Study 3, preferences did not differ between the control and high cost conditions ( $\chi^2(1)=0$ ,  $p=1$ ) demonstrating that suppliers are pessimistic when provided with no cost information.

We contribute to theoretical work in supply chain management by extending previous results to study supplier choices among contracts when retailers are heterogeneous. While other work has examined supplier preferences between coordinating contracts (Zhang et al. 2012), we are the first to examine specific factors that may

influence supplier preferences between a wholesale price contract and a coordinating contract.

In addition, we add to theoretical work highlighting the negative impact of effort dependent demand on buyback contracts by demonstrating these results experimentally. We show that these negative effects are a real concern when explaining retailer decisions and supplier preferences in a supply chain settings. We find that both retailer effort and supplier contract choice are impacted by two factors: (1) cost of effort and (2) contract type. As effort cost increases, we see retailers exerting less effort and suppliers favoring the wholesale price contract. Additionally, our results demonstrate that not only do suppliers predict lower levels of effort under the buyback contract, but participants acting as retailers actually exert lower levels of effort. Interestingly, regardless of which contract has a higher expected profit, the supplier prefers the buyback contract only when facing a retailer known to have a low cost of effort .

Our results provide many opportunities for extensions. One extension is to look at a multi-period setting. In our experiments, participants were explicitly told they were dealing with a retailer for a single season. We do not consider the situation in which retailers and suppliers engage in a repeated game, potentially forging relationships and learning the retailer's cost of effort over time. Although the potential for repeated interactions may reduce the size of the effect found, our industry interviews suggest repeated interactions do not eliminate its effect. The retailers and suppliers with whom we spoke interact with most of their partners on a repeated basis, yet they still predominantly use wholesale price contracts.

A second direction for future work is to allow communication between the retailer and supplier during the selling season. We have found that in practice, it is common for suppliers and retailers to be in contact throughout the selling season. In fact, of the three firms we interviewed who did use some form of buyback contract, all of them communicated with their clients during the season to discuss current sales and marketing strategies. This suggests that allowing suppliers to observe retailer activities and sales, as well as make suggestions, might increase preferences for buyback contracts.

Another potential direction for future research is to consider additional incentive schemes. We note that while the buyback contract increases retailer order quantity, it decreases retailer effort. Research on compensation schemes suggests that multiple incentives may be required as opposed to using only a buyback price to incentivize higher order quantities [Chen (2000), Plambeck and Zenios (2003), Chen (2005), Jerath et al. (2010), Saghaian and Chao (2011), Dai and Jerath (2013)]. It would be interesting to theoretically explore combinations of incentives that increase both retailer order quantity and effort decisions and then test their effectiveness empirically.

In summary, our results provide strong evidence for the connection between retailer effort costs and supplier contract preferences. This connection provides important insights for both suppliers and retailers. When choosing among contracts, suppliers should take into account the effort that retailers will exert to stimulate demand. Because effort costs vary, so does the optimality of particular contract types across market settings. Retailers, on the other hand, should be very open in

disclosing their efforts to stimulate demand. As seen in Section 1.3, the retailer is better off when offered a buyback contract but, as Study 3 demonstrates, the supplier is unwilling to offer the buyback contract when he has no information about the retailer's business practices. Moreover, if the retailer exerts high effort to stimulate demand, both the supplier and retailer can be better off using a buyback contract than using a wholesale price contract. There are many industries, even outside of fashion retailing, that can benefit from shared risk contracts. If we can understand factors that make these contracts more attractive to suppliers as well as retailers, we can improve contract efficiency for both parties.

## Chapter 2: The Effect of Contract Type on Risky Product Related Decisions

### 2.1 Introduction

Unlike the traditional wholesale price contract, in which the retailer bears the risk of unsold inventory, shared risk contracts such as the buyback contract theoretically achieve supply chain coordination by allowing the supplier to share the retailer's risk. When using a buyback contract, the supplier offers to buy back leftover inventory from a retailer at some price less than the initial price. This encourages the retailer to order a larger quantity, creating higher expected profits for both parties (see Cachon 2003 for a review).

Although theoretical research has shown that shared risk contracts increase the quantity purchased by the retailer, it is less clear how contracts such as the buyback contract will affect the retailers choices when selecting which products to stock. If we consider a retailer making a joint decision about which products to order and the quantity of each product to order (Van Ryzin and Mahajan 1993) in a typical newsvendor setting, the retailer must manage two different kinds of risk: quantity risk and product risk. We define quantity risk as the contribution to profit

variance that comes from ordering a smaller or large quantity of a given product. In contrast, we define product risk as the contribution to profit variance due to variability in demand across products that may be ordered.

Imagine that the retailer can choose among multiple products that vary on attributes such as color and shape. Even if these products are similar in cost or retail price, the product risk the retailer incurs may differ due to variations in their attributes. For example, women's leather handbags may be offered in basic black (low demand variability), or in a bold, multicolored pattern (high demand variability). A product with higher demand variability leads to greater variance in expected profit when the quantity purchased is held constant. Thus, the retailer assumes more product risk by choosing to stock the bold, multicolored handbag than by choosing to stock the basic black handbag.

In this research, we examine how the use of a shared risk contract such as the buyback contract affects the retailers willingness to assume product risk. Since the retailers expected losses if the product does not sell well are lower under the buyback contract than under a wholesale price contract, we might expect that a buyback contract would encourage retailers to assume more product risk by stocking products with more demand variability, all else equal.

Surprisingly, we find quite consistent evidence that retailers are willing to assume less product risk when using a buyback contract than when using a wholesale price contract, independent of their decisions about order quantity. In several pilot studies, we asked participants acting as retailers to choose whether to stock a product with high demand variability or a product with low demand variability,

holding order quantity constant. Participants were offered either a wholesale price contract or a buyback contract and they made a series of product choice decisions across independent periods. Participants who were offered a wholesale price contract were strongly and systematically more willing to choose products with high demand variability than those who were offered a buyback contract.

Behavioral decision theory offers some insight into this surprising pattern of retailer preferences. Empirical research has shown that when making choices under uncertainty, decision makers not only segregate losses and gains, but they also differentially weigh small probabilities relative to large probabilities, affecting their choices (Kahneman and Tversky 1979). The retailers choice between products with high and low demand variability is essentially a choice between profit streams with different ranges and probabilities of losses and gains. When order quantity is held constant, the low demand variance option offers smaller variance in profits, while the high demand variance option offers a greater probability of obtaining high levels of profit but a greater probability of incurring a loss. For a given order quantity a buyback contract creates a systematically lower probability and magnitude of loss relative to a wholesale price contract. Combining the effects of contract type and product choice, the buyback contract reduces the probability of loss, but does so differentially for high versus low demand variance products. Specifically, the buyback contract increases the perceived difference in losses when comparing products with high and low demand variance.

Based on this insight, we propose an analytical model in which the retailer compares the expected losses and gains for each product, assuming either a wholesale

price or buyback contract. This model allows for a differential weighting of small and large probabilities consistent with Prospect Theory. We then compare the predictive power of this model to a rational model in which the retailer chooses among products based on their expected profits. We find that our model based on Prospect Theory better predicts the product choices of participants acting as retailers than the expected profit model. Our model better predicts choices across a range of relative losses and gains (Study 1) and when participants make joint decisions about products and the quantities of each product (Study 2).

The remainder of the paper is organized as follows. In Section 2.2, we review relevant literature on supply chain contracts, retail assortment planning, and behavioral decision theory. Section 2.3 presents an analytical model of product choice given contract type from the perspective of a rational, risk neutral retailer and presents the results of our pilot study. Based on these results, we propose a model of product choice based on Prospect Theory that incorporates differential weighting of small and large probabilities of losses or gains. We explicitly test these two models of behavior in Section 2.4 with an experiment in which retailers decide which product mix to stock for a given contract type. In Section 2.5, we report a second experiment in which quantity is also a decision (a true retail assortment planning decision) as a robustness test. The results of our second study are consistent with the first. We conclude in Section 2.6 with a discussion of our results and their managerial implications.

## 2.2 Literature Review

Our research brings together several relevant streams of literature. In studying the impact of contract type on product selection decisions experimentally, we are at the interface of current behavioral operations work on supply chain contracts and theoretical operations work on retail product assortment. In addition, we connect to the broader field of behavioral decision theory which studies how decision makers are impacted by behavioral biases when faced with choices under uncertainty. Below, we review both product assortment literature and relevant behavioral decision theory in order to highlight our contribution.

### 2.2.1 Retail Product Assortment

The retailer's decision of what mix of products to stock has been studied in both marketing and operations. Both streams of literature focus on understanding how a retailer should select which products to stock in response to consumer preferences and buying behavior. Marketing research on the topic is vast and began decades ago with the earliest being Mussa and Rosen (1978) and Moorthy (1984). However, research on the topic from an operations viewpoint has expanded rapidly only in recent years and is the stronger connection to our research [Van Ryzin and Mahajan (1999), Cachon, Terwiesch and Xu (2005), Gaur and Honhon (2006), Caro and Gallien (2007), Kok and Fisher (2007), Nagarajan and Rajagopalan (2008), Aydin and Hausman (2009), Honhon et al. (2012)].

Van Ryzin and Mahajan (1999) were the first to theoretically consider choice

models in retail assortment planning. Their model integrates consumer choice (defined by MNL) with the newsvendor problem to balance the benefits of product variety with the operational costs of stockouts and overages. Using a basic model with products having identical costs and prices but different demand means and variances, they search for optimal assortments that maximize retailer profit. Their findings show that the optimal mix always includes the most popular product variant. Gaur and Honhon (2006) expand upon this work by considering a different functional form of consumer demand, showing that an optimal assortment may not include the most popular product and may force some consumers not to purchase.

Further work has enriched the results of Van Ryzin and Mahajan (1999) by increasing the complexity of the retail assortment planning problem. Cachon, Terwiesch and Xu (2005) consider how optimal assortments are affected in the presence of consumer search. Nagarajan and Rajagopalan (2008) and Kok and Fisher (2007) examine how to make the joint decision of what to stock and how much to stock when products are substitutable. Caro and Gallien (2007) consider a dynamic assortment in which they allow demand learning over time. Honhon and colleagues (2012) consider optimal assortments after relaxing the assumption that product prices and costs are identical. Finally, Aydin and Hausman (2009) consider the ability of alternate payment structures, such as slotting fees, to coordinate the supply chain in the presence of multiple products.

While this research has focused on reducing the retailer's product risk by accurately predicting consumer product choices, it has not examined the effect of contract type on the retailer's willingness to accept product risk. Our research adds

to this stream of literature by being the first to examine retail product assortment decisions from a behavioral angle and by expanding the lens through which we view retail product assortment to include the contract offered to the retailer.

## 2.2.2 Behavioral Decision Theory

The idea that human decision makers are boundedly rational was first proposed by Simon in 1955. In the decades following, behavioral decision theory emerged as a field that studies human decision makers deviations from normative decisions (Einhorn and Hogarth 1981). Numerous streams of literature have incorporated the presence of behavioral biases in decision making under uncertainty. Specifically, a number of heuristics and biases have been identified when decision makers face choices with uncertain financial outcomes, such as loss aversion, risk aversion, and Prospect Theory [Tversky and Kahneman (1974), Kahneman and Tversky (1979)]. These biases and heuristics have been researched both theoretically and experimentally in decision contexts similar to the research question we consider.

Work within the supply chain management area of behavioral operations has studied the impact of various biases on retailer and supplier decisions from both a theoretical and experimental viewpoint. In a review of supply chain contract models, Tsay, Nahimas, and Agrawal (1999) call for future research that considers suppliers/retailers who maximize objective functions other than profits. Since that time, the supply chain literature has produced models incorporating biases such as risk

aversion and loss aversion into inventory related decisions [Lau and Lau (1999), Gan et al. (2004), Wang and Webster (2007), Wei and Choi (2010)]. These papers introduce the concept of profit variance, suggesting that decision makers are impacted by both expected profits and the distribution of those profits. However, this body of work has focused on the impact of order quantity on profit variance. In contrast, our work studies how retailers can alter profit variance by selecting products with different variances in their demand distributions.

Although supply chain and retail product assortment literature have not specifically addressed the impact of behavioral biases on retailer product choice, analogous decisions have been examined in another field. The field of behavioral finance studies investor behavior over a wide range of decision contexts. Two decisions in particular are relevant to our research questions: (1) how do investors decide among investments, and (2) how do they determine how much to invest in each investment? In relation to these questions, behavioral finance examines the presence of many of the same biases studied in behavioral operations (e.g., overconfidence, loss aversion, framing, anchoring). The findings from this literature provide further evidence that decision makers are susceptible to biases by demonstrating that investors are similarly influenced by them [surveys: Kahneman and Riepe (1998), Benartzi and Thaler (2003), Ricciardi (2008), Barber and Odean (2011)]. Numerous biases related to Prospect Theory have been found to affect an investor's decision of how much to invest in a risky asset [Weber and Camerer (1998), Benartzi and Thaler (1999), Charness and Gneezy (2010)]. Weber and Camerer (1998) find that participants exhibit a disposition effect when deciding when to buy and sell assets by

holding investments that have lost value and selling investments that have gained value. Benartzi and Thaler (1999) find experimentally that participants allocate significantly more money to risky assets when losses are aggregated over a long period rather than a shorter time period in which fluctuations are highlighted. Charness and Gneezy (2010) show that participants exhibit myopic loss aversion, investing less in risky assets when they receive feedback more frequently. This growing field of research provides further evidence suggesting that behavioral biases may impact retailer product choice.

While work on behavioral decision theory is vast, researchers have yet to study how contract type may alter retailer product choice due to behavioral biases. Therefore we draw upon the biases that behavioral decision theory has identified to extend research on product assortment and supply chain contracts.

### 2.3 Model and Hypotheses

Our basic model focuses on a single risk-neutral retailer who purchases from a single risk-neutral supplier. In keeping with Van Ryzin and Mahajan (1999), the supplier offers two products from the same product class to the retailer that have identical retail prices. In addition, the supplier will offer the same per unit price for each product to the retailer (i.e.,  $r > w > 0$  is the same for both). Let us refer to these products as the low product risk product, with demand  $D_S$ , drawn from known demand distribution  $F_S(x)$ , and the high product risk product, with demand  $D_R$ , drawn from known demand distribution  $F_R(x)$ . For simplicity, we assume that both

the low and high product risk products have equal demand means (i.e.,  $\mu_S = \mu_R$ ) and differ only in their demand variance with  $\sigma_S^2 < \sigma_R^2$ .

We will define our setting by the following sequence of events. First, a supplier sets the terms of an exogenously determined contract type. This means, the supplier will set a per unit wholesale price,  $w$ , if offering the retailer the wholesale price contract. If offering the buyback contract, he will additionally offer the retailer a per unit end-of-season payment for left over items,  $b$ , where  $w > b > 0$ . After the retailer receives the terms of the supplier's contract, he selects a product to order, taking on a certain level of product risk, and selects an order quantity,  $q$ . This provide expected sales of  $E_S(q) = q - \int_0^q f_S(y) dy$  for the low product risk product and  $E_R(q) = q - \int_0^q f_R(y) dy$  for the high product risk product.

