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Bargaining Process and Channel Efficiency

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Abstract. The behavioral literature has demonstrated that the format of supply chain contracts matters even when theoretically it should not and that contracts that in theory coordinate channels fail to do so in laboratory experiments. The existing body of experimental evidence uses an ultimatum bargaining protocol to test analytical models, but there is no reason to think that bargaining in supply chains is in the form of ultimatum offers. We investigate the effect of bargaining on contract performance by extending the bargaining protocol to allow the manufacturer to make concessions. We test coordinating contract with bargaining in the laboratory by comparing wholesale price and the two-part tariff contracts using two different bargaining protocols. We then develop and estimate a statistical model of behavior with bargaining and find that this model organizes our data well. Our main finding is that the contracts that we study are more efficient when participants are allowed to make concessions. The additional channel efficiency is owing to more efficient offers made by manufacturers. The higher channel efficiency primarily benefits the retailer—the weaker party. Our main contribution is the observation that, when testing analytical models of contracts in the laboratory, the way that the bargaining process is implemented, such as the ability to make concessions, has a critical effect on conclusions.

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1. Introduction

Channel coordination is an important and widely studied topic in the supply chain literature (see Cachon 2003 for a review). A key message that comes out of the analytical modeling literature on channel coordination is that the structure of supply contracts has a large effect on channel efficiency. However, conclusions based on laboratory experiments, such as those of Lim and Ho (2007), Ho and Zhang (2008), Kalkanci et al. (2011), and Katok and Pavlov (2013) among others, find that contract structure does not affect channel efficiency very much. Many of these studies find that coordinating contracts do not even improve efficiency relative to the wholesale price (WP) contract, and others find that the improvement observed is substantially smaller than what the theory predicts. The two streams of research result in different managerial implications: the modeling literature suggests that managers should devote effort to carefully structuring contracts; in contrast, behavioral literature suggests that managerial effort is better spent on thinking how to frame contracts (Lim and Ho 2007, Ho and Zhang 2008) or managing some other aspects of the relationship, such as private information (Kalkanci et al. 2011).

Our work provides a link between analytical and behavioral research on channel coordination. Particularly, we are interested in the efficiency implications of structure, with careful attention to behavior (e.g., Gode and Sunder 1993). Most published behavioral studies on channel coordination, which report little if any improvement owing to contract structure, implement bargaining as a take it or leave it offer from the manufacturer to the retailer that the retailer can only either reject completely or accept as is. In contrast, we find that, in our experiments, contract structure matters and improves coordination but only when the experiment implements bargaining in a way that captures some amount of give and take, specifically the ability to make *concessions*.

The standard take it or leave it implementation of the manufacturer's proposal makes the contracting setting similar to the ultimatum game that has been thoroughly studied in behavioral economics since

Güth et al. (1982) (see a review of early literature in Roth 1995). In the ultimatum game, one player—the proposer—makes an offer to divide a fixed sum of money between himself and a recipient. The recipient can either accept the offer, in which case both players receive the amounts specified in the proposer's offer, or reject it, in which case both players earn zero.

The advantage of the take it or leave it implementation is that it offers clear theoretical predictions. Specifically, under coordinating contracts, such as two-part tariff (TPT), the manufacturer should be able to not only coordinate the channel but also, extract the entire channel profit. In contrast, ultimatum bargaining (UB) laboratory studies report both high levels of rejections and relatively equal profit divisions—features that are also evident in laboratory studies of contracting. The findings from our experiments show that the bargaining protocol has a large effect on channel efficiency (defined as actual channel profit divided by the first best channel profit) and profit distribution.

In this study, we directly compare two bargaining protocols. Under the UB protocol, the manufacturer proposes contract terms to the retailer. These contract terms result in some profit for the retailer; we call the maximum profit that the retailer can obtain given the manufacturer's proposed contract terms the manufacturer's *offer*. Contract terms depend on the contract type. For example, under the WP contract, the manufacturer offers the wholesale price w, and therefore, we can write manufacturer's offer as ($\pi^*_R(w)$). To streamline notation, we will omit contract parameters and refer to retailer's profit conditional on placing the optimal order as simply π^*_R and the corresponding manufacturer profit as π^*_M. The retailer observes the manufacturer's offer and either accepts it by placing some order quantity q or rejects it. If the retailer rejects the contract, both parties earn their outside option, which is zero in our experiments. If the retailer orders quantity q, the retailer earns π_R, and the manufacturer earns π_M. The difference between π^* and π is in that the former is based on the optimal order quantity, whereas the latter is based on the actual order quantity.

An important realistic feature missing from ultimatum bargaining is the ability of the parties to make concessions. There is evidence in the literature (Cialdini et al. 1975) that concessions increase the likelihood of reaching an agreement. The explanation that Cialdini et al. (1975) provide is called *reciprocal concessions*. The idea is that, during the bargaining process, when one side makes a concession, it activates a social norm to reciprocate.

We study the effect of the bargaining procedure by introducing a *structured bargaining* (SB) protocol that augments the UB protocol by adding a stage in which the manufacturer can make concessions. We do this by adding a bargaining stage before the final ultimatum stage that we call Stage 1. Stage 1 lasts a prespecified amount of time, during which the manufacturers can make offers to the retailer.[1] If the retailer accepts an offer, the game ends with the players earning π_R and π_M, but if the retailer rejects an offer, then rather than both players earning zero, the manufacturer can make another offer to the retailer.

If the players fail to reach an agreement during Stage 1's allotted time, the game reverts to the Ultimatum Stage, in which the manufacturer can make one last and final offer. If the retailer rejects this final ultimatum offer, the round ends in an *impasse*. The feature that the SB protocol can revert to the ultimatum bargaining is similar to some of the treatments in Bolton and Karagözoğlu (2016). The SB mechanism is intentionally simple (simpler that what a real bargaining process is likely to be). It is only substantively different from UB in that a retailer rejection does not automatically end the negotiation, but instead, it gives the manufacturer an opportunity to make a concession. It is the effect of this feature of bargaining on contract outcomes that we are most interested in exploring.

We are beginning to see some of work in behavioral operations that considers the effect of the bargaining process. Leider and Lovejoy (2016) test the balanced principal bargaining model of Lovejoy (2010) and use freeform bargaining as well as allow communication in a supply chain involving three tiers and multiple players on each tier. Davis and Hyndman (2018) use free bargaining with structured communication in the wholesale price contract in a setting with uncertain demand and show that efficiency improves when players can negotiate wholesale price and order quantity at the same time. Becker-Peth et al. (2017) find a similar result for the buyback contract. Davis and Leider (2018) use free bargaining in their investigation of the capacity investment problem. Katok and Tan (2017) compare behavior in a setting with supply disruptions under different bargaining and communication protocols and find that communication by itself is sufficient to restore most of the efficiency that is lost in a setting when neither bargaining nor communication are allowed. Villa and Katok (2017) report on an experiment that uses free bargaining to negotiate transfer prices in their test of the model of Rudi et al. (2001). Our paper contributes to the literature by identifying concessions as a key feature of the bargaining process that leads to improved efficiency and providing a direct and clean test of the effect of bargaining on contract performance in a fundamental simple setting.

Two streams of literature are relevant for our study: behavioral economics literature on ultimatum games and the literature on channel coordination and contracting. There are two critical findings from the ultimatum game literature (see the overview in Roth 1995): (1) low offers are often rejected, and (2) high offers (in the context of the ultimatum game, this is usually 50% of the total pie) are rarely rejected.

Laboratory experiments have been instrumental in recent behavioral operations literature in identifying behavioral implications of using different contracting arrangements. The two central findings from the experimental work are that (1) contracts that in theory should coordinate channels do not generally do so in the laboratory and that (2) the profits tend to be divided more equally than theory predicts. One source of channel inefficiency is retailer rejections that range from 26% in the two-part tariff contracts of Ho and Zhang (2008) to 11% in the two-block tariff contracts of Lim and Ho (2007). Another source of channel inefficiency is offer inefficiency. *Offer efficiency* is defined as the channel efficiency if the retailer accepts the offer and places the optimal order. Offer efficiency ranges from 93.62% in the TPT contracts of Ho and Zhang (2008) to 80.8% in the two-block tariff contracts of Lim and Ho (2007).

