Moral Hazard, Power, and Risk Sharing in Scan-Based Trading

by

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ABSTRACT

While scan-based trading (SBT) is a growing trend in the retail industry, evidence suggests that many SBT initiatives have contributed only to the retailers' bottom line at the suppliers' expense. This research attempts to disclose some of the causes of SBT failure as a collaborative inventory management initiative and identify SBT's integrative potential using both positivistic and normative research methodologies.

In the first chapter, SBT contracts are analyzed through the lens of Agency Theory. By focusing on unique inventory ownership and risks considerations resulting from retailers managing supplier-owned inventory without bearing the cost of inventory shrinkage, the effect of SBT on inventory shrinkage is examined empirically using a data set from a packaged bakery manufacturer. The results show that inventory shrinkage tends to be higher under SBT contracts compared to traditional vendor-managed inventory (VMI) contracts. The study highlights a potential loss in efficiency in food supply chains reflected in higher shrinkage under SBT contracts.

The second chapter aims to identify conditions under which SBT contracts could be mutually beneficial for retailers and suppliers. Using stylized game theoretic models involving a retailer and a supplier of a product with limited shelf life, the study finds that, while inventory shrinkage may be amplified under SBT contracts compared to VMI contracts due to the decreased retailer's incentive to manage inventory at the store, SBT could help suppliers minimize inventory overage and underage under high demand uncertainty. The integrative potential for SBT contracts, thus, lies in the trade-off between inventory shrinkage and forecasting accuracy.

In the third paper, the role of bargaining power on the performance of SBT contracts is examined. Based on the bargaining literature, it is hypothesized that perceptions of bargaining power can be reshaped in the bargaining process through concession tactics. The results of a negotiation experiment show that, while powerful retailers do tend to have the upper hand in negotiating SBT contracts, weak suppliers could ameliorate or even overcome retailer power by offering services as a concession in a way that the product-service bundle improves the value of their offerings in the eyes of the retailers.

DEDICATION

I dedicate this dissertation to God for His grace and provision throughout my life and for His faith in me through my doctoral education.

I also dedicate this work to my family in Korea without whose support and encouragement I will not have accomplished this far.
I dedicate my dissertation to my mom, Miwha, whose love never fails,
my dad, Inmoon, who passed away while I was abroad studying,
and my sister, Yujin, who has been my greatest example.

Last but not least, I dedicate this dissertation to my husband, Sungro, without whose comfort I couldn’t have trudged through the most difficult period of my life.

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PREFACE

Supply chain collaboration has been one of the hottest topics in the past few decades. More recently, manufacturers and retailers have started to revolutionize the way they work together to improve profitability and better control costs in their supply chains. Traditionally, clear boundaries existed between manufacturers and retailers since the firm owning the inventory hold it at its site as the goods flow in the supply chain. However, the borders have become blurred as the reassignment of their roles and responsibilities under new collaborative initiatives has resulted in decoupling of inventory ownership from control (Lee and Whang, 2008). While such flexible reallocation of inventory ownership, location, and control responsibility has certainly led to great improvements in efficiencies for some partners, many of such initiatives have either failed or failed to provide mutual benefits (Benavides, De Eskinazis and Swan, 2012). One of the latest collaborative initiatives, particularly popular in the food retailing sector, is scan-based trading (SBT). In SBT contracts, vendors practically own the inventory supplied to retailers′ stores until it is scanned at the stores′ points of sale because they receive payment from the retailers for the products in inventory once the products are sold to consumers. While SBT contracts could deliver some real value to the participating firms, evidence suggests that the contracts may arise from an abuse of retailer power and could result in uneven benefits.

My interest in inventory waste as a supply chain inefficiency arising from SBT contracts has started when I interviewed a regional dairy supplier, Shamrock Foods. In an ideal world, ″shrink″ or loss of inventory between suppliers′ delivery and customers′ checkout at a store should be a small fraction of the total inventory supplied to the store.

However, Shamrock Foods reported an average shrink of 9%, which seemed to be unusually high level of operational inefficiency. The operations manager I interviewed added that such a high level of shrink is a result of SBT contracts they have adopted recently and the average shrink should be around 2%. Sadly, he did not have any hard data to prove his statement. When margins between milk suppliers and retailers are typically 2% or lower, a rise in shrink of such magnitude could mean the difference between a survival or death. I decided to investigate whether SBT contracts do create inefficiencies reflected in inventory shrink and how we can overcome the issue.

Food retailing sector is a particularly relevant field to study the effectiveness of emerging contractual forms because power imbalance between producers and retailers has been chronic in this sector. While there are thousands of producers for the supply of most commodities, the number of retailers is far fewer. Since the late 1990s, food retailers have been consolidating as a strategic response to mega grocers such as Walmart and such structural imbalance between food suppliers and retailers has influenced prices for food products (Calvin et al. 2001). With declining retail margins and advances in information technologies in more recent years, retailer-supplier power asymmetry has manifested in some insidious ways (Ganesan et al. 2009). Beyond the cost and fairness issues associated with asymmetric market power, inefficiencies in food supply chain result in waste. Whether the product passes its expiration date, destroyed in handling, or lost, improper inventory management resulting from misaligned incentives among the supply chain partners leads to inventory that does not end up in consumers' homes, nor contributes to suppliers' profit. Therefore, the trend toward SBT contracts and potential misalignment of incentives could represent an additional source of food waste, at a time of unprecedentedly high food waste.

In this dissertation, I seek to investigate this rapidly-growing business practice that, if properly used, may benefit both food producers and retailers, but if not, may represent a huge step back for food supply chain in a generation. The three essays included in this dissertation investigate this phenomenon from an empirical, theoretical, and experimental perspective. In the first essay, I argue that the decoupling of inventory ownership from control in SBT creates an opportunity for retailers′ moral hazard and increase the level of waste. I support my hypothesis using data collected from a major U.S. bakery supplier, four large grocers and their stores in the Northeastern U.S., and the U.S. Census Bureau. In the second essay, I search for a reason why any supplier would rationally want to adopt SBT contracts in the presence of excess inventory shrink. Drawing from interviews I had with suppliers and retailers, I build a theoretical model describing a game between a supplier and a retailer. Results highlights an integrative potential of SBT contracts reflected in the reduction of inventory overage and underage under high demand uncertainty The third essay approaches this phenomenon from a power perspective. When SBT contracts are adopted as a result of retailer power, how can a weak supplier minimize is loss? I investigate behaviorally the impact of retailer power on the performance of SBT contracts, as well as the mitigating role of service concessions, through a bargaining experiment. The three essays in my dissertation disclose some of the causes of SBT failure as a collaborative inventory management initiative and identify SBT′s integrative potential using both positivistic and normative research methodologies.

CHAPTER 1

THE IMPACT OF SUPPLY CHAIN CONTRACTS ON INVENTORY SHRINKAGE: INFERENCE FROM PACKAGED FOOD PRODUCTS

ABSTRACT

Scan-Based Trading (SBT) contracts have emerged as a popular alternative to vendor-managed inventory (VMI) contracts as a way to improve the flow of materials and information between firms in food supply chains. In contrast to VMI, suppliers under SBT contracts remain the owners of the inventory delivered to retailers until it is sold to consumers. While SBT contracts involve clear benefits to both buyers and suppliers, they also involve unique inventory ownership and risk considerations which result from retailers managing supplier-owned inventory without bearing the cost of mismanagement. This paper examines the effect of SBT on inventory shrinkage using a data set from a packaged bakery manufacturer in the U.S. We find that the amount of inventory shrinkage tends to be higher under SBT contracts compared to VMI contracts when measured in terms of both explicit and non-explicit shrink. We attribute this effect to retailers' moral hazard under SBT contracts. Our findings are important to suppliers who are considering adopting SBT contracts as the hidden cost of inventory shrinkage may outweigh the promised benefits of SBT contracts. Our findings highlight a potential loss in efficiency in food supply chains reflected in higher inventory shrinkage under SBT contracts. Our study calls for a careful reexamination of emerging contractual forms in light of their potential impact on inventory waste.

INTRODUCTION

Advances in retail scanning technology in the consumer packaged goods industry have led to the emergence of Scan-Based Trading (SBT) contracts as an alternative to Vendor-Managed Inventory (VMI) agreements. Under VMI contracts, retailers delegate replenishment decisions and activities to suppliers, while in SBT contracts suppliers are not only responsible for planning inventory replenishments at retail stores, but they also maintain ownership of this inventory until products are scanned and sold to consumers (Kinsey, 1999). While SBT contracts promise better information flow to suppliers, but create a potential moral hazard problem as inventory ownership is separated from its control. In this paper, we examine how SBT contracts realign inventory-management incentives, and draw some implications for inventory waste from an empirical model of moral hazard and contract form.

SBT eliminates the need for inventory check-ins at the stores and, thus, gives suppliers greater autonomy and flexibility in scheduling inventory replenishment relative to VMI agreements. Moreover, invoices created by suppliers that enter SBT agreements are directly linked to the retailers' point-of-sale (POS) terminals. As a result, suppliers can gain access to real-time sales data specific to each stock keeping unit (SKU) at each retail store, thereby improving their sales forecasts and replenishment planning.

Retailers benefit from SBT contracts because they can lower the financial risk associated with carrying inventory by transferring ownership to suppliers. Moreover, because inventory ownership under SBT does not shift at the point of store-delivery, retailers can eliminate activities targeted to processing and checking inventory, decreasing backroom operations. These benefits have led to the widespread adoption of

SBT by retailers such as Walmart, Target, CVS, Sears, and Home Depot and suppliers, such as Nestle, Hallmark, and Pepperidge Farm – and the trend is growing (Wolf, 2015).

Despite the clear benefits to retailers and suppliers, SBT carries with it unique inventory ownership and risk considerations that are generally not found in VMI contracts. Namely, because suppliers retain ownership until inventory is scanned out of the store by consumers, yet retailers remain responsible for managing shelf-space and promoting sales, there is a clear moral hazard problem created by the misalignment of the incentives facing each party. As a result, SBT contracts have the potential to increase inventory shrinkage[1] at retail stores relative to that found under VMI contracts. Greater inventory shrinkage, in turn, can represent a considerable shortcoming in a SBT contract relative to VMI as it will likely go unnoticed until after the SBT contract is implemented. In this paper, we develop a set of hypotheses regarding the expected impact of SBT contracts on inventory shrinkage in relation to VMI contracts and test our hypotheses using a unique data set from the retail packaged foods industry.

By focusing on inventory shrink, we call attention to a fundamental outcome under various forms of retailer-supplier contracts, particularly SBT, which has been largely overlooked in the literature. Previous research on SBT contracts generally assume that all inventory replenished by suppliers will be available for sale (Ben-Daya et al., 2013; Gümüş, Jewkes, and Bookbinder, 2008; Ru and Wang, 2010). However, this may not necessarily be the case as inventory shrink under SBT contracts may be greater than

[1] Inventory shrinkage at retail stores corresponds to the loss of inventory between the times of supply and sales at the stores.

under VMI contracts, which may substantially offset the economic benefits of adopting SBT.

We also contribute to the empirical literature on inventory management relationships as we study the performance implications of SBT adoption from the perspective of both retailers and suppliers who are already engaged in VMI contracts. Research on SBT contracts focuses primarily on the benefits of SBT relative to traditional consignment contracts and not with respect to VMI contracts. In consignment contracts, retailers shift inventory ownership to suppliers while retaining the control of inventory replenishment decisions (Gümüş et al., 2008; Hu, Li, and Govindan, 2014; Ru and Wang, 2010), while in SBT contracts suppliers maintain both the ownership of inventories and the control of their replenishment at retail stores. Not surprisingly, past research reports notable benefits associated with SBT, relative to consignment, due to the suppliers' ability to control inventory replenishments at the stores, which is absent in consignment contracts.

Evaluating whether levels of inventory shrink at retail stores in SBT contracts exceed those observed in VMI contracts is an important question, particularly in the grocery retailing sector where SBT contracts have become a common alternative to VMI contracts. In grocery retailing, net margins are typically less than 2% (Watson, Wood, Fernie, 2015), so any unexpected loss of inventory can mean the difference between profit and loss. Further, grocery retailing is a natural setting for the growth of SBT as most supermarkets manage upwards of 30,000 unique stock-keeping units (SKUs), from thousands of different vendors.

Whether retailers benefit from SBT depends on the incentive structure put in place by handing inventory control over to vendors. SBT changes the nature of inter-organizational boundaries and the incentives facing retailers and suppliers in a fundamental way. Under VMI, inventory ownership is transferred from suppliers to retailers upon delivery and, therefore, the residual risk associated with inventory management falls on the retailer's shoulders (Lee and Whang, 2008). In SBT contracts, however, the supplier remains the owner of the inventory stocked at the retailer's stores and is exposed to the risk of inventory shrinkage (Rungtusanatham et al., 2007). The fact that the supplier is financially responsible for any deficiencies in managing retail sales by the retailer is a key distinguishing characteristic of SBT. Indeed, a clear agency problem arises under SBT as retailers are under no obligation to ensure that all of the supplier's inventory is handled properly, and sold effectively, at the retail end. We argue that SBT creates a moral hazard problem wherein SBT is likely to amplify inventory shrinkage, and reduce supplier profit.

Isolating the independent effect of contract form on shrink is not straightforward as supply relationships are inherently complex, and many variables determine how much product is lost between the supplier, and cash register. Consequently, we design a natural data experiment that allows us to estimate the causal effect of SBT contracts on shrink, and control for any other mediating factors econometrically. Specifically, along with the type of supply contract, we also consider operational factors between the supplier-retailer dyad namely, the allocation of control responsibilities in the execution of inventory deliveries between the supplier and the retail stores and the allocation of shelf space at the stores. We expect that the outsourcing by the supplier of in-store inventory deliveries to third parties will contribute additional amounts of shrink between the dyad and that the amount of shelf space allocated to an SKU and the amount of in-store traffic will increase the amount of shrink for that item.

We test these hypotheses using a unique archival dataset that describes a natural experiment in SBT relative to VMI by a major U.S. bakery supplier (referred to as *Zeta*[2] hereafter). This dataset consists of daily supply and sales quantities of *Zeta*'s SKUs at multiple grocery stores owned by different retail chains in the Northeastern U.S.

Our data offers several advantages relative to more traditional, retail scanner data alone. First, focusing on a single supplier within a market region allows us to maintain a tight control of the impact of factors such as supply lead-times and weather conditions on inventory replenishment activities which could influence the levels of observed shrink. Second, focusing on one supplier allows us to effectively control for other, potentially confounding, factors that may influence the level of observed shrink. Third, our data includes daily POS data from our supplier for its products from stores owned by retailers with which the supplier had VMI and other retailers that purchase under SBT contracts. With data on both SBT and non-SBT stores, our data describe a natural experiment in that we are able to compare shrink with and without different contract forms. In this way, we are able to cleanly identify variation in shrink that is due specifically to the SBT contract form.

Our data are both rare, and represent a unique opportunity to examine the effects of SBT, because, under VMI contracts, retailers are not obligated to share daily POS information with suppliers. Having access to daily POS data under both VMI and SBT

[2] We disguise the supplier's name per its request.

contracts enables us to incorporate a high level of detail in the empirical assessment of inventory shrinkage and test for the causal effect of supply chain contracts on shrink. Moreover, because *Zeta* is a dominant firm in the bakery-goods industry in the U.S., we minimize the possibility that its SBT and VMI contracts are subject to the type of bargaining-power asymmetries other smaller suppliers commonly face.

We find that the amount of inventory shrinkage is significantly higher under SBT contracts compared to that found under VMI contracts, ceteris paribus. This result is consistent with our prediction that the decoupling of inventory ownership and control, and the misalignment of the incentives to manage inventory properly that ensues, will cause inventory loss to rise, unless retailers are properly monitored or incentivized. If adopting SBT contracts releases retailers from the responsibility of inventory shrinkage, they are more likely to manage inventory without the same care and attention they would if the inventory was under their ownership. We also find that the use of third party providers to carry out the delivery of inventory at the stores on behalf of the supplier and the amount of shelf space allocated to inventory at the stores contribute to increasing shrinkage. Our findings highlight a potential downside to SBT contracts from a supplier's perspective.

The implications of our study go beyond food retailing and call for a careful reexamination of emerging contractual forms in terms of inventory waste more generally. Moreover, if the emergence of SBT contracts results from some form of asymmetric bargaining power in the food supply chain, then our findings may provide additional information of interest to anti-trust regulators concerned with the effects of increased concentration in either the supply industry, or among downstream retailers.

The remainder of the paper is organized as follows. Section 2 provides a review of the related literature. Section 3 develops a framework to explain SBT from an Agency Theory perspective and the hypothetical presence of excess shrinkage under SBT contracts in relation to VMI contracts as well as under various operational practices found in the food sector. Section 4 describes our empirical model of shrink, and the methods we used to analyze our data. Section 5 presents the results from our empirical analysis. We discuss the implications and contributions of the results in Section 6. And Section 7 concludes the paper with the summary and the discussion of opportunities for future research.

BACKGROUND

There is a considerable amount of research surrounding the optimality of contractual arrangements between suppliers and retailers that falls within the scope of SBT. Boyaci and Gallego (2002) show that maximum channel profits can be realized under arrangements in which suppliers can attain optimal lot sizes by offering quantity discounts. In a related study, Gümüş et al. (2008) show that this type of contract can be beneficial to both suppliers and retailers when suppliers have flexible capacity and retailers have relatively larger order costs.

These studies, however, do not consider potential discrepancies between supply and sales as reflected in inventory shrinkage. Persona, Grassi, and Catena (2005) consider such a possibility in a supply chain context. Focusing on inventory obsolescence (e.g., due to technology and market changes), the authors conclude that optimal inventory levels are lower in the presence of inventory obsolescence because of the increased risk to the supplier. We extend this research by studying agency effects on inventory shrinkage resulting from the decoupling of inventory ownership and control stipulated by SBT contracts in relation to VMI contracts.

In examining the impact of SBT contracts on inventory shrink at retail stores in relation to VMI contracts, our study also extends prior research on retail inventory shrinkage. While past research recognizes the importance of shrinkage as a determinant of retailers' performance (Bailey, 2006), academic research on the topic largely focuses on theft as the only form of shrinkage (e.g., Greenberg, 2002; Avery, Mckay, and Hunter, 2012) at the expense of other forms of shrinkage. Focusing narrowly on theft as a form of shrinkage, past studies highlight the effect of socioeconomic and demographic factors on shrink outcomes. There are, however, other factors that may influence shrink. For example, inventory could be damaged or spoiled due to careless stock management and misplaced in the course of temporal promotions. Particularly in the grocery business, spoilage could be a key contributor to shrink. Our paper takes these into consideration.

Specifically, our paper takes into account the design of retailer-supplier contracts and retail store operations as well. In particular, our research considers the impact on shrink caused by contracts designed to decouple inventory ownership and control responsibilities between retailers and suppliers. In addition, we consider shrink effects associated with in-store inventory delivery assignments to third party providers andshelf-space allocation. In so doing, we provide a more holistic understanding of the causes of retail inventory shrinkage.

By focusing on inventory shrink in the context of the retail packaged foods industry, we also contribute valuable insights regarding various sources of food waste. A range of stakeholders in the food supply chain is increasingly concerned with waste. While managers tend to worry about waste's effects on economic efficiency, policy makers look at waste from a broader sustainability perspective. Moreover, sustainability has emerged as an important issue for consumers, as they have become more aware of the environmental implications of their purchasing behaviors. As a consequence, retailers have tried to account for these consumer concerns by taking into account greenhouse gas emissions (Cachon, 2014; Belavina, Girotra, and Kabra, 2016) and inventory waste when designing their supply chains (Akkas, Gaur, and Simchi-Levi, 2014). As more retailers continue to implement sustainability initiatives to improve their energy use, emissions, and waste, research on sustainable retail operations will continue to grow (Kotzab et al., 2011; Wiese, 2013). Our study of inventory shrink under SBT and VMI contracts in the food retailing sector contributes additional insights to this research stream regarding the role that retailer-supplier contracts play in generating food waste and offers implications regarding the use of these contracts as part of sustainable retail operations.

THEORY AND HYPOTHESES

We ground our research on Agency Theory to explain how retailer-supplier contracts involving VMI and SBT influence inventory shrink. Agency Theory concerns a broad suite of issues that arise from the separation of ownership and control when an owner (the principal) delegates work to an agent (Fama and Jensen, 1983). In general, agency creates a potential conflict of interest because the objectives of the principal may differ from those of the agent. Because the principal cannot observe the actions of the agent directly, there is asymmetric information in that the agent always has more information about his/her own behavior. When the agent pursues his own interest at the expense of those of the principal under the information asymmetry, what is known as a moral hazard problem arises (Arrow, 1968). Since the agent is hired by the principal to do the work and the consequences—the costs and benefits, the residual risk—of the agent's work are largely borne by the principal, the principal assumes the costs of the agent's moral hazard in the absence of any protection mechanisms.

Retailer-Supplier Contracts and the Agency Problem

Although the generalizability of Agency Theory in understanding various contractual relationships such as employer-employee, buyer-supplier, and lawyer-client relationships is well documented in the literature (Eisenhardt, 1989; Harris and Raviv, 1978), the applicability of Agency Theory to inter-organizational contractual relationships in the context of retail supply chains, in general, and SBT, in particular, has not been carefully scrutinized. The lack of consensus as to who the principal and the agent are in a retailer-supplier relationship in SBT is a reflection of deficiencies in the application of the theory to various phenomena (Hypko, Tilebein, and Gleich, 2010; Rungtusanatham et al., 2007). The problem seems to originate from two different sources of confusion: first, in the definition of *agency* and, second, in the concept of *delegation*.

The definition of *agency* in a general sense is not exactly the same as that specific to Agency Theory. In philosophy, *agency* denotes one's ability to make choices on behalf of oneself. In a principal-agent relationship, the agent has agency—the ability to make choices for himself—and the principal has agency as well. However, Agency Theory's reference to *agency* is grounded in a situation where the agent's ability to make choices for himself influences the well-being of the principal, who is exposed to the consequences of the agent's choices. While potentially every individual and organization has agency, Agency Theory is particularly relevant in situations where agency creates problems in the context of the separation of ownership and control. The misapplication of Agency Theory to situations where there is no clear separation of ownership and control creates confusion about the nature of agency problems and the proper solutions to them.

In turn, *delegation* denotes an act of giving control and authority to another individual or party. In the classic Agency Theory context, the principal, i.e. the employer, delegates work to the agent who is hired by the principal for wages. In this context, the direction of delegation is clear: the principal delegates work to the agent for wages. However, in an SBT context, the concept of delegation is somewhat blurred. In their study of SBT, Rungtusanatham et al. (2007) treated the retailer as the principal and the supplier as the agent. They argued that, in SBT, "the retailer delegates and contracts the work and responsibility for maintaining and replenishing inventory at the retail location to the vendor. In such an agency relationship, the performance outcome of consequence is not actual sales per se, but the availability for sale of retail items measured, perhaps, in terms of such metrics as quantities on hand or units available for sale." (Rungtusanatham et al. 2007, p.120). However, from a different perspective, we argue that, in SBT, the vendor can act as the principal who delegates sales service activities to the retailer. The source of this divergence in views is that, in SBT, retailer-vendor relationships are inherently different from employer-employee relationships.