After regular season demand has occurred, the retailer has expected leftover inventory  $q - E_S(q)$  or  $q - E_R(q)$  that can be returned to the supplier for  $b$  per unit if the supplier has offered a buyback. If the retailer has not been offered a buyback, we assume that the salvage value is \$0. This sequence of events leads to expected profits of  $\pi_S = rE_S(q) - wq$  for the low product risk product and  $\pi_R = rE_R(q) - wq$  for the high product risk product if operating under the wholesale price contract. Similarly, if operating under the buyback contract, the retailer faces expected profits of  $\pi_{S,b} = rE_S(q) - wq + b(q - E_S(q))$  with the low product risk product and  $\pi_{R,b} = rE_R(q) - wq + b(q - E_R(q))$  with the high product risk product.

In this context, we would like to study retailer behavior for the single, isolated decision of the proportion of the high product risk product the retailer chooses to stock. To do this, we simplify our setting by making two additional assumptions:

(1) the combined order quantity for both products is fixed, referred to as  $Q$ , and (2) the per unit wholesale price charged under both contracts is the same, referred to as  $W$ . The assumption of a fixed order quantity allows us to study how contract type affects only the level of product risk the retailer assumes rather than the combination of product risk and quantity risk. The assumption of a fixed per unit wholesale price allows us to examine the impact of the buyback's introduction on the retailer's level of product risk rather than the combined effect of simultaneously changing the per unit price and introducing a buyback. These assumptions provide us with as much control as possible in ruling out alternative explanations in our experiments.

With  $Q$  and  $W$  exogenously determined, the retailer will make the decision of how to allocate  $Q$  between both products by assigning a fraction  $\alpha$  to the high product risk product and  $(1 - \alpha)$  to the low product risk product. His expected profits for the wholesale price contract as a function of  $\alpha$  are given by:

$$\begin{aligned} \Pi(\alpha) = [rE_S((1 - \alpha)Q) - W(1 - \alpha)Q] + \\ [rE_R(\alpha Q) - W\alpha Q] \end{aligned}$$

Similarly, his expected profits as a function of  $\alpha$  for the buyback contract are given by:

$$\begin{aligned} \Pi_b(\alpha) = [rE_S((1 - \alpha)Q) - W(1 - \alpha)Q + b((1 - \alpha)Q - E_S((1 - \alpha)Q))] + \\ [rE_R(\alpha Q) - W(\alpha)Q + b((\alpha)Q - E_R(\alpha Q))] \end{aligned}$$

We will examine theoretically and experimentally how the presence of a buyback may impact the retailer's decision,  $\alpha$ . We will begin by reviewing optimal behavior assuming that the retailer's utilities are defined by expected profits where  $\alpha$  is the  $argmax[\Pi(\alpha)]$  for the wholesale price contract and  $argmax[\Pi_b(\alpha)]$  for the buyback contract. Given the sequence of events presented above and a fixed order quantity, a profit maximizing retailer should optimally select an  $\alpha = 0$  when  $\Pi(0) > \Pi(1)$  and an  $\alpha = 1$  when  $\Pi(0) < \Pi(1)$ . Given that a buyback contract decreases the chance of loss for both products in comparison to the wholesale price contract when order quantity is fixed, this optimal  $\alpha$  is the same, regardless of contract type. Therefore, we can study how the retailer's choice of  $\alpha$  changes as a function of the expected profits from the high and low product risk products.

If their goal is to maximize expected profits, participants playing the role of a retailer, should select  $\alpha$  based on the products' expected profit levels. Therefore we can create an expression for  $\alpha$  that allows us to estimate the impact of expected profits on the fraction of the high product risk product the retailer decides to stock. Let  $\Delta EP = \Pi(1) - \Pi(0)$  ( $\Delta EP_b = \Pi_b(1) - \Pi_b(0)$ ) be defined as the difference in expected profit between the high and low product risk product for the wholesale price contract (buyback contract). Generally, when  $\Delta EP$  ( $\Delta EP_b$ ) is positive (i.e., the high product risk product has a greater expected profit),  $\alpha$  should increase. Conversely, when  $\Delta EP$  is negative (i.e., the low product risk product has a greater expected profit),  $\alpha$  should decrease. We can summarize this conclusion with Equation 2.1 presented below where  $I_{BB}$  represents an indicator variable for the buyback contract and  $\beta_{EP}$  and  $\beta_{BB}$  represent the coefficients of  $\Delta EP$  and  $I_{BB}$  respectively.

$$\alpha = (1 - \beta_{BB}I_{BB})\beta_{EP}\Delta EP + \beta_{BB}I_{BB}(\beta_{EP}\Delta EP_b) \quad (2.1)$$

Given this representation of  $\alpha$  and assuming a profit maximizing retailer, we predict that  $\beta_{EP}$  is positive and  $\beta_{BB}$  is insignificant. This would lead to an  $\alpha = 1$  when the high product risk product has greater expected profit, an  $\alpha = 0$  when the low product risk product has greater expected profit, and no effect of contract type (i.e., the participants' choice of  $\alpha$  should be increasing in  $\Delta EP$ ).

It is possible that decision makers are not selecting  $\alpha$  in a profit maximizing manner but rather are influenced by another aspect of the decision setting. In addition to expected profits, previous literature has explored the role of profit variance in a decision maker's assessment of choices. This implies that decision makers are impacted by the distribution of their profits which may lead to decisions driven by risk aversion or Prospect Theory (i.e., loss aversion or probability weighting functions). As noted in Section 2.1, we can draw parallels between the retailer's product choice decision and choosing between gambles where both probabilities and magnitudes of losses and gains influence choices. To investigate this explanation, we consider the effect of product risk on the profits generated under each product for each contract.

Prior literature has studied profit variance as a function of the retailer's order quantity,  $q$  [Wu et al. (2008), Choi et al. (2008), Choi et al. (2009), Wei and Choi (2010)]. Given that we fix  $Q$  in our model, we will study profit variance in as it changes with  $F_S(x)$  and  $F_R(x)$ . We study the impact of product risk while holding quantity risk constant. Therefore, we define profit variance under

each contract and examine how profit variance changes as a function of product type for each contract. In keeping with prior literature (Wei and Choi 2010), we define the variance in profit by determining the variance in the random variable  $S(q)$  (i.e., the variance in sales). This gives a profit variance of  $\sigma^2(\pi) = r^2\nu(q)^2$  for the wholesale price contract and  $\sigma^2(\pi_b) = (r - b)^2\nu(q)^2$  for the buyback contract where  $\nu(q) = 2q \int_0^q F(x)dx - 2 \int_0^q xF(x)dx - (\int_0^q F(x)dx)^2$ .

Under a fixed order quantity, the variance in expected sales,  $S(Q)$ , is larger for the high product risk product than for the low product risk product because  $\sigma_R^2 > \sigma_S^2$ ,  $\nu_R(Q) > \nu_S(Q)$ . Said another way, the high product risk product has a higher chance of low levels of demand but also a higher chance of high levels of demand. This product risk translates directly into the variance of sales and thus, into the variance of the retailer's profits. Controlling for the order quantity placed by the retailer, the high product risk product increases the probability of achieving very high levels of profit while at the same time opening the retailer up to a greater chance of low levels of profit (or loss).

Next, we compare product risk under the wholesale price and buyback contract. In comparing  $\sigma^2(\pi)$  with  $\sigma^2(\pi_b)$ , we see that the buyback contract has a systematically lower level of profit variance, and therefore product risk, regardless of the product type. The presence of a buyback systematically decreases the probability the retailer incurs a loss. Therefore, when the supplier offers to engage in risk sharing with the retailer by offering the buyback contract, the retailer may respond by displaying a stronger preference for the high demand variability product, regardless of expected profits. To test whether retailer preferences are driven by expected

profits, as the rational model would suggest, we conduct a pilot study.

### 2.3.1 Pilot Study

The pilot study was conducted with 126 participants via Amazon Mturk who were were paid for participation. In addition, participants had the opportunity to earn a bonus based on performance. All participants were told they would place an order for a fixed quantity to stock in their retailer kiosk. Their task was to decide whether to stock the low or high product risk product. Our experimental design was 2 (contract type: wholesale price, buyback) x 2 (visual presentation: table, graph) with both factors manipulated between subjects. In keeping with Van Ryzin and Mahajan (1993), our decision setting featured two products with equal cost, retail price and expected demand. However, one product was characterized by low product risk and one was characterized by high product risk. Each participant made a series of 24 decisions. For each decision, participants were given the terms of a contract (either wholesale price or buyback for all 24 decisions), the product category and the fixed quantity that they would order (the same quantity for either product option).

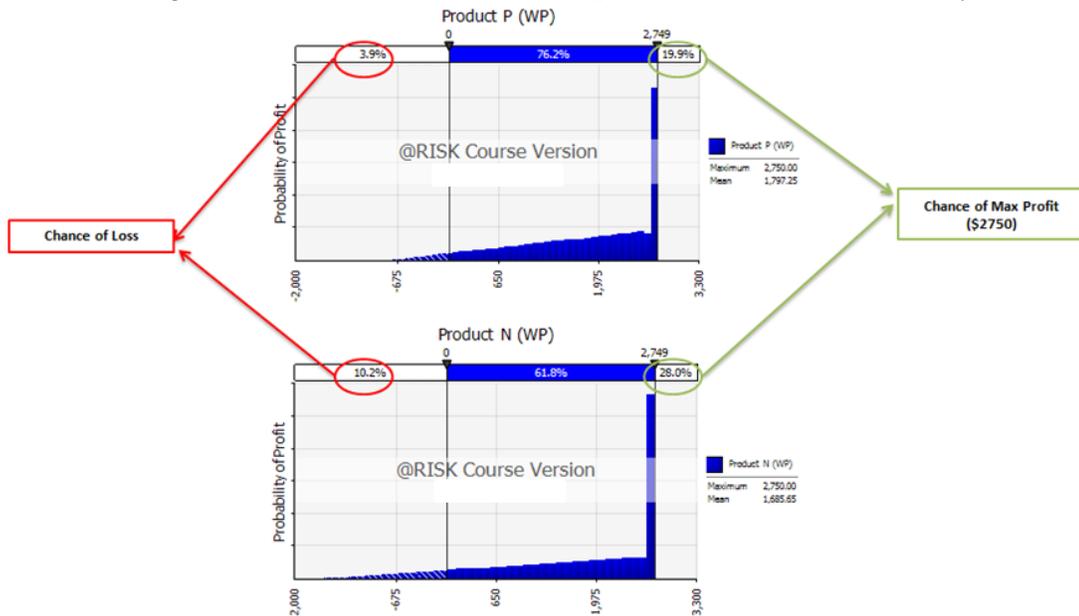
Prior to making their selection decision, participants were provided with information regarding the expected profit of each product option. In addition, participants were also provided with the probability of earning maximum profit, and probability of incurring a loss for both the low and high product risk product. This information was selected to be consistent with available information supplied by in-

ventory management software programs such as NetSuite. To manipulate the visual presentation of this information, participants saw either a table (see Figure 2.1) or a graph (see Figure 2.2). For all 24 decisions, the low product risk product had a higher expected profit and lower probability of incurring a loss but the high product risk product had a higher probability of earning maximum profit.

Figure 2.1: Screen Shot from Table Condition of Pilot Study

<b>Scarves Monthly Profit</b>	Style P	Style N
	250 units	250 units
Expected Profit	<b>\$1797</b>	<b>\$1685</b>
Chance of incurring a loss	4%	10%
Chance of earning the max potential profit (\$2750)	20%	28%

Figure 2.2: Screen Shot from Graph Condition of Pilot Study



While one might expect that a rational, risk-neutral retailer would select the product with greater expected profit (set as the low product risk product for all

decisions) regardless of contract type, this is not what we observed. In the wholesale price condition, we observed a consistent preference for the high product risk product while in the buyback condition we observed a consistent preference for the low product risk product. In the table condition, we observed that on average, participants selected the high product risk product 65% of the time when offered the wholesale price contract and 30% of the time when offered the buyback contract. Product choice behavior differed significantly in 17 out of the 24 decision periods. Similarly, in the graph condition, we observed that on average, participants selected the high product risk product 61% of the time when offered the wholesale price contract and 33% of the time when offered the buyback contract. In this condition, product choice behavior was significantly different in 18 out of the 24 decision periods (see Table 2.1).

These results indicate that contract type had an impact on product choice, whether information was presented in table or graph form. Participants acting as retailers showed a clear preference for the high product risk product when they were offered the wholesale price contract. We replicated these results in a second pilot study with 52 MBA students at a large mid-Atlantic university where information regarding the two options was presented only in table form. Results of this second pilot study revealed similar preference structures with participants selecting the high product risk product 68% of the time on average in the wholesale price condition and 36% of the time on average in the buyback condition. Not only does this violate rational, risk neutral behavior, but we also found that, surprisingly, the buyback contract leads to lower levels of retailer product risk as opposed to our prediction

of higher levels of product risk. To investigate this counterintuitive result further, we propose that a behavioral bias may be driving these results.

### 2.3.2 Potential Explanations

In this section, we consider whether risk aversion, loss aversion or differences in the weighting of small versus large probabilities (Kahneman and Tversky 1979) can explain the results of our pilot study.

We first investigate risk aversion as an explanation of the choice pattern found in our pilot study. A risk averse retailer dislikes an increase in uncertainty regarding profits. Since we know that the low product risk product generates less profit variance than the high product risk product, this results in less product risk under both contracts. This would imply that retailers prefer the low product risk product regardless of contract type. Our pilot study demonstrated that participants had a stronger preference for the high product risk product under the wholesale price contract than the buyback contract. If risk aversion were used to explain our results, this would imply that when using the wholesale price contract, participants were risk seeking while when using the buyback contract they were risk averse. Because risk aversion is an individual level factor, decision maker risk aversion should not differ based on the contract type offered. Therefore, risk aversion cannot be driving our results.

We now consider the ability of two components of Prospect Theory to explain our results: (1) loss aversion or (2) the probability weighting function. Prospect

Table 2.1: Percentage of Participants Selecting High Risk Product in Pilot Study

Period	Table Condition			Graph Condition		
	WP	BB	P-value	WP	BB	P-value
	N=31	N=32		N=31	N=32	
1	52%	28%	.06	52%	28%	0.05
2	74%	28%	< 0.001	58%	28%	0.02
3	61%	19%	< 0.001	61%	19%	< 0.001
4	58%	41%	0.17	58%	34%	0.05
5	74%	13%	< 0.001	65%	31%	0.01
6	54%	38%	0.17	52%	47%	0.71
7	68%	44%	0.05	52%	41%	0.38
8	71%	28%	< 0.001	58%	34%	0.05
9	71%	38%	0.01	61%	25%	0.01
10	58%	34%	0.06	61%	38%	0.05
11	64%	47%	0.16	65%	34%	0.02
12	52%	25%	0.03	61%	47%	0.25
13	61%	28%	0.01	58%	34%	0.05
14	61%	25%	0.06	55%	19%	0.01
15	55%	19%	< 0.001	55%	16%	0.001
16	71%	56%	0.23	71%	50%	0.09
17	71%	28%	< 0.001	71%	28%	< 0.001
18	61%	16%	< 0.001	55%	34%	0.10
19	68%	31%	0.003	68%	41%	0.03
20	68%	22%	< 0.001	68%	22%	< 0.001
21	74%	16%	< 0.001	61%	22%	0.001

Theory proposes that decision makers consider probability of loss, conditional losses, probability of gain, and conditional gains separately. Rather than weighting each of these components equally, leading to expected profit, the decision maker assigns differential weights to these components, deriving a utility. Therefore, we will first rewrite expected profits as the sum of these components for each contract.