We find that SB improves channel efficiency primarily by improving offer efficiency while maintaining essentially the same rejection rates as UB. Interestingly, SB starts with offers that resemble UB offers, but offer efficiency increases as Stage 1 progresses, and the main beneficiary from the added offer efficiency turns out to be the retailer. This happens in both TPT and WP contracts, and the effect persists in late rounds.

In the next section, we formally describe our setting and the theoretical benchmarks when players are fully rational expected profit maximizers. We also summarize behavioral predictions for our settings based on what we know from the literature. In Section 3, we describe the details of the design of our experiments. In Section 4, we present data analysis. In Section 5, we develop and estimate a statistical behavioral model that includes concessions and loss aversion, and we show that this model predicts actual bargaining dynamics quite well. We conclude in Section 6 by summarizing our results, mentioning some limitations, and discussing managerial implications.

2. Analytical Background with Full Rationality

We examine a one-period bilateral channel commonly used in modeling papers in which a single manufacturer sells its product to a single retailer that then sells it to consumers (e.g., Iyer and Bergen 1997, Padmanabhan and Png 1997, Iyer and Villas-Boas 2003, Biyalogorsky and Koenigsberg 2010; see Desai et al. 2004 and Iyer et al. 2007 for settings with competing retailers).

In this section, we begin by summarizing the contract structure and analytical results of the TPT and WP contracts when the players are fully rational expected profit maximizers. We consider a channel with a single manufacturer and a single retailer. The manufacturer has a constant marginal production cost c. The retailer faces a linear demand $q = A - p$, where p is the retail price and A is a constant. The product has no salvage value; therefore, the retailer sells the entire quantity ordered.

The channel is coordinated if the outcome in terms of units produced (and therefore, the total channel profit) is the same as the *first best* amounts—the outcome that would have resulted from an integrated channel with a single decision maker maximizing the channel profit. We investigate two contracts within this framework: WP and TPT. We chose the WP as one of the contracts that we examine, because it is the simplest contract, having only a single parameter; it provides a good baseline in that a substantial amount of laboratory data on WP has already been published, and its performance is quite consistent across studies. We chose the TPT contract to compare with WP, because TPT is a coordinating contract and most like the ultimatum game in that, if the manufacturer sets the wholesale price to coordinate the channel, the fixed fee corresponds to the proposer's demand in the ultimatum game. TPT is one of many coordinating contracts; some, such as the quantity discount, are mathematically equivalent to it, whereas others, such as the block tarif, or the minimum order quantity contract, are not. We leave extending this research program to other contracts to future research.

Under WP, the retailer pays to the manufacturer a wholesale price w per unit. Under standard rationality and profit maximization assumptions, it is well known that theoretical channel efficiency under the WP contract is below that of the integrated contract. This channel inefficiency of the wholesale price contract relative to the integrated channel is known as *double marginalization*.

Although coordinating contracts are numerous, there is a large class of these contracts that, in one way or another, induces the retailer to place the first best order by making the retailer's marginal cost w equal to the manufacturer's marginal cost c. The manufacturer then extracts some of the profit from the channel. For example, the two-block tariff (Lim and Ho 2007) coordinates the channel by setting $w = c$ in the last block. The profit is allocated by setting a higher wholesale price for orders below a certain break point. In the TPT, which we investigate here, the manufacturer coordinates the channel by setting $w = c$ and extracts channel profit by charging the retailer a fixed fee F. The equilibrium properties of WP and TPT contracts are

Table 1. Properties of the WP and TPT Contracts and the Integrated Channel

Contract	Channel profit	Optimal wholesale price w^*	Optimal fixed fee F^*	Optimal order quantity q^*
Integrated channel	$\frac{(A-c)^2}{4}$	c	NA	$\frac{A-c}{2}$
Wholesale price	$\frac{3(A-c)^2}{16}$	$\frac{A+c}{2}$	NA	$\frac{A-w}{2}$
Two-part tariff	$\frac{(A-c)^2}{4}$	c	$\frac{(A-w)^2}{4}$	$\frac{A-c}{2}$

established, and we summarize in Table 1 the expressions for optimal decisions in the integrated channel, the wholesale price contract, and the TPT contract.

Under the UB protocol, the manufacturer moves first and makes an offer (w, F) in the TPT setting or (w) in the WP setting. The retailer then determines the optimal order quantity given the offer, computes the corresponding profits, and decides whether to accept or reject the offer. If both players are profit maximizers, the manufacturer's proposal and the retailer's order follow the expressions in Table 1, and the retailer accepts any offer that results in a nonnegative profit.

SB involves two stages. The last stage, which we call the Ultimatum Stage, is identical to the UB setting. The first stage, Stage 1, involves sequential offers by the manufacturer.[2] The retailer can either accept a standing offer, ending the round, or reject it, in which case the manufacturer can make another offer as long as there is time remaining in Stage 1. A retailer motivated by profit (or one with reference-dependent preferences, such as in Ho and Zhang 2008) may accept a Stage 1 offer if she believes that subsequent offers are unlikely to result in the higher utility or reject it, hoping for better offers.

The total channel profit under the TPT contract depends on the wholesale price w—the closer w is to the production cost c, the larger the channel profit. Ho and Zhang (2008) already demonstrated that manufacturers under the TPT indeed set wholesale prices above production costs ($w > c$) and attribute this to retailers' reference dependence (or loss aversion) with respect to the fixed fee. Unlike UB, under SB, offers can be adjusted, and therefore, if a manufacturer makes an SB offer #t (w_t, F_t) with $w_t > c$, it is always possible to follow it up with another offer (w_{t+1}, F_{t+1}) so that $w_{t+1} < w_t$, $F_{t+1} \geq F_t$, $\pi^R_{t+1} > \pi^R_{,t}$, and $\pi^M_{t+1} \approx \pi^M_t$. In other words, any offer to the retailer that involves $w_t > c$ can be improved—the manufacturer can offer the retailer a concession. This can be done without making the manufacturer worse off, because as w approaches the efficient level, both manufacturer and retailer can be made better off.[3]

Because Ho and Zhang (2008) already showed that wholesale prices under the TPT contract are significantly above production cost, the above argument implies that it would be reasonable for wholesale prices to decrease during Stage 1 of the SB treatment. Whether they do and how this affects contract performance are empirical questions that we intend to answer with our laboratory experiment. We summarize them below.

1. Will manufacturers under SB make concessions in Stage 1, and will retailers sometimes accept Stage 1 offers?
2. Will average wholesale prices decrease during Stage 1 of SB?
3. Will SB exhibit higher efficiency than UB?

3. Experimental Setting and Design

3.1. Experimental Setting

Contracting arrangements in our experiments are the wholesale price contract (*WP*) and the two-part tariff contract (*TPT*). In all treatments, we set the manufacturer's production cost to be $c = 20$, and the demand function $q = 100 - p$ (i.e., $A = 100$). For these parameters, the first best production quantity of $q^* = 40$ results in the total channel profit of 1,600 to be allocated between the manufacturer and the retailer. Assuming profit maximization and no errors, under the wholesale price contract, in equilibrium, the manufacturer charges $w_{WP} = 60$, and the retailer orders $q_{WP} = 20$, which result in the manufacturer profit of 800, the retailer profit of 400, and the channel efficiency of $(800 + 400)/1{,}600 = 75\%$. Under the TPT contract, the manufacturer should set $w_{TPT} = c = 20$ in equilibrium and charge $F = 1{,}600$ to extract the entire channel profit. This would result in the retailer order of $q_{TPT} = 40$, manufacturer profit of 1,600, retailer profit of 0, and channel efficiency of 100%.

To investigate the effect of the bargaining protocol on contract performance, we tested contracting mechanisms under both UB and SB bargaining protocols. Under the UB protocol, the manufacturer makes an offer, and the retailer either orders q or rejects the manufacturer's offer; in the latter case, the round ends with both players earning zero. Under the SB protocol, the players have 5 minutes, during which the manufacturer can make offers to the retailer. If the retailer accepts an offer, the round ends. If the retailer rejects it, the manufacturer can make another offer. This initial stage is called Stage 1.

If Stage 1 ends without an agreement, the bargaining process enters stage 2—the ultimatum stage, which is identical to the UB protocol; the manufacturer makes one last and final offer, and the retailer can either order q or declare the final impasse, which results in zero profits for both players.