In an employer-employee relationship, the employee is hired by the employer and is delegated to make choices on behalf of the employer in exchange for wages. These choices lie within a single point in the value creating process and their delegation is unidirectional (from the employer to the employee). However, in retailer-vendor relationships under SBT, the retailer and the vendor are in charge of different parts of the value creation process that ultimately tries to satisfy end consumers' demand. Their work is divided in an attempt to maximize the efficiency of the supply chain. In a sense, they are making choices on each other's behalf in order to profit from end customers' demand (Vargo, Maglio, and Akara, 2008). Such a process of mutual exchange can take place under various inter-organizational governance structures. Therefore, the simple fact that a retailer pays (passes along profits to) a vendor does not entitle the retailer to be the principal.

The Principal-Agent Relationship under SBT

The principal-agent relationship between a retailer and a vendor under an SBT contract differs substantially from the relationship in a VMI contract. When a vendor and retailer engage in a VMI contract, once inventory is delivered to the stores, the ownership and control of the inventory are transferred from the vendor to the retailer. Inventory ownership and control are never decoupled under this type of contract. In contrast, SBT involves a distinct decoupling of inventory ownership and control at the time suppliers deliver inventory to the stores. Even after inventories are delivered to the retailers' premises, the suppliers continue to own the inventories throughout the sales process and, and consequently, the retailers become agents that control, arrange, and rotate the inventories owned by the suppliers.

We focus on the principal-agent relationship that arises from the moment the supplier's products are delivered to the retailer's premises until final sales are made to consumers (i.e., post-delivery). In this case, the supplier is a principal because it owns the inventory and the retailer is an agent because it holds the supplier's inventory on the supplier's behalf. Moreover, the way in which the retailer supervises the supplier's products during this period has an important role in influencing the supplier's profitability. Specifically, the retailer's decisions on how to market the supplier's products to stimulate interest, assure quality, and protect them from misplacement, theft, or damage will determine sales and shrink. In turn, the supplier's profitability depends on how the retailer chooses to display, rotate, and organize the inventory at its stores (Chevalier, 1975; Chandon et al., 2009; Nordfält and Lange, 2013).

Principal-agent relationships often give rise to moral hazard, or "hidden action" problems (Arrow, 1968). A moral hazard arises in SBT relationships when suppliers cannot monitor perfectly how retailers merchandize their products at the store level. And even though retailers and SBT suppliers normally have a common goal of generating sales from end customers, conflicts may arise when retailers deal simultaneously with numerous suppliers in each product category that contribute to their own profitability. Retailers seek to maximize category profit, while suppliers are only concerned with profit from their own sales. In this case, the risk of poor inventory management is born by the SBT supplier because items from other non-SBT suppliers insulate the retailer from the risk of lost sales. Moreover, because payment in SBT contracts is based on actual sales, the retailer does not pay for lost inventory.

Under these conditions, retailers may direct their efforts to those activities and suppliers that contribute the most to retail profitability, and not necessarily to maximizing profit for each individual supply relationship. As a result, suppliers under SBT contracts may end up being exposed to higher levels of shrink at retail stores than those observed under other contracts, particularly VMI, where retailers own and control the inventories of products available at their stores. Therefore, our primary hypothesis is as follows:

Hypothesis 1. Shrink levels at retail stores are higher in retailer-supplier relationships governed by SBT contracts than in retailer-supplier relationships governed by VMI contracts

Besides the contractual choice and the resulting agency problem, there are a number of operational elements in retail supply chains that may impact inventory shrink. Two of such factors are the outsourcing by the supplier of in-store inventory deliveries and the allocation of shelf space at the stores.

Outsourcing of In-Store Inventory Deliveries

Companies outsource delivery and other logistics operations to reduce infrastructural investments and operating costs as well as to improve operational flexibility (Ashenbaum, Maltz, and Rabinovich, 2005; Maloni and Carter, 2006). Logistics outsourcing, or the use of 3rd party logistics (3PL), has grown so rapidly in the past several decades that nearly 80% of the Fortune 500 companies were relying on it in 2005 (Lieb and Bentz, 2005). The food industry is not an exception to this trend. According to a survey of food and beverage logistics managers conducted by Saddle Creek Corporation in 2007, the U.S. food industry relies on 3rd party motor carries with 80% of its shipments.

Food companies increasingly rely on 3PL operators because the use of 3PL has helped food companies avoid the use of food distributors who often add significant margins on route to the retailer, increasing the consumer prices and lowering competitiveness (Anderson, 2015). Moreover, with the increasing need for small and frequent deliveries for perishable items, food companies often suffer from low utilization of their logistics assets. Given the extremely high logistics costs in these supply chains, the use of 3PL operators can be cost competitive since they enjoy higher levels of asset utilization by consolidating shipments across different clients (Bourlakis and Weightman, 2004). In a similar vein, without having to invest in capital intensive logistics assets, food companies can maintain flexibility in rapidly changing environment by turning investments in in-house logistics into variable costs through the use of 3PL (McKinnon, 2004).

While it may be true that logistics outsourcing helps suppliers reduce investments, improve utilization, and cut down operating costs, these advantages may come at the expense of a decrease in the quality of execution of inventory replenishments. It may be the case that in-store shrink rises due to suppliers' inability to prevent employees working for 3PL providers from behaving negligently when they deliver inventory to the retailers. 3PL employees may shirk their work responsibilities by handling products in a way that does not preserve their quality (Rayner, 1998), which results in more shrink due to damage, spoilage, misplacement, and theft. We expect that shrink levels at retail stores will be higher in retailer-supplier relationships when 3PL providers are in charge of carrying out inventory replenishments than when suppliers are directly in charge of carrying out these replenishments.

Hypothesis 2: Shrink levels at retail stores are higher when store deliveries are outsourced to 3PL providers compared to the case where the supplier is directly responsible for the deliveries' execution.

Shelf Space Allocation

Shelf space is precious real estate in the retail industry. Given that an average retailer carries more than 42,214 SKUs in a 46,000-square-feet store (Food Marketing Institute, 2014), negotiating shelf space for individual product is one of the most critical contractual decisions in the supplier-retailer dyad. Accordingly, suppliers negotiate for greater shelf space (Dréze, Hoch, and Purk, 1994), paying substantial slotting fees for new products, or pay-to-stay fees for existing products in order to secure the most visible shelf location (O'Dwyer, 2015; Wilkie, Desrochers, Gundlach, 2002). Shelf-space, however, is also likely to affect shrink.

When a supplier is granted a large amount of shelf space, the exposure to product obsolescence is high. For perishable items, in particular, customers often check the "sell by" dates of available inventory to find the freshest item. The larger the number of items available, the harder it is for the retailer to sell the oldest items first (i.e., FIFO), so the number of expired items rises. In addition, as shelf space size rises, it becomes increasingly more difficult to rotate inventory to minimize obsolescence. Moreover, the larger the shelf space allocated to a product, the larger the amount of inventory exposed to theft and damage by customers at any given time (Corsten and Gruen, 2003). As a result, as the amount of shelf space allocated to a product increases, inventory shrink for that product is likely to go up as well.

Hypothesis 3. Shrink levels at retail stores are positively associated with the shelf spaces assigned to the inventory

EMPIRICAL METHODOLOGY

Having developed our study's theoretical framework, we turn our attention to explaining how we test this framework using an econometric model of shrink in a natural experiment generated by a retailer that uses both SBT and VMI replenishment methods.

Our data consist of supply, inventory, and retail sales values for products in *Zeta*'s bakery brand portfolio. Our focus on *Zeta*'s bakery products is particularly relevant to our research for a number of reasons. First, these products have a short shelf life and, therefore, a high potential for shrinkage. Second, retail sales of bakery products are economically significant, generating approximately $30 billion in revenue annually in the U.S. Third, the perishable nature of bakery goods, coupled with an on-going, continuous demand, generates frequent and short replenishment cycles, which provides us with the opportunity to collect deep time-series, cross-sectional, panel data. Fourth, products manufactured by *Zeta* include many of the top national brands valued by customers. Accordingly, regardless of the type of contract used with *Zeta* (VMI or SBT), retailers have a clear motivation to ensure these products' availability at their stores in order to prevent any loss in customer goodwill.

Contracts governing the relationship between *Zeta* and each of the grocers it works with are based exclusively on either SBT or VMI. There are no consignment contracts in place that could distort the direct comparison of shrink between SBT and VMI contracts. SBT contracts are extensions of VMI contracts such that, under SBT and

VMI contracts, *Zeta* is responsible for the delivery and replenishment of inventories. Under both types of contract, no inventory is placed at retail stores' backrooms. However, under SBT, *Zeta* financially owns the inventories at the stores until they are purchased by consumers. Therefore, our data experiment is "clean" in the sense that our data capture only the essential differences between outcomes under VMI and SBT contracts. In this section, we first summarize the Zeta data, and provide some stylized facts regarding our primary hypothesis regarding the difference in shrink among contract forms, and then provide more detail on our econometric methodology.

Data Description

The dataset consists of daily supply and sales quantities for *Zeta*'s stock-keeping units (SKUs) sold at stores owned by four major supermarket chains in the New England and Mid-Atlantic regions of the U.S. These four chains are comparable in size and cover the majority of markets in these regions (See Figure 1). Moreover, while the relationships between *Zeta* and two of these retail chains (*Alpha* and *Gamma*) are governed by VMI contracts, its relationships with the two other chains (*Beta* and *Delta*) are governed by SBT contracts. This data structure offers a natural experiment setting in which comparable products sold at comparable retail outlets are subject to two different forms of contractual arrangement. In our dataset, we track 36 stores and 96 SKUs across all four chains for 168 days, from January 2015 to June 2015. Although stores carried different subsets of SKUs, the data we gathered across the four chains had a balanced number of 80 store-SKU combinations per chain (Figure 2). Moreover, for each chain, half of the store-SKU combinations involved deliveries by 3PL providers while the other half involved deliveries made directly by *Zeta*. Taken together, we collected a total of 53,760 observations across all stores and SKUs for the sample period.

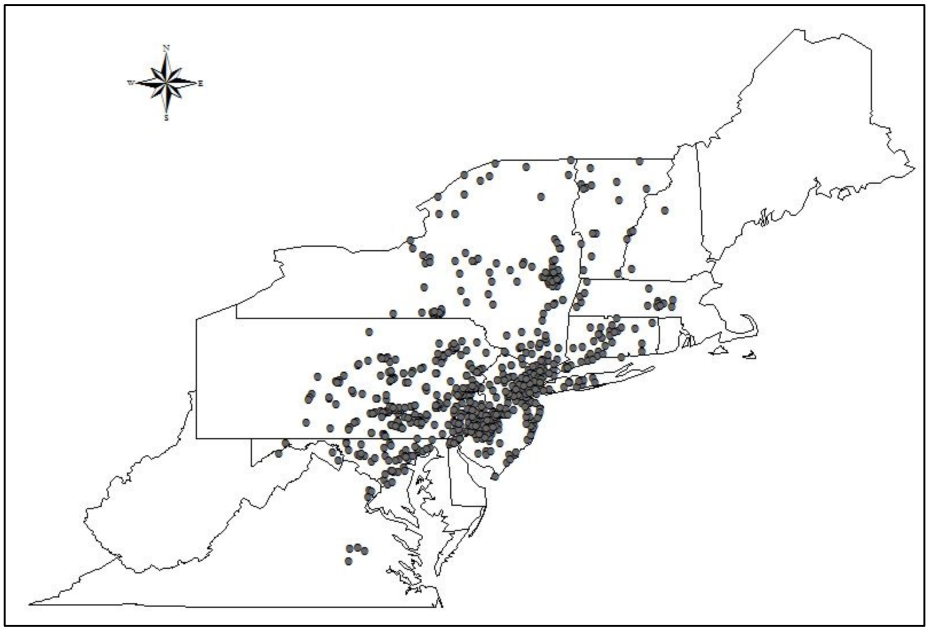


Figure 1. Market Coverage of the Four Supermarket Chains

		Contract Type	
		VMI	SBT
In-Store Inventory Replenishment	*Zeta*	*Alpha* (40 SKU-store pairs) *Gamma* (40 SKU-store pairs)	*Beta* (40 SKU-store pairs) *Delta* (40 SKU-store pairs)
	3PL	*Alpha* (40 SKU-store pairs) *Gamma* (40 SKU-store pairs)	*Beta* (40 SKU-store pairs) *Delta* (40 SKU-store pairs)

Figure 2. Structure of Data

Our data also contains daily supplier credit quantities. These credit quantities reflect the number of damaged or expired units for each SKU at all stores on a daily basis. These quantities provide a measure of daily shrink that is *explicit* to both *Zeta* and the retailers. Henceforth, we will refer to this measure as *explicit shrink*. We also captured shrink that is *not explicit* to both *Zeta* and the retailers. This form of shrink (henceforth referred to as *non-explicit shrink*) corresponds to the loss of inventory due to theft, misplacement, or otherwise unexplained loss at the stores. Computing the exact values of daily non-explicit shrink requires the full knowledge of daily on-hand inventory levels for the 168-day period for each SKU-store combination. Since Zeta does not count inventory on a daily basis, we estimated daily non-explicit shrink using available data on daily deliveries, sales, and explicit shrink.

We estimate non-explicit shrink using a two-step process. First, for each SKU-store combination, we calculated a daily net oversupply, corresponding to the number of new items delivered, minus sales, and minus the explicit shrink quantities observed per day. In essence, the daily net oversupply values reflect the maximum amount of inventory from each day's new delivery that is exposed to causes of non-explicit shrink (theft, misplacement, etc.) after daily sales have been realized and explicit shrink volumes have been deducted. Thus, daily net oversupply values serve as a conservative, but consistent, basis to measure non-explicit shrink from daily new store replenishments[3].

[3] Note that these values can be negative when there are positive amounts of inventory on-hand prior to each day's new replenishments. When that happens, we know for a fact that the amount of non-explicit shrink from that day's new shipment is zero. Therefore, we were only concerned about the case when the daily net oversupply was positive.

In the second step, we adjust daily net oversupply values downward in order to account for the possibility that these surplus amounts could have been used potentially to meet future demand during the rest of the product's shelf life. Given that *Zeta*'s products have a seven-day shelf life, we considered the next six days when adjusting each day's net oversupply.

Consider the following examples of daily oversupply for a product's 7-day period shelf life: (12, -3, -4, -2, 0, -1, -2). On Day 1, there was a daily net over supply of 12 units. In theory, there should be 12 units remaining on the shelf for the next day's sale. On Day 2, the net oversupply is -3. Since we have 12 units of oversupply from Day 1 (which are good for sale until the end of Day 7), we can satisfy the 3 units of extra demand on Day 2 from Day 1's inventory. Extending this logic until the end of Day 7, we know that none of the 12 units of daily oversupply on Day 1 was lost because the daily sales that were larger than the daily new replenishments and explicit shrink amounts on Day 2 through Day 7 should have been made from this inventory. Had there been a positive amount of daily oversupply left from Day 1 after adjusting for the following six days' oversupplies, we would have been able to identify a positive amount of non-explicit shrink from Day 1[4].

Using this estimated non-explicit shrink series, we then calculated simple summary statistics to determine whether greater shrink under SBT contracts was a feature of our data, even before accounting for other factors that may explain shrink. A simple t-test of the difference in average shrink between items under SBT and VMI revealed that,

[4] Note that we are assuming that sales are made according to the last-in-first-out (LIFO) approach. This is a fair behavioral assumption for most perishable grocery items such as milk, yogurt, bread, and eggs (Bramorski, 2008).

on average, shrink is indeed significantly higher for items sold under SBT contracts compared to those under VMI contacts. Comparing shrink under SBT and VMI yields a difference of 1.05 unit of explicit shrink and 1.14 unit of non-explicit shrink ($p<0.001$, t= -9.90 for non-explicit shrink and p<0,001, t= -17.80 for explicit shrink). However, this summary evidence does not control for other factors that may explain shrink, such as logistics operations, shelf space, product characteristics, or differences in customers across stores.

The variable, *Outsourcing*, accounts for whether inventory replenishments at retail stores are carried out directly by *Zeta* or by a 3PL provider. *Outsourcing* takes a value of 1 when inventory replenishments are carried out by a 3PL provider and 0 otherwise. Our data set includes indicators of whether each SKU distributed to each of the store location was delivered by *Zeta* or a 3PL provider. We expect that explicit and non-explicit shrink levels at retail stores will be higher in retailer-supplier relationships when 3PL providers are in charge of carrying out inventory replenishments than when suppliers are directly in charge of carrying out these replenishments.

The variable, *Shelf Space,* measures the amount of shelf space allocated to products at retail stores. We used the average of the replenishment quantities delivered for each SKU at each store over the sample period to measure the shelf space assigned to each SKU at each store. This approach is superior to measuring shelf space directly from store planograms because it incorporates instances in which large replenishments were made in order to accommodate for temporary promotional displays.

Two control variables in our model correspond to retail store demographics, as reflected in each store's customer traffic (*Customer Traffic*) and average purchasing power among nearby households (*Household Purchasing Power*). First, we expect that shrink will be higher at retail stores with higher customer traffic relative to stores with limited traffic because inventory at the former is exposed to more customers at any given time (Clarke, 2002), and so it is subject to a higher probability of damage, theft, or loss.

Second, we expect that shrink will be lower at stores located in areas in which households have, on average, high purchasing power relative to stores in areas where households have low purchasing power (Miller and Gaines, 1997). Stores in relatively low income neighborhoods are more likely to be subject to shrink due to theft and vandalism, which can seriously undermine profits and even result in store closures (Clarke and Petrossian, 2013). We measure these variables using data from the U.S. Census Bureau and from Nielsen demographic statistics for each store's zip code area. We used zip code population density (total population divided by total square miles of the zip code area) as a measure of customer traffic for each store and zip code and household spending (retail spending divided by the number of households in the zip code area) as a measure of consumer purchasing power for each store.

The nature of products may also influence shrink. Research has shown that shrink is higher for items that are of relatively high unit value or price and are highly desired by different segments of the population (Bamfield, 2004). By focusing on a single product category, bakery, we limit the range of product desirability in our study. We control for product *price* to capture the variance in shrinkage due to the value of the products. We also segment SKUs in our data across four subcategories in order to control for potential differences in shrink among products in these subcategories.

Consistent with common practice in the bakery industry, we group the SKUs into the following four subcategories: (1) baked breads-loaves (33% of sampled SKUs), (2) buns, muffins, and bagels (33% of SKUs), (3) soft cakes and donuts (32% of SKUs), and (4) others (e.g., pita wraps, pizza dough) (2% of SKUs). We use binary representations for each of these categories in our statistical analyses.

Finally, we controlled for temporal effects. We constructed a binary variable (*Weekend*) that takes a value of 0 if the day on which we measured shrink is a weekday or 1 otherwise (i.e., Saturday or Sunday) in order to account for the effect of different shopping patterns inherent in the timing of purchases. We will discuss the effect of this as well as other time specifications as part of our analyses in Section 5.3.

Table 1 summarizes the data for the 36 grocery stores and 96 SKUs in our sample. Both shrink measures refer to daily amounts of product losses, the contract and outsourcing variables are binary and take the value of 1 for SBT contracts and 3PL, respectively. Our data show that the amounts of inventory shrinkage fluctuates highly on a daily basis. On average, products in our sample have roughly one unit of product loss due to damage or spoilage and two units of product loss due to unspecifiable reasons such as theft or misplacement. Given the average shelf space of 36.9 units, these amounts of product loss seem significant.

Our summary statistic provides strong evidence that shrink at stores using SBT is higher than stores using VMI contracts. However, econometric confirmation of this evidence may be confounded by the observation that contract choice may be endogenous to the amount of shrink observed at each type of store. That is, SBT contracts may be offered to stores that are inherently more conducive to shrink, so the identification of the precise, independent effect of contract form requires a more nuanced approach.

Table 1

Descriptive Statistics

Variables	Mean	Std. Dev.	Min.	Max.
Explicit Shrink (Units)	1.02	6.83	0	517
Non-Explicit Shrink (Units)	2.38	13.37	0	579
Contract (Binary: 1= SBT, 0= VMI)	0.50	0.50	0	1
Outsourcing (Binary: 1= 3PL, 0= *Zeta*)	0.50	0.50	0	1
Shelf Space (10 Units)	3.69	3.43	0.27	18.44
Customer Traffic (Population Density at Store Zip Code ;1000 People/Miles^2)	3.58	8.85	0.10	45.78
Household Purchasing Power (Household Spending in $10,000at Store Zip Code)	6.22	0.96	4.48	8.37
Price (Dollar)	2.41	0.88	0.78	5.16
Product Category				
Category 1-Loaves (binary: 1 or 0)	0.33	0.47	0	1
Category 2-Buns, muffins, and bagels (binary: 1 or 0)	0.32	0.47	0	1
Category 3-Soft cakes and donuts (binary: 1 or 0)	0.32	0.47	0	1
Category 4-Others (binary: 1 or 0)	0.03	0.17	0	1
Weekend (Binary: 1= Shrink on Saturday or Sunday, 0= Otherwise)	0.29	0.45	0	1

Identification

Our aim is to estimate the size of daily shrink (both explicit and non-explicit) as a function of contract form, outsourcing choice, shelf space, store-specific factors (customer traffic and household purchasing power), time-specific factors, and product characteristics. The simplest approach to estimating our model is to use a pooled ordinary least square (OLS) regression method. However, pooled OLS is inappropriate when the error terms are serially correlated. When the error terms are serially correlated, the standard errors are biased, and any inferences drawn will be incorrect. We checked the presence of serial correlation in our model using the Wooldridge test for autocorrelation in panel data (Drukker, 2003). The test results do not reject the null hypothesis of no first order autocorrelation in our models of explicit and non-explicit shrink at the significance level of p=0.05. Based on these test results, we conclude that serial correlation is not a threat in our estimation.

The next econometric issue we consider is the potential endogeneity of contract terms. Estimation by OLS requires that each of the regressors be uncorrelated with the error term. If not, then at least one explanatory variable is endogenous, and the equation estimates will be biased and inconsistent. In our case, contract choice is likely to be non-random as unobservable factors may determine both shrink, and the decision to offer a SBT contract to the retailer in question. If this is the case, the independent SBT treatment effect is not identified without further modification. Rather, it reflects the characteristics of retail chains, particularly their inherent inventory management capabilities, which may also influence shrink. For example, retailers with subpar inventory management capabilities may prefer contract forms that delegate most of the inventory management responsibilities to the suppliers. As a result, the contract choice variable in the model may be endogenous with respect to shrink.