We begin by establishing the point at which the retailer experiences negative versus positive profits under each contract type. When demand, either  $D_S$  or  $D_R$ , is greater than the fixed quantity  $Q$ , the retailer earns positive profits equal to  $(r - W)Q$  with both the wholesale price and buyback contract since  $r > W$ . When demand is less than the fixed  $Q$ , the retailer's profits under the wholesale price contract can be generally expressed as  $rD - WQ$  and the retailer only incurs a loss when  $rD < WQ$ . Therefore, when the retailer is operating under the wholesale price contract, he incurs a loss whenever realized demand is less than  $\frac{WQ}{r}$ . Define the probability of loss as  $p(L)_S = Prob(D_S < \frac{W(1-\alpha)Q}{r})$  for the low product risk product and  $p(L)_R = Prob(D_R < \frac{W\alpha Q}{r})$  for the high product risk product. The probability of gain is then defined as  $p(G)_S = Prob(D_S > \frac{W(1-\alpha)Q}{r})$  for the low product risk product and  $p(G)_R = Prob(D_R > \frac{W\alpha Q}{r})$  for the high product risk product.

Under the buyback contract, profits can be generally expressed as  $rD - WQ + b(Q - D)$ , implying that a loss is incurred whenever revenues of  $rD + b(Q - D)$  are less than costs of  $WQ$ . Therefore, when the retailer is operating under the buyback contract, he incurs a loss whenever realized demand is less than  $\frac{(W-b)Q}{r-b}$ . Define the probability of loss as  $p(L)_{S,b} = Prob(D_S < \frac{(W-b)(1-\alpha)Q}{r-b})$  for the low product risk product and  $p(L)_{R,b} = Prob(D_R < \frac{(W-b)\alpha Q}{r-b})$  for the high product risk product.

Similarly, the probability of gain is defined as  $p(G)_{S,b} = Prob(D_S > \frac{(W-b)(1-\alpha)Q}{r-b})$  for the low product risk product and  $p(G)_{R,b} = Prob(D_R > \frac{(W-b)(\alpha)Q}{r-b})$  for the high product risk product.

Let  $C(L)_S$ ,  $C(G)_S$ ,  $C(L)_R$ , and  $C(G)_R$  denote conditional losses and gains for both the low and high product risk product under the wholesale price contract (a subscript of  $b$  will indicate buyback contract). With established expressions for probability of loss/gain, we can break expected profits down into expected losses and expected gains, and apply weights to the components to define utility. This will allow us to consider the ability of loss aversion and Prospect Theory to explain our results.

Consider a general weighting function applied to probability of loss,  $\omega_L(p)$ , and probability of gain,  $\omega_G(p)$ . This provides a general expected utility under the wholesale price contract is given by:

$$U(\alpha) = \omega_L(p(L)_S)C(L)_S + \omega_G(p(G)_S)C(G)_S + \\ \omega_L(p(L)_R)C(L)_R + \omega_G(p(G)_R)C(G)_R$$

Similarly, the expected utility under the buyback contract is given by:

$$U_b(\alpha) = \omega_L(p(L)_{S,b})C(L)_{S,b} + \omega_G(p(G)_{S,b})C(G)_{S,b} + \\ \omega_L(p(L)_{R,b})C(L)_{R,b} + \omega_G(p(G)_{R,b})C(G)_{R,b}$$

Next, we consider how loss aversion changes utility. A loss averse retailer places a greater weight on losses than gains (i.e.,  $\omega_L(p) = \lambda * p$  where  $\lambda > 1$  and

$\omega_G(p) = p$ ). With a fixed order quantity,  $Q$ , expected losses are larger for the high product risk product than the low product risk product regardless of the contract type. As in Tversky and Kahneman (1991), we assume a constant  $\lambda$  for all decision makers. Under this assumption, we again should observe a stronger preference for the low product risk product under both types of contracts. Therefore, while both loss aversion and risk aversion may alter the evaluation of an individual product across contract types, the comparison of the two products under a given contract type is not altered when  $Q$  is fixed. Loss aversion alone cannot explain the results of the pilot study.

Finally, we consider a second tenet of Prospect Theory that proposes that decision makers overweight small probabilities and underweight large probabilities. Returning to the utility functions described above, Prospect Theory suggests that decision makers apply a nonlinear probability weighting function,  $\omega_L(p)$  and  $\omega_G(p)$ , when evaluating utility (see Prelec 1998). In line with Cumulative Prospect Theory (Tversky and Kahneman 1992), we assume that the probability of loss is weighted with  $\omega_L(p) = \omega(p)$  and the probability of gain is weighted with  $\omega_G(p) = 1 - \omega(p)$ . For consistency with prior research, we will assume throughout the paper a weighting function  $\omega(p) = \exp(-(-\ln(p)^\lambda))$  where  $0 < \lambda < 1$ . This function is both regressive (i.e., first  $\omega(p) > p$ , then  $\omega(p) < p$ ) and s-shaped (i.e., is first concave, then convex) and is therefore able to describe behavior consistent with Prospect Theory. Notably, this function can explain a flip in preferences between the low and high product risk product as  $p(L)_S$  and  $p(L)_R$  or  $p(L)_{S,b}$  and  $p(G)_{R,b}$  increase.

When the probability of loss is low for both the high and low product risk

product (i.e., close to 0%),  $\omega(p)$  leads to an overweighting of losses and a higher utility with the low product risk product. When the probability of loss is high for both the high and low product risk product (i.e., close to 100%),  $\omega(p)$  leads to an overweighting of gains and a higher utility with the high product risk product. Because the buyback contract systematically decreases the chance of loss for both products when  $Q$  is fixed, this may lead to a distinctly different comparison of the two products under the buyback contract than under the wholesale price contract.

### 2.3.3 Prospect Theory Model

Given that Prospect Theory's two components (loss aversion and differences in weighting small versus large probabilities) can explain a flip in preferences for the high versus low product risk product across contract types while risk aversion and loss aversion alone cannot, we develop a new model of retailer decision making based on Prospect Theory. We develop formal hypotheses based on this model to be tested in Section 2.4.

Recall that Equation 2.1 described a retailer's choice of  $\alpha$  in terms of the difference in expected profit between the high and low product risk product (i.e.  $\delta EP$ ). Rather than use  $\Delta EP$  to predict changes in  $\alpha$  as in Equation 2.1, we will now define utilities derived from each product assuming that probabilities are weighted by  $\omega(p) = \exp(-(-\ln(p)^\lambda))$  with  $0 < \lambda < 1$ . This provides a difference in expected utility of  $\Delta U = U(1) - U(0)$  for the wholesale price contract and  $\Delta U_b = U(1) - U(0)$

for the buyback contract. Thus, in contrast to Equation 2.1, Equation 2.2 allows for decision makers to weight probabilities consistent with Prospect Theory.

$$\alpha = (1 - \beta_{BB} * I_{BB})\beta_U * \Delta U + \beta_{BB} * I_{BB}(\beta_U * \Delta U_b) \quad (2.2)$$

The results of our pilot study suggest that  $\beta_U$  is positive, leading to an  $\alpha = 1$  when the utility of the high product risk product is greater and an  $\alpha = 0$  when the utility of the low product risk product is greater. Specifically, this utility function predicts that for very small probabilities of loss, the participant will overweight loss, selecting the low product risk product. In contrast, when the probability of loss is large, participants will overweight gains, selecting the high product risk product. Below, we develop testable hypotheses based on this model.

### 2.3.4 Hypotheses

As noted in above, our pilot test revealed that participants acting as retailers did not align with rational, risk neutral behavior in selecting which product to stock (i.e., behavior did not adhere to Equation 2.1). It is possible that two behavioral influences are at play. First, we acknowledge that introducing a buyback may change the framing of the decision causing the decision maker to evaluate choices differently than under the wholesale price contract.

**Hypothesis 2.1.** *The product mix selected under the buyback contract will be significantly different from the product mix selected under the wholesale price contract (i.e., the coefficient of  $I_{bb}$  in Equation 2.2 will be significant).*

Our second hypothesis is derived from results found in the pilot study. While Equation 2.1 predicts profit maximizing behavior, we found in our pilot study that this does not accurately explain participant preferences. However, the model of retailer behavior presented in Equation 2.2 assumes that participants overweight small probabilities and underweight large probabilities, potentially creating a flip in preferences for the low product risk product across contract types. Therefore, as in Equation 2.2, we propose that retailers will be impacted by the gains and losses presented.

**Hypothesis 2.2.** *Participants will overweight gains when the chance of gain is less than the chance of loss and will overweight losses when the chance of gain is greater than the chance of loss (i.e., Equation 2.2 will better predict product mix selections than Equation 2.1).*

Study 1 was designed to test these hypotheses in an environment where quantity is fixed and the sole choice is allocating the fixed quantity between a high and low product risk product.

## 2.4 Study 1: Retailer Product Choice

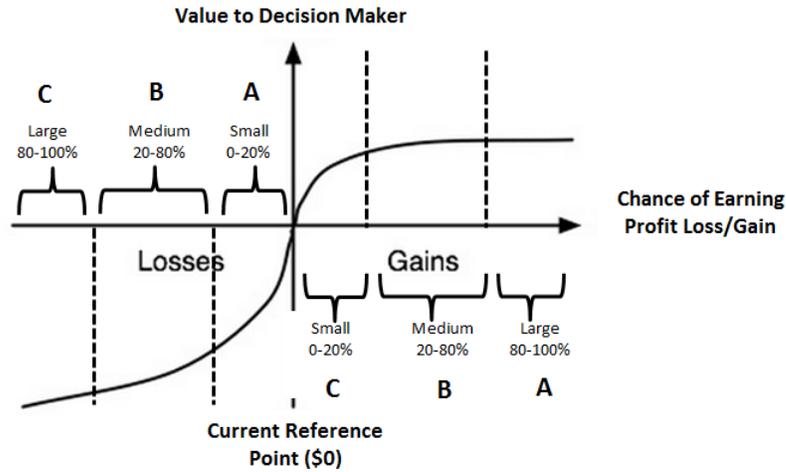
Study 1 was designed to explicitly test retailer preferences between high and low product risk products when offered either the wholesale price or buyback contract. Specifically, we test whether preferences shift as the probability of loss varies so that we may examine the power of Prospect Theory to explain our findings in the pilot study. Rather than restricting participants to a binary choice between the

high or the low product risk product as in the pilot study, we offered participants the opportunity to stock a mix of high and low product risk products to fulfill a fixed order quantity,  $Q$ , by setting  $\alpha$  as defined in Section 2.3.

The results of our pilot study suggests that participants may evaluate utility by applying a probability weighting function. This theory claims that human decision makers are more sensitive to differences in chance of loss or chance of gain when the numbers are relatively close to zero because they overweight small probabilities (i.e., at the steepest points on the S-curve as seen in Figure 1 associated with region A: small percentages). For example, in a comparison of  $p(L)_R = 5\%$  with  $p(L)_S = 1\%$  versus a comparison of  $p(L)_R = 25\%$  with  $p(L)_S = 21\%$ , the 4% difference looms larger in the first. Therefore, the difference in distance from a reference point of 0% can create a flip in preferences.

H2.2 suggests that product mix selections depend on the relative probabilities of gains and losses. Thus, in Study 1, we examine loss percentages,  $\mathbf{p(L)}$ , over a spectrum where  $\mathbf{p(L)} = [p(L)_S, p(L)_R, p(L)_{S,b}, p(L)_{R,b}]$ . In addition to manipulating contract type, we manipulate loss percentage by breaking the spectrum into three ranges: (1) small  $p(L)$ : 0-20% (Region A in Figure 1), (2) medium  $p(L)$ : 20-80% (Region B in Figure 1) and (3) large  $p(L)$ : 80-100% (Region C in Figure 1). Note that while we refer to the range of  $p(L)$ , a small  $p(L)$  implies large  $p(G)$  and large  $p(L)$  implies small  $p(G)$ . Essentially, we have a one-to-one mapping between  $p(L)$  and  $p(G)$ .

Figure 2.3: Illustration of Prospect Theory Value Function



### 2.4.1 Procedures

Study 1 was conducted with 177 undergraduates from a large mid-Atlantic university who were compensated based on performance via an incentive compatible lottery. Our experimental design was  $2$  (contract type: wholesale price, buyback)  $\times$   $3$  ( $p(L)$ : small, medium, large) where both contract type and  $p(L)$  were manipulated between subjects. Manipulating contract type allowed us to examine a possible effect of offering a buyback contract rather than wholesale price, while manipulating  $p(L)$  allowed us to study the role of Prospect Theory in retailer product selection.

Participants were told that they would operate a small kiosk that stocks a fixed quantity of a single product category every period,  $Q$ . At the start of each period, they were presented with two product options, one with low product risk and one with high product risk. The decision task was to allocate the preset quantity,  $Q$ , between the two options. This decision was made 6 times. Participants were informed that profits from one of the 6 periods would be randomly selected to

determine the performance-based portion of their payment. Therefore, our reward structure encouraged participants to view each period independently. In each of the 6 periods, the participants were provided with four pieces of relevant information prior to making their decision: (1) product category information, (2) contract parameters, (3) demand distributions of product options, and (4) comparable metrics for product options. Below, we describe the information given to subjects by presenting the parameters we used in Period 1. Please see the Appendix for a table detailing the specific parameters used in Periods 1-6.

#### 2.4.1.1 Product Category Information

At the start of each period, participants were told which product category they would be stocking (e.g., handbags, belts, bracelets, gloves)<sup>1</sup>. The product category was the same for all conditions by period with each product category seen only one time by each participant. For example, in Period 1, all participants were told they were selling scarves. After seeing the product category, participants were shown the retail price (\$25 for Period 1) for the product and were told that they will order a fixed quantity,  $Q$  (with  $Q = 225$  in Period 1).

Although each product has a different optimal order quantity under each contract, we have fixed the order quantity across conditions since we are not interested in the quantity decision but rather, how participants choose to stock high and low

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<sup>1</sup>The product type was varied as a robustness check of our results. This ensured that participants' preconceived notions of a particular product was not driving choices.

product risk products. Studying this single decision allows us to isolate any effects that may be altered if participants made the joint product/quantity decision. While this quantity is not optimal, it does not detract from our findings regarding what level of product risk retailers choose to take. We vary this  $Q$  to be either less than the mode, equal to the mode, or greater than the mode of the triangular distribution in a given decision period. The appendix details the demand distribution and fixed  $Q$  for each decision period. Regardless of whether or not  $Q$  is optimal, one product is characterized by lower product risk, therefore, we can study the retailer's level of product risk for any fixed  $Q$ .

Finally, participants were informed that the resale value of leftover items was equal to the cost to process leftover items, essentially creating a salvage value of \$0.