3.2. Experimental Design

The main experiment manipulates two factors, the contract mechanism (WP and TPT) and the bargaining protocol (*UB* or *SB*), for a 2×2 full factorial design. We manipulate all factors between subjects. Participants play for 15 rounds, keeping their roles (manufacturer or retailer) for the entire 15 rounds. In each round, a retailer and a manufacturer are randomly matched with a person in the other role within the same cohort. We conducted all treatments in cohorts of six people (three manufacturers and three retailers in each), and in all treatments, there were three or four cohorts in the laboratory at any given time. Participants were not told the cohort size. We summarize all treatments and sample sizes in Table 2. In total, 186 subjects participated in our study.

We ran only three WP-UB cohorts, because results of WP-UB experiments are well established in the literature (Lim and Ho 2007, Ho and Zhang 2008, Loch and Wu 2008, Katok and Pavlov 2013), and our data replicated existing results; therefore, there was no reason to collect more observations in this treatment. We ran four cohorts of the WP-SB treatment, because the analysis of the wholesale price contract is not the main focus of our paper. Even with this small number of independent observations of the WP contract, we will show in the next section that the effect of structured bargaining on profits and some of the contract parameters is statistically significant.

In all sessions, participants arrived at the computer laboratory at a prespecified time and read experimental instructions that described the rules of the game, the use of the software, and the payment procedures (see Online Appendix A.3). After all participants had a chance to read the instructions, the experimenter read instructions to them aloud to ensure common knowledge. Participants then completed multiple rounds of the game, which was implemented in zTree (Fischbacher 2007), and were paid their actual accumulated earnings privately in cash. Participants were not allowed to communicate during the experiment.

All sessions were conducted at an experimental laboratory at a public university in Texas. SB sessions lasted approximately 1.5 hours, and UB sessions lasted approximately 1 hour. Average earnings, including a $5 participation fee, were $27. Participants were students recruited through a web-based recruitment system, with cash being the only incentive offered. The majority of our participants were graduate students in business and engineering.

4. Results

4.1. Overall Negotiation Outcomes

We organize the first part of the results section to correspond to the research questions that we summarized at the end of Section 2. We then proceed to propose a simple behavioral model that qualitatively organizes our data and report on structural estimation of this behavioral model.

Figure 1 shows the outcomes of negotiations in the four treatments of our study. For UB treatments in Figure 1, (a) and (b), we show the proportions of negotiations that ended in agreement and impasse. For SB treatments in Figure 1, (c) and (d), we show the proportions of negotiations that were successfully completed in Stage 1 and the ultimatum stage and the proportion of negotiations that ended in impasse. Overall, the bargaining protocol does not affect the proportion of negotiations that ended in impasse, which is quite low (see Table 3 for exact proportions). Under SB, over 70% of negotiations were completed in Stage 1 (69.1% in TPT and 70.5% in WP).

4.2. Manufacturers' Concessions Under the SB Protocol

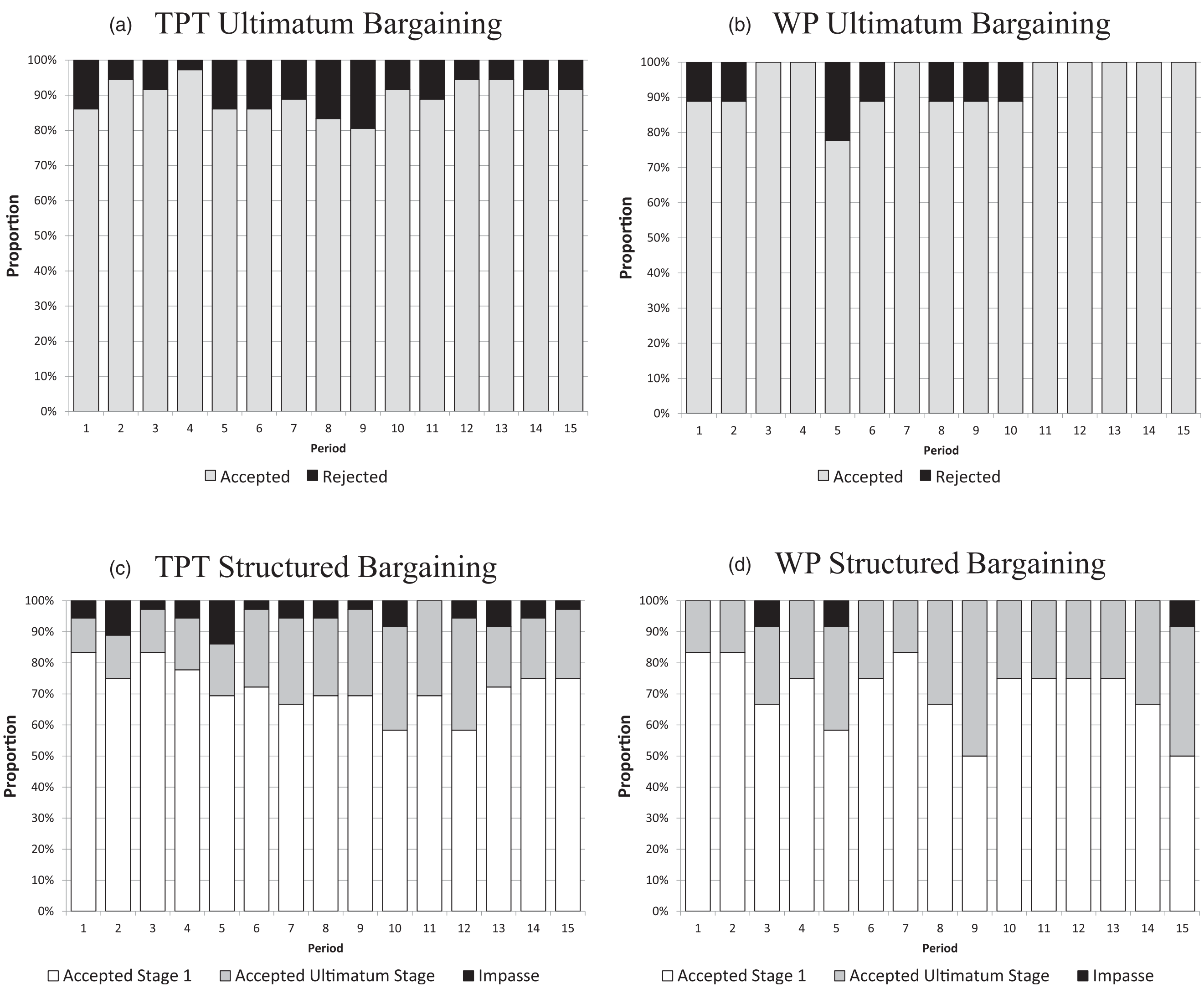
The first question that we ask is whether manufacturers will make Stage 1 offers as well as concessions under SB and whether retailers will sometimes accept these offers. We already showed that Stage 1 offers are both made and often accepted. Next, we examine the extent to which manufacturers make concessions. We define a manufacturer concession as the difference between an offer and the previous offer in terms of retailer profit (not utility), conditional on the retailer placing the profit-maximizing order. In other words, it is the amount by which a retailer profit conditional on placing the optimal order increases from one offer to the next.

Figure 2 shows how the bargaining process evolves over the 15 periods of the experiment. The average amount that manufacturers concede (Figure 2(a)) seems to be stable. From Figure 2(b), the average

Table 2. Experimental Design and Sample Sizes[4]

	Bargaining protocol	
Contract mechanism	Ultimatum bargaining	Structured bargaining
WP	3 cohorts of 6	4 cohorts of 6
TPT	12 cohorts of 6	12 cohorts of 6

Figure 1. Proportion of Impasses and Offers Accepted in the Two SB Stages



duration is shorter than the maximum of 300 seconds. Toward the end of the session, participants make about 5–10 concessions in less than 200 seconds. This observation that manufacturers learn to make smaller concessions is reminiscent of results reported in experimental economics. For example, McKelvey and Palfrey (1995) estimate logistic Quantal Response Equilibrium (QRE) and show that errors are smaller in later rounds, and De Bruyn and Bolton (2008) report the same phenomenon in the context of bargaining. Correctly accounting for the error structure is particularly important in stochastic choice models (Wilcox 2011, pp. 99–100).

4.3. Contract Performance

Table 3 presents descriptive statistics for all four treatments along with first and last round averages for SB treatments.[5] The table also displays the results of comparisons between the first and last round SB averages and between the UB and last round SB averages. Unless otherwise noted, all statistical tests use cohort average as the unit of analysis, and p-values are two sided and refer to the Wilcoxon rank sum test.