Our remedy employs an instrumental-variables estimator (Angrist and Imbens, 1995) to overcome this identification problem. An ideal instrument would explain the supermarket's choice of contract form (i.e., relevant) but not the levels of shrink at its stores directly (Stock and Watson, 2003). We considered several basic supermarket-level variables as instruments, including the year the chains were founded, their number of employees, and their revenues. Each of these variables fulfill the logical requirements for instrument validity, namely that they are correlated with the endogenous explanatory variable, but mean-independent of the error term However, due to the frequent mergers and acquisitions in the grocery industry, the year of founding did not seem to be meaningfully related to how the supermarket chains operate today. Moreover, two of the chains are privately owned and, therefore, no objective information about the number of employees and revenues was available.

Exogenous pressure to reduce operating costs could serve as an alternative instrument. SBT significantly lowers supermarkets' cost of goods sold because they do not need to purchase the inventory they use for sales. SBT also reduces supermarkets' labor costs since there is no need for retail managers to check inventory at the point of delivery. Given that most traditional supermarket chains follow a low cost strategy with thin margins, expanding the chain's market coverage seems to be one of the critical success factors for growth. This observation may also explain the frequent mergers and acquisitions among grocery retailers. Nevertheless, market expansion is costly, so chains that have yet to expand their market may be in the most need for cost reductions in the future. Hence, a smaller market coverage implies a greater need for cost reduction in the future, and a higher likelihood of choosing a low cost contract form such as SBT down the road. Therefore, we use market coverage for each of the supermarket chains as our instrumental variable.

We measure market coverage as the total number of neighborhood areas served by each of the supermarket chain stores. To that end, we counted the number of unique zip codes where each supermarket chain's stores are located and estimated the model using the method described below.

Model Estimation

We model the SBT treatment effect by including a binary variable (*Contract*) that takes a value of 1 when SBT contracts are used, and 0 when a retailer uses VMI contracts. Due to the identification arguments presented above, we used an endogenous dummy variable approach that uses the modified two-stage least squares (2SLS) method proposed by Wooldridge (2002)[5].

The modified 2SLS procedure, in fact, follows three stages. In the first stage, we estimated a probit model in which we explain the choice of contract form as a function of the instrument variable and a set of exogenous explanatory variables that include Shelf Space, Outsourcing, Consumer Traffic, Household Purchasing Power, the Product Category dummies, and Weekend, and computed the fitted probabilities. In the second stage, we regressed Contract on the fitted probabilities and the exogenous explanatory variables from the first stage. In the third stage, we regressed Shrink on the fitted values for Contract from the second stage and all the other predictors and covariates, except

[5] There are three alternative approaches to endogenous dummy variable models. Linear probability models, although the simplest to implement, are not robust to the level of endogeneity. Two control function models based on the work of Heckman (1978), a two-step approach and a full-information maximum likelihood method (FIML), are generally accepted but FIML is less robust to the specification error (Alvarez and Glasgow, 1999). In section 5.3, we present the results using a two-step CF approach as a robustness check.

Contract[6]. Unlike the two-stage probit least squares, the approach we adopt does not require adjustments of standard errors (Wooldridge, 2002).

The first stage probit model is formally written as:

$$\Pr(Contract = 1|z, \boldsymbol{x}) = \Phi(\theta_0 + \theta_0 z + \mathbf{x}\delta), \tag{1}$$

where *Contract* is a binary variable with a value of 1 if the contract is SBT and 0 otherwise, $\Phi(\cdot)$ is the cumulative distribution function for a standardized normal random variable, z is the instrument, and $\mathbf{x}$ is the vector of covariates. In this stage, the endogeneity is purged from *Contract* using the instrument variable. It is important to note that we evaluated the robustness of the estimates with respect to our chosen instrument variable in relation to other potential instrument variables. We will discuss this evaluation in section 5.3.

In the second stage, we regressed *contract* on the fitted probabilities from the first stage and all other exogenous predictors in the model as follows:

$$Contract = \alpha_0 + \alpha_1 \widehat{\Phi} + \mathbf{x}\boldsymbol{\tau} + \epsilon, \tag{2}$$

where $\widehat{\Phi} = \Phi\left(\hat{\theta}_0 + \hat{\theta}_0 z + \mathbf{x}\hat{\delta}\right)$ from the first-stage probit. Using the parameters estimated from this model, we then computed predicted values for contract form, written $\widehat{Contract}$. This step enables us to use a non-linear probability for the treatment assignment without enforcing a specific distributional assumption for the first-stage

[6] This procedure is different from a two-stage probit least squares (2SPLS) approach (Alvarez and Glasgow, 1999) in which the predicted values from the probit model replaces the endogenous dummy variable in the second-stage OLS regression. This approach is also known as "the forbidden regression" since there is no guarantee that the fitted values from the first-stage will be uncorrelated with the error term in the second-stage (Angrist and Pischke, 2008).

model. In this way, the specification of the first-stage probit is not required to be precise. As long as the endogenous variable is partially correlated with Φ, this approach is robust to the misspecification of the probit model (Wooldridge, 2002). The approach simply requires that the instruments be correlated with the endogenous variable.

In the third stage, we regressed shrink on $\widehat{Contract}$ and all other exogenous predictors:

$$y_i = \beta_{i0} + \beta_{i1}\widehat{Contract} + \beta_{i2}Outsourcing + \beta_{i3}Shelf\ Space + \beta_{i4}Shelf\ Space^{2} + \acute{\mathbf{x}}\boldsymbol{\gamma}_i + \mathrm{u}_i \qquad (3)$$

where i assumes values of 1 and 2 for explicit and non-explicit shrink, respectively, and $\acute{\mathbf{x}}$ is a vector of covariates besides Outsourcing and Shelf Space. Note that we include a quadratic term to capture the non-linear effect of Shelf Space on shrinkage outcomes.

This three-step procedure allows us to interpret the coefficients from the final stage OLS in a straightforward way as the bias due to endogeneity is taken into consideration in the earlier stages. We expect the coefficients β_{11} and $\beta_{21}$to be positive and significant as we hypothesize that SBT contracts will induce greater shrinkage relative to VMI contracts. Similarly, we expect β_{12} and β_{22} to be positive. As for the impact of Shelf Space, we expect β_{13} and β_{23} as well as β_{14} and β_{24} to be positive, reflecting the increasing difficulty in managing inventory as the amount of shelf space increases. For the control variables, we expect the coefficients for *Customer Traffic* to be positive while the coefficients for *Household Purchasing Power* to be negative. However, we do not have specific a priori expectations about the coefficients for the different product category dummies and the *Weekend* variable. It is possible, for instance, that inventories across product categories are exposed to different levels of shrink due to variations in packaging quality. There may also be differences in shrink during weekdays versus weekends due to variations in customer traffic and retail employee availability during those days of the week.

RESULTS

Instrument Validity

Before evaluating the relationship between *Contract* and *Shrink*, we must confirm the validity of the instrument we chose for our analysis. To be considered valid, the instrument must be relevant *and* exogenous (Stock and Watson, 2003). Relevant instruments are those that are highly correlated with endogenous predictors even after controlling for all other exogenous variables that explain variation in the dependent variable. This requirement can be tested empirically for our instrument in the first stage of the three-stage procedure (Wooldridge, 2002). The generally accepted requirement in the econometrics literature is that the value of the F-statistic for the instruments be higher than 10 for a set of instruments to be relevant (Staiger and Stock,1997). In the case of a single endogenous variable and a single instrument, the absolute value of the t-statistic for the instrumental variable in the first-stage regression should be higher than 3.2. However, options for assessing instrument strength are limited in the case of endogenous dummy variable models. One commonly used test is to evaluate the statistical significance of the purging variable in the first-stage probit (Adams, Almeida, and Ferreira, 2009). As shown in Table 2, the absolute value of the z-statistic for our instrument (*Zipcode*) is 80.74 with p-value <0.001, after controlling for all other exogenous variables. Thus, our instrument not only has a significant relationship with the contract choice in the expected direction but also does not appear to suffer from a weak instrument problem.

Table 2

The Determinants of Contract: Probit Model

Independent Variables	Coeff.	S.E.	Z	P-Value	95% Confidence Interval
Intercept	1.152	0.062	18.72	0.000	(1.031, 1.277)
Zipcode (Instrument)	-0.033	0.000	-84.47	0.000	(-0.033, -0.032)
Outsourcing	-0.112	0.017	-6.44	0.000	(-0.147, -0.078)
Shelf Space	0.302	0.008	64.18	0.000	(0.015, 0.016)
Shelf Space^2	-0.013	0.001	-25.09	0.000	(-0.014, - 0.012)
Price	-0.304	0.012	-25.56	0.000	(-0.327, 0.280)
Category2	-0.157	0.018	-8.76	0.000	(-0.191, -0.122)
Category3	1.030	0.031	33.14	0.000	(0.968, 1.090)
Category4	-0.976	0.045	-21.67	0.000	(-1.065, -0.888)
Customer Traffic	0.021	0.003	7.70	0.000	(0.016, 0.027)
Household Purchasing Power	0.576	0.010	62.22	0.000	(0.558, 0.595)
Log likelihood	-20,965.8				
Chi squared [D.F.=9]	32,595.5				
P-value	0.000				
McFadden Pseudo R-squared	0.437				

Exogeneity requires that the instrument be uncorrelated with the error term in the main regression equation. Logically, the endogeneity of an instrument cannot be empirically tested, so the appropriateness of an instrument is typically supported through logical arguments. As explained in Section 4.2, a supermarket chain’s market coverage can explain its choice of supply-chain contract form. We argue that supermarket chains with relatively small market coverage will exhibit a greater need for market expansion, and SBT will help them reduce costs, and prepare to open new stores at lower costs. We do not believe that the current market coverage directly influences shrink except, of course, through the choice of SBT. Furthermore, there is no reason to believe that shrink influences market coverage. Therefore, the possibility of reverse causality is safely ruled out.

The Impact of Supply Chain Contracts on Inventory Shrink

With the instrument validity established, we can now evaluate the relationship between contract and shrinkage. As a further test of the validity of our results, we checked for evidence of *Contract* endogeneity using Wu-Hausman tests[7]. For both explicit and non-explicit shrink, the test rejects the null hypothesis that *Contract* is exogenous ($p=0.043$ and $p<0.001$ respectively). Therefore, we can proceed to interpret the estimation results from our instrumental variables estimator.

Tables 3 and 4 report the main results from the endogenous dummy variable model. The results show that the type of supply chain contract does have a significant impact on the level of explicit and non-explicit shrink, in support of our main hypothesis. Specifically, SBT contracts result in additional 0.923 units of explicit shrink and 0.701 units of non-explicit shrink on average, compared to VMI contracts. Considering that the average shelf space is 36.94 in our data, these amounts translate into roughly a 2.5 percent increase in explicit shrink and a 1.9 percent in non-explicit shrink. While the literature predominantly focuses on product- and customer-related factors of shrink

[7] The logic behind the Wu-Hausman test is that one compares a less efficient but consistent estimator (under the alternative model) to a more efficient but potentially inconsistent estimator (under the null model). If the two models produce the (statistically) same results, one can then choose the more efficient estimator (the null).

(Bamfield, 2004), our findings suggest that supply chain contracts contributes economically and statistically significant amounts of loss both in terms of explicit and non-explicit shrinkage.

Table 3

Endogenous Dummy Variable Model Results: Explicit Shrink

Independent Variables	Coeff.	S.E.	Z	P-Value	95% Confidence Interval
Intercept	-1.175	0.231	-5.10	0.000	(-1.627, -0.723)
Contract	0.923	0.145	6.36	0.000	(0.639, 1.208)
Outsourcing	0.180	0.070	2.56	0.010	(0.042, 0.318)
Shelf Space	0.073	0.028	2.63	0.008	(0.019, 0.027)
Shelf Space^2	0.011	0.002	5.50	0.000	(0.007, 0.015)
Price	0.131	0.048	2.73	0.006	(0.037, 0.226)
Category 2	-0.023	0.086	-0.26	0.792	(-0.191, 0.146)
Category 3	-0.470	0.111	-4.25	0.000	(-0.687, -0.253)
Category 4	0.079	0.191	0.41	0.681	(-0.296, 0.454)
Customer Traffic	0.013	0.004	3.31	0.001	(0.005, 0.020)
Household Purchasing Power	0.152	0.036	4.25	0.000	(0.082, 0.222)
Weekend	-0.190	0.065	-2.94	0.003	(-0.316, -0.063)
F-statistic [9, 53750]	940.2				
P-value	0.000				
Adjusted R-squared[8]	0.019				

Shelf space also has a consistent effect on both explicit and non-explicit shrink. As expected, this effect is positive and significant. Specifically, a 10-unit increase in shelf space results in additional 0.073 unit of explicit shrink and 0.558 unit of non-explicit shrink on average, which corresponds respectively to 0.2 percent and 1.5 percent

[8] R-squared values from instrumental variable estimation cannot be interpreted in the usual way as a basis for F-tests of joint restrictions. The goal of instrumental variable estimation is "to provide better estimates of the ceteris paribus effect of x on y when x and u are correlated; goodness-of-fit is not a factor." (Wooldridge, 2002:517)

increases, when compared against the average amount of shelf space available for these products. Moreover, these relationships become significantly stronger as the size of shelf space increases, as we anticipated.

Table 4

Endogenous Dummy Variable Model Results: Non-Explicit Shrink

Independent Variables	Coeff.	S.E.	Z	P-Value	95% Confidence Interval
Intercept	-0.545	0.449	-1.21	0.225	(-1.423, 0.334)
Contract	0.701	0.282	2.48	0.013	(0.147, 1.255)
Outsourcing	0.405	0.137	2.96	0.003	(0.136, 0.673)
Shelf Space	0.558	0.054	10.34	0.000	(0.452, 0.664)
Shelf Space^2	0.009	0.004	2.30	0.022	(0.001, 0.016)
Price	0.224	0.093	2.40	0.017	(0.041, 0.407)
Category 2	0.369	0.167	2.21	0.027	(0.042, 0.697)
Category 3	0.105	0.215	0.49	0.089	(-0.317, 0.527)
Category 4	0.359	0.372	0.96	0.335	(-0.371, 1.088)
Customer Traffic	-0.004	0.007	-0.58	0.564	(-0.109, 0.010)
Household Purchasing Power	0.105	0.070	-1.51	0.131	(-0.241, 0.031)
Weekend	0.179	0.126	1.42	0.155	(-0.067, 0.425)
F-statistic [11, 53750]	154.1				
P-value	0.000				
Adjusted R-squared	0.030				

The use of 3PL providers has a positive and significant effect on both types of shrink as expected. However, the effect of logistics outsourcing on non-explicit shrinkage was much bigger than its effect on explicit shrink (coefficients of 0.405 and 0.180 respectively). Considering the average shelf space available, these amounts are roughly equivalent to additional 1.1 percent and 0.5 percent loss of inventory when store delivery is outsourced to a 3PL provider compared to cases when the supplier is directly in charge of delivery. In terms of product characteristics, a one-dollar increase in price is associated with 0.131 unit increase in explicit shrinkage and 0.224 unit increase in non-explicit shrinkage which can be interpreted respectively as a 0.4 percent and a 0.6 percent increase in relation to the average amount shelf space available for these products.

Among other variables, customer traffic and household purchasing power, though not significantly associated with the amount of non-explicit shrink, do influence explicit shrinkage positively. Last, there is no significant difference in the non-explicit shrinkage amounts that occur on weekdays versus weekends whereas there are significantly lower amounts of explicit shrinkage during weekends versus weekdays.

In terms of dollar values, the supplier in our sample loses, on average, a total of $27.397 per SKU per store per week due to shrinkage ($15.571 of explicit shrink and $11.826 of non-explicit shrinkage) when switching from VMI to SBT contracts. Considering the actual number of SKUs each store carries and the total number of stores under SBT contracts, not to mention the potential loss of customer goodwill caused by such inventory waste, these losses are significant. Our findings suggest that suppliers—the principal of SBT contracts—would be willing to pay a certain amount for third-party compliance services to ensure that the SBT provisions are properly carried out by the retailers or have the retailers assume the cost of shrinkage above the industry average level to curb the retailer's moral hazard.

Robustness Analyses

While our data supports our main hypothesis, there is still the possibility that these specific findings will depend on our choice of instrumental variable and model specification. Therefore, in this section, we will examine the sensitivity of our results with respect to our choice of instrumental variable as well as various model specifications.

As a means of establishing the robustness of our findings with respect to our model specification, we compared our main results from the Tables 3 and 4 (referred to as Model 1) with nine different specifications described in Table 5. These alternative specifications included uses of different instrumental variables (Model 2-3), different ways to control for time (Model 4-6), different product categorizations (Model 7-9), and an alternative estimation method (Model 10).

Model 2 uses the number of stores each supermarket chain runs as the instrumental variable, whereas Model 3 uses the total population living across the zip codes where each chain's stores are located as an alternative instrumental variable. Both the number of stores and the size of the population across the stores' zip codes reflect the retailers' market coverage, which might explain their choice of supply chain contract. The results from the first-stage probit models of the three-step approach are consistent with this causality (each instrument's effect is statistically significant at $p<0.001$) and provide support for the appropriateness of these instruments. Moreover, both Model 2 and Model 3 show stronger relationships between supply contract and inventory shrinkage for both explicit and non-explicit shrink. The coefficients for the control variables show similar patterns as those in our main model's results.

Model 4 employs dummy variables that denote which day of the week the observation was made, instead of using weekend as the control variable for time. The results are strikingly similar to the main model. In fact, the other two models, Model 5 which controls for the month when the observation was made and Model 6 which controls for the month as well as weekend versus weekdays, produce similar results. Model 7-Model 9 use different categorizations of the bakery products. Although the coefficients for *Contract* are slightly lower than those from the main results, the results are comparable to our main model.

Finally, Model 10 uses a control function (CF) approach based on Heckman's 2-step model which is an alternative procedure to Woolridge's (2002) 3-step approach to endogenous dummy variable models[9] (Petrin and Train, 2010). The results of the CF model are quite similar to the main model not only for our main variable of interest but also for the control variables. The selectivity-correction variable is significant for both explicit and non-explicit shrink models, confirming the presence of endogeneity.

Overall, our findings are qualitatively consistent across all the different model specifications (see Table 5). Compared to these coefficients, our main results in Section 5.2 (Model 1) imply a slightly more conservative effect of SBT on shrink, but our primary conclusions do not change. That is, our finding that shrink is higher under SBT relative to VMI contracts is robust to a wide variety of plausible modeling alternatives.

[9] The main idea behind the CF approach is to first estimate a model of treatment assignment and then use the predicted probability of being assigned to the treatment as a covariate, a selectivity-correction variable, known as inverse Mill's ratio. This approach offers an indirect method for testing for endogeneity through the statistical significance of the inverse Mill's ratio.

Table 5

Robustness Analyses: Coefficients of Contract

		Explicit Shrink		**Non-Explicit Shrink**	
	Description	Coeff.	Sig.	Coeff.	Sig.
Model 1	Main Results (from Table 3 & 4)	0.923	***	0.701	**
Model 2	Instrument = Number of Stores	1.175	***	1.446	***
Model 3	Instrument = Total Population	1.078	***	1.355	***
Model 4	Time Control = Day of Week	0.923	***	0.701	**
Model 5	Time Control = Month	0.923	***	0.701	**
Model 6	Time Control = Month, Weekend	0.923	***	0.701	**
Model 7	Product Control = 6 Categories	0.748	***	0.549	*
Model 8	Product Control = 5 Categories	0.902	***	0.680	**
Model 9	Product Control = 2 Categories	0.904	***	0.677	**
Model 10	Estimation = Control Function	0.820	***	0.692	**
	Coefficient Range	0.748 - 1.175		0.549 - 1.446	

*Note: *, **, *** indicate statistical significance of two-tailed tests at 10%, 5%, and 1% respectively.*

DISCUSSION

Our empirical analysis shows evidence that the type of contract (SBT versus VMI) does have a significant impact on the level of inventory shrinkage. Controlling for product, store-demographic, and time-related factors, SBT contracts contribute to 2.5 percent and 1.9 percent increases in explicit shrink and non-explicit shrink, compared to VMI contracts. Under SBT contracts, suppliers not only become responsible for the non-explicit shrinkage costs that retailers traditionally absorb under VMI contracts but also must absorb higher explicit shrinkage costs relative to those observed under VMI contracts. While these are significant losses that affect suppliers directly, they also impact retailers indirectly. This is because inventory shrinkage generates lost sale opportunities for retailers. For instance, the 4.4% of combined additional shrinkage due to SBT contracts in our results represents an annual loss of $126.44 million in gross margin opportunity across bakery retailers in the U.S., which is economically significant[10].

The other two variables which reflect operational factors in the supplier-retailer dyad also show significant influence on inventory shrinkage. The outsourcing of in-store inventory replenishment to 3PL providers contributes positively to inventory loss, as reflected in additional increases in explicit and non-explicit shrink of 0.5 percent and 1.1 percent, respectively. Moreover, increases in the shelf space volumes assigned to inventory at retail stores increase explicit and non-explicit shrink levels by 0.2 percent and 1.5 percent, respectively.

Our findings offer several important managerial implications. First, it is well known that suppliers can improve demand forecasting and reduce logistics costs through SBT contracts. However, there is a dark side to SBT contracts that is not well understood by suppliers. Our findings highlight potential risks suppliers face in SBT contracts by examining the inventory shrinkage outcomes in the packaged bakery industry. As predicted by Agency Theory, shifting inventory ownership does not simply remove the necessity to check-in inventory at the point of delivery, but also creates incentive misalignments in the operations of retailers by decoupling the ownership of inventory from its management thereby amplifying the amount of inventory shrinkage in the supply chain. We suggest that suppliers facing the decision to adopt SBT contracts carefully

[10] According to the Food Marketing Institute (FMI), U.S. bakery sales revenue was $14,367.68 million in 2011. Assuming 20% average gross margin for packaged bread, the annual total gross margin in the U.S. bakery industry is $2,873.54 million. We used this as a basis for our calculation.

compare the benefits of improved forecasting and reduced logistics costs with the cost of inventory shrinkage. Retailers should also be concerned about lost sales opportunities their reduced effort brings in the long-run, even though they derive short term benefits from transferring the direct costs of shrinkage to their suppliers under SBT.

Second, suppliers may also need to reevaluate their logistics strategies when choosing to adopt SBT contracts. Since, under SBT contracts, suppliers become responsible even for the shrinkage generated by 3PL providers, the choice of supply contracts and the degree of logistics outsourcing need to be jointly optimized. Moreover, when deciding the optimal shelf space volumes allocated to different SKUs, retailers and suppliers must consider these volumes' impact on inventory shrinkage. Academic literature on shelf space allocation has focused primarily on its positive effect on sales (Desmet and Renaudin, 1998; Dréze, Hoch, and Purk, 1994). The reasoning is that if a product occupies a large amount of shelf space, customers will see it more easily and, thus, they will be more likely to purchase it. In addition, large amounts of shelf space are believed to have promotional effects. The merchandizing adage "pile it high, watch it fly" implies that large product quantities placed on shelves can stimulate demand. Our findings show that shelf space can also have negative effects on profits through increased inventory shrink. These effects are often overlooked in the literature. Our findings also highlight the non-linear relationship between shelf space and shrinkage in which the loss of inventory is amplified as shelf space volume increases.