#### 2.4.1.2 Contract Parameters

Following basic product information, participants were shown a diagram explaining how either the wholesale price or buyback contract operated (See Appendix for screenshots). Following this, participants saw the specific terms of the given contract for the current period. In the wholesale price condition, participants were told explicitly that the supplier was offering them a basic wholesale price in which he would charge  $\$w$  per item, regardless of the product option selected. In the buyback condition, participants were told that the supplier would charge  $\$w_b$  (with  $w_b = w$  within each Period) per item and, if any items were leftover at the end of the selling

season, the supplier would buy them back for  $\$b$  per unit.<sup>2</sup> Contract parameters,  $w$  and  $b$ , were used to manipulate  $p(L)$  and were therefore the only parameters that change by  $p(L)$  condition. In Period 1, we have  $w = w_b = \$12.50$  with  $b = \$4$  in the small  $p(L)$  condition,  $w = w_b = \$17.25$  with  $b = \$4$  in the medium  $p(L)$  condition, and  $w = w_b = \$22$  with  $b = \$4$  in the large  $p(L)$  condition.

These contract parameters were designed specifically to create a difference in expected profits of less than 3% (i.e.,  $|\frac{\Pi(1)-\Pi(0)}{\Pi(0)}| < 0.03$ ). This restriction was imposed so that, in terms of expected profits, participants should be relatively indifferent when selecting  $\alpha$  if they are profit-maximizing. In contrast, if their behavior is governed by a probability weighting function consistent with Prospect Theory (as defined in Equation 2.2), then the low product risk product will generate higher utility when  $p(L)$  is small (i.e., region A of Figure 2.3) and the high product risk product will generate higher utility when  $p(L)$  is large (i.e., region C of Figure 2.3).

### 2.4.1.3 Demand Distribution of Product Options

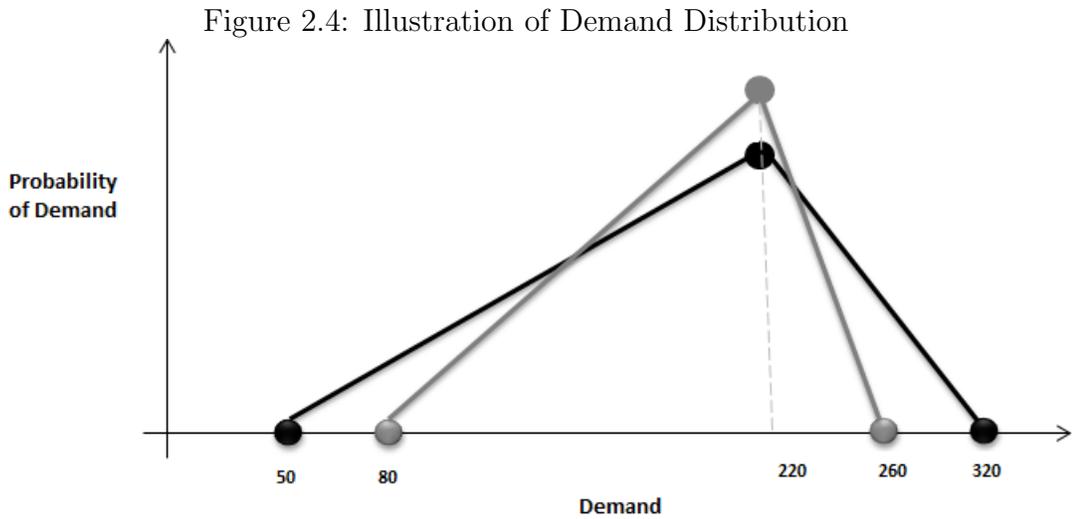
The next piece of information given to the participants showed the demand distribution of the product options. Both product options were assigned a random letter as a label. For instance, in Period 1, the high product risk product was labeled “Style A” and the low product risk product “Style B.” It was explained to participants that while both products follow a triangular distribution with the same “most likely demand” (i.e., mode), one product option (the high product risk product)

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<sup>2</sup>The same  $w$  was provided in each condition so that we could isolate the effect of the presence of a buyback.

had a lower minimum demand and higher maximum demand. In Period 1, both products had a mode equal to 220 for all conditions. The high product risk product had a maximum of 320 with a minimum of 50 while the low product risk product had a maximum of 260 with a minimum of 80. This information was also displayed visually as a graph of the demand distributions (see Figure 2).

The triangular distribution was chosen because it is easily understood by participants and allowed us to generate the ranges for probability of loss/gain necessary for verifying Prospect Theory. With this in mind, we study both left and right skewed triangular distributions as well as fixed order quantities that are above and below the mode. By considering all combinations of these pairings we provide a robustness check for our results.



#### 2.4.1.4 Comparable Metrics for Product Options

Finally, participants were given information by which to compare the two product options and their profit streams. Although expected profits were not explicitly

shown, participants were shown probability of loss,  $p(L)$ , conditional losses,  $C(L)$ , probability of gain,  $p(G)$ , and conditional gains,  $C(G)$ . This information was provided for five different mix options that participants could select: (1) stocking 100% of the low product risk product, (2) stocking 75% of the low product risk product and 25% of the high product risk product, (3) stocking 50% of each product option, (4) stocking 25% of the low product risk product and 75% of the high product risk product, (5) stocking 100% of the high product risk product.

These were the only mixing options presented to the participants. This information was displayed to the participants in table form. In Figures 3 and 4, we present the tables provided to participants in Period 1 in the small  $p(L)$  condition for both the wholesale price and buyback contract. From these figures, we see that as a participant stocks more of the high product risk product (product B in the figures), the variance in his profit stream increases as a result of added product risk.

Figure 2.5: Comparable Metrics provided in Wholesale Price Condition for Small  $p(L)$

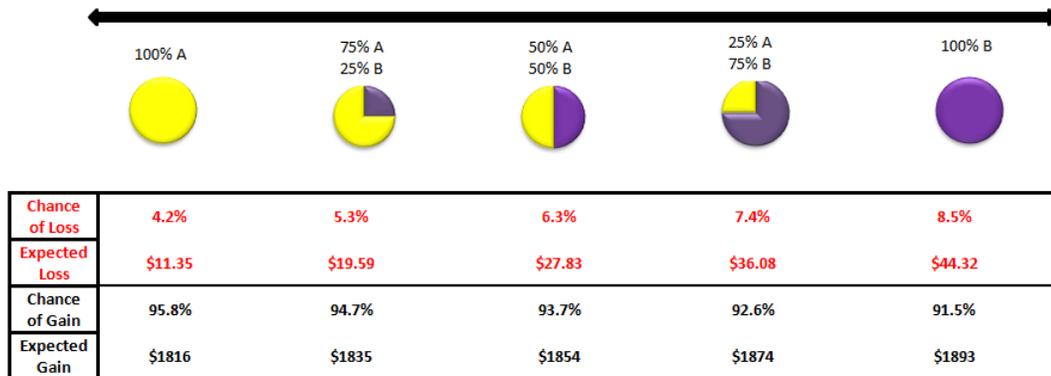
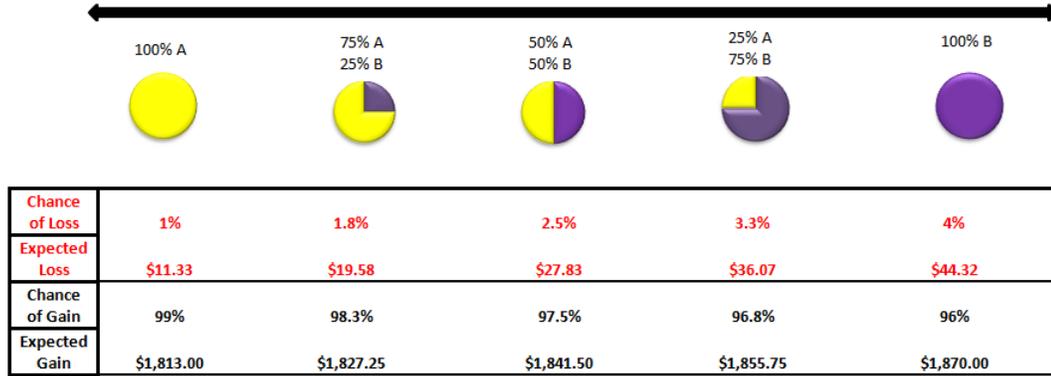


Figure 2.6: Comparable Metrics provided in Buyback Condition for Small  $p(L)$



#### 2.4.1.5 Dependent Measures

After being presented with the information above, participants were asked to select which mix of products they would like to stock. Demand was then randomly generated from the appropriate distribution and profits/losses were shown to participants at the end of each period.

After all 6 periods had concluded, participants were presented with the same loss/gain information framed as a lottery rather than inventory decision. This dependent measure was used to explore the effects of framing on behavior. Following this, participants completed four scales measuring individual differences in (1) numeracy (Fagerlin et al. 2007), (2) anticipated regret (Kugler et al. 2009), (3) loss aversion (Zhang et al. 2012), and (4) risk aversion (Weber et al. 2002). While risk aversion and loss aversion were conceptually ruled out as drivers of the results in our pilot study, we collect information regarding these individual differences to act as controls in our analysis. In addition, we collect information to gauge the ability of anticipated regret and numeracy to explain our results.

## 2.4.2 Results

Table 2.2 presents the results of Study 1 as percentage of high product risk product selected by condition, by period. Stocking 0% indicates a participant selected 100% of the low product risk product (i.e.,  $\alpha = 0$ ) while stocking 100% indicates that the participant selected 100% of the high product risk product (i.e.,  $\alpha = 1$ ). A star indicates that the percentage is significantly different from a 50/50 mix of products in a two-tailed test with  $p < 0.05$ . We will first discuss preliminary results evident in Table 2.2. Following this, we will examine the results of a series of regression models to confirm our hypotheses.

As we observe in Table 2.2, the wholesale price contract appears to induce a 50/50 split the majority of the time with only 5 cases having an average significantly different from 50/50. The buyback contract, however, leads to product mixes significantly different from 50/50 split in all but the medium  $p(L)$  condition. These preliminary observations support H2.1, indicating significant differences in behavior when offered the buyback contract.

Another notable observation is that participants appear to stock more of the low product risk product in the small  $p(L)$  condition but less of the low product risk product in the large  $p(L)$  condition. This supports H2.2's prediction that participant preferences are sensitive to losses when  $p(L)$  is small and gains when  $p(L)$  is large (i.e.,  $p(G)$  is small). Given that the buyback contract produces smaller  $p(L)$  than the wholesaleprice contract for a given  $w = w_b$ , participants are more sensitive to the difference in loss percentage between products when  $p(L)$  is small and a

Table 2.2: Percentage of High Product Risk Product Chosen by Condition and Period

Condition		Period 1	Period 2	Period 3	Period 4	Period 5	Period 6	N
WP	Small $p(L)$	53%	50%	45%*	46%	46%	43%*	28
		(1.8)	(2.1)	(1.6)	(2.0)	(1.7)	(2.1)	
	Medium $p(L)$	43%*	42%*	44%	48%	51%	48%	30
		(2.3)	(1.5)	(1.5)	(1.5)	(1.6)	(1.9)	
	Large $p(L)$	48%	52%	51%	52%	57%*	51%	29
		(1.7)	(1.6)	(1.9)	(1.8)	(2.1)	(2.2)	
BB	Small $p(L)$	35%*	32%*	32%*	32%*	33%*	34%*	31
		(2.1)	(1.9)	(1.9)	(1.8)	(1.9)	(1.6)	
	Medium $p(L)$	54%	50%	56%	51%	54%	51%	29
		(2.8)	(2.4)	(2.5)	(2.5)	(2.8)	(2.7)	
	Large $p(L)$	64%*	60%*	65%*	66%*	67%*	65%*	30
		(2.1)	(2.2)	(2.0)	(1.9)	(1.8)	(2.5)	

Percentages represent average stocking mixes by condition with the standard deviation reported in parentheses. A \* indicates significantly different from a 50/50 mix in a two-tailed test with  $p \leq 0.05$

buyback contract is offered.

To provide additional support for this we conducted a two-way repeated measures ANOVA with period as the repeated factor. The results show that  $p(L)$  significantly impacts choice ( $F(2) = 109, p < 0.001$ ). While the main effect of contract type is not significant ( $F(1) = 3.833, p < 0.11$ ), the interaction between contract type and  $p(L)$  is significant ( $F(2) = 86, p < 0.001$ ). This indicates that contract type does not directly influence participant stocking decisions over the 6 periods; the impact of  $p(L)$  differs across contract type.

To test our hypotheses directly, we conducted two regressions based on Equations 2.1 and 2.2. The first model, based on Equation 2.1, predicts that expected profits drive the participants' choice of  $\alpha$  such that  $\alpha = (1 - \beta_{BB} * I_{BB})\beta_{EP} * \Delta EP + \beta_{BB} * I_{BB}(\beta_{EP} * \Delta EP_b)$ . Conversely, Equation 2.2 predicts that participants apply a probability weighting function consistent with Prospect Theory,  $\omega(p) = \exp(-(-\ln(p))^\lambda)$  with  $0 < \lambda < 1$ <sup>3</sup>. This dictates that  $\alpha = (1 - \beta_{BB} * I_{BB})\beta_U * \Delta U + \beta_{BB} * I_{BB}(\beta_U * \Delta U_b)$ .

Let us first examine Equation 2.1 which predicts profit maximizing behavior (see Table 2.3). Our study was designed such that participants should be indifferent between the two products in terms of expected profits (i.e., selecting a 50/50 split in all conditions). In our regression model,  $\Delta EP$  is not a significant predictor of the retailer's level of product risk,  $\alpha$ . While we designed the experiment so that expected profit would not be a significant predictor, Table 2.2 clearly indicates a

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<sup>3</sup>Although three values of  $\lambda$  were tested ( $\lambda=0.1, 0.5$ , and  $0.9$ ), only the results of the model with  $\lambda=0.1$  are reported. Results are similar across different values of  $\lambda$ .