First, considering the differences between the first and last rounds of SB treatments, wholesale prices decrease, the fixed fees under TPT do not change, the best reply order increases, the retailer's profit increases, and offer efficiency increases. The manufacturer profit decreases under TPT. All differences, except in the fixed fee between the first and last offers, are statistically significant under TPT and are not significant under WP.

Second, we consider the differences between the UB treatments and the last offer of SB treatments: Here again, wholesale prices are higher, fixed fees (in the TPT treatments) are not different, and both conditionally optimal and actual UB orders are slightly lower than corresponding SB orders. Retailer profits and offer

Table 3. Summary of Contract Parameters and Performance

	TPT			WP		
	SB: First offer	SB: Last offer	UB	SB: First offer	SB: Last offer	UB
w	41.96 (2.36)	36.18* (2.08)	43.03**** (2.27)	57.40 (5.14)	50.54 (1.74)	57.11*** (2.14)
F	478.44 (38.02)	463.13 (52.20)	418.74 (77.10)	NA		
Optimal order (q*)	29.01 (1.16)	31.91 (1.04)	28.45 (1.21)	21.30 (2.57)	24.79 (0.88)	21.69*** (1.23)
Actual order (q) for accepted offers	NA	29.58 (1.30)	28.58*** (1.13)	NA	24.14 (0.91)	18.02**** (1.02)
Proposal retailer profit	428.43 (46.75)	600.81** (33.63)	448.74**** (32.55)	486.82 (95.19)	622.81 (42.60)	473.31*** (45.98)
Proposal manufacturer profit	985.74 (34.99)	887.99* (24.59)	962.47 (39.58)	730.56 (22.10)	732.65 (16.03)	768.79 (6.63)
Offer efficiency	0.8839 (0.0187)	0.9305* (0.0104)	0.8868**** (0.0140)	0.7609 (0.0692)	0.8472 (0.0170)	0.7763 (0.0248)
Final efficiency	NA	0.8653 (0.0196)	0.7845**** (0.0256)	NA	0.8111 (0.0243)	0.6637**** (0.0192)
Impasse rate		0.0574 (0.0143)	0.1019*** (0.0176)		0.0167 (0.0107)	0.05926 (0.0323)

Note. Standard errors are in parentheses.
*$p < 0.10$ average difference between the first and last offers according to Wilcoxon rank sum tests; **$p < 0.05$ average difference between the first and last offers according to Wilcoxon rank sum tests; ***$p < 0.10$ average difference between the last round SB and UB according Wilcoxon rank sum tests; ****$p < 0.05$ average difference between the last round SB and UB according Wilcoxon rank sum tests.

efficiency are significantly lower under UB, whereas impasse rates under UB are slightly higher (weakly significant). As a result, overall efficiency under UB is significantly lower. At the same time, manufacturer profits are not different under the two protocols.

The story that emerges is that, under SB, our participants improve efficiency through a series of concessions that manufacturers make by lowering wholesale prices while keeping the fixed fees mostly fixed. This allows the manufacturers to improve retailers' profits while not substantially lowering their own.

Average contract parameters evolve over the 15 rounds of the session under the TPT contract (Figure 3, (a) and (b)). The figure shows that, over the course of the session, average TPT wholesale prices seem to decrease and that average TPT fixed fees seem to increase, but the resulting profits seem to be quite stable (Figure 3, (c) and (d)).[6]

To check whether the better performance under SB can be attributed to the fact that manufacturers make and retailers observe more offers, we conducted an additional long TPT-UB treatment in which participants interacted for 40 rounds instead of 15. All other aspects of the experiment were the same as in the TPT-UB treatment, and 48 participants (eight cohorts of 6 participants) were included in the long TPT-UB treatment. We provide a detailed analysis in Online Appendix A.1 that shows that learning in the long TPT-UB treatment lasts for the first 10–15 rounds only.

Figure 2. Bargaining Behavior Under the SB Protocol

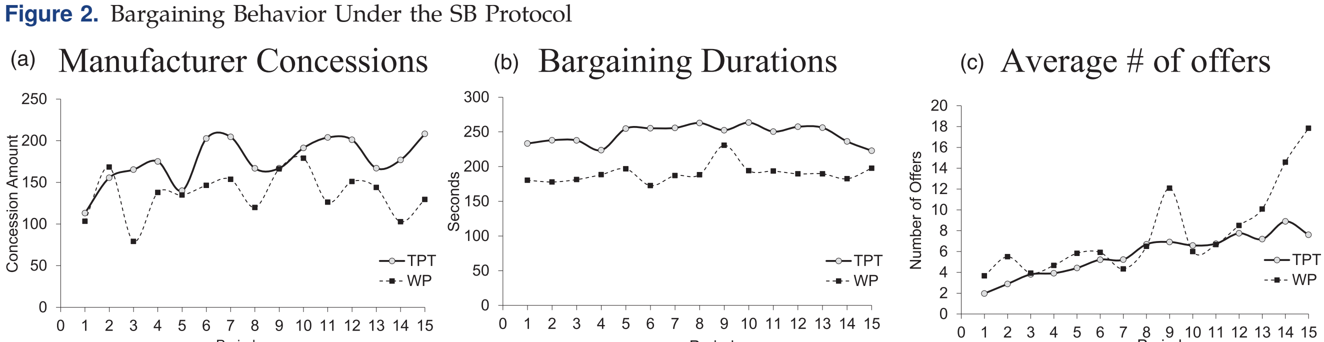
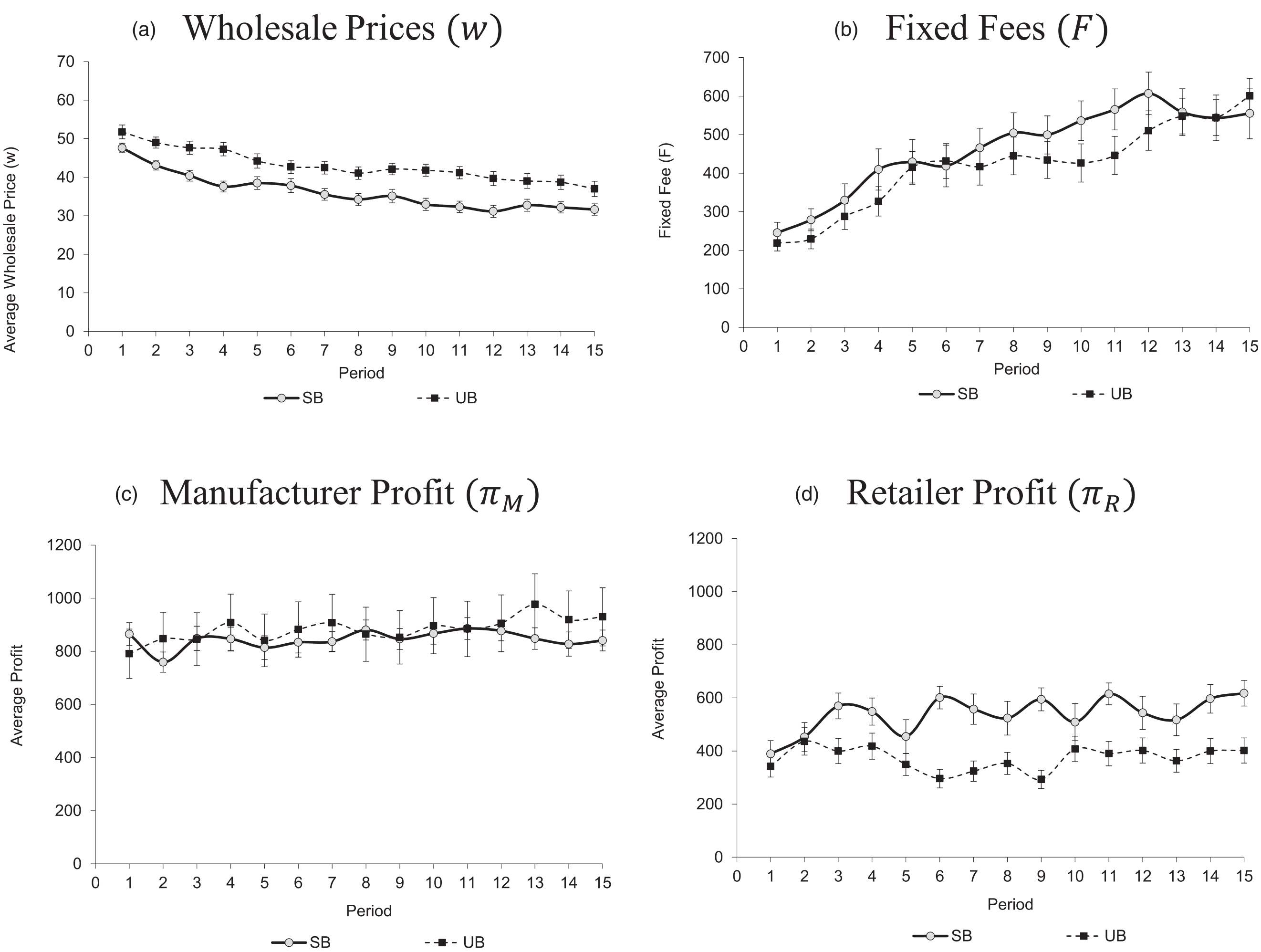


Figure 3. Average Contract Parameters and Profits over Rounds Under the TPT Contract



Notes. Vertical bars represent standard errors.