Overall, our findings underscore the importance of supply chain design, and the choice of supply contracts in particular, on supply chain performance measured in terms of inventory shrinkage. These findings are especially relevant in times when large retailers such as Walmart and Target are implementing SBT contracts with many of their food suppliers. These retailers sometimes offer immediate financial incentives to suppliers (e.g., wholesale price premiums) to persuade them to adopt SBT contracts. Suppliers, however, need to be aware of the potential risk of high shrinkage involved in SBT and carefully evaluate the long-term benefit of SBT contracts.

SBT contracts, when scaled to entire product categories, could eventually transform the traditional serial supply chain into a two-sided market where retailers become platforms for exchange between suppliers and consumers. When successful, these platforms could enjoy numerous benefits from being the bridges between the two groups and making profits from both sides (Eisenmann, Parker, and Van Alstyne, 2006). Two-sided markets could also benefit the economy by lowering transaction costs for both sides (Evans, 2010). If SBT contracts offer retailers such a great opportunity to improve their strategic positioning, why wouldn't retailers care about doing it right? Perhaps, retailers are not seeing through the fundamental change SBT contracts will bring about and are pushing SBT for the wrong reasons. While shifting the cost of shrinkage to suppliers may offer retailers short-term cost savings, such risk may scare away other potential SBT suppliers and take away great opportunities from the retailers in the long-run.

CONCLUSIONS

In this paper, we present an empirical analysis of the level of inventory shrink involving packaged bakery items sold across 40 stores owned by 4 supermarket chains in the Northeastern U.S. In our analysis, we focus on the impact of retailer-supplier contracts on inventory loss reflected in explicit and non-explicit shrink. Through an econometric analysis of our natural experiment, we find support for our hypotheses that supply contract, logistics outsourcing, and shelf space allocation are critical factors influencing inventory waste in the grocery sector. Our findings are important to suppliers who consider switching from VMI to SBT contracts as the hidden cost of inventory shrinkage may outweigh the anticipated benefits of SBT contracts. Our findings also provide insights to retailers who should be concerned about the long-term consequences of shifting shrink costs to suppliers in light of their potential to become platforms. Our study calls for a careful reexamination of emerging contractual forms and management practices in light of their potential impact on inventory waste.

In future work, we hope to build on the empirical findings presented in this paper and evaluate how the shift in the inventory ownership involved in SBT contracts influences pricing decisions in the supply chain. We expect that, in the face of increased financial burden from shrinkage, SBT suppliers are likely to revise their supply decisions to optimize their profits. This change in suppliers' decisions will, in turn, influence retailers' decisions and influence both supplier and retailer profits. Issues such as these are difficult to answer completely using field data. Designing normative models of optimal inventory decisions under alternative contract forms (e.g., DSD vs. SBT) while taking into account shrink implications may allow future researchers to prescribe optimal supply chain contracts with respect to profits of individual supply chain members as well as overall inventory waste. Further, because SBT contracts appear to offer substantial benefits for retailers, despite the potential for greater shrink, we intend to test for whether market power considerations are at least partially responsible for the emergence of this contract form.

CHAPTER 2

THE IMPACT OF DEMAND UNCERTAINTY ON PERFORMANCE IN SCAN-BASED TRADING CONTRACTS

ABSTRACT

In the perishable grocery retail sector, suppliers under traditional vendor-managed inventory (VMI) contracts are switching to scan-based trading (SBT) by agreeing to retain ownership of their products stocked at retail stores until they are sold to consumers. One obvious reason for retailers to defer the ownership of inventory until point of sale (POS) is to reduce their investment in inventory purchase. However, with a deferral in ownership comes a shift in inventory risk from retailers to suppliers. Since retailers pay only for what goes through their POS scanners, their excess inventory as well as shrinkage become the suppliers' responsibility. In this paper, we aim to find explanations for the suppliers' adoption of SBT contracts despite such obvious pitfalls. Using a set of stylized game theoretic models involving a retailer and a supplier of a product with limited shelf life, we find conditions under which SBT contracts could be beneficial for both the retailer and the supplier. We find that, under constant demand, SBT contracts not only shift the cost of retail inventory shrinkage to the supplier but also amplify the level of retail shrinkage by lowering the retailer's incentive to exert effort to manage inventory compared to VMI contracts. When demand is uncertain, however, the supplier may benefit from SBT contracts because it could use the real-time sales information accompanying SBT payments to improve demand forecasting and minimize the cost of overage and underage. Our numerical examples show that even the presence of slight

demand uncertainty can incentivize the supplier's SBT adoption. These results provide rational explanations for suppliers' decisions to switch from VMI to SBT contracts.

INTRODUCTION

In many retail supply chains, vendors retain ownership of their products stocked at retail stores until they are sold to consumers. Only when an item is scanned at a retail store's point of sale (POS) by a consumer, does the retailer pay the vendor for the unit supplied. This form of supply contract, known as scan-based trading (SBT), is becoming increasingly more common these days in the distribution of products with limited shelf lives. In the perishable grocery sector, in particular, these contracts are often adopted as extensions of vendor-managed inventory (VMI) contracts in which suppliers take full responsibility for maintaining inventory at retail locations by determining replenishment quantities and delivering the items directly to the stores.

One obvious reason for a retailer to defer ownership of inventory until the point of sale is to shift inventory risk to its supplier. Since the retailer pays only for what goes through the POS scanners, the inventory which has yet to be sold becomes the supplier's responsibility. Why would then suppliers be willing to accept such risk? Literature that has focused on risks involved in excess inventory has shown that shifting the inventory ownership to suppliers (through, for example, a supplier's full credit returns policy) allows retailers to order larger quantities, which can improve sales of the suppliers' products (Pellegrini, 1986). Moreover, such policies may free retailers from competing on quantities thereby intensifying price competition among retailers in order to increase the sale of these products (Padmanabham and Png, 1997).

The explanations for shifting inventory ownership from retailers to suppliers found in the literature, however, do not explain why a vendor would switch from a VMI contract to a SBT contract. Since, under both types of contracts, it is the vendor who determines the replenishment quantity, not the retailer, order sizes may not increase when inventory risk is shifted to the supplier. Nevertheless, we do observe suppliers in consumer packaged goods' segments involving bakery and dairy products switching from VMI to SBT contracts.

In this paper, we focus on two distinguishing characteristics of SBT contracts to seek an explanation for this phenomenon. First, unlike VMI contracts, SBT contracts make suppliers liable for both unsold items and inventory shrinkage at retail stores since retailers' payments to suppliers are based on the amount of products that go through the stores' POS scanners. Therefore, for suppliers, these liabilities originate from two sources: uncertainty in customer demand and retailers' incentives to manage supplier-owned inventories. Second, invoices under SBT contracts are automatically generated by POS records in real-time. Compared to VMI contracts in which the vendors could gather information about retail sales only when they receive inventory replenishment orders in bulk from retailers and when retailers return excess inventory back to suppliers, payments based on POS data under SBT contracts give suppliers access to sales information specific to each product and store real-time.

This study aims to explain why suppliers would switch from VMI to SBT contracts focusing on the above two features of SBT contracts. The setting for this study involve the sale of perishable items in which retailers' inventory rotation effort is a critical factor influencing retail shrinkage. We limit our attention to the case of exogenous (competitive) market price in order to focus on the dynamics between demand uncertainty and inventory shrinkage resulting from SBT contracts. We consider two scenarios, a known demand case and an uncertain demand case, and derive conditions for a vendor's decision to switch from VMI to SBT contracts.

We find that, under constant demand, SBT contracts not only shift the cost of retail inventory shrinkage to the supplier but also amplify the level of retail shrinkage by lowering the retailer's incentive to exert effort to manage inventory compared to VMI contracts. Except in extreme cases where SBT contracts decrease suppliers' marginal cost sufficiently to compensate for the cost of shrinkage, suppliers may not prefer SBT to VMI contracts. When demand is uncertain, however, we find that suppliers may prefer SBT contracts even in the absence of any reduction in the supplier costs because they could use the real-time sales information accompanying the payments they receive from the retailers in order to improve their demand forecasts. That is, for suppliers, there exists a trade-off between forecasting error and retail shrinkage under demand uncertainty and even when the risk of retail shrinkage is shifted to the suppliers, the savings from forecast improvements could fully compensate the additional cost. These results provide rational explanations for suppliers' decisions to switch from VMI to SBT contracts.

We also examine two additional forms of SBT contracts which might increase the likelihood of suppliers' acceptance of SBT contracts even in the case of known demand. We first examine performance-based SBT contracts, in which the supplier sets wholesale prices dependent upon realized shrinkage outcomes. Consistent with the economics literature, a performance-based pricing scheme applied to SBT contracts effectively shifts the risk of retail inventory shrinkage back to the retailer thereby incentivizing the retailer to exert more effort than that under the wholesale price SBT contract. The expected profits for the supplier, the retailer, and the supply chain all converge to the levels under the VMI contract in the absence of changes in the supplier's cost. Thus, any small reduction in the supplier's cost due to SBT contracts will increase the supplier's acceptance of SBT contracts under a performance-based SBT contract. Another (perhaps more practical) form of SBT contracts we examine is a risk-sharing contract in which the cost of realized retail shrinkage is shared between the retailer and the supplier. Intuitively, the performance outcomes of a risk-sharing contract run between those under the wholesale price SBT contract and the performance-based SBT contracts. Interestingly, however, the expected retail inventory shrinkage decreases with the retailer's share of shrinkage only when the baseline sales (i.e. sales when the retailer doesn't exert any effort) are sufficiently large. Our models do not explain why a supplier chooses not to employ these contracts to coordinate the supply chain. We focus here simply on the supplier's decision between VMI and SBT contracts.

The paper is organized as follows. After reviewing related research in Section 2, we present the basic model setting in Section 3 and analyze the supplier's choice between VMI and SBT contracts in the case of known demand. We then consider the effects of demand uncertainty in Section 4. In Sections 5 and 6, we examine a performance-based and a risk-sharing contract and their impact on the supplier's decision under known demand. In Section 7, we provide a numerical example to offer insights as to when the supplier would prefer SBT contracts to VMI contracts. Section 8 concludes this paper with a summary and a discussion for future research.

RELATED RESEARCH

Coordination in supply chains is an issue that has been studied extensively in the past. It is well known that the performance of a decentralized supply chain is generally lower than that in a centralized one because firms in the decentralized supply chain try to maximize their own profits instead of the total channel profit. One area of particular interest has been the design of contracts between retailers and suppliers in order to incentivize them to operate as if they were a centralized firm while seeking their individual objectives (Lariviere, 1999; Taylor, 2002). Various types of contracts have been offered as a mechanism for supply chain coordination (Cachon, 2003). One such contract is a buy-back contract whereby the vendor allows the retailer to return unsold inventory (Pasternack, 1985; Lee and Rhee, 2007). Studies on buy-back contracts have emphasized the role of vendors' return acceptance as a mitigating force to the effect of double marginalization, which improves the total profits available for the whole supply chain (Padmanabhan and Png, 1997; Pellegrini, 1986).

Other contracts conceptually similar to buy-back contracts involve consignment stocks (Figure 3). In these contracts, vendors place inventory at the retailer stores without receiving payment until the products are sold to consumers. Studies on consignment stock contracts have observed that they differ from buy-back contracts in that inventories at retailer stores are owned by the vendors and payment is made only after products are sold to consumers (Adida and Ratisoontorn, 2011; Ru and Wang, 2010; Wang, Jiang, and Shen, 2004). Our work is closely related to the literature on consignment stock in that we also consider the case in which the ownership of inventory at the retailer remains with the vendor. However, in our models, we explicitly consider the possibility of inventory shrinkage—one that is dependent on the level of retailer effort to care for inventory at the stores. In the presence of inventory shrinkage, a consignment contract diverges further from a buy-back contract as the nature of the risks the retailer shifts to the vendor changes.

Another contract mechanism which has received much attention in the literature is VMI contracts (Yao and Dresner, 2008). Under VMI contracts, the retailer no longer triggers the movement of goods in the supply chain. However, as in traditional wholesale contracts, the ownership and the custody of the inventory is transferred from the supplier to the retailer when the products arrive at the retailer's premises (Figure 3). Scholars have shown that VMI contracts could improve the efficiency in the supply chain by encouraging suppliers to deliver more frequently in smaller lot sizes thereby reducing surplus production capacity and excess finished inventory (Waller, Johnson, and Davis, 1999). VMI contracts have been popularized by Walmart and Proctor & Gamble in the late 80s and, since then, these contracts have been widely adopted in the retail industry (Bookbinder, Gümüş, and Jewkes, 2010).

SBT contracts can be seen as a combined use of VMI and consignment contracts in that both the inventory replenishment control and the ownership of the inventory at the retail store are shifted from the retailer to the supplier (See Figure 3). A number of studies have examined the performance of SBT contracts in comparison to that of consignment contracts (Gümüş, Jewkes, and Bookbinder, 2008; Hu, Li, and Govindan, 2014; Ru and Wang, 2010) and traditional wholesale contracts (Ben-Daya et al., 2013). While these comparisons are valuable to understand the value of SBT contracts in general, they do little to explain why suppliers of perishable grocery items switch from VMI to SBT contracts. In this study, we compare the performance of SBT contracts with that of VMI contracts, following the evolutionary path in the different forms of contracts in retail supply chains. One study that has compared these two contracts is Chen, Lin, and Cheng (2010). In this study, the authors show that suppliers would always prefer SBT contracts to VMI contracts whereas the benefits of SBT contracts to retailers are not guaranteed. These results, however, appear to be driven by the assumption that suppliers set retail prices under SBT contracts while retailers set retail prices under VMI contracts. Our models differ from those in Chen, Lin, and Cheng (2010) in that we let the supplier decide only wholesale prices under both contracts. Specific model settings used in our models are discussed in the next section.

		Inventory Ownership	
		Retailer	Supplier
Inventory Control	Retailer	Traditional	Consignment
	Supplier	VMI	SBT

Figure 3. Four Types of Supply Chain Contracts

BASIC SETTING

We consider a channel with a manufacturer who supplies a product with a limited shelf life at a constant marginal cost of m and a retailer that sells the manufacturer's product to the consumers at a price of p. Given the price, demand for the product is stable at Q. Besides pricing, the retailer's other activities also influence its profit. In particular, the retailer's inventory management effort stochastically determines the availability of the product at the store. Since the product is perishable, rotating inventory on the shelf is critical in minimizing inventory shrinkage due to spoilage. Moreover, the retailer's effort to protect items from being stolen or preventing/correcting inventory misplacement all contribute to minimizing inventory shrinkage. When there is not enough inventory to meet customer demand, the retailer loses sales opportunities.

For simplicity, we assume that the manufacturer incurs no fixed cost but a constant marginal cost of production while the retailer incurs two types of costs, the payment of the wholesale price to the manufacturer and the cost of inventory management effort. We assume that both parties are risk-neutral. We use this stylized model to study the effect of contract choices on inventory shrinkage and profits. We first examine the effect of a supply contract on inventory shrinkage in the simplest setting before proceeding to a more general case. In this section, we develop a benchmark scenario in which there is no demand uncertainty.

The channel coordination problem in the benchmark scenario comes from two factors: unobservable and costly retailer effort and a shift in the inventory ownership. We assume the retailer's inventory management effort is unobservable by the manufacturer. That is, the manufacturer does not know exactly how much retailer effort was exerted to produce the observed shrinkage outcome and hence, cannot enforce the effort level in the contract. The unobservability of the retailer's effort creates channel coordination issues consistent with the Moral Hazard problem in the Agency Theory literature. We model this uncertainty in a parsimonious fashion. Nevertheless, our model captures key aspects of the coordination problem. Inventory shrinkage may be either high (X_H) or low (X_L). There is some baseline probability that the shrinkage will turn out to be low (k) when the retailer exerts no effort at all (i.e., e=0). As the retailer puts increasingly more effort (e) to manage (i.e. rotate, organize, and protect) the inventory, the probability of low shrinkage increases such that $Pr\{Shrink = X_L\} = k + le$ where $e \in [0,1]$, $k + l \leq 1$, and $k, l \geq 0$. Accordingly, the probability of high shrinkage is given as: $Pr\{Shrink = X_H\} = 1 - k - le$. The retailer's inventory management effort is assumed to have decreasing returns to scale as the marginal cost of effort is increasing. Under VMI contracts, the unobservable retailer effort is not an issue to the manufacturer because the quantity Q is owned by the retailer once delivered to the store. However, under SBT contracts, inventory ownership remains with the manufacturer until items are scanned at the stores' POS and, thus, the retailer's effort becomes relevant to the manufacturer.

We first present the structure of the game between the retailer and the supplier under the basic setting (See Figure 4). In the first stage, the retailer and the manufacturer agree on a type of supply contract for a fixed quantity Q. For the purpose of this study, we restrict our attention to two types of contracts—VMI and SBT. Under a VMI contract, the retailer will pay the manufacturer for the quantity Q when they inventory is delivered to the store. That is, the ownership of the inventory is transferred from the manufacturer to the retailer at the point of delivery and the retailer becomes responsible for each of the units in Q from that point on. Under an SBT contract, in contrast, the retailer will pay the manufacturer only for the quantities sold to consumers. In this case, the manufacturer bears the cost of inventory shrinkage at the store. Once the contract type is decided, the manufacturer sets the wholesale price which is uniform for each unit of Q. Based on the contract, the manufacturer supplies the quantity to the retailer's store and the retailer manages the inventory at the store to maximize sales.

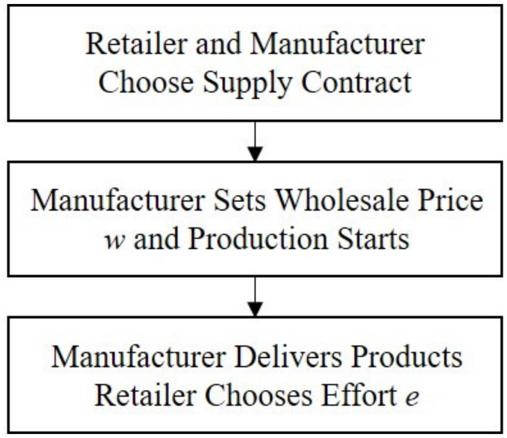


Figure 4. Sequence of Events: Basic Setting

The following is the summary of notations used in our models:

Q - constant demand

p - per unit retail price

w - per unit wholesale price

m - per unit manufacturing cost under VMI contracts

m' - per unit manufacturing cost under SBT contracts

e - degree of the retailer's inventory management effort $e \in [0,1]$

c - cost of full effort s.t. $C(e) = ce^2$, $c > 0$

x - inventory shrinkage X $\in \{X_L, X_H\}$, $0 < X_L < X_H < Q$

l - increase in probability of X_L when *e*=1, $l \in [0,1]$

k - baseline probability of X_L when *e*=0, $k \in [l, 1]$ and $k + l \leq 1$

u_0 - retailer's outside option value

Wholesale Price Contract under Vendor-Managed Inventory

Suppose a retailer and a manufacturer agreed to adopt a VMI contract (Stage 1). Under a VMI contract, the retailer purchases Q units of inventory from the supplier at the unit price of w. The retailer pays the supplier wQ regardless of the realized amount of shrink. The supplier sets the wholesale price w to maximize its expected profit while making sure that the retailer has incentive to participate in this contract.

Supplier's Problem (Stage 2):

$$\max_{w} E\Pi_0^S = (w - m)Q \tag{4}$$

$$s.t.\ p[Q - (1 - k - le)X_H - (k + le)X_L] - ce^2 - wQ \geq u_0 \tag{5}$$

Retailer's Problem (Stage 3):

$$\max_{e}\ E\Pi_0^R = p[Q - (1 - k - le)X_H - (k + le)X_L] - ce^2 - wQ \tag{6}$$

We assume that $pl(X_H - X_L) - 2c < 0$. That is, there is an optimal level of effort which is less than the maximum for the retailer to exert in order to maximize its expected profit when it owns the inventory. We solve the sequential game by backward induction. Checking the first and the second order conditions for the retailer's expected profit with respect to the effort, the retailer's optimal effort choice is given by

$$e_0^* = \frac{pl(X_H - X_L)}{2c} \tag{7}$$

which is independent of the wholesale price the supplier sets. This result is intuitive: once the manufacturer sets the wholesale price w, in the second stage, the retailer's cost of the inventory becomes sunk. Therefore, the retailer's problem in the third stage becomes independent of the wholesale price.

Knowing the retailer's optimal effort level, the supplier's optimal wholesale price which maximizes its expected profit in the second stage is then given by:

$$w_0^* = \frac{p[Q-(1-k)X_H - kX_L]}{Q} + \frac{p^2 l^2 (X_H - X_L)^2}{4cQ} - \frac{u_0}{Q} \tag{8}$$

Assuming that this wholesale price is greater than the manufacturer's marginal cost, the profits of the supplier, the retailer, and the supply chain are given by:

$$E\Pi_0^S = p[Q-(1-k)X_H - kX_L] + \frac{p^2 l^2 (X_H - X_L)^2}{4c} - mQ - u_0 \tag{9}$$

$$E\Pi_0^R = u_0 \tag{10}$$

$$E\Pi_0^{SC} = p[Q-(1-k)X_H - kX_L] + \frac{p^2 l^2 (X_H - X_L)^2}{4c} - mQ \tag{11}$$

Wholesale Price Contract under Scan-Based Trading

Next, we consider a wholesale price contract under SBT (Stage 1). Under this contract, the manufacturer delivers *Q* units of inventory to the retailer's store. However, the supplier gets paid only for the units sold to consumers (not the amount delivered) at the unit price of *w*. The supplier sets the wholesale price *w* to maximize its expected profit while making sure that the retailer has incentive to participate in this contract.

Supplier's Problem (Stage 2):

$$\max_{w} E\Pi_1^S = w[Q-(1-k-le)X_H - (k+le)X_L] - m'Q \tag{12}$$

$$s.t.\ (p-w)[Q-(1-k-le)X_H - (k+le)X_L] - ce^2 \geq u_0 \tag{13}$$

Retailer's Problem (Stage 3):

$$\max_{e} E\Pi_1^R = (p-w)[Q-(1-k-le)X_H - (k+le)X_L] - ce^2 \tag{14}$$

Given that the first-order condition for the retailer's expected profit is concave with respect to the effort choice, we find the retailer's optimal effort choice in this case to be

$$e(w) = \frac{l(p - w)(X_H - X_L)}{2c} \tag{15}$$

which is a decreasing function of the wholesale price the supplier sets in the second stage. Intuitively speaking, under an SBT contract, the retailer shifts the cost of inventory shrinkage completely to the manufacturer. As a result, the retailer's sunk cost is turned into a variable cost and the marginal revenue for sales decreases to $p - w$.

Knowing the retailer's optimal response to the wholesale price, the supplier's optimal wholesale price in the second stage is then given by:

$$w_1^* = \frac{p}{2} + \frac{c[Q - (1 - k)X_H - kX_L]}{l^2(X_H - X_L)^2} \tag{16}$$

Plugging the optimal wholesale price back to the retailer's response function, the retailer's effort choice is given by the following:

$$e_1^* = \frac{pl(X_H - X_L)}{4c} - \frac{[Q - (1 - k)X_H - kX_L]}{2l(X_H - X_L)} \tag{17}$$

Note that the profit maximizing effort level for the retailer under an SBT contract is smaller than that under a VMI contract as the marginal cost of the effort relative to the marginal revenue increases.