Table 2.3: Results of Logistic Regression on Product Choice (Equation 2.1)

	Small $p(L)$	Medium $p(L)$	Large $p(L)$	All Conditions
Intercept	0.634*** (0.047)	0.492*** (0.067)	0.591*** (0.051)	0.578*** (0.036)
$I_{BB}$	-0.185*** (0.037)	0.109 (0.062)	0.231*** (0.041)	0.05 (0.03)
$\Delta EP$	-0.014 0.025	0.022 0.031	0.029 (0.024)	0.004 (0.018)
$I_{BB} * \Delta EP$	0.013 (0.033)	-0.001 (0.044)	-0.077* (0.035)	-0.027 (0.025)
Loss Aversion	-0.005 (0.016)	0.058 (0.042)	-0.028 (0.017)	-0.002 (0.012)
Risk Aversion	0.005 (0.007)	0.016 (0.009)	-0.002 (0.006)	0.008 (0.005)
Anticipated Regret	-0.003 (0.005)	-0.018 (0.068)	0.0004 (0.005)	-0.012 (0.008)
Numeracy	-0.003 (0.005)	0.003 (0.007)	0.002 (0.006)	0.003 (0.004)
Period	-0.01 (0.006)	0.007 (0.007)	0.007 (0.006)	0.002 (0.004)

Table 2.4: Results of Logistic Regression on Product Choice (Equation 2.2)

	Small $p(L)$	Medium $p(L)$	Large $p(L)$	All Conditions
Intercept	0.775*** (0.079)	0.492*** (0.065)	0.614*** (0.048)	0.597*** (0.034)
$I_{BB}$	-0.345*** (0.089)	-0.0002 (0.0002)	0.191*** (0.034)	-0.021** (0.0059)
$\Delta U$	0.004* (0.002)	0.091* (0.036)	0.0003** (0.003)	0.017* (0.004)
$I_{BB} * \Delta U$	0.003* (0.002)	0.0002 (0.0003)	-0.0006 (0.0005)	0.000003 (0.0003)
Loss Aversion	-0.003 (0.016)	0.059 (0.042)	-0.031 (0.017)	-0.00009 (0.0124)
Risk Aversion	0.005 (0.007)	0.016 (0.009)	-0.002 (0.006)	0.007 (0.048)
Anticipated Regret	-0.003 (0.005)	-0.018 (0.068)	0.0005 (0.005)	-0.011 (0.036)
Numeracy	-0.003 (0.005)	0.003 (0.007)	0.0006 (0.006)	0.003 (0.004)
Period	0.001 (0.009)	0.005 (0.008)	0.005 (0.006)	0.0008 (0.004)

pattern in participants decisions where a 50/50 split is not consistently selected. This pattern suggests differences in product choice behavior under the buyback contract, however, this pattern is only detectable in our regression when the results are separated by condition. When  $p(L)$  is small, we see that the coefficient of  $I_{BB}$  is negative and significant indicating a stronger preference for the low product risk product under the buyback contract as in the pilot study. When  $p(L)$  is large, we see that the coefficient of  $I_{BB}$  is positive and significant indicating a reversal of preferences.

Equation 2.2, which predicts that participants will evaluate expected loss and expected gains through the lens of a probability weighting function appears to better predict our data. The coefficient of  $I_{BB}$  in the full model is negative and significant,  $-0.021$ , demonstrating that participants select more of the low product risk product when offered the buyback contract as compared to the wholesale price contract (see Table 2.4). When broken down by  $p(L)$  condition, we find a pattern consistent with that of the results using Equation 2.1. This finding confirms H2.1 which posits that the buyback contract will evoke different behavior.

Now we will turn our attention to understanding the role that expected losses and gains play. The coefficient of  $\Delta U$  is both positive and significant in all regression models indicating that participants stock more of the high product risk product when it generates higher utility (i.e.,  $\alpha$  increases) and stock more of the low product risk product when it generates higher utility (i.e.,  $\alpha$  decreases). This finding provides evidence that participants evaluate the chance of loss and chance of gain using a prospect theory probability weighting function, supporting H2.2. In addition, we

find that there is no significant effect of period or the individual level factors (i.e., loss aversion, risk aversion, anticipated regret, and numeracy).

To test which model better fits our data, we built the same full regression models (column 4 in both Table 2.3 and 2.4) using a randomly selected 75% of the data. These models were then applied to a hold out set consisting of the remaining 25% of the data. For both Equation 2.1 and Equation 2.2, we computed the mean squared error (MSE) between the predicted product mix and the actual product mix on this hold out set. The model built using Equation 2.1 resulted in an MSE of 0.38 while the model using Equation 2.2 resulted in an MSE of 0.051. These results suggest that a model consistent with a Prospect Theory weighting function better explains the results of our study.

### 2.4.3 Discussion

Study 1 manipulated contract type and  $p(L)$  between subjects, allowing us to test H2.1 and H2.2. Participants acting as retailers assumed markedly different levels of product risk when offered a buyback contract, as opposed to a wholesale price contract, opting to stock more of the low product risk product under the buyback contract. This finding suggests that although the buyback contract introduces supplier risk-sharing, seems to encourage retailers to assume less product risk under some conditions. In addition, we find that product choice is influenced by the relative size of  $p(G)$  and  $p(L)$ . While we do find behavior consistent with Prospect Theory, the more interesting result is that the buyback contract may lead to stock-

ing more of the low product risk product when  $p(L)$  is low but this effect is reversed when when  $p(L)$  is high.

Consistent with our pilot study, we find a pattern of results that is consistent with Prospect Theory that cannot be explained by either loss aversion or risk aversion. In this study, we attempt to eliminate two additional explanations of behavior, anticipated regret and complexity. First, we consider task complexity. The wholesale price contract creates an arguably less complex decision setting than the buyback contract does, potentially influencing choice behavior across contract types. However, product preferences also change as the probability of loss grows larger. Because of this, we can rule out task complexity as an explanation of behavior. Finally, we address anticipated regret as a possible explanation for behavior. If a decision maker anticipates regretting his decision to stock the high product risk product should realized demand be low, a buyback would potentially decrease this anticipated regret, suggesting that retailer's would stock more of the high product risk product when offered the buyback contract. Like task complexity, however, anticipated regret cannot explain changes in preferences due to changes in probabilities of loss. Therefore, we rule out anticipated regret as an explanation.

This study achieved two primary goals. First, we have demonstrated that contract type affects the level of product risk taken by the retailer. Second, we have found that results are not aligned with risk neutral behavior but rather are in line with a Prospect Theory explanation. However, Study 1 considered product choice as an isolated decision. In reality, retailers make a full retail assortment planning decision, deciding which products to stock and how much of them to stock. Given

the copious amounts of research regarding the quantity decision for a fixed product, it is interesting to study if the observed behavior changes when making both decisions at the same time. Although research suggests that human decision makers consider decisions in an isolated, sequential manner (Kahneman and Lovallo 1993), it is possible that participants will balance quantity risk with product risk when the quantity decision is considered simultaneously with product choice. Therefore, in the following section we present Study 2 where we allow participants to first select a product to stock and then determine how much of that product to order. The next section proposes new hypotheses and presents the procedures and results of Study 2.

## 2.5 Study 2: The Joint Product/Quantity Decision

Study 1 confirmed our predictions that decision makers' product choices are subject to behavioral influences. Since in practice, the decision of what product to stock is considered in conjunction with quantity, it is important to study how one decision maker approaches both decisions. Therefore, we have designed Study 2 to study how the retailer's behavior changes when making the joint decision of what to stock and how much to stock under both the wholesale price and buyback contract. Below, we extend our hypotheses to consider the joint decision and then explain the procedures of Study 2.

### 2.5.1 Hypotheses

Our previous studies suggest that the wholesale price contract encourages retailers to assume more product risk, but these studies have not incorporated quantity decisions. A rational decision maker may use quantity to balance product risk. For example, a retailer using a wholesale price contract may choose to stock a product with higher demand variance but order a lower quantity of that product, balancing higher product risk with lower quantity risk.

Although taking a broad perspective of decision problems is generally recognized as a requirement for rational decision making, empirical research suggests that actual decision makers tend to make decisions one at a time, neglecting the connection between current and future decisions (Kahneman and Lovallo 1993). There is copious evidence that decision makers approach multiple decisions sequentially but in an isolated manner, compounding the effects of behavioral biases. In their paper on choice bracketing, Read, Loewenstein and Rabin (1999) propose that when decision makers approach a set of connected decisions, they can consider them one at a time (a very narrow bracket) or many simultaneously (a broad bracket). Simonson (1990) refers to this tendency to segregate or aggregate decisions as sequential versus simultaneous choice. Notably, decision makers are more likely to use narrow bracketing when they face mentally taxing decisions (Read, Loewenstein and Rabin 1999). Consistent with this earlier work, we expect that participants will approach product and quantity decisions in an isolated manner, implying that product choice behavior will be consistent with Study 1 and quantity decisions should be consistent

with prior research (Schweitzer and Cachon 2000).

**Hypothesis 2.3.** *Quantity decisions will not be significantly influenced by the participant's product choice selection.*

### 2.5.2 Procedures

The goal of Study 2 is to provide a robustness check for the effect of contract type on retailer product choice in the presence of quantity decisions. Given that Study 1 examined the full range of  $p(L)$ , in Study 2 we truncate the range of  $p(L)$  and focus solely on the effect of contract type, using only small  $p(L)$ . Our experimental design is 2-cell (contract type: wholesale price, buyback), where contract type is manipulated between subjects. The study was conducted with 50 undergraduate students from a large Mid-Atlantic university who were currently enrolled in an Operations Management course. They were provided course extra credit for participation and were also compensated via an incentive compatible lottery.

The procedures of Study 2 were similar to Study 1 with a few minor changes. First, participants were told that they operated 6 independent stores and were going to make 6 joint decisions of a product to stock and quantity to stock. It was made clear that the profits of the 6 stores were not linked in any way. As in Study 1, in each of the 6 decisions, the participants were given 2 product options. Again, participants saw product category information, contract parameters, demand distributions, and comparable metrics. The only differences were that the demand distribution provided for both products was the normal distribution (rather than triangular) and

comparable metrics were provided, in a similar format found in Figures 3 and 4, for each product for the 25th, 50th, and 75th percentiles. Finally, parameters were set such that the optimal order quantity was the 40th percentile in decision 1-3 and the 60th percentile in decisions 4-6 <sup>4</sup>. The Appendix provides tables detailing the parameter selections for each of the 6 decisions in Study 2.

After being exposed to all relevant information, participants were asked to make a binary choice between products. Study 1 allowed a mix of products, but, since we have now incorporated quantity as a variable, a binary choice simplifies the decision setting for the participants while still being able to test our hypotheses. Following this, the participant entered a quantity to order. It was made clear to participants that they could enter any quantity they desired and it did not have to be the 25th, 50th, or 75th percentiles shown as examples (See Figure 5). While participants made the two choices in a sequential manner, all information was presented prior to either of the decisions and therefore the decisions could have been considered jointly by participants. After they made choices for each of the 6 independent stores, the participants answered a series of scale questions to gauge their individual risk aversion, loss aversion, and numeracy.

### 2.5.3 Results

Tables 2.5 and 2.8 below present a summary of the results from Study 2. Table 2.5 outlines the percentage of participants who selected the high product risk

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<sup>4</sup>Given research demonstrating a pull to center effect in order quantities, we consider optimal quantities on both sides of the mean.

Figure 2.7: Screen Shot of Tables Provided in Study 2

**Product H**

	Chance of Loss	Expected Loss	Chance of Gain	Expected Gain
153 units	4.6%	\$374	95.4%	\$911
200 units	11.5%	\$461	88.5%	\$970
247 units	23.1%	\$578	76.9%	\$930

**Product J**

	Chance of Loss	Expected Loss	Chance of Gain	Expected Gain
153 units	8.2%	\$614	91.8%	\$847
200 units	19.6%	\$750	80.4%	\$988
247 units	34.6%	\$935	65.4%	\$1101

product in each condition for each of the 6 decisions. Table 2.8 summarizes the quantity decisions each participant made and includes the optimal order quantity (Opt. Q) and mean demand (Mean) were for each of the decisions for comparison. We will first address the product choice decisions of the participants and then the quantity decisions.

Table 2.5: Summary of Study 2 Product Choice Decisions

Contract Type	Decision 1*	Decision 2*	Decision 3*	Decision 4*	Decision 5*	Decision 6*
WP	76%	68%	64%	72%	84%	76%
BB	28%	12%	16%	28%	44%	24%

A \* indicates that percentages are significantly different across contract types for that Decision period in a two-tailed test with  $p < 0.05$ .

To begin analyzing the product choice decisions of Study 2, we first examine preliminary conclusions drawn from Table 2.5 and then present the analysis of a logistic regression model (see Table 2.6). As we observe from Table 2.5, there is a strong preference for the high product risk product when participants are offered the wholesale price contract and a strong preference for the low product risk product

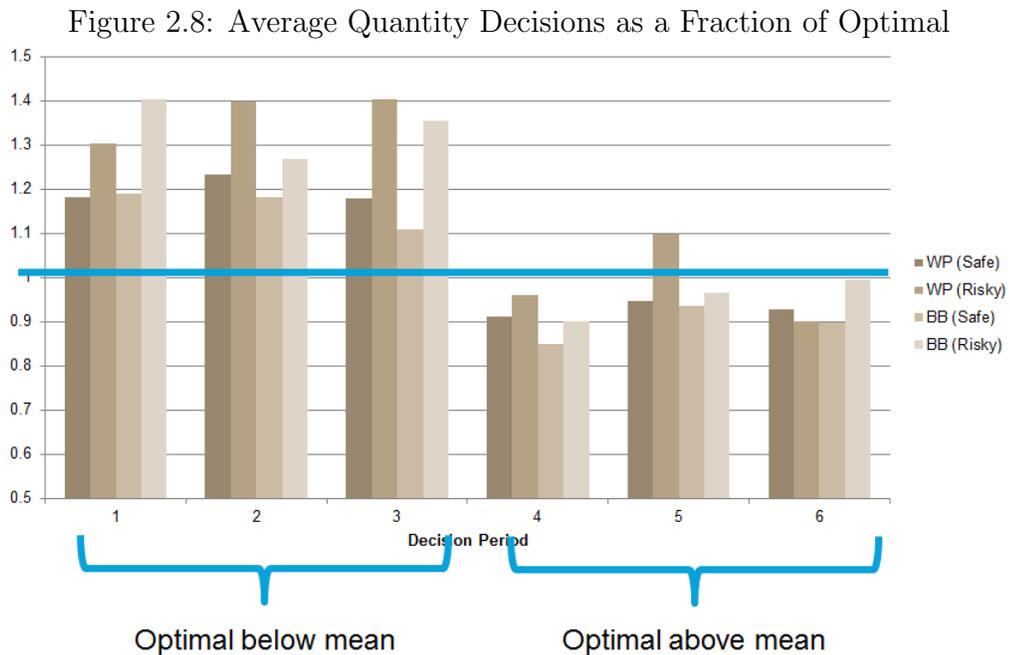
when offered the buyback contract. This evidence demonstrates that results were qualitatively similar to those in Study 1. To verify this conclusion more rigorously, we conducted two logistic regression models, similar to Equation 2.1 and Equation 2.2, in which the baseline is the probability that a participant chose to stock the high product risk product.

Similar to Study 1, a regression testing Equation 2.1 suggests that expected profit is not a significant factor in predicting participant product choice. Again, we see that a model testing Equation 2.2 better explains our results. We see that the coefficient of  $I_{BB}$ ,  $-0.28$ , is both negative and significant. This indicates that when offered the buyback contract at a low  $p(L)$ , the likelihood that a participant selected the low product risk product increases. Also in line with Study 1, we see that as  $\Delta U$  increases, participants are more likely to select the high product risk product (i.e., selecting the product that offers greater utility). This effect is enhanced under the buyback contract (as indicated by the positive and significant coefficient of  $I_{BB} * \Delta U$ ).

To examine the fit of both equations with our data, we again conducted analysis using a hold out set. Both Equation 2.1 and Equation 2.2 were built on a randomly selected 75% of the data. These models were then tested on the remaining 25% of the data used as a hold out set. Using a cut off point of 0.5 (i.e., model prediction resulting in  $< 0.5$  indicates selecting the low product risk product and  $> 0.5$  indicates selecting the high product risk product) we compare the models' predictions of product choice with actual product choice (see Table 2.7). The results of this test show that the model using Equation 2.1 accurately predicts product

choice in 58% of the cases whereas the model using Equation 2.2 accurately predicts product choice in 70% of the cases. This provides robust support for our findings in Study 1 and confirms that behavior did not change when participants also made the quantity decision.