5. Behavioral Model and Estimation

5.1. Probabilistic Choice and Reference-Dependent Utility

The purpose of the behavioral model that we estimate in this section is to explain the dynamic patterns of Stage 1 offers in terms of w and F. Theoretically, with TPT, whether under UB or SB protocols, the manufacturer and the retailer should be able to reach full channel efficiency (coordination) and distribute the surplus between themselves. This full efficiency outcome occurs when the manufacturer charges a wholesale price equal to the marginal cost of 20.

Although no behavioral model has hitherto been proposed for the dynamic framework of SB that we investigate here, we can begin with a model that has been proposed for the static UB-TPT setting and extend it to the dynamic setting. Our goal is to have a model that is *parsimonious* and can fit both static and dynamic settings with one set of parameters while capturing the qualitative differences between the static and dynamic settings.

We build on the model of Ho and Zhang (2008), who proposed a reference-dependent utility model in which the retailer has disutility from the fixed fee and also, makes random errors. If the retailer places a profit-maximizing order $q^* = (A - w)/2$, then her monetary profit from offer (w, F) is $\pi_R^* = (p - w)q^* - F$. Let the retailer's utility from (w, F) under UB condition be

$$u_R(w, F) = \pi_R(w, F) - \beta F + \varepsilon, \quad (1)$$

where β is the reference dependence parameter with respect to the fixed fee. Note that Equation (1) is equivalent to the retailer's utility function in Ho and Zhang (2008).

Like Ho and Zhang (2008), we model retailers as making random errors (McKelvey and Palfrey 1995). Under the assumption that the error terms follow a type I extreme value distribution, we consider the retailer's probability of accepting some offer that results in utility of $u_R(w, F)$ versus rejecting this offer and earning utility of zero. Under the UB protocol, we specify this probability P of acceptance as a logit:

$$P = \frac{\exp(\tau u_R(w, F))}{1 + \exp(\tau u_R(w, F))}, \tag{2}$$

where τ is the rationality parameter. If a player never makes errors, then $\tau = \infty$, and the probability of accepting any offer for which $u_R(w, F) > 0$ is 1. If $\tau = 0$, then any offer is accepted with probability 0.5. For any intermediate values of τ, we can say that the probability of acceptance is monotonically increasing in the expected utility to the retailer.

5.2. Reciprocal Concessions Model

Recall that SB differs from UB only by the presence of Stage 1, which gives manufacturers an opportunity to make concessions. Cialdini et al. (1975) show that concessions increase the likelihood of agreement, which they explain by the idea that a concession activates a social norm to reciprocate. Cialdini et al. (1975) summarize this reciprocal concession idea by observing that "…the likelihood of a concession by one party is positively related to the occurrence of a concession by another party" (Cialdini et al. 1975, p. 207). Cialdini et al. (1975) report on a set of experiments in which subjects are more likely to agree to a small favor when the request was preceded by another request for a much larger favor that was rejected. Much work has followed the original experiments, and the idea has been refined. For example, Fern et al. (1986) and O'Keefe and Hale (1998) found that the likelihood of acceptance does not seem to depend on the size of the initial concession, and therefore, Hale and Laliker (1999) proposed that the reciprocity norm becomes activated as long as the concession size exceeds some threshold. The full review of this literature is beyond the scope of our paper, and we refer interested readers to a review by Cialdini and Goldstein (2004). However, our main point is that there exists a parallel between this work and our setting in that retailers are more likely to accept a Stage 1 offer when it was a result of one or more concessions.

We model the idea that concessions matter by including the concession amount into retailer's utility function. Therefore, we will add the subscript t to represent Stage 1 offer number t. A Stage 1 offer t, (w_t, F_t) results in the retailer's potential profit of

$$\pi^R(w_t, F_t) = (p_t - w_t)q_t^* - F_t.$$

Let Δ_t be concession from offer t. For the first offer, $\Delta_1 = 0$, and after the first offer, the concession from Stage 1 offer t is

$$\Delta_t = \pi^R(w_t, F_t) - \pi_R(w_{t-1}, F_{t-1}). \tag{3}$$

If the retailer were to place the profit-maximizing order $q_t^* = (A - w_t)/2$, then we can write the retailer's utility from offer t as

$$u_R(w_t, F_t) = \pi^R(w_t, F_t) + \sum_{i=1}^{t} \theta_i \Delta_i - \beta F_t + \varepsilon. \tag{4}$$

The difference in retailer's utility from *accepting* an offer under the UB and SB protocols is that, in the SB, Δ_t affects the maximization of the manufacturer's profit in the previous period, because w_{t-1} and F_{t-1} appear in the expressions for the concessions. The utility from concessions captures the fact that the retailer reacts to past offers. We let the probability that the retailer accepts offer number t be $P_t = \Pr(\text{Accept}| w_{t-1}, F_{t-1}, w_t, F_t)$ specified as

$$P_t = \frac{\exp(\tau u_{Rt}(w_t, F_t, w_{t-1}, F_{t-1}))}{\exp(\tau\psi) + \exp(\tau u_{Rt}(w_t, F_t, w_{t-1}, F_{t-1}))}, \tag{5}$$

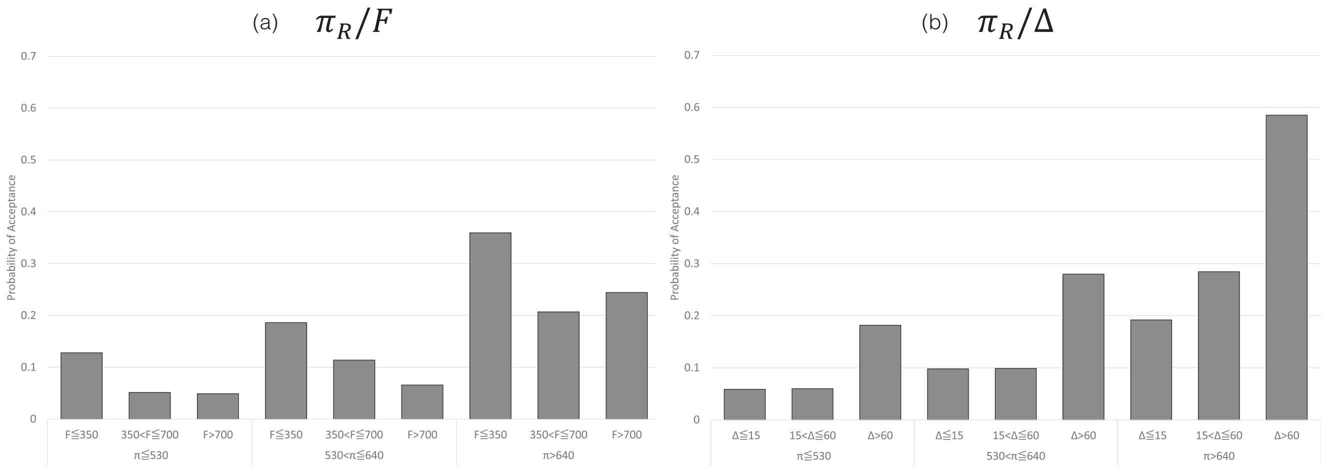
where $u_{Rt}(w_t, F_t)$ is defined by Equation (4) and denotes the retailer's utility form accepting the offer number t and ψ denotes the retailer's belief about what would be his expected utility from potential future offers that will come if offer t is rejected. In this formulation, ψ is a constant, and we will show in Section 5.5 that the value of ψ has a minor effect on the optimal contract parameters.