Now we need to check the retailer's participation constraint at the optimal wholesale price w_1^*.

$$E\Pi_1^R(w_1^*) = \frac{p}{4}[Q - (1 - k)X_H - kX_L] + \frac{p^2 l^2 (X_H - X_L)^2}{16c} \tag{18}$$

$$- \frac{3c[Q - (1 - k)X_H - kX_L]^2}{4l^2(X_H - X_L)^2}$$

If $E\Pi_1^R(\mathrm{w}_1^*) \geq u_0$ then, the profits of the supplier, the retailer, and the supply chain that satisfy the retailer's participation constraint are given by:

$$E\Pi_1^S = \frac{p}{2}[Q-(1-k)X_H - kX_L] + \frac{p^2 l^2 (X_H - X_L)^2}{8c} + \frac{c[Q-(1-k)X_H - kX_L]^2}{2l^2(X_H - X_L)^2} - m'Q \tag{19}$$

$$E\Pi_1^R = \frac{p}{4}[Q-(1-k)X_H - kX_L] + \frac{p^2 l^2 (X_H - X_L)^2}{16c} - \frac{3c[Q-(1-k)X_H - kX_L]^2}{4l^2(X_H - X_L)^2} \tag{20}$$

$$E\Pi_1^{SC} = \frac{3p}{4}[Q-(1-k)X_H - kX_L] + \frac{3p^2 l^2 (X_H - X_L)^2}{16c} - \frac{c[Q-(1-k)X_H - kX_L]^2}{4l^2(X_H - X_L)^2} - m'Q \tag{21}$$

If $E\Pi_1^R(\mathrm{w}_1^*) < u_0$ then, the supplier will either choose a wholesale price different from w_1^* which makes the retailer's participation constraint binding, but makes the supplier's expected profit even lower than that expressed in equation (19). Or the supplier would choose not to participate in the contract if the price that makes the retailer's participation constraint binding gives him a negative expected profit. The retailer will earn u_0 from the contract or elsewhere regardless.

Under a VMI contract, having one extra unit of inventory available for sales is worth the market price p since, independent of realized shrinkage, the retailer has to pay the manufacturer wQ. However, under an SBT contract, the retailer pays the manufacturer only for the quantity sold to the consumers. Therefore, the marginal revenue for sales decreases from p to $p - w$ and the optimal retailer effort decreases. Proposition 1 summarizes the impact of SBT contracts on the expected profits of the manufacturer, the retailer, and the supply chain, as well as SBT contracts' impact on inventory shrinkage. As we can see, under SBT contracts with no demand uncertainty, the retailer's expected profit increases at the expense of the manufacturer's profit when the manufacturing cost does not change after adopting SBT contracts. Moreover, the realized inventory shrinkage is higher under SBT contracts due to the decrease in the retailer's effort.

If we assume that SBT contracts reduce manufacturer's cost by, for example, improving logistics efficiency, it is possible that the manufacturer's profit as well as the overall supply chain profit increase under SBT contracts compared to VMI contracts. Our aim in presenting the benchmark case is to show the baseline impact of inventory ownership transfer to the upstream player on retail inventory shrinkage.

Proposition 1. When demand is certain and the manufacturer distributes through a retailer using a uniform wholesale price,

(a) $E\Pi_1^S < E\Pi_0^S$: The manufacturer's expected profit is strictly smaller under SBT contracts compared to VMI contracts when the manufacturing cost remains unchanged;

(b) $E\Pi_1^S \geq E\Pi_0^S$: The retailer's expected profit is weakly greater under SBT contracts compared to VMI contracts given that the price under the SBT contract assures the retailer's participation;

(c) $e_1^* < e_0^*$ & $EX_1^* > EX_0^*$: Retail inventory shrinkage is strictly larger under SBT contracts compared to VMI contracts due to the strictly lower retailer effort under SBT contracts;

(d) $E\Pi_1^{SC} < E\Pi_0^{SC}$: The expected profit for the supply chain is strictly lower under SBT contracts compared to VMI contracts when the manufacturing cost remains unchanged;

(e) In order for the supplier to prefer SBT contracts to VMI contracts under known demand, the manufacturer's marginal cost should be reduced at least by the following amount (a necessary condition):

$$m - m' = \frac{p[Q-(1-k)X_H - kX_L]}{2Q} + \frac{p^2 l^2 (X_H - X_L)^2}{8cQ} - \frac{c[Q-(1-k)X_H - kX_L]^2}{2l^2(X_H - X_L)^2 Q} \quad (22)$$

DEMAND UNCERTAINTY

In the previous section, we considered how SBT contracts influence profits and shrinkage outcomes by shifting inventory ownership to the upstream member assuming that market demand is known. Let us now consider how the results depend on demand uncertainty. To address this issue, we change slightly one assumption made in the basic setting. Let retail demand be either Q_H or Q_L at price p with the probability of Q_H being $\theta, 0 < \theta < 1$. We assume that retail price is fixed and θ is known. With this simple change, we can introduce demand uncertainty in two ways: the range of possible demand realizations $Q_H - Q_L$ and the probability θ. The sequence of events under the uncertain demand case is shown in Figure 5.

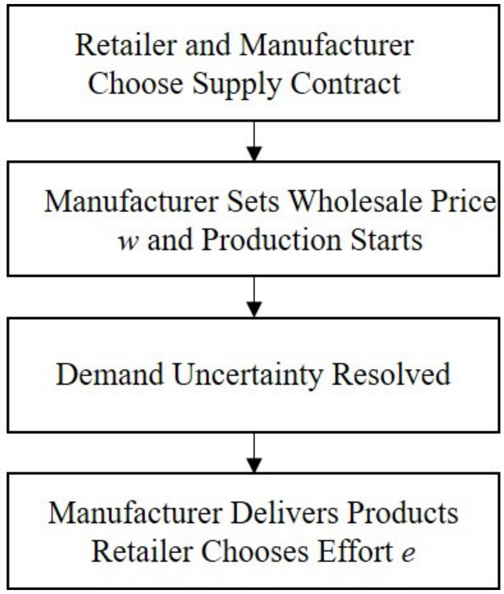


Figure 5. Sequence of Events: Uncertain Demand Case

Vendor-Managed Inventory

The retailer will want to purchase Q_H units of inventory from the manufacturer in case demand turns out to be high and Q_L units of inventory when demand turns out to be low. Before demand uncertainty is resolved, however, the manufacturer needs to decide how much to produce. Since the product in question is perishable and the leftover inventory has no salvage value, the supplier wouldn't quite produce Q_H units under demand uncertainty. In the absence of any additional information, the manufacturer produces the amount of average demand, $\bar{Q} \equiv \theta Q_H + (1-\theta) Q_L$. As a result, in times of high customer demand, the amount of inventory the manufacturer is able to supply would be limited to $\bar{Q}$. Regardless of the quantity purchased, per unit wholesale price is assumed to be uniform. The supplier sets the wholesale price $\boldsymbol{w}$ to maximize his expected profit while making sure that the retailer has incentive to participate in this contract.

Supplier's Problem (Stage 2):

$$\max_{w} E\Pi_2^S = \theta(w-m)\bar{Q} + (1-\theta)(wQ_L - m\bar{Q}) \tag{23}$$

$$s.t.\ \theta\{p[\bar{Q} - (1-k-le)X_H - (k+le)X_L] - w\bar{Q}\} \tag{24}$$

$$+(1-\theta)\{p[Q_L - (1-k-le)X_H - (k+le)X_L] - wQ_L\} - ce^2 \geq u_0$$

Retailer's Problem (Stage 3):

$$\max_{e}\ E\Pi_2^R = \ \theta\{p[\bar{Q} - (1-k-le)X_H - (k+le)X_L] - w\bar{Q}\} \tag{25}$$

$$+\ (1-\theta)\{p[Q_L - (1-k-le)X_H - (k+le)X_L] - wQ_L\} - ce^2$$

Checking the first and the second order condition for the retailer's expected profit with respect to the effort, the retailer's optimal effort choice is given by

$$e_2^* = \frac{pl(X_H - X_L)}{2c} \tag{26}$$

which is independent of the wholesale price set by the supplier. Knowing the retailer's optimal effort level, the supplier's optimal wholesale price that maximizes its expected profit in the second stage is then given by:

$$\mathrm{w}_2^* = \mathrm{p} - \frac{p[(1-k)X_H - kX_L]}{[\theta^2 Q_H + (1-\theta^2)Q_L]} + \frac{p^2 l^2 (X_H - X_L)^2}{4c[\theta^2 Q_H + (1-\theta^2)Q_L]} \tag{27}$$

$$- \frac{u_0}{[\theta^2 Q_H + (1-\theta^2)Q_L]}$$

Assuming that this price is greater than the manufacturer's marginal cost, the profits of the supplier, the retailer, and the supply chain are given by:

$$E\Pi_2^S = p[\theta^2 Q_H + (1-\theta^2)Q_L - (1-k)X_H - kX_L] \tag{28}$$

$$+ \frac{p^2 l^2 (X_H - X_L)^2}{4c} - m\bar{Q} - u_0$$

$$E\Pi_2^R = u_0 \tag{29}$$

$$E\Pi_2^{SC} = p[\theta^2 Q_H + (1-\theta^2)Q_L - (1-k)X_H - kX_L] + \frac{p^2 l^2 (X_H - X_L)^2}{4c} - m\bar{Q} \tag{30}$$

Moreover, the expected overage and underage in this case become $\theta(1-\theta)(Q_H - Q_L)$.

Scan-Based Trading with a Single Wholesale Price

One of the main incentives for the manufacturers to adopt an SBT contract is the access to real-time POS data from the retailer's store. With these data, the manufacturer could improve forecasting and better mitigate demand uncertainty. For simplicity, we assume that the manufacturer could perfectly predict the market demand and plan its production accordingly under an SBT contract based on the POS data.

Supplier's Problem (Stage 2):

$$\max_w E\Pi_3^S = \theta\{w[Q_H - (1-k-le)X_H - (k+le)X_L] - m'Q_H\} + (1-\theta)\{w[Q_L - (1-k-le)X_H - (k+le)X_L] - m'Q_L\} \tag{31}$$

$$s.t.\ \theta\{(p-w)[Q_H - (1-k-le)X_H - (k+le)X_L]\} + (1-\theta)\{(p-w)[Q_L - (1-k-le)X_H - (k+le)X_L]\} - ce^2 \geq u_0 \tag{32}$$

Retailer's Problem (Stage 3):

$$\max_e E\Pi_3^R = \theta\{(p-w)[Q_H - (1-k-le)X_H - (k+le)X_L]\} + (1-\theta)\{(p-w)[Q_L - (1-k-le)X_H - (k+le)X_L]\} - ce^2 \tag{33}$$

Under this setting, we find the retailer's optimal effort choice to be

$$e(w) = \frac{l(p-w)(X_H - X_L)}{2c} \tag{34}$$

which is a decreasing function of the wholesale price the supplier sets in the second stage.

The optimal wholesale price and the retailer's effort are analogues to the results from section 3 where demand is assumed to be certain.

$$w_3^* = \frac{p}{2} + \frac{c[\bar{Q} - (1-k)X_H - kX_L]}{l^2(X_H - X_L)^2} \tag{35}$$

$$e_3^* = \frac{pl(X_H - X_L)}{4c} - \frac{[\bar{Q} - (1-k)X_H - kX_L]}{2l(X_H - X_L)} \tag{36}$$

If $E\Pi_3^R(\mathrm{w}_3^*) \geq u_0$, the profits of the supplier, the retailer, and the supply chain are given by:

$$E\Pi_3^S = \frac{p}{2}[\bar{Q} - (1-k)X_H - kX_L] + \frac{p^2l^2(X_H - X_L)^2}{8c} + \frac{c[\bar{Q} - (1-k)X_H - kX_L]^2}{2l^2(X_H - X_L)^2} - m'\bar{Q} \tag{37}$$

$$E\Pi_3^R = \frac{p}{4}[\bar{Q} - (1-k)X_H - kX_L] + \frac{p^2l^2(X_H - X_L)^2}{16c} - \frac{3c[\bar{Q} - (1-k)X_H - kX_L]^2}{4l^2(X_H - X_L)^2} \tag{38}$$

$$E\Pi_3^{SC} = \frac{3p}{4}[\bar{Q} - (1-k)X_H - kX_L] + \frac{3p^2l^2(X_H - X_L)^2}{16c} - \frac{c[\bar{Q} - (1-k)X_H - kX_L]^2}{4l^2(X_H - X_L)^2} - m'\bar{Q} \tag{39}$$

If $E\Pi_3^R(\mathrm{w}_3^*) < u_0$ then, the supplier will either choose a wholesale price different from w_3^* which makes the retailer's participation constraint binding, but makes the supplier's expected profit lower than that expressed in equation (37). Or the supplier would choose not to participate in the contract if the price that makes the retailer's participation constraint binding gives him a negative expected profit. The retailer will earn u_0 from the contract or elsewhere regardless.

Note that the profit maximizing effort level for the retailer under an SBT contract becomes smaller than that under a VMI contract, analogously to the case under no demand uncertainty. However, under demand uncertainty, VMI contracts create a positive amount of expected inventory overage at the manufacturer due to a lack of forecasting accuracy. Moreover, the forecasting inaccuracy creates lost sales opportunity. Therefore, there exists a trade-off between overage/underage and retail shrinkage under demand uncertainty. Proposition 2 summarizes our findings.

Proposition 2. When demand is uncertain and the manufacturer distributes through a retailer using a uniform wholesale price,

(a) Even in the absence of any reduction in the manufacturing cost, the manufacturer's expected profit could be higher under SBT contracts compared to VMI contracts if the following inequalities hold (sufficient condition):

$$p[\theta^2 Q_H + (1-\theta^2)Q_L] - \frac{p\bar{Q}}{2} - \frac{p[(1-k)X_H + kX_L]}{2} + \frac{p^2 l^2 (X_H - X_L)^2}{8c} + \frac{c[\bar{Q} - (1-k)X_H - kX_L]^2}{2l^2(X_H - X_L)^2} < u_0 \quad (40)$$

$$\frac{p}{4}[\bar{Q} - (1-k)X_H - kX_L] + \frac{p^2 l^2 (X_H - X_L)^2}{16c} - \frac{3c[\bar{Q} - (1-k)X_H - kX_L]^2}{4l^2(X_H - X_L)^2} \geq u_0; \quad (41)$$

(b) $E\Pi_3^S \geq E\Pi_2^S$: The retailer's expected profit is weakly greater under SBT contracts compared to VMI contracts;

(c) $e_3^* < e_2^*$ & $EX_3^* > EX_2^*$: Retail inventory shrinkage is strictly larger under SBT contracts compared to VMI contracts due to a strictly lower retailer effort under SBT contracts. However, the expected overage and underage for the manufacturer decrease from $\theta(1-\theta)(Q_H - Q_L)$ to zero under SBT contracts;

(d) $E\Pi_3^{SC} \geq E\Pi_2^{SC}$: The expected profit for the supply chain could be higher under SBT contracts compared to VMI contracts if the condition (41) and the following inequality hold (sufficient condition):

$$p[\theta^2 Q_H + (1-\theta^2)Q_L] - \frac{3p\bar{Q}}{4} - \frac{p[(1-k)X_H + kX_L]}{4} + \frac{p^2 l^2 (X_H - X_L)^2}{16c} + \frac{c[\bar{Q} - (1-k)X_H - kX_L]^2}{4l^2(X_H - X_L)^2} - (m - m')\bar{Q} \leq 0; \quad (42)$$

(e) A sufficient condition for the manufacturer to prefer SBT contracts to VMI contracts under demand uncertainty is that the manufacturing cost is reduced by the following amount when condition (41) holds:

$$m - m' = \frac{p[\theta^2 Q_H + (1-\theta^2)Q_L]}{\bar{Q}} - \frac{p}{2} - \frac{p[(1-k)X_H + kX_L]}{2\bar{Q}} + \frac{p^2 l^2 (X_H - X_L)^2}{8c\bar{Q}} - \frac{c[\bar{Q} - (1-k)X_H - kX_L]^2}{2l^2(X_H - X_L)^2\bar{Q}} \quad (43)$$

Note that this threshold is lower than the threshold found in Proposition 1(e) when we assume $\bar{Q} = Q$.

PERFORMANCE-BASED SBT CONTRACT

Following Agency Theory's prescription, the supplier, who is a principal delegating the inventory management tasks to the retailer (an agent), may adopt a performance-based SBT contract in which he sets the wholesale price dependent on the realized shrink outcomes. That is, instead of receiving $\boldsymbol{w}$ for each unit sold, the supplier may receive $\boldsymbol{w_H}$ per unit sold when the realized shrink is $\boldsymbol{X_H}$ and $\boldsymbol{w_L}$ when the realized shrink is $\boldsymbol{X_L}$. Note that the retailer's effort is not observable. However, the shrink outcome is an increasing function of the retailer's effort. The supplier will set the two wholesale prices to maximize his expected profit while making sure that the retailer has incentive to participate in this contract. In this section, we examine the results of a performance-based SBT contract assuming that demand is known.

Supplier's Problem:

$$\max_{\{w_L, w_H\}} E\Pi_4^S = (Q - X_H)(1 - k - le)w_H + (Q - X_L)(k + le)w_L - m'Q \quad (44)$$

$$s.t.\ (Q - X_H)(1 - k - le)(p - w_H) + (Q - X_L)(k + le)(p - w_L) - ce^2 \geq u_0 \quad (45)$$

Retailer's Problem:

$$\max_e\ E\Pi_4^R = (Q - X_H)(1 - k - le)(p - w_H) + (Q - X_L)(k + le)(p - w_L) - ce^2 \quad (46)$$

Since $l[(Q - X_H)(p - w_H) - (Q - X_L)(p - w_L)] - 2c < 0$, we find the retailer's optimal effort choice in this case is given by

$$e(w_L, w_H) = \frac{l[(Q - X_L)(p - w_L) - (Q - X_H)(p - w_H)]}{2c}. \quad (47)$$

Rewriting the supplier's problem in a Lagrangian form using the retailer's effort function gives:

$$\max_{\{w_L, w_H, \lambda\}} L = (Q - X_H)(1-k)w_H + (Q - X_L)kw_L \tag{48}$$

$$+ \frac{l^2 p(X_H - X_L)[(Q - X_L)w_L - (Q - X_H)w_H]}{2c}$$

$$- \frac{l^2[(Q - X_L)w_L - (Q - X_H)w_H]^2}{2c} - m'Q$$

$$+ \lambda \Bigg\{ (Q - X_H)(1-k)(p - w_H) + (Q - X_L)k(p - w_L)$$

$$+ \frac{l^2[(Q - X_L)w_L - (Q - X_H)w_H]^2}{4c} - u_0 \Bigg\}$$

Taking partial derivatives of the Lagrangian function with respect to w_L, w_H, and λ and setting them equal to zero, we found that λ cannot be zero as long as $c > 0$. Therefore, the retailer's participation constraint must be binding at the optimum. That is:

$$(Q - X_H)(1-k)(p - w_H) + (Q - X_L)k(p - w_L) \tag{49}$$

$$+ \frac{l^2[(Q - X_L)w_L - (Q - X_H)w_H]^2}{4c} = u_0$$

Noticing that when $(Q - X_L)w_L = (Q - X_H)w_H$ the retailer's optimal effort level under SBT converges to that under VMI, we find a set of optimal prices that binds the above participation constraint.

$$w_L^* = \frac{(Q - X_H)}{(Q - X_L)}(1-k)p + kp + \frac{l^2(X_H - X_L)^2}{4c(Q - X_L)} - \frac{u_0}{(Q - X_L)} \tag{50}$$

$$w_H^* = (1-k)p + \frac{(Q - X_L)}{(Q - X_H)}kp + \frac{l^2(X_H - X_L)^2}{4c(Q - X_H)} - \frac{u_0}{(Q - X_H)} \tag{51}$$

Then, the profits of the supplier, the retailer, and the supply chain are given by:

$$E\Pi_4^S = p[Q - (1-k)X_H - kX_L] + \frac{p^2 l^2 (X_H - X_L)^2}{4c} - m'Q - u_0 \tag{52}$$

$$E\Pi_4^R = u_0 \tag{53}$$

$$E\Pi_4^{SC} = p[Q - (1-k)X_H - kX_L] + \frac{p^2 l^2 (X_H - X_L)^2}{4c} - m'Q \quad (54)$$

Note that, with the outcome-dependent prices, the supplier can assure the same amount of expected profit as in the case of VMI. Moreover, the amount of shrink under an SBT contract is the same as that under an VMI contract since the amount of retailer's efforts under these two contracts is the same. Under both contracts, the prices are set to bind the retailer's participation constraint and, thus the retailer's expected profits are the same as u_0 and the supply chain profits become identical. Notice that any reduction in the manufacturer's marginal cost resulting from SBT contract adoption will strictly improve the manufacturer's profit while holding the retailer's profit, as well as the level of retail shrinkage constant.

Proposition 3. When demand is certain and the manufacturer distributes through a retailer using a performance-based pricing scheme based on w_H^* and w_L^* described above,

(a) $E\Pi_4^S = E\Pi_0^S, E\Pi_4^R = E\Pi_0^R, E\Pi_4^{SC} = E\Pi_0^{SC}, e_4^* = e_0^*$ & $EX_4^* = EX_0^*$: The expected profits of the supplier, the retailer, and the supply chain converge to those under the VMI wholesale price contract and the expected retail shrinkage also converges to that under the VMI wholesale price contract when the manufacturer's cost remains unchanged;

(b) Any reduction in the manufacturer's marginal cost strictly improves the manufacturer's expected profit while keeping the retailer's profit and the retail shrinkage unchanged.

RISK SHARING CONTRACT

In reality, there are more than two levels of shrinkage outcomes and, in such cases, setting up outcome-dependent prices could easily become impractical. Instead, we often observe companies implementing a simpler pricing scheme which involves a sharing of realized shrinkage between a retailer and a supplier. Both VMI and SBT contracts with single prices could be expressed in terms of the following shrink sharing scheme: the retailer pays the supplier w for each unit sold; in addition, the retailer pays a penalty of αw for each unit of shrinkage, where $0 \leq \alpha \leq 1$. Notice that, when $\alpha = 1$, the contract converges to VMI and, when $\alpha = 0$, the contract converges to SBT with single price.

We now consider a risk sharing SBT contract where $0 < \alpha < 1$.