We will now turn our attention to an examination of the quantity decision. In Table 2.6, it is obvious that participants are not selecting the optimal quantity; however, a pattern is detectable. In the first 3 decisions, participants are consistently ordering more than is optimal (when optimal is 40th percentile) and order less than optimal in decisions 4-6 (when optimal is 60th percentile). This suggests that a pull to center bias is occurring, similar to what previous research has found in retailer order quantity decisions (Schweitzer and Cachon 2000).



The main focus of Study 2, however, is to determine if product choice impacts the subsequent quantity decision (i.e., if participants consider the decisions in iso-

Table 2.6: Results of Logistic Regression Model: Chance of selecting high product  
risk product

	Equation 2.1 Expected Profits	Equation 2.2 Expected Utility
Intercept	1.206*** (0.103)	0.911*** (0.134)
$I_{BB}$	-2.239*** (0.412)	-0.28* (0.138)
$\Delta EP$	0.003 (0.002)	
$\Delta U$		0.0005*** (0.0004)
$I_{BB} * \Delta EP$	0.002 (0.003)	
$I_{BB} * \Delta U$		0.015* (0.007)
Loss Aversion	0.117 (0.256)	0.159 (0.255)
Risk Aversion	0.158 (0.16)	0.155 (0.159)
Anticipated Regret	0.198 (0.123)	0.202 0.123
Numeracy	-0.283 (0.24)	0.583 (1.674)

Table 2.7: Measure of Model Fit: Product Choice

	Expected Profit		Expected Utility	
	Equation 1		Equation 2	
	Predicted	Predicted	Predicted	Predicted
	Low Product Risk	High Product Risk	Low Product Risk	High Product Risk
Selected Low Product Risk	21%	13%	30%	9%
Selected High Product Risk	28%	37%	21%	40%

lation or simultaneously). To do this, we conducted a regression model to estimate retailer order quantity. Rather than estimate order quantity exactly since order quantities should vary through decisions 1-6, we have normalized all order quantities to be a fraction of optimal. In this regression, we include similar variables as in the product choice model with the addition of three new variables. Given the evidence of a pull to center bias, we have included an indicator variable for if the optimal quantity is below the mean (*Opt.BelowMean*) as well as an interaction between  $I_{BB}$  and *Opt.BelowMean*. Finally, in order to determine the impact of product choice on quantity decisions, we include a variable indicating the high product risk product has been select ( $I_R$ ). The results of this model are presented in Table 2.9.

We will first note that the coefficient of  $I_R$  is not significant. This indicates that the product choice made by participants has not significantly impacted their

Table 2.8: Summary of Study 2 Quantity Decisions

Condition			D1	D2	D3	D4	D5	D6
WP	Chose Low Product Risk	Avg. Order Q	205.55	256.59	290.95	193.83	255.35	303.73
		Opt. Q	174	208	247	213	270	328
		Mean	200	250	300	200	250	300
	Chose High Product Risk	Avg. Order Q	212.28	276.66	322.5	209.28	301.72	310
		Opt. Q	163	198	230	218	275	344
		Mean	200	250	300	200	250	300
BB	Chose Low Product Risk	Avg. Order Q	222.4	271.8	301.64	192.1	272.4	320.1
		Opt. Q	187	230	272	226	291	357
		Mean	200	250	300	200	250	300
	Chose High Product Risk	Avg. Order Q	255.6	284.2	358.9	212.4	291.4	367.99
		Opt. Q	182	224	265	236	302	370
		Mean	200	250	300	200	250	300

quantity choice. This result, in conjunction with the fact the product choice behavior is qualitatively similar in Study 1 and Study 2, confirm that participants consider the decisions sequentially rather than simultaneously. Finally, we take note of the impact of the pull to center bias. Recall that the baseline model estimates quantity under the wholesale price contract when the optimal quantity is below the mean. *Opt.BelowMean* has a positive and significant coefficient, 0.374, suggesting that when the optimal quantity is below the mean, participants order quantities increase as a percentage of optimal. More interesting, are the coefficients of  $I_{BB}$  and  $I_{BB} * Opt.BelowMean$ . The coefficient of  $I_{BB}$ , 0.223, is both positive and significant, indicating that when optimal is above the mean, order quantities are higher (i.e., closer to optimal) under the buyback contract. The coefficient of  $I_{BB} * Opt.BelowMean$ , 0.092, is negative and significant indicating the reverse. When the optimal order quantity is below the mean, participants order significantly less under the buyback contract (i.e., closer to optimal). These results suggest that, while there still exists a pull to center effect under both contracts, the effect is dampened by the buyback contract.

#### 2.5.4 Discussion

Study 2 was designed to both reaffirm the results of Study 1 and explore how incorporating quantity choice affects behavior. By manipulating contract type, we were able to replicate the behavior found in Study 1. This finding, coupled with the pull to center bias observed in the quantity decision, demonstrates that when

Table 2.9: Results of Linear Regression Model Estimating Normalized Quantity

Decision

Variable	Coefficient
Intercept	0.924*** (0.117)
Period	-0.110 (0.368)
$I_R$	0.0236 0.0553
$I_{BB}$	0.223*** (0.0149)
$p(L)$	2.713* (1.074)
<i>Opt.BelowMean</i>	0.374*** (0.026)
$I_{BB} * p(L)$	-1.457 (0.832)
$I_{BB} * \text{Opt.BelowMean}$	-0.092** (0.012)

making the decisions jointly, participant behavior is not different than when making the decisions in an isolated manner.

Together, Study 1 and Study 2 show that contract type affects inventory decisions in multiple ways. Study 1 showed that the buyback contract can lead to choices of more conservative products with less demand risk. Study 2 replicates this effect and also provides evidence that buyback contracts moderate the pull to center bias in quantity decisions.

## 2.6 Conclusion

In this paper, we study how contract type influences the product risk assumed by a retailer. We propose that decision makers acting as retailers consider a combination of losses and gains rather than expected profit when evaluating the choice between two products. Given that a buyback contract alters the framing of this decision, we examine how the level of product risk the retailer assumes changes when the retailer is offered a wholesale price versus a buyback contract. The results of our pilot study provide strong evidence that instead of acting in a profit maximizing manner, decision makers assume more product risk when offered a wholesale price contract than when offered a buyback contract. We attempt to explain these results by building a predictive model based on Prospect Theory and testing this model experimentally.

We find that a model consistent with Prospect Theory better explains retailer choice behavior than a model consistent with expected profit maximization. A

wholesale price contract reduces the relative difference in losses when comparing products with high and low demand variance. When choosing a product to stock, the retailer compares the expected losses and gains for a product with high demand variance and a product with low demand variance. Because the wholesale price contract makes the losses appear to be more similar across options, participants may focus more on the chance of gains than on the chance of losses than they do when using the buyback contract. In Study 1, we examine the mix of high and low product risk products participants acting as retailers choose to stock using each contract, provided the quantity decision has been predetermined. Across a wide range of loss percentages, we find that a model of retailer behavior including the Prospect Theory probability weighting function best explains product choice preferences. Moreover, in Study 2, we demonstrate consistent product choices when retailers make joint product choice and quantity decisions.

We contribute to current literature on product assortment planning by expanding the scope of the decision problem. While the product assortment literature focuses on optimal retail assortments in response to consumer demand functions, the contract between the retailer and supplier is assumed to be exogenous. Therefore, we provide insight by demonstrating that because decision makers are subject to behavioral biases, the contract type can influence the set of products a retailer wishes to stock and the overall level of product risk they assume. Furthermore, we connect product assortment planning decisions with behavioral decision theory by demonstrating that decision makers exhibit similar biases in an inventory context.

Our results provide many opportunities for extensions. One extension is to

consider alternate forms of contracts. We have studied only how a buyback contract affects the level of product risk taken by the retailer. There are numerous contracts at the disposal of suppliers and retailers. Any number of these contracts could similarly alter the decision framing creating systematic differences in product choices.

A second direction for future work is to explore when other decision bias impact the retail assortment planning decisions. We have found evidence that when faced with a buyback contract, loss percentages are altered in such a way that the influence of Prospect Theory governs participant decisions. There are various behavioral biases that have been found to impact choices under uncertainty such as loss aversion and risk aversion. An interesting extension would be to consider when alternate biases are present or conditions under which we can mediate the effect of Prospect Theory.

In summary, we provide strong evidence for a connection between contract type and retailer product risk. This connection provides important insight for both suppliers and retailers. Suppliers who offer multiple products to retailers should be aware that the structure of their contract may be influencing the retailers choice among the offered products. It is possible that suppliers could use contract type as a way to induce retailers to purchase specific products. If contract type does substantially affect retailer product choice as our results suggest, contracts may be shaping product lines offered by retailers in the long run, affecting suppliers, retailers and the end consumer. Therefore, understanding how contracts interact with product choice decisions provides useful theoretical and practical insight.

## Chapter A: Retailer/Supplier Interview

Interviews conducted with retailers and suppliers were done both by phone and online survey. Below, we present the set of questions asked during the interviews. While these are the basic questions asked during every interview, interviewees were allowed to either not answer questions, expand upon certain topics if necessary, or provide additional information.

### **Basic Information**

- (1) Job Title
- (2) Current Company Name
- (3) Current Number of Employees at Company
- (4) Current Company's Annual Revenue/Sales
- (5) What types of items do you buy/sell for your company?

Stock items (items that infrequently change such as basic white undershirts

Fashion/Seasonal items

- (6) Which category/categories best describe the type of inventory that you sell/buy?

Women's Apparel

Men's Apparel

Women's Footwear

Men's Footwear

Jewelry/Accessories

Purses/Handbags

### **Retailer-Supplier Relationship Questions**

- (1) Do you deal with most companies on a repeat basis?
- (2) Do you generally speak with the same representative from each company?
- (3) How does a company's past performance influence your future interactions with them?

### **Contract Specific Questions**

(1) Typically, before the start of the season, you must set/accept the terms of a purchase agreement for the items that you intend to sell/buy. Please think about one or two of the buyers/suppliers with whom you deal and use the box below to describe, in detail, the specifics of these interactions. Include details such as how far in advance of the season the purchasing terms are agreed upon, who proposes the purchasing terms, what is the payment structure, etc. Following this, we will ask a series of follow-up questions.

(2) The following questions will help us understand the specifics of your purchase agreements.

Is there typically only a wholesale price charged per item?

Who proposes the price, you or the other party?

Is the initial quantity ordered final, or are additional items allowed to be or-

dered during the course of the season?

Is the retail price for the item already set? If so, who sets this, you or the other party?

Is there ever a lower wholesale price offered for a larger order quantity (quantity discount)?

If so, how many different prices are usually offered?

If so, under what circumstances is this lower wholesale price offered? (for particular items, for particular clients, if the order is large enough, etc.)

How frequently do you buy/sell items for your company? (once a month, 3 times per year, etc.)

### **Questions Regarding Activity During the Selling Season**

Please indicate whether you are a buyer or a seller.

#### *Retailer Questions*<sup>1</sup>

(1) Can you describe what, if anything, you do during the season in order to promote your inventory to consumers (require employees to approach customers, design store layouts, run promotions, etc.)

(2) Do you have promotional sales/deals during the season?

(3) Can you ever place a second order with the seller if a particular item is experiencing higher than normal demand?

(4) How frequently do you update your website (weekly, every season, etc.)?

(5) How frequently do you email your customers (daily, weekly, during promotions,

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<sup>1</sup>These questions were asked only when the interview was conducted with a buyer/retailer

etc.)?

(6) Are you ever offered promotional money from the seller?

(7) If so, is this amount negotiated as part of the purchase agreement?

(8) Does the seller ever request sales data for the inventory from you during the selling season?

(9) If so, do they use this information so as to suggest ways to increase the sales of their inventory (lower price, re-position in store, etc.)?

### *Supplier Questions<sup>2</sup>*

(1) Can you describe what, if anything, you do during the season to track the sale of your items through the retailer (are you in communication with the retailer, do they send you frequent sales reports, etc.)

(2) How influential do you think the retailer's business practices are to the success of your items?

(3) Are you able to influence the manner in which the retailer sells your items (price, placement in store, promotions, etc.)?

(4) Can the retailer ever place a second order during the season if an item is experiencing higher than normal demand?

(5) How frequently do you update your website (weekly, every season, etc.)?

(6) How frequently do you email your customers (daily, weekly, during promotions, etc.)?

(7) Do you ever offer the retailer promotional money (money used to advertise your

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<sup>2</sup>These questions were asked only when the interview was conducted with a seller/supplier

items and/or cover the cost of promotional prices)?

(8) If so, is this amount negotiated as part of the purchase agreement?

(9) Do you ever request sales data from retailers for your items during the selling season?

### **Questions Regarding Activity at the End of the Selling Season**

#### *Retailer Questions*

(1) Could you describe, in detail, what happens to items at the end of the selling season (put on sale incrementally, sent to other stores, returned, etc.)?

(2) How many markdowns do you typically use?

(3) Is the size of the markdown influenced by the number of items you have left?

(4) Does the seller ever offer you markdown money (meaning that they offer to subsidize your profit margin loss for selling items on sale)?

(5) Is there ever a minimum price/floor price below which you are not allowed to price merchandise?

(6) Is there a larger parent company or outlet store to which you can send unsold merchandise?

(7) Do you ever sell unsold merchandise to liquidators?

(8) Do you ever donate unsold merchandise to charities?

(9) Can you ever send unsold merchandise back to the seller at the end of the season and be reimbursed a fraction of the wholesale price?

(10) If so, is there limit on the quantity you can send back?

*Supplier Questions*

- (1) Could you describe, in detail, any information you know regarding what happens to items at the end of the regular selling season (does the retailer put them on sale, does the retailer send them back to you, etc.)?
- (2) Do you know how many markdowns are typically used by retailers at the end of the selling season?
- (3) Is the size of the markdown influenced by the number of items left?
- (4) Do you ever offer the retailer markdown money (meaning that you offer to subsidize profit margin loss for selling items on sale)?
- (5) Is there ever a minimum price/floor price below which you do not allow the retailer to sell your merchandise?
- (6) Is there a larger parent company or outlet store to which you can send unsold merchandise?
- (7) Do you ever sell unsold merchandise to liquidators?
- (8) Do you ever donate unsold merchandise to charities?
- (9) Do you ever allow retailers to send unsold merchandise back at the end of the season and be credited a fraction of the wholesale price?
- (10) If so, is there a limit on the quantity they can send back?
- (11) If so, are there conditions under which you allow items to be sent back?

## Chapter B: Chapter 1 Study Procedures

Below we provide the stimuli provided to participants in Study 1, 2, and 3. First we present screen shots of the diagrams shown to participants in order to describe the contracts (both wholesale price and buyback contract). These diagrams were used throughout all three studies. Following that, we provide the text based stimuli used in each of the three studies. Finally, we provide the scale questions used to measure (1) loss aversion, (2) risk aversion, (3) anticipated regret, and (4) numeracy.