5.3. Exploring Retailer Behavior

In this section, we explore retailers' behavior in order to further examine the factors that we conjecture to affect the likelihood that retailers accept offers. To provide the reader with a sense of how retailer's probability of accepting an offer depends on the fixed fee and the concession amount, we categorized all offers according to the retailer's profit from this offer ($\pi_R \le 530$, $530 \le \pi_R < 640$, and $\pi_R > 640$), the magnitude of the fixed fee ($F \le 350, 350 < F \le 700$, and $F > 700$), and the magnitude of the concession ($\Delta \le 15, 15 < \Delta \le 60$, and $\Delta > 60$).[7] In Figure 4(a), we plot the probability of acceptance for the nine π_R/F pairs. In Figure 4(b), we plot the probability of acceptance for the nine π_R/Δ pairs.

It is apparent from the figure that, on aggregate and controlling for profit, higher fixed fees decrease probability of acceptance, whereas higher concessions increase probability of acceptance. To show this formally, we estimate a logit model with fixed effects for individuals with the dependent variable of one if an offer was accepted and zero if it was rejected. In the baseline model (Model 1), we include only independent variables from Equation (4): $\pi^R(w_t, F_t)$, F_t Δ_t. In Model 2, we add Δ_{t-1} in order to check the extent to which retailers pay attention to the concession history in addition to the latest concession. To see how retailer behavior evolves over time, we add,

Figure 4. Relationship Between Offer Acceptance, Fixed Fee, and Concession Amount



in Model 3, the period number, the offer number, and an interaction variable between the period number and the fixed fee. We report estimates of the logit model in Table 4.

Consistent with the behavior that we formalized in Equations (4) and (5), we see that the likelihood of an offer being accepted increases with the size of the offer and with the size of the latest concession, whereas it decreases with the size of the fixed fee. The coefficient for the previous offer's concession (Δ_{t-1}) is also positive and significant. Therefore, we conclude that Equations (4) and (5) capture the main behavioral drivers. The effect of concession history exists but is of secondary importance.[8] We estimated Model 3 to gain insight into dynamics. It shows that the propensity to accept offers decreases over rounds and increases with the offer number. Additionally, the decrease in the likelihood of the offer being accepted owing to the size of the fixed fee becomes smaller over rounds (positive and significant coefficient for $Period \times F_t$), suggesting that retailers' sensitivity to the fixed fee may be transitory.

5.4. Behavioral Model Estimation

Now that we have evidence that concessions matter to retailers, we proceed to estimate retailers' behavioral parameters using maximum likelihood estimation. For this estimation, we estimate the effect on the latest concession only. We specify the log likelihood to be maximized in Equation (6), where $Accept_t$ is an

Table 4. Logit Model for the Likelihood of Accepting an Offer

Parameter	Description	Model 1	Model 2	Model 3
$\pi^R(w_t, F_t)$	Retailer profit from offer t conditional on optimal order	0.0080*** (0.0006)	0.0080*** (0.0006)	0.0084*** (0.0006)
F_t	Fixed fee from offer t	–0.0008*** (0.0002)	–0.0008*** (0.0002)	–0.0013*** (0.0005)
Δ_t	Latest concession	0.0078*** (0.0002)	0.0080*** (0.0009)	0.0073*** (0.0009)
Δ_{t-1}	Previous concession		0.0020** (0.0099)	0.0014 (0.0010)
Period	Period number (1–15)			–0.2121*** (0.0272)
t	Offer number			0.1101*** (0.0178)
$Period \times F_t$	Period number × fixed fee from offer t			0.0001** (0.00005)
Average of fixed effects		–4.0791*** (0.2264)	–4.1242*** (0.2292)	–3.1627*** (0.2834)
Observations (N)			3,091	
LL		–846	–844	–791

Notes. LL, log-likelihood.
$^{**}p < 0.05$; $^{***}p < 0.01$.

indicator variable that takes on the value of one if retailer accepted offer number t and zero otherwise:

$$\ln L = \sum_R \sum_t \big[Accept_t \ln(P_t) + (1 - Accept_{Rt})\ln(1 - P_t)\big]. \tag{6}$$

The estimation entails a binary logit using only retailer's acceptance/rejection decision.

We report in Table 5 separate estimates for SB and UB in columns labeled "Behavioral." We also estimate and display in Table 5 for comparison a model in which we restrict $\beta = \theta = 0$, which we label "noise only." All estimates in Table 5 include individual effects.

The procedure for testing whether the β and τ parameters for UB and SB treatments are statistically different is as follows: we estimated the model on the pooled data and then, compared the Bayesian information criteria (BIC) for the unrestricted model (separate parameters for UB and SB) and the restricted model (some or all parameters are the same across the two treatments). Using this method, we cannot reject the null hypothesis that β and τ estimates are the same for UB and SB, and β estimates are positive. We also conclude that the behavioral model provides a much better fit than the model with noise only.

Our aggregate estimates of the β parameter, which capture the aversion to the fixed fee, are close to the analogous estimate of Ho and Zhang (2008).[9] The interpretation of the positive and significant estimate of θ is that retailers derive utility from receiving concessions in addition to the utility that they derive from profit.

In addition to estimating models for the data aggregated over all 15 rounds, we examined whether retailers' behavioral parameters evolve over time. We did this by estimating the model for rounds 1–5, 6–10, and 11–15. We show these estimates in Table 5 immediately below the aggregate estimates. We note two observations about the estimates of behavioral parameters over rounds. First, under SB, the aversion to the fixed fee seems to disappear after about 5 rounds, whereas under UB, it does not. Second, the preference for concessions persists virtually unchanged over rounds.

5.5. Manufacturer's Behavior

We would like to model the manufacturer as a fully rational expected profit maximizer who is aiming to maximize her expected profit and reacting to the retailer's response function. In our experimental setting, the manufacturer is not constrained in terms of the number of offers that she can make, but there is a time limit in Stage 1; therefore, as a simplification, let us assume that the maximum number of offers is T. Then, the manufacturer's optimization problem at time 1 is

$$\max_{w_t, F_t} \sum_{t=1}^{T} \left[\prod_{i=1}^{t-1} (1 - P_i)\right] P_t \pi_t^M, \tag{7}$$

where P_t is defined in Equation (5) and $\pi_t^M = (w_t - c)(\frac{A - w_t}{2}) + F_t$.

Table 5. Estimates for Equation (5) for SB and UB Separately

	SB						UB					
Parameter	Noise only			Behavioral			Noise only			Behavioral		
Period	1–5	6–10	11–15	1–5	6–10	11–15	1–5	6–10	11–15	1–5	6–10	11–15
τ		0.007*			0.007*			0.015*			0.015*	
		(0.0005)			(0.0005)			(0.002)			(0.002)	
	0.006*	0.010*	0.015*	0.006*	0.010*	0.015*	0.057*	0.028*	0.066*	0.057*	0.046*	0.166*
	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.024)	(0.009)	(0.034)	(0.024)	(0.018)	(0.100)
β		NA			0.108*			NA			0.077*	
					(0.024)						(0.041)	
				0.219*	0.027	0.037				0.070	0.135*	0.054*
				(0.076)	(0.034)	(0.024)				(0.109)	(0.030)	(0.036)
θ		NA			1.090*				NA			
					(0.139)							
				0.804*	0.804*	0.892*						
				(0.274)	(0.180)	(0.171)						
N			3,091						540			
$-2lnL$		1,966.0			1,853.0			157.0			153.6	
AIC		2,034.0			1,925.0			231.0			229.6	
BIC		2,239.2			2,142.3			389.8			392.7	

Notes. AIC, Akaike information criterion; BIC, Bayesian information criterion. Standard errors are in parentheses. BIC formula: $BIC = -2lnL + kln(N)$. For the reference-dependent model, $k = 40 = 4$ parameters + 36 individual intercepts for SB, and $k = 38 = 2$ parameters + 36 individual intercepts for UB. For the noise-only model, $k = 37$.
$^*p < 0.01$.