Supplier's Problem:

$$\max_{w} E\Pi_5^S = \mathrm{w}[Q - (1 - k - le)X_H - (k + le)X_L] \tag{55}$$

$$+\alpha w[(1 - k - le)X_H + (k + le)X_L] - \mathrm{m}'\mathrm{Q}$$

$$s.t.\ (p - w)[Q - (1 - k - le)X_H - (k + le)X_L] \tag{56}$$

$$-\alpha w[(1 - k - le)X_H + (k + le)X_L] - ce^2 \geq u_0$$

Retailer's Problem:

$$\max_{e} E\Pi_5^R = (p - w)[Q - (1 - k - le)X_H - (k + le)X_L] \tag{57}$$

$$- \alpha w[(1 - k - le)X_H + (k + le)X_L] - ce^2$$

Given that the first-order condition for the retailer’s expected profit is concave with respect to the effort choice, we find the retailer’s optimal effort choice in this case is given by

$$e(w) = \frac{l[p-(1-\alpha)w](X_H - X_L)}{2c} \tag{58}$$

which is a decreasing function of the wholesale price the supplier sets and an increasing function of retailer's shrink share.

Knowing the retailer's optimal response to the wholesale price, the supplier's optimal wholesale price is then given by:

$$w_5^* = \frac{p}{2(1-\alpha)} + \frac{c[Q-(1-\alpha)(1-k)X_H-(1-\alpha)kX_L]}{(1-\alpha)^2 l^2 (X_H - X_L)^2} \tag{59}$$

The retailer's effort choice is given by:

$$e_5^* = \frac{pl(X_H - X_L)}{4c} - \frac{[Q-(1-\alpha)(1-k)X_H-(1-\alpha)kX_L]}{2(1-\alpha)l(X_H - X_L)} \tag{60}$$

Now we need to check the retailer's participation constraint at the optimal wholesale price w_3^*. We use the following additional notations: $\Sigma \equiv l^2(X_H - X_L)^2$, $\Omega \equiv Q-(1-k)X_H - kX_L$ and $\Omega' \equiv Q-(1-\alpha)(1-k)X_H-(1-\alpha)kX_L$.

$$E\Pi_5^R(w_5^*) = \frac{p\Omega}{2} - \frac{p\Omega'}{4(1-\alpha)} + \frac{\Sigma p^2}{16c} - \frac{c\Omega\Omega'}{(1-\alpha)\Sigma} + \frac{c{\Omega'}^2}{4(1-\alpha)^2\Sigma} - \frac{\alpha p Q}{2(1-\alpha)} - \frac{\alpha c\Omega' Q}{(1-\alpha)^2\Sigma} \geq u_0 \tag{61}$$

If the condition (61) holds, profits of the supplier, the retailer, and the supply chain that ensure the retailer's participation are given by:

$$E\Pi_5^S = \frac{p\Omega'}{2(1-\alpha)} + \frac{p^2\Sigma}{8c} + \frac{c{\Omega'}^2}{2(1-\alpha)^2\Sigma} - m'Q \tag{62}$$

$$E\Pi_5^R = \frac{p\Omega}{2} - \frac{p\Omega'}{4(1-\alpha)} + \frac{\Sigma p^2}{16c} - \frac{c\Omega\Omega'}{(1-\alpha)\Sigma} + \frac{c{\Omega'}^2}{4(1-\alpha)^2\Sigma} - \frac{\alpha p Q}{2(1-\alpha)} - \frac{\alpha c\Omega' Q}{(1-\alpha)^2\Sigma} \tag{63}$$

$$E\Pi_5^{SC} = \frac{p\Omega}{2} + \frac{p\Omega'}{4(1-\alpha)} + \frac{3p^2\Sigma}{16c} + \frac{3c\Omega'^2}{4(1-\alpha)^2\Sigma} - \frac{c\Omega\Omega'}{(1-\alpha)\Sigma} - \frac{\alpha pQ}{2(1-\alpha)} - \frac{\alpha c\Omega' Q}{(1-\alpha)^2\Sigma} - m'Q \quad (64)$$

Proposition 4 summarizes our findings from the risk sharing contract models.

Proposition 4. When demand is certain and the manufacturer distributes through a retailer using a risk-sharing contract,

(a) When $\alpha = 1$ & $m = m'$, (i) $E\Pi_5^S = E\Pi_0^S$, (ii) $E\Pi_5^R = E\Pi_0^R$, (iii) $E\Pi_5^{SC} = E\Pi_0^{SC}$ & (iv) $e_5^* = e_0^*$;

(b) When $\alpha = 0$ & $m = m'$, (i) $E\Pi_5^S = E\Pi_1^S$, (ii) $E\Pi_5^R = E\Pi_1^R$, (iii) $E\Pi_5^{SC} = E\Pi_1^{SC}$ & (iv) $e_5^* = e_1^*$;

(c) For $0 < \alpha < 1$, the manufacturer's expected profit increases in α and the retailer's expected profit decreases in α;

(d) For $0 < \alpha < 1$, a sufficient condition for the supply chain profit to increase in α under condition (61) is $2\Omega > Q$.

NUMERICAL EXAMPLES

We provide, in this section, a small numerical example in order to gain insights about the parametric conditions under which suppliers would prefer SBT contracts to VMI contracts. Since suppliers would not prefer SBT contracts without changes in the supply cost under known demand, we focus on the uncertain demand case and examine how the degree of demand uncertainty as well as parameters related to shrinkage influence the supplier's contract choice with the assumption that the supply cost remains unchanged. Specifically, our baseline parameters are the following:

$[\theta, Q_H, Q_L, k, l, X_H, X_L, c, p, m, u_0, \alpha]$ = [0.075[11], 150, 100, 0.2, 0.6, 45, 10, 200, 20, 4, 70, 0]. We then evaluate the sensitivity of the supplier's expected profits under both types of contracts to the changes in the following four variables— θ, Q_H, l, X_H—while holding the rest of the parameters fixed at their baseline values. We also evaluate the level of retailer's effort under the two contracts as a function of the four parameters we are changing. Figure 6 shows the results.

As expected, the supplier's profits are higher under VMI contracts than those under SBT contracts when demand uncertainty is low. Figure 6(a) shows the supplier's profit as a function of θ. When θ is close to zero, the supplier prefers VMI contracts because there is little demand uncertainty it can mitigate using the information accompanying the payments under SBT contracts. Moreover, as shown in Figure 6(e), the retailer's effort level under SBT contracts are much higher than that under VMI contracts which increases the supplier's burden of inventory shrinkage. Therefore, the supplier would want to avoid SBT contracts when demand uncertainty is low. However, Figure 6(a) shows that even a small amount of demand uncertainty could incentivize the supplier to adopt SBT contracts.

In Figure 6(b) we evaluate another measure of demand uncertainty, $Q_H - Q_L$, the gap between high and low demand and examine its impact on the supplier's decision. Similar to the case of θ, the supplier prefers VMI contracts when the gap is relatively small. As the range of demand uncertainty increases, however, the supplier starts to prefer SBT contracts. Again, the retailer's effort is much higher under VMI contracts

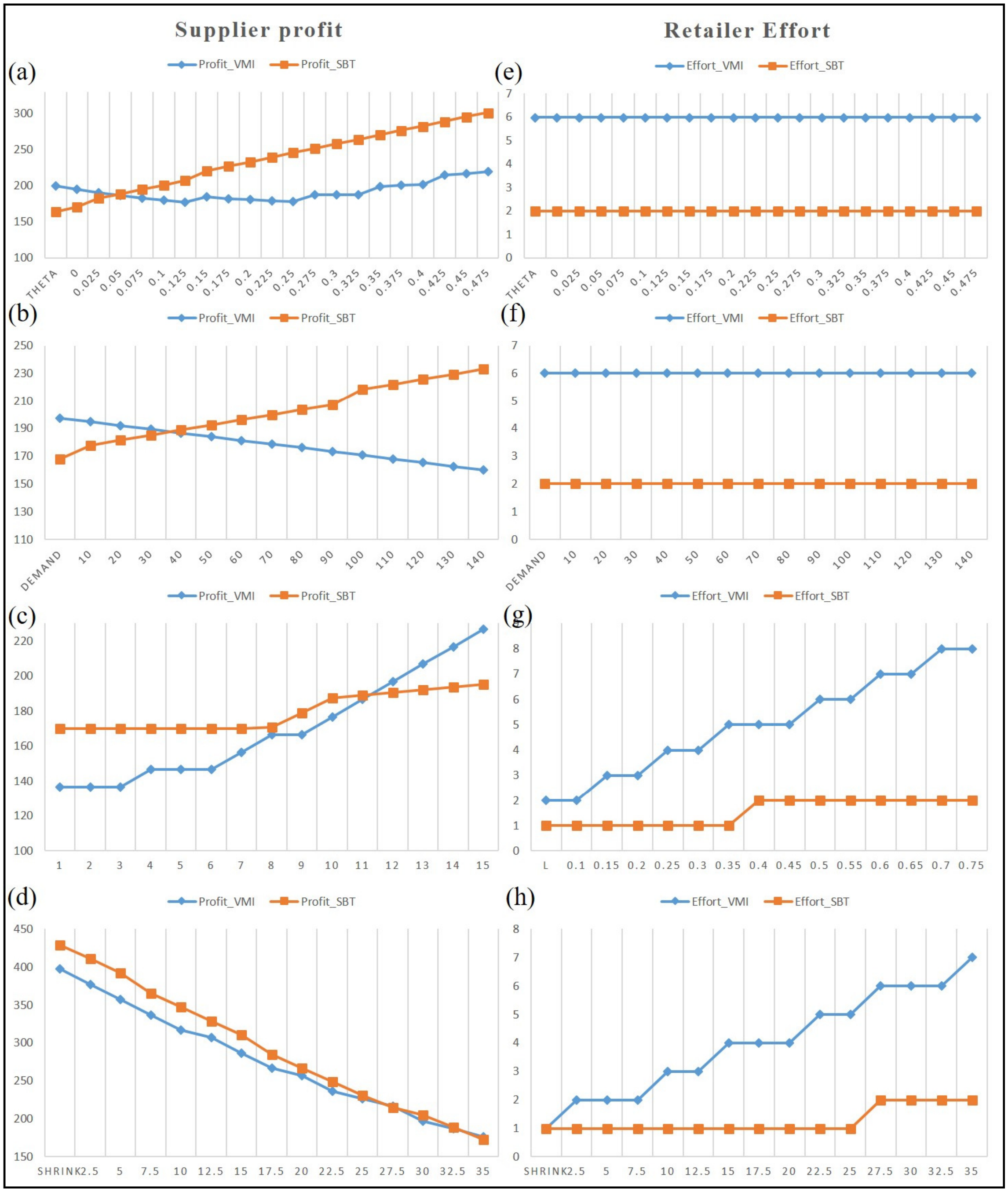
[11] Note that we use a very small value of θ for the baseline case because any larger value of θ strongly incentivize the supplier to adopt SBT and make the decision insensitive to other parameters.

relative to SBT contracts at the baseline parameter values and the levels are insensitive to demand uncertainty.

Figure 6(c) shows how the supplier's profit changes as the probability *l* changes from 10% to 80%. The probability denotes how the inventory shrinkage levels are sensitive to the retailer's effort. As expected, in the presence of slight demand uncertainty, the supplier prefers an SBT contract when the retail shrinkage levels are insensitive to retailer's effort. However, as the sensitivity of retail shrinkage to the retailer's effort increases, the supplier starts to prefer VMI contracts. Figure 6(g) shows another finding. Not only is the level of retailer effort higher under SBT contracts compared to VMI contracts, the gap also increases as *l* increases.

Lastly, Figure 6(d) evaluates the supplier's contract choice as a function of $X_H - X_L$, the gap between high and low shrinkage outcomes. Similar to the previous case, we expect that the supplier will prefer SBT contracts when the gap is small thereby shielding itself from the retailer's moral hazard. Even though we do find this result, the difference in the supplier's profit was very small, despite the fact that shrinkage is highly dependent on the retailer's effort at the baseline (i.e. l=60%). As $X_H - X_L$ increases, the benefit of SBT contracts coming from mitigating demand uncertainty starts to erode. An interesting observation is that even though supplier profits under VMI and SBT were not much different in Figure 6(d), the levels of retailer effort under VMI and SBT are starkly different in Figure 6(h). Examining the optimal wholesale prices under the two contracts, we find that the supplier's ability to set the wholesale price in our Stackaberg game allows it to offset much of the additional shrink cost it is liable for under SBT contracts.

Figure 6. Numerical Examples



DISCUSSION

In Sections 3-6, we examined stylized models of VMI and SBT contracts under various assumptions. When demand is known, we can see that a wholesale price contract based on SBT will shift the cost of retail inventory shrinkage to the manufacturer thereby lowering the retailer's effort to manage inventory compared to VMI contracts. The shift in the cost of shrinkage not only hurts the manufacturer's profit but also generates inventory shrinkage amounts higher than the ideal level for the supply chain. In order for the wholesale price at the SBT contract to be profitable for both the supplier and the retailer, the manufacturer's marginal cost should be sufficiently lowered to compensate for the cost of shrinkage. Nevertheless, inventory waste due to retail shrinkage under the SBT contract is inevitably high compared to the VMI contract even when the manufacturer's cost is lowered.

With performance-based SBT contracts, the manufacturer can effectively shift the risk of inventory shrinkage back to the retailer thereby incentivizing the retailer to exert more effort than that under the wholesale price SBT contract. The expected profits for the manufacturer, the retailer, and the supply chain all converge to the levels under the VMI contract when the manufacturer's cost remains unchanged. Any reduction in the manufacturer's cost, however, will strictly improve the manufacturer's and the supply chain's expected profits without additional inventory shrinkage.

When a performance-based contract is not feasible, a risk-sharing SBT contract in which the cost of realized retail shrinkage is shared between the retailer and the manufacturer can also be a practical way to reduce the burden of the manufacturer when adopting SBT contracts. Intuitively, the manufacturer's expected profit under the risk-sharing SBT contract is increasing in the retailer's share of inventory shrinkage and the retailer's expected profit is decreasing in it. Interestingly, however, the expected retail inventory shrinkage decreases with the retailer's share of shrinkage only when the baseline sales (Ω) is sufficiently large ($2\Omega > Q$). This is the case where the baseline shrinkage (i.e. shrinkage at $e = 0$) is small relative to the avoidable shrinkage, $l(X_H - X_L)$, given the fixed demand Q. That is, when the relative size of the avoidable shrinkage is large, assigning the retailer with increasingly more responsibility for shrinkage reduces the shrinkage outcome. The expected profit for the supply chain is non-monotone in α. We find, however, that when the baseline sales are sufficiently large ($\sqrt{2}\Omega \geq Q$), an increase in the retailer's share of shrink benefits the supply chain as well.

When demand is uncertain, the profit maximizing effort level for the retailer under an SBT contract becomes smaller than that under a VMI contract. This is analogous to the case under demand certainty. However, under demand uncertainty, VMI contracts create inventory waste from inventory overage at the manufacturer due to a lack of forecasting accuracy. This amount of manufacturing waste can be eliminated under SBT contracts through the effective use of the real-time sales information. Moreover, retail stock-outs can also be minimized using the sale information. Therefore, there exists a trade-off between forecasting inaccuracy and retail shrinkage under demand uncertainty. What this means is that, even in the absence of any reduction in the manufacturing cost, the manufacturer's expected profit could be higher under SBT contracts compared to VMI contracts which could support our observation in the grocery retailing sector. Although we do not examine the performance-based and the risk-sharing contract under demand uncertainty, we can easily see that these contracts would further increase the manufacturer's incentive to adopt SBT contracts under demand uncertainty because they would lower overage and decrease the burden of retail shrinkage relative to VMI contracts.

The findings of this study have several important implications. First, despite the negative sentiment expressed by industry experts regarding supply chain initiatives led by powerful retailers, SBT adoption can be a valuable choice for manufacturers interested in reducing demand uncertainty and lowering their manufacturing costs. Whether SBT contracts are beneficial only for the retailers' bottom-line in practice, however, is a question that must be addressed empirically. Second, our study shows that even when SBT contracts can theoretically benefit both the supplier and the retailer, the supply chain may operate more efficiently when the retailer shares the cost of retail shrinkage with the supplier thereby reducing inventory loss and improving sales. Nevertheless, we rarely observe retailers sharing the cost of shrinkage in practice. By sharing shrinkage with the supplier, retailers could incentivize more suppliers to adopt SBT contracts and, perhaps, negotiate a better wholesale price based on the benefits achieved by the supplier. Third, even though SBT contracts are most commonly adopted for perishable groceries in retailing, items with very high demand uncertainty but with very low perishability may be good candidates for SBT contracts. For example, the use of SBT for inventory involving slow moving items, such as obscure maintenance service parts, which are essentially non-perishable could offer mutual benefits to the retailer and the supplier.

LIMITATION AND FUTURE RESEARCH

Our goal in this paper is to explain why manufacturers would switch from VMI to SBT contracts. To that end, we relied on mathematical modeling to compare performance outcomes of the two contracts. Although our models are parsimonious and relevant, we relied on key modeling assumptions in their construction that contributed to their tractability. In particular, we treated the market price to be exogenous in our discussions of VMI and SBT contracts. This enabled us to focus on the dynamics between wholesale price and retail effort. Also, uncertainty in shrinkage, as well as in demand in Section 4, were captured using binary states. These assumptions may over-simplify reality. Future research could relax our modeling assumptions to include an endogenous market price and a continuous and probabilistic distribution of demand as a function of price in order to verify whether the results hold under more general assumptions.

Taking our research even further, we could model SBT contracts as two-sided markets in which a retailer works as the platform that connects suppliers and different consumer groups. Since the retailer's profit relies on attracting more vendors on the supplier side (which will lead to more customers to use the platform), the externalities among the suppliers could influence the retailer's optimal effort choice and the resulting profits for the parties involved. The simplest way we could examine this effect would be to consider two suppliers where the probability of the second supplier joining the SBT platform depends on the existing supplier's shrinkage outcome.

Another potential way to extend our research is to test the implications of our models empirically. The best way to compare performance implications of the two contracts empirically is to conduct an interrupted time series (ITS) analysis for a supplier-retailer dyad that has recently switched from a VMI to an SBT contract. ITS analysis would allow for the estimation of changes in different outcomes after the switch in contracts through the use of longitudinal data covering a period before and after this change (Kontopantelis et al., 2015). The analysis would account for any existing trends prior to the shift from VMI to SBT and would help make stronger causal inferences about the impact of this policy change. The analysis can serve to test whether (i) shrink levels are higher under SBT contracts compared to VMI contracts and whether (ii) demand uncertainty is better mitigated under SBT contracts compared to VMI contracts.

Shrink levels could be measured explicitly using supplier credits or estimated implicitly by counting the difference between supply and sale over a product's shelf life. Mitigation of demand uncertainty could be measured in various ways. One potential measure is a stock-out rate. According to Corsten and Gruen (2003), one of the major reasons for stock-outs is insufficient order quantities at retail stores. If a supplier has access to daily POS data to improve forecasting under SBT contracts, these insufficiencies in order quantities may be corrected and stock-out rates will decrease after switching from VMI to SBT contracts (Lee, 2002).

We propose a primary data collection approach based on a field observation of on-hand inventory levels before and after the contract switch. For feasibility, we will focus on a single supplier and select SKUs at a single store that is planned to go through a VMI to SBT conversion in the near future. For these SKU, we will observe occurrences of zero on-hand inventory (i.e., product unavailability) three weeks before and after the conversion as a measure of stock-out. If we know what time of the day the supplier replenishes the store, we could measure the on-hand inventory levels just before the replenishment. Additionally, we could monitor these SKUs' on-hand levels two more times a day in 8-hour intervals to add precision to our inventory level estimates. We can take pictures of the shelves at the store and convert the images to numbers or use image analytics services such as the one provided by Trax Image Recognition (see www.traxretail.com). By having three data points per day, we could estimate both the occurrence and the length of stock-out.

Admittedly, our comparison of stock-out rates before and after the contract conversion is not a perfect test of the supplier's ability to mitigate demand uncertainty because increased shrink could aggravate stock-out rates. However, if the shrink levels are indeed higher after switching to an SBT contract yet the stock-out rates are lower, our comparison of stock-out rates will serve as a critical test of our second hypothesis.

This work serves as a first step explaining the adoption of SBT contracts among grocery suppliers. Armed with a better understanding of SBT contracts and their implications, we could perhaps envision newer designs of supply contracts to improve coordination of decentralized supply chains.

CHAPTER 3

NEGOTIATING WITH GIANTS: THE IMPACT OF BARGAINING POWER AND THE MITIGATING ROLE OF SERVICE CONCESSION

ABSTRACT

While researchers agree that a firm's power gives it a leverage to obtain favorable outcomes in a negotiation, they do not provide a prescription for a weaker party to mitigate the influence of a powerful opponent at the bargaining table. This study examines what weaker parties can do to mitigate powerful opponents' influence and reorient the bargaining process to achieve more desirable outcomes. To that end, we first conceptually distinguish the objective aspect of power—one that arises from dependency created by hard resources bargaining parties have—from the subjective aspect of power—one that is shaped by perceptions of dependency which can be manipulated by bargaining tactics. We then argue that perceptions of bargaining power, initially set at the outset of a negotiation, can be reshaped in the bargaining process through concession tactics. We test our hypothesis via a behavioral experiment in the context of contract negotiations between retailers and suppliers in a distribution channel. Our results show that, while powerful retailers do tend to have the upper hand in negotiations, weak vendors could ameliorate or even overcome the influence of retailer power by offering services as a concession and as a bundle with the products that they supply. In so doing, vendors may improve the value of their offerings in the eyes of retailers. This study highlights the subjective and manipulative aspects of bargaining power and provides implications for bargaining strategies for power-deprived parties.

INTRODUCTION

Power is a fundamental force in any interaction. From interpersonal interactions to interfirm relations, power plays a vital role. While various definitions of power exist, scholars across disciplines seem to agree that the essence of power lies in one party's ability to cause another party to do something that it would not have done otherwise (Mintzberg, 1983). In the study of channel relationships, scholars have long been interested in the unequal distribution of power between a buyer and a supplier and in the conflicts that result from such power imbalance. In 2001, for example, Bloom and Perry observed that the largest U.S. retailer, Walmart, had pressured its suppliers financially using its power. As a result, they found evidence that Walmart's smaller suppliers exhibited a poorer financial performance when compared to suppliers working with other retailers. More recently, concerns have emerged about how retailers such as Amazon.com have abused their excess monopsony power to squeeze their suppliers (Krugman, 2014). In some cases, powerful retailers have put suppliers at a disadvantage by disrupting the suppliers' sales in subtle ways when suppliers disagree with the retailers' terms (Streitfeld, 2014)

Where does power come from? An important assumption of the channel relationship literature is that interorganizational power is based on dependencies. Formalized by Pfeffer and Salancik (1978) in their development of Resource Dependence Theory, scholars in this stream of research argue that the resources an organization possesses or has access to provide it with the capacity to influence other organizations that desire those resources (Emerson 1962). Scholars have used several metrics to evaluate resource dependency. These include firm size (Provan, Beyer, and Kruytbosch, 1980), business volume (Frazier, 1983), market leadership (Blau, 1964), and network centrality (Brass and Burkhardt, 1993). Implicit in these metrics of dependency is the view that power relationship is a static concept and it is difficult to change the power relationship in the short-term.