### B.0.1 Contract Diagrams

### B.0.2 Study 1

#### *Introduction*

Before retailers sell goods to consumers, they need to buy these goods from a supplier. The retailer and supplier often enter into a contract in which they specify terms such as the price of the goods, how many goods will be purchased, and what happens if the retailer is unable to sell all of the goods. In this experiment you will be playing the role of a retailer. As a retailer - you will be presented with a contract

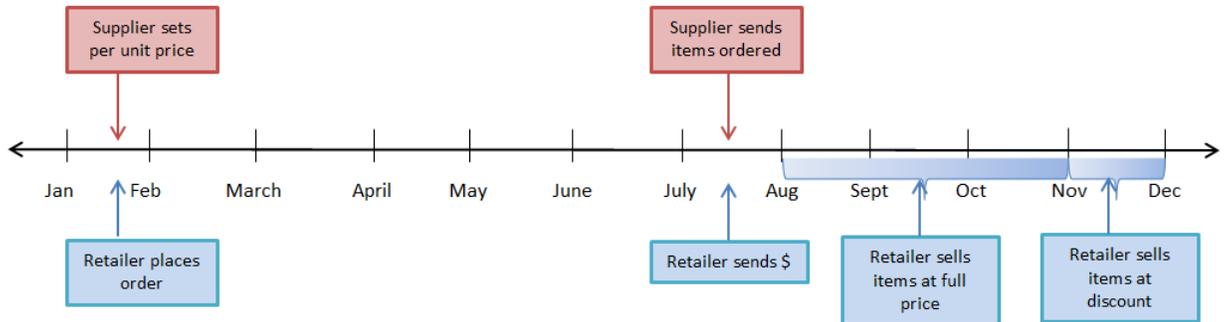
### The Wholesale Price Contract

The wholesale price contract is the most basic form of contract you can use.

**January 5:** Supplier sets a **per unit price** to charge per pair of boots (in francs)

**January 15:** Retailer will **place an order** for a preset number of pairs of boots (Retailer pays upon delivery but payment is guaranteed)

**August 20:** The entire order is **shipped** and the retailer pays in full. Retailer decides whether or not to schedule overtime workers.



#### For Example:

If a wholesale price of 20 francs is set, and you choose to order 200 units, you will pay the supplier 4000 francs when the order is shipped. This is the only exchange the retailer has with the supplier for the season.

from a supplier. After viewing the contract, an order for items will be placed. Your job will be to indicate how much effort you would like to exert in order to sell the items you purchased.

### Your Payment

You have the chance to win \$100 in today's study. ONE participant from this class will be selected. Your chance of being picked is based on your performance in this study. The more profit you earn, the larger your chance of being selected.

Thus, please consider your choices carefully. You may want to have a pen and paper in order to take notes during the study.

### *Setting Information*

Currently, it is January 1st and you will be buying boots for the Fall season from Tip Top Manufacturers.

Information that you know:

### The Buyback Contract

A buy-back contract is slightly more complex and allows the supplier to share some of the risk with the retailer by agreeing to buy back any unsold items at the end of the selling season.

#### July 5:

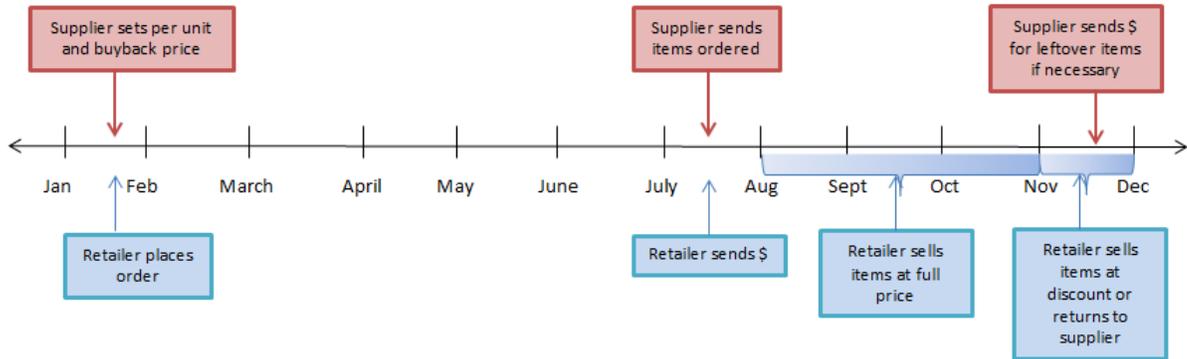
- (1) Supplier sets a per unit price to charge for each pair of sandals
- (2) Supplier sets a per unit buy back price they will pay per item for items not sold by November 28

**July 15:** Retailer will place an order for number of pairs of sandals (Retailer pays upon delivery but payment is guaranteed)

#### February 20:

- (1) The entire order is shipped and the retailer pays in full
- (2) Retailer determines whether or not they will schedule overtime workers

**May 28:** Unsold items can be returned to the supplier for the buyback price OR leftovers can be placed on sale



#### For example:

If the supplier charges 20 francs per pair of sandals with a 5 franc buy-back price and the retailer orders 800 pairs of sandals, the retailer will pay  $800 \times 20 = 16,000$  francs on February 20. If the retailer sells only 690 of the sandals at full price, then:

- (1) The retailer can choose to physically send the remaining 110 sandals back to supplier and they will owe the retailer  $110 \times 5 = 550$  francs or
- (2) The retailer may choose to sell the remaining 110 sandals at a discount for 8 francs each, making more than the 5 francs per pair of sandals promised by the supplier.

You know that each pair of boots costs the supplier 18 francs and that you will sell the boots for 48 francs at full price. Market research has shown that retail stores of the same size and in the same geographical region as yours are expected to sell at least 110 pairs and at most 510 pairs (i.e., demand is uniformly distributed between 110 and 510 pairs).

At the end of the season, you can place unsold items on sale. You have already decided that an appropriate sale price is 8 francs. At this reduced price, you know that all leftovers will sell.

During the season, you can exert effort to increase demand by asking employees to stay after closing to rearrange the store layout and restock items. Since employees must work overtime to do this, it is costly but increases expected sales. Just before the season begins, you will have to choose to schedule employees to stay late either

once or twice per month<sup>1</sup>:

(Option 1)

Employees do not work overtime

Cost=0 francs

Expected demand remains between 150 and 350

(Option 2)

Employees work overtime once per month

Cost=200 francs

Expected demand increases to 170 to 370

(Option 3) Employees work overtime twice per month

Cost=additional 455 francs (655 in total)

Expected demand increases to 190 to 390

At the end of the season, you can place unsold items on sale for 8 francs and will be guaranteed to sell all pairs of boots that are left over.

We will now present you with a description of the contract that Tip Top Manufacturers has offered you this season followed by the actual contract they have offered.

(The wholesale price contract or buyback contract diagram was inserted here depending on the condition. Following this, participants were told the terms of the contract and the order quantity they would place. These pieces of information also varied by condition as specified in Section 4).

*Dependent Measure*

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<sup>1</sup>Numbers presented are for the high cost condition.

What level of effort would you like to exert?

- (1) Schedule no overtime workers (resulting in demand between 110 and 510 units).
- (2) Schedule overtime workers once per month (resulting in demand between 170 and 570 units).
- (3) Schedule overtime workers twice per month (resulting in demand between 230 and 630 units).

### *Realized Profits*

(Wholesale Price Condition)

Demand for this season was  $X$  pairs. This means that you have  $Y$  pairs left over to sell at the discount of 8 francs per pair. Your profits for the season are  $Z$  francs.

(Buyback Condition)

Demand for this season was  $X$  pairs. This means that you have  $Y$  pairs left over to send back to the supplier for  $b$  francs each. Your profits for the season are  $Z$  francs.

## B.0.3 Study 2

### *Introduction*

Before retailers sell goods to consumers, they need to buy these goods from a supplier. The retailer and supplier often enter into a contract in which they specify terms such as the price of the goods, how many goods will be purchased, and what happens if the retailer is unable to sell all of the goods.

In this experiment you will be playing the role of a supplier. As a supplier - you must select a contract to offer to one of your retailers (buyers). Several different types of contracts exist. You will be presented with the descriptions of a few contracts and asked to answer a few questions about your preferences for the contracts.

Thus, please consider your choices carefully. You may want to have a pen and paper in order to take notes during the study.

Imagine that you work for a women's shoes supplier, Tip Top Manufacturers. Your company sells a variety of shoe products to fashion retailers and department stores. For the next Fall season, you will be selling women's boots to Highland Fashions. Because it takes time to produce shoe products, and many of the required materials come from overseas, you must plan sales for each season 9 months in advance.

As an employee for Tip Top Manufacturers, your job is to choose a contract to offer Highland Fashions for the current Fall selling season so that you maximize profits.

In the following section, you will be provided with information regarding cost and demand for womens boots. You know from experience that the actual number of items sold is affected by the amount of effort the retailer exerts during the season in order to sell the items. Therefore, if available, you will be provided with information regarding how much this type of effort costs Highland Fashions and the resulting increase in sales that it produces.

We will describe two types of contracts to you that are used in your industry. You will be asked to consider using each type of contract and indicate your preference between the two for this particular season.

Your Payment

You have the chance to win \$100 in today's study. ONE participant from this class will be selected. Your chance of being picked is based on your performance in this study. The more profit you earn, the larger your chance of being selected.

### *Setting Information*

Currently, it is January 1st and you need to consider contracts for the upcoming Fall season. You will be selling women's boots to Highland Fashions.

Information that you know:

You know that each pair of boots costs you 18 francs and that Highland Fashions will sell the boots for 48 francs at full price.

Market research has shown that retail stores of the same size and in the same geographical region as Highland Fashions are expected to sell at least 110 pairs and at most 510 pairs during the selling season (i.e., demand is uniformly distributed between 110 and 510 units).

At the end of the season, Highland Fashions can place unsold items on sale. They have already decided that an appropriate sale price is 8 francs. At this reduced price, Highland Fashions has always sold all boots that did not sell at full price.

During the season, Highland Fashions can exert effort to increase demand by asking employees to stay after closing to rearrange the store layout and restock items. Since employees must work overtime to do this, it is costly for Highland Fashions but increases expected sales. Just before the season begins, Highland Fashions can

choose to schedule employees to stay late either once or twice per month<sup>2</sup>:

(Option 1)

Employees do not work overtime

Cost=0 francs

Expected demand remains between 150 and 350

(Option 2)

Employees work overtime once per month

Cost=200 francs

Expected demand increases to 170 to 370

(Option 3) Employees work overtime twice per month

Cost=additional 455 francs (655 in total)

Expected demand increases to 190 to 390

At the end of the season, Highland Fashions can place unsold items on sale. They know that if the boots are marked down to 8 francs they are guaranteed to sell all pairs of boots that are left over.

We will now present you with a description of the two contracts you can choose.

(Diagrams for both the wholesale price and buyback contract were presented here in randomized order).

Now that you have become familiar with the different contracts, we will present you with the prices you will charge and the resulting order quantity under each contract.

This will help you make your decision about which contract you'd prefer to use. You may wish to take notes while going through this. When you are finished, you will

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<sup>2</sup>Numbers provided are for the high cost condition.

be asked to indicate your preference.

If you choose the Wholesale price contract:

Optimal wholesale price is set at 40 francs per pair of boots, and Highland Fashions orders 310 pairs. Under the wholesale price contract, Highland Fashions' order quantity (and in turn, your expected profit) is the same regardless of the effort exerted by Highland Fashions.

If you choose the Buy Back contract:

Optimal wholesale price to set is 40.5 francs per pair of boots with a 38 franc buy-back price. Under the Buyback contract, Highland Fashions' order quantity (and in turn, your expected profit) under each effort scenario depends on the amount of effort exerted by Highland Fashions.

(1) Schedule no overtime workers: order quantity=410

(2) Schedule 1 overtime work shift: order quantity=470

(3) Schedule 2 overtime work shifts: order quantity=530

\*\*Notice that with the wholesale price contract, your profits are stable regardless of Highland Fashions' effort choice, while with the buyback contract your profits are dependent on their effort choice (which influences actual demand).

### *Dependent Measures*

If you choose to offer them the Wholesale Price Contract, in which you charge Highland Fashions a wholesale price of 40 francs, what level of effort do you think Highland Fashions will exert to sell their items?

(1) Highland Fashions will choose to schedule no overtime workers (cost to them of

0 francs, no increase in demand)

(2) Highland Fashions will choose to schedule overtime workers once per month (cost to them 200 francs, 60 unit increase in demand)

(3) Highland Fashions will choose to schedule overtime workers twice per month (cost to them of 655 francs, 120 unit increase in demand)

If you choose to offer them the Buy Back Contract, in which you charge Highland Fashions a wholesale price of 40 francs and they can send unsold items back to you at 38 francs, what level of effort do you think Highland Fashions will exert to sell their items?

(1) Highland Fashions will choose to schedule no overtime workers (cost to them of 0 francs, no increase in demand)

(2) Highland Fashions will choose to schedule overtime workers once per month (cost to them 200 francs, 60 unit increase in demand)

(3) Highland Fashions will choose to schedule overtime workers twice per month (cost to them of 655 francs, 120 unit increase in demand)

Which contract would you like to offer the retailer?

(1) Wholesale price contract

(2) Buyback contract

*Realized Profit*

(Participants were then presented with the effort exerted by the retailer which var-

ied by condition and by contract offered)

(Wholesale Price Condition)

Demand for this season was  $X$  pairs. Your profits for the season are  $Z$  francs.

(Buyback Condition)

Demand for this season was  $X$  pairs. This means that the retailer had  $Y$  pairs left over. They sent these back to you for 38 francs each. Your profits for the season are  $Z$  francs.

## B.0.4 Study 3

### *Introduction*

Imagine that you work for a women's shoes supplier, Tip Top Manufacturers. Your company sells a variety of shoe products to fashion retailers and department stores.

In the next season, you will be selling women's boots to Highland Fashions.

(High Cost Condition)

You have gathered some information about the retailer's business practices and reputation. For example, you know that Highland Fashions does not actively promote items in their store via ads or targeted emails to customers throughout the season.

They also do not go to great lengths to maximize foot traffic throughout their store.

Recently, customers have noticed that the retailer is either understaffed or the salespeople have not been very helpful.

(Control Condition)

You have not been able to gather information about the business practices of both retailers.

(Low Cost Condition)

You have gathered some information about the retailer's business practices and reputation. For example, you know that Highland Fashions actively promotes items in their store via ads or targeted emails to customers throughout the season. They also go to great lengths to maximize foot traffic throughout their store. Recently, customers have commented that the salespeople are very helpful.

Because it takes time to produce shoe products, and many of the required materials come from overseas, you must plan sales for each season 9 months in advance.

Your job:

As an employee for Tip Top Manufacturers, your job is to select a contract to offer to Highland Fashions so that you maximize expected profits.

In the following sections, you will be provided with information regarding cost and demand for the product. We will then describe two types of contracts to you that are used in your industry. You will be asked to consider using each type of contract and indicate your preference between the two.

### *Setting Information*

Currently, it is January 1st and you need to consider contracts for the upcoming Fall season. You will be selling women's boots to Highland Fashions.

Information that you know:

You know that each pair of boots costs you 18 francs and that Highland Fashions

will sell the boots for 48 francs at full price.

Market research has shown that retail stores of the same size and in the same geographical region as Highland Fashions are expected to sell at least 200 pairs and at most 500 pairs during the selling season (i.e., demand is uniformly distributed between 200 and 500 units).