An important issue that we must consider is manufacturer's *beliefs* about retailer's behavioral parameters (β, θ, and τ). The natural assumption would be for the manufacturer to have rational expectations and at least on average, correctly consider retailer's behavioral parameters as we estimated them in Table 5. We can check whether manufacturers (on average) have rational expectations with respect to the loss aversion parameter β, because Ho and Zhang (2008) showed that there is a one to one relationship between the wholesale price that the manufacturer offers under the TPT contract and the manufacturer's belief about retailer's loss aversion, namely

$$\hat{\beta} = \frac{w - A}{2w - (A + c)} - 1. \tag{8}$$

For illustrative purposes, we use $\hat{\beta} = 0.66$ (based on the average wholesale price of $w = 43.03$ that we observe in the TPT-UB treatment) when we solve the manufacturer's optimization problem, but qualitatively, results are unaffected for $\hat{\beta}$ in the 0.4 to 0.8 range. We note that the $\hat{\beta}$ inferred from manufacturers' proposals is higher than the $\hat{\beta}$ inferred from retailers' rejections. In other words, retailers' actions do not match manufacturers' beliefs about their likely actions. The causes of this inconsistency are beyond the scope of this paper. That said, we note that manufacturers made relatively few offers with large fixed fees. Therefore, they never had an opportunity to learn whether retailers are likely to accept them. In general, the manufacturer's optimization problem in Equation (7) does not have a closed form solution, but there is a closed form solution for the wholesale price in the last period, w_T (see the appendix for details):

$$w_T^* = \frac{(1 + \theta + \beta)c + \beta A}{1 + \theta + 2\beta}. \tag{9}$$

Solving for the other variables requires deriving the first-order conditions (FOCs). As an illustration, we also include in the appendix the FOC derivations for the last period fixed fee, F_T.

There is no additional insight that can be gained from analytical derivations for earlier periods $t < T$, and therefore, we omit them, and instead, we solve the problem numerically. We present computational results for the case of $\hat{\beta} = 0.66$, and parameters θ and τ come from Table 5.[10] We use exponentially declining weights on past concessions $\theta_1 \ldots \theta_{t-1}$. There is also an additional set of constraints $\pi_t^R \geq \bar{\pi}\ \forall t$, restricting offers to ones that result in a minimum level of retailer profit. We set this minimum acceptable profit at $\bar{\pi} = 200$. These constraints are binding in early periods; without them, the optimal early offers include an arbitrarily high F_t, because they maximize the size of the subsequent concessions, increasing retailer's utility and the probability of acceptance. We also set parameter $\psi = 300$ (recall from Equation (5) that ψ denotes the retailer's belief about what would be his expected utility from potential future offers if offer t is rejected). We performed sensitivity analysis on these constants.[11]

In Figure 5, we display a distribution of the lengths of negotiations that we observe in our data. The distribution of lengths seems to be in the range from $T = 1$ to $T = 15$, with average negotiation length of 5.72 and only about 3.7% of negotiations having more than 15 offers. Therefore, we solved the problem for $T = 15$.[12]

From this setup, we obtain several insights about how the manufacturer, faced with a behavioral retailer, would optimally adjust contract parameters. Figure 6 graphically compares optimized and average observed offers from negotiations that lasted not more than 15 rounds. Figure 6 shows that our model predicts bargaining dynamics well.

We conclude that manufacturers' behavior in terms of how they structure their offers is qualitatively close to expected profit maximization that accounts for the retailer's behavior and overestimates the retailers' sensitivity to the fixed fee.

5.6. Discussion

The behavioral model that we propose is one in which the retailer dislikes the fixed fee in the TPT contract and likes concessions. Although Ho and Zhang (2008) were the first to note the disutility from the fixed fee, we are the first to develop a quantitative model of dynamic bargaining that explicitly models concessions. Although stylized and parsimonious, our model of retailer captures realistic human behavior, because when people negotiate, they start with aggressive offers and then, make multiple concessions to

Figure 5. Distribution of the Lengths of Negotiations Observed in Our Data

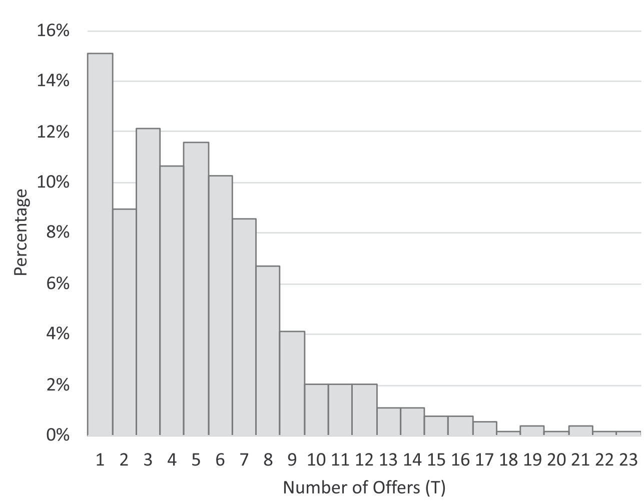
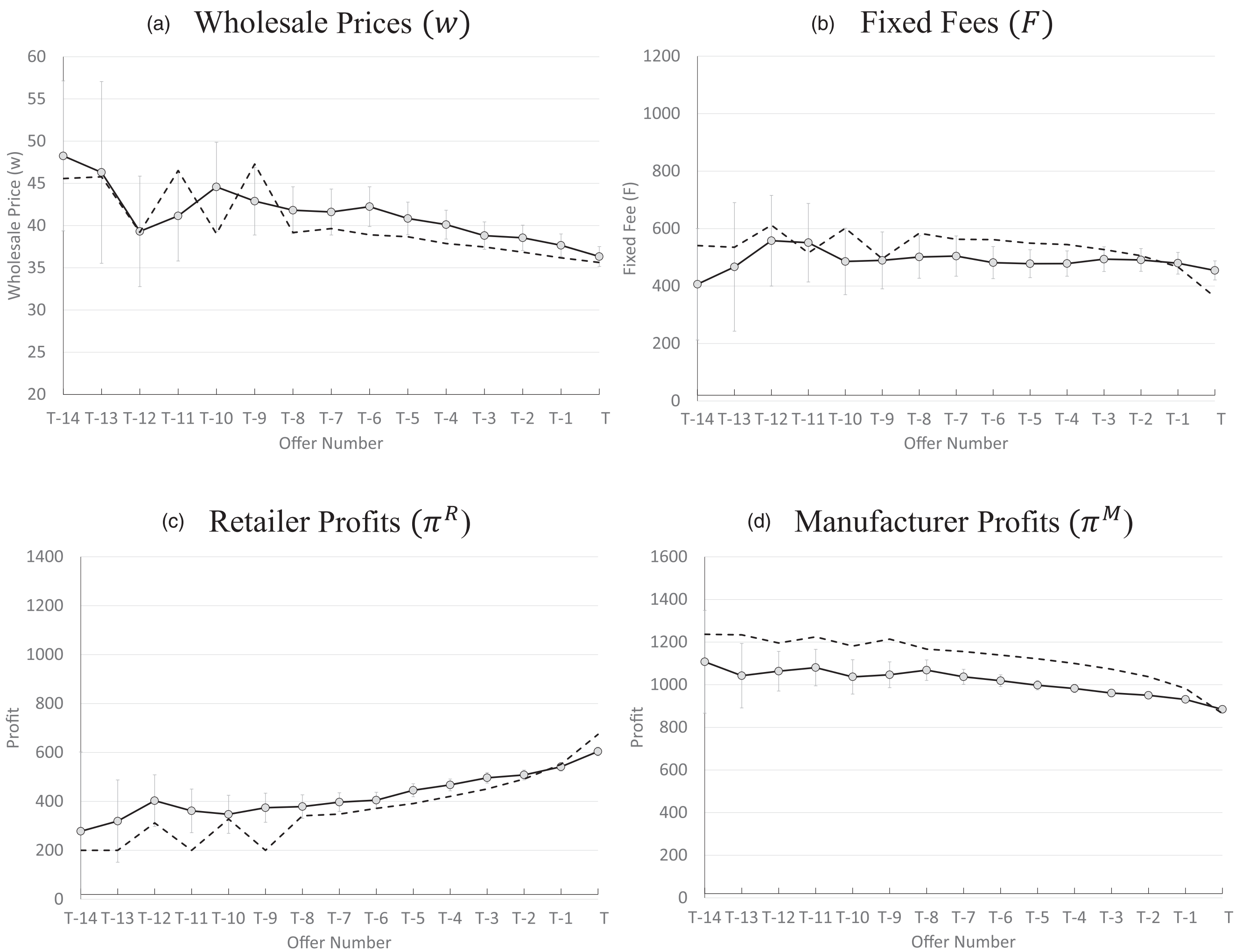


Figure 6. Comparison Between Optimal and Observed Bargaining Process



finally arrive at a compromise solution. Therefore, our model captures the qualitative model of Cialdini et al. (1975) in a quantitative framework that we apply to contracting in supply chains.