Another assumption is that power in a dyadic relationship is an objective concept that can be unequivocally measured (Pfeffer and Salancik, 2003). According to Perrow, (1970), the distribution of power in a relationship is a function of the allocation of objective resources between the parties in the relationship and is reflected in the structural dependency of one party on another. Nevertheless, Adler and Silverstein (2000) have observed that negotiations are prevalent between parties even when there is a seemingly asymmetric power distribution between them. This implies that there may be more to bargaining power than the structural dependency created by objective resources between two parties. There may be a way for the weaker party in a relationship to mitigate the dominant force of the stronger party and reorient the bargaining process to achieve more favorable outcomes.

In this study, we seek strategies based on subjective aspects of bargaining power for parties in power-disadvantaged positions, a topic that has not received much attention in the literature. To that end, we first conceptually distinguish the objective aspect of power—one that arises from dependencies created by hard resources owned by bargaining parties—from the subjective aspect of power—one that is shaped by perceptions of dependency which can be manipulated by tactics during the bargaining process. We then argue that the perception of bargaining power, initially set at the outset of the negotiation, can be reshaped in the bargaining process through service concession tactics. Drawing on two alternative views of service concession making, namely impression management theory and service-dominant (S-D) logic, we postulate two competing propositions about how service concession shapes the relationship between power and bargaining outcomes.

We test our hypotheses via a behavioral experiment in the context of contract negotiations in a retail distribution channel. Our results support the S-D logic's view of service concession making. They show that while powerful retailers do tend to have the upper hand during negotiations, weak suppliers could ameliorate or even overcome the influence of retailers' power by offering services as concessions. The results from the experiments show that service concessions, when properly bundled with the core products being negotiated, can improve perceived value of the offerings and generate greater dependency by retailers on suppliers. Moreover, the results suggest that services that offer immediate and concrete benefits turn out to be more effective in overcoming retailer power than those with long-term abstract benefits. Through these results, our study highlights the subjective and manipulative aspects of bargaining power and provides tactical advice for power disadvantaged parties during negotiations.

The rest of the paper is organized as follows. In the next section, we review relevant theory and establish our research propositions. In Section 3, we explain our experiment setting, the operationalization of power and service concession, and our hypotheses. Section 4 presents the results of the experiment. Section 5 discusses the implications of the results. Section 6 concludes by discussing our study's limitations and future research directions.

THEORY

Organizations differ in their resources and such heterogeneity in resource allocation creates dependency among organizations. Organizations that have scarce and critical resources will generally have advantages over other organizations that desire those resources (Pfeffer and Salancik, 1978). In a dyadic relationship, the extent to which an organization is dependent on its partner firm may not necessarily be the same as the extent to which the partner firm is dependent on the organization (Emerson, 1962). When an organization is relatively more dependent on its exchange partner, it gives its partner more power to influence it. The larger the asymmetry in the dependence between two organizations, the greater the power the partner firm has over the other firm (Casciaro and Piskorski, 2005).

While this form of resource dependence is a central construct in understanding interorganizational relationships in the abstract, it is insufficient to predict particular bargaining outcomes because bargaining is an inherently social process between human actors. Human bargainers often show deviations from rationality because they are cognitively limited (Pruitt and Rubin, 1986). In that regard, bargaining is a cognitive process through which bargainers select, interpret, and infer information presented to them throughout the course of their bargaining process (Hammond et al. 1975). Therefore, bargainers may subjectively interpret objective conditions when they translate cues from the environment about their opponents and the situation into usable information at the bargaining table.

Bargaining is also a process of social interaction in which bargainers act and react to their adversaries' actions. In that sense, Bacharach and Lawler (1981) viewed bargaining as a "game of managing impression" through information manipulation (p.42). A bargainer's ultimate mission is then to manipulate his opponent's perceptions of his power through various tactics in order to achieve his goal. This subjective and tactical view of bargaining power provides the weaker bargaining party an opportunity to maneuver the negotiation towards more favorable outcomes (Kim, Pinkley, and Fragale 2005; Lewicki and Robinson, 1998; Shapiro and Bies, 1994).

Once we view bargaining as a process of social interaction between two entities with bounded rationality, it is possible to picture a series of concessions and counter-concessions going back and forth between two parties with asymmetric resource dependencies. Extant literature on concession-making views concessions as part of an outcome variable. Studies in this stream of research generally agree that when power imbalances exist, the weaker party tends to make more concessions and, consequently, obtains smaller outcomes relative to the powerful party (Giebels, De Dreu, and Van de Vliert, 2000; Pinkley, Neale, and Bennett, 1994; for a review, see Pruitt and Carnevale, 1993).

However, concessions are not only outcomes but also critical inputs to bargaining through which participants communicate their positions and attitudes (Bacharach and Lawler, 1981). As such, concession making offers also an opportunity for one party to manipulate its opponent's perception regarding its bargaining power. Can a weaker party make concessions as a bargaining tactic in order to mitigate the impact of power imbalance? According to impression management perspectives, bargainers can infer their opponents' aspirations based on their concession behaviors. If a bargaining party makes little or no concessions, its opponent will ascribe a strong image and a high level of aspirations to the bargaining party and, in response, the opponent will lower its aspiration level and make more concessions (Siegel and Fouraker, 1960). From this perspective, the perception of one's level of aspiration becomes a particularly important target of manipulation at the negotiation table. The old adage "give someone an inch and they'll take a mile" expresses this perspective and stresses the need for bargainers to look strong. In a bargaining context with power imbalance, if the weaker party makes concessions, then the opponent's perception of the weaker party's aspirations may be reinforced and may further heighten the opponent's level of aspirations. Thus, concessions made by the weaker party may create a vicious cycle by reinforcing the gap in the dependencies. This view of concession making is closely related to the zero-sum approach to bargaining where the bargaining process is considered a purely distributive game which focuses on the relative power between the bargaining parties (Pinkley. Griffith, and Northcraft, 1995).

However, the impact of concession making could also be understood from an alternative perspective in which power is rooted in the possession of *valued* resources (Emerson, 1962). Focusing on the value of concessions made by the bargainer rather than the impression made by the act of concession making itself, one may argue that the power imbalance, perceived prior to the bargaining process, could be adapted to the extent that the bargainer's concession influences the opponent's perception of the value of bargainer's resources. How can concessions change the perceived value of one's resources? According to S-D logic, resources are inherently value-neutral and the value of tangible resources is realized only when they deliver useful services to users (Vargo and Lusch, 2004). Hence, any additional services that can facilitate the process of value realization could improve the perceived value of the resources provided by the party offering these services. In the context of power imbalance, by making service concessions that could enhance the overall value of the offerings being exchanged, the weaker party could manipulate its bargaining power, as perceived by its opponent, and achieve a more favorable outcome than what would be feasible in the absence of such concession.

These arguments point to a definite impact of relative structural power on bargaining outcomes. This is summarized in Proposition 1 below. However, they also point to two competing effects, summarized in Proposition 2a and 2b below, regarding the impact of concession making on the bargaining outcomes. Our goal is to test these propositions empirically through the use of a bilateral negotiation experiment.

Proposition 1: A bargainer's relative structural power negatively influences its opponent's bargaining outcome.

Proposition 2a: By offering a service concession, a bargainer adds to the negative impact of its opponent's relative power on its outcome.

Proposition 2b: By offering a service concession, a bargainer offsets the negative impact of its opponent's relative power on its outcome.

EXPERIMENT

We conducted a bilateral negotiation experiment to examine the effects of relative structural power and supplier concession making on bargaining outcomes. The design of the experiment involved relative power and supplier concession as within-subject factors.

The context of the bargaining was a negotiation of a scan-based trading (SBT) contract between a grocery retailer and a milk supplier. SBT contracts are emerging alternatives to vendor-managed inventory (VMI) contracts where suppliers make inventory replenishment decisions at retail stores and maintain ownership of this inventory until products are sold to consumers (Kinsey, 1999). SBT contracts provide a particularly relevant context for studying negotiation because the decoupling of inventory ownership from control creates additional opportunities for incentive misalignment, which requires a more careful approach to bargaining especially from the weaker party's perspective. Literature on SBT contracts have mainly focused on comparing performance implications of SBT contracts with those of more traditional types of contracts using mathematical modeling and, in so doing, assumed away the role of particular power and negotiation dynamics in these relationships (Ben-Daya et al., 2013; Gümüş, Jewkes, and Bookbinder, 2008; Ru and Wang, 2010). Our examination of the impact of bargaining power and bargaining tactics on the distribution of outcomes under SBT contracts seeks to address this deficiency in the literature. We ground our experiment in the bargaining between a grocery retailer and a milk supplier where SBT contracts are frequently observed in practice.

The negotiation of the SBT contract in the experiment involved two specific parameters, the wholesale price of milk and the retailer's share of inventory shrink costs at the retailer's stores. The share of inventory shrink costs between retailers and suppliers is a particularly important negotiation aspect in SBT contracts not only because it can be used as a tool to distribute the cost of inventory shrinkage between the retailer and the supplier but also because it can potentially influence the amount of total shrinkage by adjusting the retailer's incentives to manage SBT inventories at its stores. In order to ensure that our bargaining context closely resembles actual practice, we allowed participants to bargain over the shrink share along with the wholesale price simultaneously instead of providing them with an exogenous contract price. The main dependent variable was the total payoff from the bargaining which was the sum of the payoffs from their agreements on the two parameters above.

Participants

We recruited a total of 152 undergraduate business students from Arizona State University. These students received course credits in exchange for their participation in the experiment. We deemed the use of student subjects to be appropriate for this study because the study focuses on general behavioral patterns related to tactics and perceived power (Knemeyer and Naylor, 2011). Since we are not interested in measuring actual decision makers' preferences but rather fundamental human processes, recruiting working professional is not required. Rather, working professionals' experience in SBT could be considered counter-productive for the purpose of our study since their preexisting knowledge (e.g., relational dynamics with existing SBT partners) may render the experimental priming ineffective. To ensure external validity while avoiding unnecessary bias from experience, we recruited only students who had taken or were taking relevant coursework in areas such as Purchasing Management or Negotiation. Recruiting such qualified students ensured that the participants had enough fundamental knowledge about the phenomenon of interest (Biyalogorsky, Boulding, and Staelin, 2006).

Manipulation of Treatment Variables

Drawing from the classical bargaining theory, we manipulated relative structural power using disagreement payoffs, namely the payoff each party will receive when negotiation fails to reach an agreement (Nash, 1950, 1953; Pinkley, Neale, and Bennett, 1994; Tripp and Sondak, 1992). These values reflect the availability of alternative options each bargaining party has. Therefore, the larger the value of a party's disagreement payoff, the less dependent it becomes on its bargaining counterpart. The difference between a party's disagreement payoff and its counterpart's represents the bargaining party's relative power derived from the structure of the resource distribution. The relative structural power construct has three levels: retailer-powered, balanced-power, and supplier-powered conditions. In the retailer-powered condition, the retailer would receive $40,000 whereas the supplier would earn nothing when the negotiation fails. This means that the retailer is relatively less dependent on the supplier and, consequently, has more power. In the balanced-power condition, both the retailer and the supplier would earn $20,000 each. Therefore, they are equal in structural power. In the supplier-powered condition, the supplier would earn $40,000 while the retailer would receive nothing. This condition reflects the case in which the supplier has relative structural power. Note that, in all conditions, the sum of the bargainers' disagreement payoffs was held constant at $40,000 to avoid any confounding effect resulting from different levels of absolute dependence (in contrast to the relative dependence). In measuring the structural and objective element of dependence, we, thus, strictly focus on the relative power.

We also incorporated different forms of service concession offered by the supplier: no service, inventory audit service, and sales analytics report service. Each of these service forms was exogenously given in each of the negotiation rounds. Among all possible services to offer as a concession, we choose inventory audit services and sales analytics report services because these auxiliary service forms can be introduced as concessions without shifting the focus of the negotiation away from its main parameters (wholesale price and inventory shrink share). Our choice of these two particular types of services was grounded in our desire to evaluate whether the value perspective of concession making (Proposition 2b) holds true and, if so, how different types of services will have different effect on bargaining outcomes. We choose inventory audits to represent a type of service with immediate short-term benefits. Since SBT contracts eliminate daily inventory check-ins, inventory audits have great complementary value for retailers who will be in need of objective inventory data to save costs. In contrast, services involving sales analytics reports provide greater long-term benefits to retailers as cumulative knowledge of consumers' purchasing patterns would help retailers rationalize shelf space and product assortments to improve overall sales. Nevertheless, such benefits may take relatively longer to realize, and there may not be immediate monetary benefits derived from them. If service concessions do improve the supplier's bargaining outcome by altering the perceived power dependence, services which differ in their salient values may have a different impact on the outcome. Specifically, we suspect inventory audit services to have a stronger effect on the supplier's payoffs because their benefits are more immediate and, hence, brought to the mind of the retailers more readily (Ratneshwar et al., 1997). We do not attach particular costs to these services even though one could be costlier for the supplier to offer than the other. We believe that attaching dollar values to these costs could artificially force specific bargaining outcomes. Since we are focusing on the perceived values of these services by the retailer, we believe that the results would be more meaningful without explicit costs. Of course, the implicit assumption here is that the supplier would not offer services that are so costly that they would offset the effect of mitigated power completely.

Based on our operationalization of relative structural power and supplier concession making, we can restate our research propositions into the following testable hypotheses. Specifically, Hypothesis 1 tests Proposition 1; Hypothesis 2a and 2a' test Proposition 2a using inventory audit services and sales analytics services, respectively; and Hypothesis 2b and 2b' test Proposition 2b using these two service concessions

Hypothesis 1: Retailers' relative structural power negatively influences suppliers' total bargaining payoffs.

Hypothesis 2a: Under a given level of relative structural power, offering inventory audit services as a bargaining concession negatively influences suppliers' total bargaining payoffs compared to the case when no service is offered.

Hypothesis 2a': Under a given level of relative structural power, offering sales analytics services as a bargaining concession negatively influences suppliers' total bargaining payoffs compared to the case when no service is offered.

Hypothesis 2b: Under a given level of relative structural power, offering inventory audit services as a bargaining concession positively influences suppliers' total bargaining payoffs compared to the case when no service is offered.

Hypothesis 2b': Under a given level of relative structural power, offering sales analytics services as a bargaining concession positively influences suppliers' total bargaining payoffs compared to the case when no service is offered.

Procedure

To conduct the bilateral negotiation experiment, we randomly grouped the 152 participants into 76 pairs. The participants in each of these pairs played the role of either the retailer or the supplier. Each pair of participants was seated at a table at some distance apart from other pairs. Initially, the participants in each pair were given a script which contained general information about the SBT contract and the terms being negotiated. The script also contained instructions about each participant's role, their tasks, and the negotiation procedure as well as charts that showed their private payoffs as a function of their choices of the wholesale price and the shrink share (See Appendix A[12]). The preferences for the two parameters were structured completely opposite for the two parties such that the retailer prefers lower wholesale prices while the supplier prefers high wholesale prices and, similarly, the retailer prefers to have no share of shrink cost while the supplier prefers the retailer to be responsible for the entire share of the shrink cost. Participants were not allowed to show their private payoff charts to their bargaining partners. Such information was only allowed to be discovered by communication in the negotiation process.

[12] Our experiment was designed based on the script kindly provided by Professor Simon Gaechter at the University of Nottingham. Although the nature of our experiment differs from his, his script helped us greatly in building our own script. The design of our payoff chart drew on valuable comments from Professor Thomas M. Tripp at Washington State University-Vancouver and his seminal paper, Tripp and Sondak (1992).

Once the participants in each pair had a chance to read the script about the bargaining experiment, they were given 30 minutes to complete nine rounds of bargaining tasks (a full factorial design involving three levels of relative structural power and three levels of service concession). The bargaining took place face-to-face with each round of negotiation limited to a three-minute duration. When no agreement was made within the three-minute window for any round of negotiation, an impasse was declared and the subjects were to earn the payoff values described as their respective disagreement payoffs for that round. During this phase, the participants could freely communicate each other's preferences and exchange offers. To motivate the participants' involvement in the task, the script indicated that each of the participants will earn course credits based on their achievements from the bargaining. Specifically, 45 points were promised for participants whose payoffs were above the average and 15 points were offered for those whose payoffs were below the average. These points were equivalent to 4.5% and 1.5% of their final grade, respectively. To avoid non-agreement, no points were offered for those who did not complete all the rounds of the negotiation. Upon completion of the bargaining tasks, the subjects were asked to fill out a questionnaire about their sociodemographic information (See Appendix B).

RESULTS

We analyzed our data using a random effects panel Tobit model to account for the dependence between outcomes from the same dyads over the nine rounds of negotiation and the limited ranges of outcomes resulting from the utilization of our payoff charts. Our Tobit model assumes that there is an unobserved latent variable, y_{it}^*, which denotes the participant i's true payoff from negotiation round t. This variable, y_{it}^*, linearly depends on the explanatory variables. Moreover, the random effects (v_i) are independent and identically distributed (i.i.d.) following a normal distribution with mean zero and variance of σ_v^2 and the error term (u_{it}) is also i.i.d. with mean zero and variance of σ_u^2. The following equation describes our main econometric model:

$$y_{it}^* = \beta_0 + \beta_0 \text{RPower} + \beta_0 \text{BPower} + \beta_0 \text{Audit} + \beta_0 \text{Analytic} + \beta_0 \text{RPower} * \text{Audit} \quad (65)$$
$$+\beta_0 \text{RPower} * \text{Analytic} + \beta_0 \text{BPower} * \text{Audit} + \beta_0 \text{BPower} * \text{Analytic} + v_i + u_{it},$$

where RPower and BPower are dummy variables indicating the three power condition (i.e. RPower equals one when retailer has relative power; BPower equals one when power is balanced between the two parties; supplier-powered conditions are used as the baseline), Audit is a binary variable that takes one for inventory audit service, and Analytic is a binary variable equals to one for sales analytics service. We used STATA 14.1's *xttobit* command with robust estimations of standard errors using the bootstrapping method to analyze the results from our experiment. After briefly discussing the characteristics of our participants, we present our main results.

Participant Characteristics

In order to ensure proper randomization of participants into the roles of supplier and retailer, we tested for significant differences in their sociodemographic profiles. Overall, participants who took the role of suppliers and those who took the role of retailers were not significantly different from each other regarding socio-demographics variables including age, gender, nationality, ethnicity, and test scores. We concluded that, overall our participants were properly randomized into the two roles.

Table 6

Participant Characteristics

	Supplier		Retailer		T-test*
	Mean	Std. Dev.	Mean	Std. Dev.	P-value
Age	22.670	4.411	22.211	3.248	0.952
Female	0.474	0.500	0.395	0.489	0.413
U.S. Born	0.671	0.470	0.671	0.470	0.863
White	0.618	0.486	0.553	0.498	0.412
Hispanic	0.105	0.307	0.105	0.307	1.000
Native	0.013	0.114	0.000	0.000	1.000
African	0.000	0.000	0.053	0.223	1.000
Asian	0.263	0.441	0.289	0.454	0.718
Other	0.053	0.223	0.013	0.114	1.000
SAT	1801.852	261.065	1706.632	351.497	0.535
ACT	26.705	3.598	27.452	3.217	0.498

* Two-tailed t-test was conducted assuming unequal variances. Observations two standard deviations away from the means were excluded from the analyses.

Individual Payoffs from the Bargaining Experiments

Since we are interested in how structural power and service concessions influence bargaining outcomes, we combined payoffs from the two bargaining parameters, the wholesale price and the share of shrinkage, to construct a bargainer's total payoff from the negotiation. As we anticipated, participants did make tradeoffs between the two parameters in order to reach agreements. Overall, there was a statistically significant negative correlation coefficient (-0.321 at α=0.05 level) between the payoffs from the two parameters. According to this coefficient, there was a 10 cent decrease in the wholesale price associated with a 3.21% increase in the retailer's share of shrinkage (See Figure 7 below).

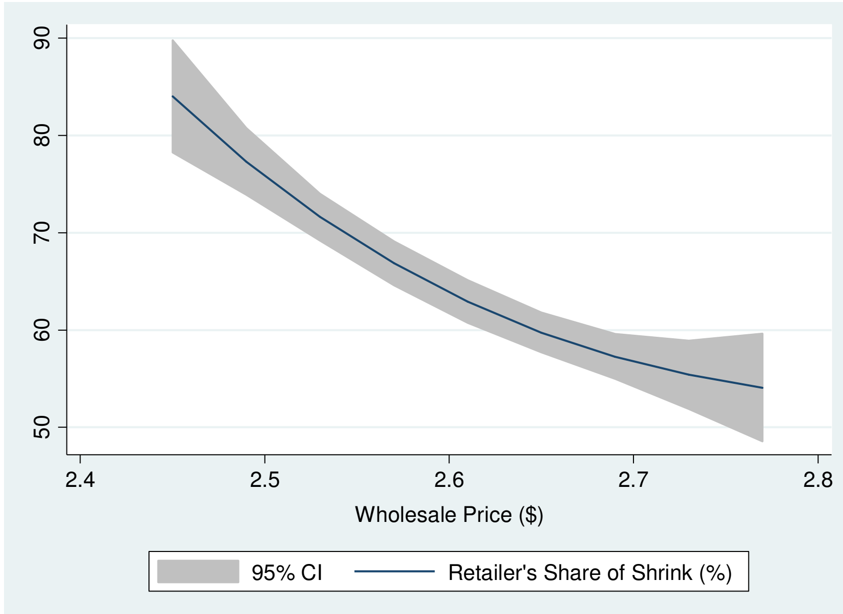


Figure 7. Relationship between Wholesale Price and Shrink Payoff

Since the range of possible dollar payoffs was different for the suppliers and the retailers (See Table 7), we used a normalized measure of total payoffs as our dependent variable in the subsequent analyses. Therefore, our dependent variable, Total Payoff (%), runs between 0 and 1, denoting how far a bargainer's earned payoff is from the lowest possible payoff (or how close it is to the highest possible payoff).

Table 7

Summary of Total Payoff ($)

Total Payoff ($)	Mean	Std. Dev.	Min	Max
Supplier	$67,631.22	$8,592.88	$29,869	$99,769
Retailer	$86,543.77	$6,978.73	$68,848	$114,920

Impact of Relative Structural Power

We first examined the impact of relative structural power on the bargainer's total payoff. Table 8 presents the results from this evaluation. Consistent with the extant literature, a bargainer's relative power dominance had a significant and negative impact on its counterpart's payoff (Dahl, 1957; El-Ansary and Stern, 1972; Emerson, 1962; Gaski, 1984; Wilemon, 1972). On average, a supplier's total payoff was 3.6% farther from the highest possible outcome he could earn when the retailer had more power compared to the case when the supplier had more power. Similarly, a retailer's total payoff was 3.1% closer to the highest possible outcome when he had more power compared to the case when the supplier had more power. Our results are consistent with the extant literature regarding the role of relative power in that the party with higher relative power appropriates a larger share of the overall benefits available from the negotiation (Friedkin, 1986; Casciaro and Piskorski, 2005). Hypothesis 1 is thus supported.