At the end of the season, Highland Fashions can place unsold items on sale. They have already decided that an appropriate sale price is 8 francs. At this reduced price, Highland Fashions has always sold all boots that did not sell at full price.

#### *Dependent Measures*

Recall the information provided regarding the retailer's business practices. Given this, how many units do you expect Highland Fashions to sell during the selling season?

(Participants indicated their answer by sliding a cursor between 200 and 500 units).

On a scale of 1 to 7, please indicate how successful you think Highland Fashions will be in selling boots this season (1 being not successful and 7 being very successful).

#### *Contract Presentation*

Participants were provided with the screen shots of both the wholesale price and buyback contracts indicating how each contract functioned. They were then shown what their actual profits would be under five randomly selected realizations of demand. For the wholesale price contract, their profits were the same for each of the five while with the buyback contract, their profits were affected by realized demand.

*Dependent Measures*

Which contract would you prefer to offer the retailer?

(1) Wholesale price

(2) Buyback

Please indicate in the space below why you selected this contract.

*Realized Profits*

(Wholesale Price Condition)

Demand for this season was  $X$  pairs. Your profits for the season are  $Z$  francs.

(Buyback Condition)

Demand for this season was  $X$  pairs. This means that the retailer had  $Y$  pairs left over. They sent these back to you for 38 francs each. Your profits for the season are  $Z$  francs.

## Chapter C: Chapter 2 Study Procedures

This appendix provides detailed information regarding the parameters used in the pilot study, Study 1 and Study 2. In the sections below, we present tables listing the specific information used in each of the conditions of the studies.

### C.1 Pilot Study

The pilot study tested a retailer's discrete choice between a risky and a safe product. This decision was made over 24 periods. In Table C.1 we list the demand parameters used for both the risky and the safe product. Please note that each participant saw each set of parameters twice (i.e., there are 12 sets of parameters) and demand followed a triangular distribution.

In addition to the demand parameters, the fixed order quantity,  $Q$ , and contract parameters  $(w, b)$  varied by decision therefore, resulting in different expected profits each period. In Table C.2 we list  $Q$ ,  $(w, b)$ , and expected profits for each of the products under each contract.

Table C.1: Demand Parameters Used in Pilot Study

Period	Safe Product			Risky Product		
	Min	Mode	Max	Min	Mode	Max
1 and 13	80	220	260	50	220	320
2 and 14	75	150	300	40	300	360
3 and 15	60	130	200	45	200	215
4 and 16	35	90	145	25	90	155
5 and 17	80	200	260	50	200	230
6 and 18	90	240	300	60	240	350
7 and 19	65	190	240	40	190	300
8 and 20	100	235	280	50	235	350
9 and 21	95	240	290	60	240	335
10 and 22	80	175	320	55	175	355
11 and 23	85	120	210	55	120	295
12 and 24	70	150	280	50	150	315

Table C.2: Additional Pilot Study Parameters

Period	Q	Wholesale Price Contract			Buyback Contract			
		$w$	$\Pi(0)$	$\Pi(1)$	$w$	$b$	$\Pi_b(0)$	$\Pi_b(1)$
1 and 13	185	\$12.50	\$1428	\$1118	\$12.50	\$6	\$1520	\$1238
2 and 14	150	\$18	\$949	\$748	\$18	\$6	\$1414	\$1188
3 and 15	132	\$14	\$452	\$452	\$14	\$4.50	\$550	\$515
4 and 16	120	\$15	\$875	\$850	\$15	\$5	\$1028	\$1008
5 and 17	200	\$8	\$582	\$440	\$8	\$4	\$708	\$576
6 and 18	255	\$11	\$774	\$665	\$11	\$5	\$953	\$846
7 and 19	190	\$13	\$673	\$554	\$18	\$8	\$673	\$554
8 and 20	260	\$5	\$511	\$409	\$5	\$3	\$550	\$515
9 and 21	245	\$10	\$1052	\$801	\$10	\$5	\$1178	\$1011
10 and 22	190	\$20	\$1011	\$936	\$20	\$8	\$1260	\$1133
11 and 23	155	\$10	\$851	\$735	\$10	\$5	\$959	\$836
12 and 24	150	\$8	\$851	\$735	\$8	\$3	\$959	\$836

## C.2 Study 1

Study 1 tested how the retailer chose to mix a fixed order quantity,  $Q$ , between a risky and a safe product. This decision was made over 6 periods. In Table C.3 we list the demand parameters used for both the risky and the safe product. These demand parameters remain constant across all conditions. Please note that demand followed a triangular distribution.

Table C.3: Demand Parameters Used in Study 1

Period	Safe Product			Risky Product		
	Min	Mode	Max	Min	Mode	Max
1	8	220	260	50	220	320
2	60	130	200	45	130	215
3	75	150	300	40	150	360
4	80	175	320	55	175	355
5	100	235	280	50	235	280
6	95	240	390	60	240	335

In Study 1 we manipulated both contract type (WP, BB) and loss percentage (small, medium, large). In Table C.4 and C.5 we present all parameters that varied by condition and the resulting  $p(L)$ ,  $C(L)$ ,  $p(G)$ , and  $C(G)$  for each product under each contract type.

Table C.4: Study 1: Wholesale Price Condition Parameters

	Period	$w$	$(p_S(L), C_S(L))$	$(p_S(G), C_S(G))$	$(p_R(L), C_R(L))$	$(p_R(G), C_R(G))$
Small $p(L)$	1	\$12.50	(.042, \$11.35)	(.958, \$1816)	(0.085, \$44.32)	(0.915, \$1893)
	2	\$7.50	(.07, \$120)	(.93, \$1000)	(0.13, \$140)	(0.87, \$1075)
	3	\$18	(.10, \$34)	(.90, \$1240)	(0.15, \$60)	(0.85, \$1350)
	4	\$20	(.09, \$178)	(.90, \$915)	(0.16, \$202)	(0.84, \$1013)
	5	\$5	(.08, \$56)	(.92, \$711)	(.14, \$79)	(0.86, \$808)
	6	\$15	(.12, \$81)	(.88, \$1414)	(0.18, \$99)	(0.82, \$1533)
Medium $p(L)$	1	\$25	(.36, \$771)	(.64, \$605)	(0.40, \$800)	(0.60, \$670)
	2	\$8.50	(.42, \$699)	(.58, \$502)	(0.49, \$723)	(0.51, \$584)
	3	\$20	(.39, \$665)	(.61, \$700)	(0.45, \$680)	(0.55, \$752)
	4	\$24.50	(.57, \$405)	(.43, \$581)	(0.64, \$492)	(0.36, \$613)
	5	\$6.50	(.52, \$211)	(.48, \$190)	(.58, \$242)	(0.42, \$212)
	6	\$19	(.60, \$303)	(.40, \$284)	(0.66, \$365)	(0.36, \$306)
Large $p(L)$	1	\$22	(.91, \$1286)	(.09, \$240)	(0.96, \$1304)	(0.04, \$316)
	2	\$11	(.77, \$893)	(.23, \$442)	(0.83, \$951)	(0.17, \$564)
	3	\$24	(.83, \$887)	(.17, \$315)	(0.90, \$924)	(0.10, \$489)
	4	\$27	(.81, \$903)	(.19, \$211)	(0.88, \$961)	(0.12, \$489)
	5	\$8	(.86, \$754)	(.14, \$51)	(.92, \$812)	(0.08, \$123)
	6	\$25	(.82, \$511)	(.18, \$116)	(0.88, \$582)	(0.12, \$278)

Table C.5: Study 1: Buyback Condition Parameters

	Period	$w$	$b$	$(p_S(L), C_S(L))$	$(p_S(G), C_S(G))$	$(p_R(L), C_R(L))$	$(p_R(G), C_R(G))$
Small $p(L)$	1	\$12.50	\$4	(.01, \$11.33)	(.99, \$1813)	(0.04, \$44.32)	(0.96, \$1813)
	2	\$7.50	\$3	(.11, \$120)	(.89, \$1000)	(0.13, \$140)	(0.87, \$1000)
	3	\$18	\$5	(.04, \$34)	(.96, \$1240)	(0.08, \$60)	(0.92, \$1240)
	4	\$20	\$6	(.06, \$178)	(.94, \$915)	(0.14, \$202)	(0.86, \$915)
	5	\$5	\$2.50	(.04, \$56)	(.96, \$711)	(.09, \$79)	(0.91, \$711)
	6	\$15	\$7	(.05, \$81)	(.95, \$1414)	(0.11, \$99)	(0.89, \$1414)
Medium $p(L)$	1	\$25	\$4	(.32, \$771)	(.68, \$605)	(0.36, \$782)	(0.64, \$605)
	2	\$8.50	\$3	(.37, \$699)	(.63, \$502)	(0.43, \$700)	(0.57, \$502)
	3	\$20	\$6.50	(.39, \$665)	(.61, \$700)	(0.45, \$680)	(0.55, \$700)
	4	\$24.50	\$7	(.53, \$400)	(.47, \$560)	(0.60, \$498)	(0.40, \$560)
	5	\$6.50	\$5	(.47, \$209)	(.53, \$198)	(.53, \$240)	(0.47, \$198)
	6	\$19	\$8	(.55, \$303)	(.45, \$284)	(0.59, \$360)	(0.41, \$284)
Large $p(L)$	1	\$22	\$4	(.85, \$1226)	(.15, \$240)	(0.90, \$1286)	(0.10, \$240)
	2	\$11	\$3	(.75, \$893)	(.25, \$442)	(0.79, \$951)	(0.21, \$442)
	3	\$24	\$6.50	(.80, \$887)	(.20, \$315)	(0.82, \$924)	(0.18, \$315)
	4	\$27	\$9	(.76, \$887)	(.24, \$315)	(0.82, \$924)	(0.18, \$315)
	5	\$8	\$3	(.80, \$754)	(.20, \$51)	(.84, \$812)	(0.16, \$51)
	6	\$25	\$8	(.76, \$511)	(.24, \$116)	(0.81, \$582)	(0.19, \$116)

### C.3 Study 2

Study 2 tested the joint quantity/product decision. In this study, participants selected a quantity and a product type to stock over 6 periods. In Table C.6 we provide information regarding demand parameters, contract parameters, and optimal order quantities under each contract type. Please note that in this study, demand was normally distributed.

Table C.6: Study 2 Demand and Parameters

Period	$r$	$w$	$b$	$(\mu_S, \sigma_S)$	$(\mu_R, \sigma_R)$	WP		BB	
						$Q_S$	$Q_R$	$Q_S$	$Q_R$
1	\$20	\$14	\$2	(200, 50)	(200,70)	174	163	187	182
2	\$30	\$21	\$3	(250,80)	(250,100)	208	198	230	224
3	\$25	\$17.50	\$2.5	(300,110)	(300,135)	247	230	272	265
4	\$20	\$8	\$2	(200, 50)	(200,70)	213	218	226	236
5	\$30	\$12	\$3	(250,80)	(250,100)	270	275	291	302
6	\$25	\$10	\$2.5	(300,110)	(300,135)	328	334	357	370

In Table C.7 we list  $p(L)$ ,  $C(L)$ ,  $p(G)$ , and  $C(G)$  for each product for each contract type, assuming that the optimal order quantity was selected.

Table C.7: Study 2 Additional Information

	Period	$(p_S(L), C_S(L))$	$(p_S(G), C_S(G))$	$(p_R(L), C_R(L))$	$(p_R(G), C_R(G))$
Buyback Contract	1	(.064, \$371)	(.936, \$956)	(.129, \$607)	(.8710, \$940)
	2	(.112, \$1005)	(.888, \$1771)	(.156, \$1353)	(.844, \$1751)
	3	(.158, \$1399)	(.842, \$1770)	(.178, \$1556)	(.822, \$1753)
	4	(.01, \$177)	(.99, \$2085)	(.04, \$464)	(.96, \$2044)
	5	(.027, \$710)	(.973, \$3424)	(.066, \$1329)	(.934, \$3809)
	6	(.049, \$930)	(.951, \$3839)	(.094, \$1254)	(.906, \$3753)
Wholesale Price Contract	1	(.057, \$405)	(.943, \$932)	(.109, \$641)	(.891, \$885)
	2	(.094, \$1078)	(.906, \$1684)	(.131, \$1439)	(.869, \$1621)
	3	(.122, \$1316)	(.878, \$1667)	(.151, \$1619)	(.849, \$1583)
	4	(.01, \$248)	(.99, \$2039)	(.051, \$549)	(.949, \$1994)
	5	(.037, \$852)	(.963, \$3416)	(.08, \$1242)	(.92, \$3755)
	6	(.061, \$328)	(.939, \$3745)	(.107, \$1462)	(.893, \$3674)

## Chapter D: Individual Differences Scales

### D.1 Loss Aversion

(Zhang et al. 2012)

Which would you prefer?

\$598 for sure

50% chance of \$1000 and 50% chance of \$0

Which would you prefer?

\$598 for sure

75% chance of \$1000 and 25% chance of \$0

Which would you prefer?

\$598 for sure

63% chance of \$1000 and 37% chance of \$0

Which would you prefer?

\$598 for sure

57% chance of \$1000 and 43% chance of \$0

Which would you prefer?

\$598 for sure

60% chance of \$1000 and 40% chance of \$0

## D.2 Risk Aversion

(Weber et al. 2002)

Please indicate how likely you are to engage in each of the following activities. All questions were answered on a scale of 1 to 5 with 1 being extremely unlikely and 5 being extremely likely.

- (1) Betting a day's income at the horse races.
- (2) Co-signing a new car loan for a friend.
- (3) Investing 10% of your annual income in a blue chip stock.
- (4) Investing 10% of your annual income in a very speculative stock.
- (5) Investing 10% of your annual income in government bonds (treasury bills).
- (6) Investing in a business that has a good chance of failing.
- (7) Lending a friend an amount of money equivalent to one month's income.
- (8) Spending money impulsively without thinking about the consequences.
- (9) Taking a day's income to play the slot machines at the casino.
- (10) Taking a job where you get paid exclusively on a commission basis.

## D.3 Anticipated Regret

(Kugler et al. 2009)

Imagine that you loaned a friend a small amount of money and he did not pay you

back. Please indicated how much you agree with each statement below on a scale of 1 to 5 where 1 is disagree and 5 is agree.

- (1) I would regret this outcome.
- (2) I would regret my decision.
- (3) I would blame myself for what happened.
- (4) I would behave differently in a similar situation in the future.
- (5) I would advise others not to act like this in a similar situation.

#### D.4 Numeracy

(Fagerlin et al. 2007)

Please indicate your preference for the numerical information below on a scale of 1 to 7.

- (1) When reading the newspaper, how helpful do you find tables and graphs that are part of a story? (1 not very helpful and 7 very helpful)
- (2) When people tell you the chance of something happening, do you prefer that they use words (“it rarely happens”) or numbers (“there’s a 1% chance it happens”)? (1 prefer words and 7 prefer numbers)
- (3) When you hear weather forecast, do you prefer predictions using percentages (“there will be a 20% chance of rain”) or predictions using only words (“there’s a small chance of rain today”)? (1 prefer numbers and 7 prefer words)
- (4) How often do you find numerical information useful? (1 never and 7 always)

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