Table 8

Impact of Structural Power on Total Payoff

	Supplier's Total Payoff (%)			Retailer's Total Payoff (%)		
	Coefficient	Std. Err.	P-value	Coefficient	Std. Err.	P-value
Retailer-Powered	-0.036	0.009	0.000	0.031	0.010	0.002
Power-Balanced	-0.017	0.011	0.111	0.020	0.013	0.108
Constant	0.643	0.013	0.000	0.367	0.014	0.000
N	675			675		
Wald Chi^2	18.470			9.560		
Log likelihood	441.467			413.719		
Prob>Chi^2	0.000			0.008		

Impact of Service Concession

To test how the supplier's provision of an independent but relevant service as a concession influences the bargaining outcomes, we added six variables to the models in Table 8, including two dummy variables indicating the provision of inventory audit and analytics report services as well as four interaction terms between structural power and the service concession terms. Inclusion of the interaction terms is necessary to test the second set of Hypotheses 2 because the effects of services is contingent on the relative level structural power between the negotiating parties.

Interestingly, after we added the service concessions terms along with the interaction terms, the direct effects of structural power on the bargaining outcome shown in Table 8 disappeared for both the supplier's and the retailer's payoffs. In turn, the direct effect we obtained for inventory audit services was positive and statistically significant. The effect of structural power remained significant only in its interaction terms.

Specifically, when the relative structural power favored the supplier, suppliers could improve their total payoff by 6.5% by offering inventory audit services as a concession compared to the case when no service is offered. However, such effect was significantly attenuated by the retailer's relative power. That is, when the relative structural power favored the retailer (or when the power is balanced), the net improvement of supplier's payoff induced by the inventory audit service was only 1.7%. Nevertheless, the overall effect of inventory audit service on the supplier's payoff was positive and significant, supporting Hypothesis 2b.

Similarly, offering inventory audit service significantly reduced the retailer's payoff (β= -0.073, p<0.001). However, the retailer's relative power neutralized the impact of inventory audit service on his total payoff (β= 0.055, p=0.025). Introducing analytics report service did not influence the bargainers' total payoff directly nor indirectly by interacting with structural power. Overall, our findings support the S-D logic's view of service concession making. However, specific choices of service concession do seem to matter as well.

Table 9

Impact of Structural Power and Service Concession on Total Payoff

	Supplier's Total Payoff (%)			Retailer's Total Payoff (%)		
	Coeff.	S.E.	P-value	Coeff.	S.E	P-value
Retailer-Powered	-0.018	0.011	0.300	0.006	0.015	0.733
Power-Balanced	-0.008	0.012	0.645	0.013	0.013	0.482
Inventory Audit	**0.065**	**0.017**	**0.000**	**-0.073**	**0.017**	**0.000**
Analytics Report	0.003	0.015	0.871	-0.020	0.017	0.266
Retailer-Powered x Inventory Audit	**-0.048**	**0.019**	**0.050**	**0.055**	**0.025**	**0.033**
Retailer-Powered x Analytics Report	-0.008	0.028	0.753	0.021	0.029	0.425
Power-Balanced x Inventory Audit	**-0.048**	**0.024**	**0.049**	**0.039**	**0.022**	**0.129**
Power-Balanced x Analytics Report	0.021	0.017	0.398	-0.016	0.022	0.538
Constant	0.621	0.014	0.000	0.398	0.013	0.000
N	675			675		
Wald Chi^2	35.200			32.370		
Log likelihood	452.290			425.150		
Prob>Chi^2	0.000			0.000		

DISCUSSION

Optimal supply chain performance requires a high level of coordination among individual firms who are primarily concerned with their individual objectives. Power asymmetry in a buyer-supplier relationship, however, results in uneven distributions of profits between the two parties, which often creates conflicts and prevents successful coordination. For example, severe inefficiencies are observed in the retail industry due to lack of retailers' responsibility for the retail inventory shrinkage. While most people attribute adoptions of such inefficient contracts to excessive retailer power and offer few strategies for weak suppliers, the current study provides a theoretical framework to understand the subjective and manipulative aspects of power which can be influenced by bargaining tactics.

In particular, this study shows, through a behavioral experiment, that service concession making could be a useful tactic for power-disadvantaged suppliers when negotiating contracts with powerful retailers. Even when the gap between bargaining parties' structural and objective power is clear, the dark side of power imbalance could still be ameliorated or even overcame due to the cognitively complex nature of the negotiation process and the bounded rationality of human bargainers. Bargaining is a cognitive process through which bargainers select, interpret, and infer information presented to them throughout the course of bargaining (Hammond et al. 1975). Bargainers with bounded rationality may subjectively interpret objective conditions when they collect information about the opponent and the bargaining situation. The complexity of bargaining processes also provides opportunities for the weaker parties. More often than not, multiple issues are simultaneously negotiated with new issues being added and existing issues being separated dynamically to achieve the best bargaining outcomes. In such a dynamic process, each issue's contribution to the overall bargaining objective is also changing, rendering opportunities to influence perceptions of dependence through effective concession making tactics. The fact that bargaining is an inherently social process through which bargainers interact with their opponents by exchanging offers and counter-offers also provides the weaker parties opportunities to maneuver the negotiation towards more favorable outcomes (Kim, Pinkley, and Fragale 2005; Shapiro and Bies, 1994).

Among all bargaining tactics that could be used by weaker suppliers to ameliorate the influence of retailer power, we examine the role of service concessions. Drawing on the S-D logic, we emphasize the importance of the perceived value of resources which could be improved by bundling complementary goods with services. While it may be difficult for a supplier to change its resource portfolio in a short term, offering additional services as a concession during the bargaining process could enhance the buyer's perception of the overall value of the supplier's offerings and help the supplier achieve more favorable bargaining outcomes. Our results show that it is important to offer services that have a strong and salient value in order to manipulate the retailer's perception of resource dependence effectively.

Taking into account both the social nature of bargaining process and the bounded rationality of human decision makers in the context of contract negotiation, this study offers some valuable insights as to how relatively weaker bargaining parties could effectively curb the effect of the opponent's power dominance. While the extant literature approaches bargaining power primarily from the power dominant party's perspective, our study offers the first attempt to offer practical influence strategies for the weaker party to overcome power disadvantage and improve their bargaining outcomes.

LIMITATIONS AND FUTURE DIRECTIONS

This study is not without limitations. First of all, even though the theory framework presented in this study implies that it is through changes in the perceived power dependence that the valuable service concession improves the achieved bargaining outcomes, we do not directly measure this perception in our study. Moreover, the design of the current study provides concessions exogenously thereby limiting our ability to measure changes in perceptions. A promising direction for future research would be to design an experiment such that changes in the perception of power dependence are dynamically evaluated before and after concession making.

Another interesting area of future research is to identify antecedents to specific combinations of wholesale price and shrink share outcomes. In the current study, these two parameters are simultaneously settled between the two parties, which makes the negotiation process unstructured and close to reality but also makes it impossible to evaluate the influence of structural power and service concession on the wholesale price and the retailer's share of shrinkage, respectively. In searching for antecedents to choices of shrink share, future studies may highlight the uncertain nature of shrinkage which was not addressed in the current study. In practice, inventory shrinkage could be highly uncertain which makes shrink share a fundamentally different parameter compared to the wholesale price. In that regard, bargainers' risk attitudes may also be measured to examine the dynamics of power, risk attitude, and concession tactics in their effect on bargaining outcomes.

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APPENDIX A

CHAPTER 2 PROOFS

Proof of Proposition 1(a)

If $E\Pi_1^R(\mathrm{w}_1^*) \geq u_0$,

$$E\Pi_0^S = p[Q-(1-k)X_H - kX_L] + \frac{p^2 l^2 (X_H - X_L)^2}{4c} - mQ - u_0$$

$$\geq \frac{3p}{4}[Q-(1-k)X_H - kX_L] + \frac{3p^2 l^2 (X_H - X_L)^2}{16c} + \frac{3c[Q-(1-k)X_H - kX_L]^2}{4l^2(X_H - X_L)^2} - mQ.$$

$$\begin{aligned} E\Pi_0^S - E\Pi_1^S \geq\ & \frac{3p}{4}[Q-(1-k)X_H - kX_L] + \frac{3p^2 l^2 (X_H - X_L)^2}{16c} \\ & + \frac{3c[Q-(1-k)X_H - kX_L]^2}{4l^2(X_H - X_L)^2} - mQ \\ & - \left\{\frac{p}{2}[Q-(1-k)X_H - kX_L] + \frac{p^2 l^2 (X_H - X_L)^2}{8c}\right. \\ & \left. + \frac{c[Q-(1-k)X_H - kX_L]^2}{2l^2(X_H - X_L)^2} - m'Q\right\} \\ & = \frac{p}{4}\{Q-(1-k)X_H - kX_L\} + \frac{p^2 l^2 (X_H - X_L)^2}{16c} \\ & + \frac{c\{Q-(1-k)X_H - kX_L\}^2}{4l^2(X_H - X_L)^2} - (m-m')Q. \end{aligned}$$

When $m = m'$, $E\Pi_0^S > E\Pi_1^S$.

If $E\Pi_1^R(\mathrm{w}_1^*) < u_0$, the supplier's expected profit under SBT contracts is even lower.

Proof of Proposition 1(b)

$E\Pi_1^R \geq u_0$ holds by the construction of the game.

Proof of Proposition 1(c)

If $E\Pi_1^R(\mathrm{w}_1^*) \geq u_0$,

$$e_1^* = \frac{pl(X_H - X_L)}{4c} - \frac{[Q-(1-k)X_H - kX_L]}{2l(X_H - X_L)} < \frac{pl(X_H - X_L)}{2c} = e_0^*.$$

If $E\Pi_1^R(\mathrm{w}_1^*) < u_0$, the wholesale price will decrease to satisfy the retailer's participation constraint. However, as long as the wholesale price is positive, the optimal effort level under SBT contracts will always be strictly lower than that under VMI contracts.

$EX_1^* > EX_0^*$ follows since the expected shrink is a decreasing function of e.

Proof of Proposition 1(d)

If $E\Pi_1^R(\mathrm{w}_1^*) \geq u_0$,

$$E\Pi_0^{SC} - E\Pi_1^{SC} = [Q-(1-k)X_H-kX_L] + \frac{p^2l^2(X_H-X_L)^2}{4c} - mQ$$

$$-\left\{\begin{array}{c}\frac{3p}{4}[Q-(1-k)X_H-kX_L] + \frac{3p^2l^2(X_H-X_L)^2}{16c} \\ -\frac{c[Q-(1-k)X_H-kX_L]^2}{4l^2(X_H-X_L)^2} - m'Q\end{array}\right\}$$

$$= \frac{p}{4}[Q-(1-k)X_H-kX_L] + \frac{p^2l^2(X_H-X_L)^2}{16c} + \frac{c[Q-(1-k)X_H-kX_L]^2}{4l^2(X_H-X_L)^2}$$

$$-(m-m')Q$$

When $m = m'$, $E\Pi_0^{SC} > E\Pi_1^{SC}$.

The gap is even larger when $E\Pi_1^R(\mathrm{w}_1^*) < u_0$ under SBT contracts, since the supplier's expected profit is lower and the retailer's expected profit is binding at u_0.

Proof of Proposition 1(e)

Proposition 1(e) follows from Proposition 1(a).

Proof of Proposition 2(a)

Under $E\Pi_3^R(\mathrm{w}_3^*) \geq u_0$,

$E\Pi_3^S > E\Pi_2^S$

$$\Leftrightarrow \frac{p}{2}[\bar{Q}-(1-k)X_H-kX_L] + \frac{p^2l^2(X_H-X_L)^2}{8c} + \frac{c[\bar{Q}-(1-k)X_H-kX_L]^2}{2l^2(X_H-X_L)^2} - m'\bar{Q}$$

$$> p[\theta^2 Q_H + (1-\theta^2)Q_L - (1-k)X_H - kX_L] + \frac{p^2 l^2 (X_H - X_L)^2}{4c} - m\bar{Q} - u_0$$

$$\Leftrightarrow p[\theta^2 Q_H + (1-\theta^2)Q_L] - \frac{p\bar{Q}}{2} - \frac{p[(1-k)X_H + kX_L]}{2} + \frac{p^2 l^2 (X_H - X_L)^2}{8c}$$

$$-(m - m')\bar{Q} + \frac{c[\bar{Q} - (1-k)X_H - kX_L]^2}{2l^2 (X_H - X_L)^2} < u_0$$

Proof of Proposition 2(b)

$E\Pi_3^R \geq u_0$ holds by the construction of the game.

Proof of Proposition 2(c)

If $E\Pi_3^R(\mathrm{w}_3^*) \geq u_0$,

$$e_3^* = \frac{pl(X_H - X_L)}{4c} - \frac{[\bar{Q} - (1-k)X_H - kX_L]}{2l(X_H - X_L)} < \frac{pl(X_H - X_L)}{2c} = e_2^*.$$

If $E\Pi_3^R(\mathrm{w}_3^*) < u_0$, the wholesale price will decrease to satisfy the retailer's participation constraint. However, as long as the wholesale price is positive, the optimal effort level under SBT contracts will always be strictly lower than that under VMI contracts.

$EX_3^* > EX_2^*$ follows since the expected shrink is a decreasing function of e.

The expected overage is $\theta(\bar{Q} - Q_L) = \theta(1-\theta)(Q_H - Q_L)$ and the expected underage is $(1-\theta)(Q_H - \bar{Q}) = \theta(1-\theta)(Q_H - Q_L)$.

Proof of Proposition 2(d)

If $E\Pi_3^R(\mathrm{w}_3^*) \geq u_0$,

$E\Pi_3^{SC} - E\Pi_2^{SC} \geq 0$

$$\Leftrightarrow \frac{3p}{4}[\bar{Q} - (1-k)X_H - kX_L] + \frac{3p^2 l^2 (X_H - X_L)^2}{16c} - \frac{c[\bar{Q} - (1-k)X_H - kX_L]^2}{4l^2 (X_H - X_L)^2} - m'\bar{Q}$$

$$- \left\{ p[\theta^2 Q_H + (1-\theta^2)Q_L - (1-k)X_H - kX_L] + \frac{p^2 l^2 (X_H - X_L)^2}{4c} - m\bar{Q} \right\} \geq 0$$

$$\Leftrightarrow p[\theta^2 Q_H + (1-\theta^2)Q_L] - \frac{3p\bar{Q}}{4} - \frac{p[(1-k)X_H + kX_L]}{4}$$

$$+ \frac{p^2 l^2 (X_H - X_L)^2}{16c} + \frac{c[\bar{Q} - (1-k)X_H - kX_L]^2}{4l^2(X_H - X_L)^2} - (m - m')\bar{Q} \leq 0.$$

Proof of Proposition 2(e)

From Proposition 1(a), we know that under $E\Pi_3^R(\mathrm{w}_3^*) \geq u_0$,

$E\Pi_3^S > E\Pi_2^S$

$$\Leftrightarrow \frac{p}{2}[\bar{Q} - (1-k)X_H - kX_L] + \frac{p^2 l^2 (X_H - X_L)^2}{8c} + \frac{c[\bar{Q} - (1-k)X_H - kX_L]^2}{2l^2(X_H - X_L)^2} - m'\bar{Q}$$

$$\geq p[\theta^2 Q_H + (1-\theta^2)Q_L - (1-k)X_H - kX_L] + \frac{p^2 l^2 (X_H - X_L)^2}{4c} - m\bar{Q} - u_0$$

$$\Leftrightarrow m - m' \geq \frac{p[\theta^2 Q_H + (1-\theta^2)Q_L]}{\bar{Q}} - \frac{p}{2} - \frac{p[(1-k)X_H + kX_L]}{2\bar{Q}} + \frac{p^2 l^2 (X_H - X_L)^2}{8c\bar{Q}}$$

$$- \frac{c[\bar{Q} - (1-k)X_H - kX_L]^2}{2l^2(X_H - X_L)^2 \bar{Q}} - \frac{u_0}{\bar{Q}}.$$

Since $\theta^2 Q_H + (1-\theta^2)Q_L < \bar{Q}$ for $0 < \theta < 1$,

$$\frac{p[\theta^2 Q_H + (1-\theta^2)Q_L]}{\bar{Q}} < p$$

and the reduction of the manufacturing cost stated in Proposition 2(e) is smaller than that stated in Proposition 1(e).

Proof of Proposition 3(a)

By expressing w_L in terms of w_H using $(Q - X_L)w_L = (Q - X_H)$ solving the sequential game shown in equation (44) through (46), we get with the prices shown below, we get $E\Pi_4^S = E\Pi_0^S$, $E\Pi_4^R = E\Pi_0^R$, $E\Pi_4^{SC} = E\Pi_0^{SC}$, $e_4^* = e_0^*$ & $EX_4^* = EX_0^*$.

Proof of Proposition 3(b)

Since SBT contracts converge to VMI contracts with the performance-based wholesale prices, any reduction in the manufacturer' cost will strictly improve the supplier's expected profit while leaving the retailer's profit and the retail shrinkage unchanged.

Proof of Proposition 4(a) & 4(b)

Applying $\alpha = 1$ & $m = m'$ to equations (55) through (57), one can easily check that problems under the risk-sharing contract converge to those under VMI contracts. Similarly, applying $\alpha = 0$ & $m = m'$ to equations (55) through (57), we see that problems under the risk-sharing contract converge to those under SBT contracts with single wholesale price.

Proof of Proposition 4(c)

$$\frac{\partial E\Pi_5^R}{\partial \alpha} = -\frac{p[(1-k)X_H + KX_L]}{4(1-\alpha)} - \frac{p\Omega}{4(1-\alpha)^2} - \frac{c[(1-k)X_H + KX_L]\Omega}{\Sigma(1-\alpha)} - \frac{c\Omega\Omega'}{\Sigma(1-\alpha)^2}$$
$$- \frac{c[(1-k)X_H + KX_L]\Omega'}{2\Sigma(1-\alpha)^2} - \frac{c\Omega'^2}{2\Sigma(1-\alpha)^3} - \frac{p\mathrm{Q}}{2(1-\alpha)^2}$$
$$- \frac{cQ\{\Omega + 2\alpha[(1-k)X_H + KX_L]\}}{\Sigma(1-\alpha)^2} - \frac{2\alpha cQ\Omega'}{\Sigma(1-\alpha)^3} < 0$$

$$\left.\frac{\partial E\Pi_5^R}{\partial \alpha}\right|_{\alpha=0} = -\frac{p[(1-k)X_H + KX_L]}{4} - \frac{p\Omega}{4} - \frac{c[(1-k)X_H + KX_L]\Omega}{\Sigma} - \frac{c\Omega^2}{\Sigma}$$
$$- \frac{c[(1-k)X_H + KX_L]\Omega}{2\Sigma} - \frac{c\Omega^2}{2\Sigma} - \frac{p\mathrm{Q}}{2} - \frac{cQ\Omega}{\Sigma} < 0$$

$$\frac{\partial E\Pi_5^S}{\partial \alpha} = \frac{p[(1-k)X_H + KX_L]}{2(1-\alpha)} + \frac{p\Omega'}{2} + \frac{c[(1-k)X_H + KX_L]\Omega'}{\Sigma(1-\alpha)^2} + \frac{c\Omega'^2}{\Sigma(1-\alpha)^3} > 0$$

$$\left.\frac{\partial E\Pi_5^R}{\partial \alpha}\right|_{\alpha=0} = \frac{p[(1-k)X_H + KX_L]}{2} + \frac{p\Omega'}{2} + \frac{c[(1-k)X_H + KX_L]\Omega'}{\Sigma} + \frac{c\Omega'^2}{\Sigma} > 0$$

Proof of Proposition 4(d)

$$\frac{\partial E\Pi_5^{SC}}{\partial\alpha} = \frac{p(1-\alpha)\Sigma\{\Omega - [(1-k)X_H + KX_L]\}}{4\Sigma(1-\alpha)^3} + \frac{2c\{\Omega^2 - (1+\alpha)[(1-k)X_H + KX_L]\Omega - \alpha[(1-k)X_H + KX_L]^2\}}{4\Sigma(1-\alpha)^3}$$

which is positive when $2\Omega > Q$.

$$\left.\frac{\partial E\Pi_5^{R}}{\partial\alpha}\right|_{\alpha=0} = \frac{p\Omega}{4} - \frac{p[(1-k)X_H + KX_L]}{4} + \frac{c\Omega^2}{2\Sigma} - \frac{c[(1-k)X_H + KX_L]\Omega}{2\Sigma}$$

which is positive when $2\Omega > Q$.

APPENDIX B

NEGOTIATION EXPERIMENT

Round 1[13]

In this round of negotiation, you will be negotiating two terms, wholesale price and shrink share. To increase the chance of successful negotiation, you decided to offer value-added service to the retailer. You are going to offer **free inventory audit** at the time of replenishment, which will relieve the retailer from conducting the audit himself. In order to offer the service, you will incur the additional effort. The following table shows your payoff which depends on the terms you agree to. Your total payoff is the sum of the two payoffs. *For example, if you and the retailer agree to choose options A & K, then your payoff will be $90,168-$2,445=$87,723; if agree to choose options I & Q, then your payoff will be $61,880-$26,454=$35,426. You are free to choose any options as long as your partner agrees.*

Note: Shrink share refers to the % of shrink the retailer assumes. So you want shrink share to be high.

	Wholesale Unit Price	Your Payoff
A	$2.77	$90,168
B	$2.73	$86,632
C	$2.69	$83,096
D	$2.65	$79,560
E	$2.61	$76,024
F	$2.57	$72,488
G	$2.53	$68,952
H	$2.49	$65,416
I	$2.45	$61,880

	Shrink Share by Retailer	Your Payoff
J	100%	$0
K	87.5%	$-2,445
L	75%	$-5,335
M	62.5%	$-8,670
N	50%	$-12,449
O	37.5%	$-16,673
P	25%	$-21,341
Q	12.5 %	$-26,454
R	0%	$-32,011

Circle your final negotiation outcomes. The agreement will be verified by checking your opponent's choices.

Payoffs if **no agreements** made on both within 3 min.:

You earn $0
The retailer earns $40,000

[13] This is an example of a single round where the supplier offers inventory audit service and the retailer has relative power. There are eight more of rounds with different service and power conditions. Note that the payoff chart does not change over the nine rounds. However, the retailer and the supplier have different payoff chart. This particular example is for the supplier.

APPENDIX C

SURVEY QUESTIONS

For the following questions, check or fill in the answers which best describe you.

How old are you? ______years

What is your gender? Female ______Male ______

Are you a… (Mark the box next to the **highest** level of education you have completed.)

Undergraduate student ______
Graduate student ______

Were you born in the U.S.?

YES _____ NO _____

If you were not born in the U.S., which of the following answers applies?
__ I have lived in the U.S. for less than 5 years
__ I have lived in the U.S. for 5 to 10 years
__ I have lived in the U.S. for more than 10 years
Are you a U.S. citizen?

YES ______ NO ______

If not, what country are you a citizen of? ________________________

What is the primary language you speak at home?
____

What is your race?

White	______	African American	______
Hispanic	______	Asian/Pacific Islander	______
Native American	______	Other	______

What is your SAT or ACT test score?

SAT _____ ACT ______can't remember ____ never had to take either test _____