Our model of manufacturer is also reasonable. Manufacturer in our setting tries to be rational and maximize his expected profit but overestimates the retailers' disutility from the fixed fee. Retailer's disutility from the fixed fee is measured by the behavioral parameter β, which we estimate to decrease from about 0.2 in the first five rounds to about 0.03 in subsequent rounds. Manufacturers, however, estimate β to be about 1.1 in rounds 1–5, 0.66 in rounds 6–10, and 0.48 in rounds 11–15. Manufacturer also treats the problem with indefinite end as if it was a finite, although long, problem. We do not argue that our behavioral model fully captures the complex process of bargaining. To date, no model exists that does that. However, the model that we propose is parsimonious, trackable, and sufficiently realistic to capture several important features of the real bargaining process (aggressive initial offers and multiple concessions that improve offer efficiency) as well as organize the data in our experiment.

A limitation of our model is that the retailer is not fully strategic. A strategic profit-maximizing retailer, faced with a manufacturer who makes concessions, would reject all Stage 1 offers—not observed in our data. A strategic profit-maximizing manufacturer, anticipating that the retailer would reject all Stage 1 offers, would not make concessions. Thus, a model with two strategic profit-maximizing players does not have a hope of organizing our data.

6. Conclusions

We began our work with an observation that the UB protocol has been commonly used in laboratory studies that tested analytical models of channel coordination. One contribution of our paper is to compare the UB protocol with the SB protocol and show that the protocol for bargaining used in the laboratory can make a difference to the conclusions regarding contract performance.

The SB protocol that we introduced has properties that imply an outcome that should be similar to the UB protocol, making it a useful step in exploring the effect of bargaining on contract performance.[13] Although we cannot claim that a bargaining mechanism that allows manufacturers to make concessions is the true mechanism responsible for the treatment effect that we observe, it is both intuitively plausible and consistent with our data.

An important feature of our setting is that the negotiation between the manufacturer and the retailer is not a zero-sum game, but rather, there is an opportunity to expand the channel profit through setting efficient contract parameters. The two-part tariff contract is an ideal vehicle to demonstrate the tradeoff between using a contract that seems intuitively attractive (one with high wholesale price and a low fixed fee) and using one that is efficient (one with low wholesale price and high fixed fee). The aspect of our paper that is both novel and managerially relevant is that there is a complementarity between the structure of the contract and the process used for negotiating this contract. In other words, the structure of the contract is not independent from how specific contract parameters are negotiated. Under the two-part tariff, the natural contract with a high wholesale price and a low fixed fee is inefficient. The need to make concessions in the SB condition forces the manufacturer to discover a way to expand the channel profit by lowering the wholesale price—an opportunity absent in the UB condition.

The insight that the contract structure is not independent of the bargaining process is likely a general one. Coordinating supply contracts are often complex, and this complexity is difficult for decision makers to manage. For example, Kalkanci et al. (2011) explore a setting with stochastic demand and asymmetric information and compare the wholesale price contract with two different quantity discount contracts. Like our study (as well as the previously cited studies of a deterministic demand setting by Lim and Ho 2007, Ho and Zhang 2008, and Katok and Pavlov 2013, and others cited in the review article by Chen and Wu 2018), they find that coordinating contracts do not improve efficiency. However, a bargaining process that would allow the buyer and the seller to share some of their private information may well reverse this conclusion.

Therefore, a managerial takeaway from our study is that an effective bargaining process should present opportunities for the bargainers to guide the evolution of contract parameters toward efficiency. How contract parameters evolve and what the best bargaining process is to enable evolution toward an efficient outcome depend on the contract structure. We showed that, under the two-part tariff, it is sufficient to allow concessions, and the need to make concessions naturally guides the contract toward efficiency. Davis and Hyndman (2018) show that, with stochastic demand, the bargaining process that includes not only the wholesale price but also, the order quantity helps counter the inefficiency that comes from suboptimal newsvendor problem solution. Additionally, it is likely that, in settings with asymmetric information, such as that of Kalkanci et al. (2011), a bargaining process that facilitates some information sharing would improve the efficiency of the quantity discount contract.

Acknowledgments

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Appendix. Optimal Contract Parameter Characterization at the End of the Time Horizon

In period $t = T$ (terminal period), supplier maximizes with respect to w_T and F_T:

$$\max_{w_T, F_T} Z_T = \left[(w_T - c)\left(\frac{\mathrm{A} - w_T}{2}\right) + F_T\right] P_T,$$

where we use P_T to represent the probability of an offer that provides utility u_t to the retailer in the final period ($t = T$), and $u_t = \pi^R + \sum_{i=1}^{t} \theta_i \Delta_i - \beta F_t$ per Equation (4).

Let us to rewrite retailer's utility from offer T as $u_T = (1+\theta_T)\pi_T^R - \theta_T \pi_{T-1}^R - \lambda_T F_T + \mathit{Past concessions}$ by denoting[14] $\lambda_t = 1 + \theta_t + \beta$ and $\mathit{Past\ concessions} = \sum_{i=1}^{T-1} \theta_i \Delta_t$. Also, the supplier profit from offer in period T is $\pi_T^S = (w_T - c)(\frac{\mathrm{A} - w_T}{2}) + F_T$.

Necessary conditions are expressed by the FOCs: $\frac{\partial Z_T}{\partial w_T} = 0$; $\frac{\partial Z_T}{\partial F_T} = 0$. Solving, we get

$$\frac{\partial Z_T}{\partial w_T} = \pi_T^S \mathrm{Pr}'_T \frac{\partial u_{RT}}{\partial w_T} + \mathrm{Pr}_T \frac{\partial \pi_T^S}{\partial w_T} = 0$$
$$\frac{\partial Z_T}{\partial F_T} = \pi_T^S \mathrm{Pr}'_T \frac{\partial u_{RT}}{\partial F_T} + \mathrm{Pr}_T \frac{\partial \pi_T^S}{\partial F_T} = 0.$$

Combining the two: $\frac{\partial u_{Rt}}{\partial w_T} / \frac{\partial u_{RT}}{\partial F_T} = \frac{\partial \pi_T^S}{\partial w_T} / \frac{\partial \pi_T^S}{\partial F_T}$, where $\frac{\partial u_T}{\partial w_T} = (1 + \theta_T)\frac{w - A}{2}$; $\frac{\partial u_{RT}}{\partial F_T} = -(1 + \theta_T + \beta)$; $\frac{\partial \pi_T^S}{\partial w_T} = \frac{A + c - 2w}{2}$; $\frac{\partial \pi_T^S}{\partial F_T} = 1$.

Therefore, $(1 + \theta)\frac{w_T - A}{2} = -\lambda_T \frac{A + c - 2w_T}{2}$, which comes out to $w_T{}^* = \frac{\lambda_T(A + c) - (1 + \theta)A}{(2\lambda_T - (1 + \theta))}$ and can be rewritten as Equation (9).

To derive F^*, we plug w^* into the FOC, and the expression simplifies to

$$1 + \exp(\tau u_{RT}) = \tau \lambda \pi_T^S.$$

Note that the *Past concessions* constant is important. It changes the u_T, and therefore, the F_T determined previously.

Incidentally (not needed in the computation but used for verification), before combining the FOCs, the FOC with respect to w is

$$\frac{\partial Z_T}{\partial w_T} = \tau\pi_T^S \Pr_T(1-\Pr_T)\frac{w_T - A}{2} + \Pr_T\frac{A + c - 2w_T}{2} = 0.$$

Endnotes

[1] The fixed duration of Stage 1 is reminiscent of the deadline effect in the behavioral economics literature (for example, see Ochs and Roth 1989, Roth and Xing 1994, and Gneezy et al. 2003 among others). In our experiment, Stage 1 is followed by the ultimatum stage, and therefore, the deadline effect is not pronounced.

[2] We conducted some sessions with "good faith bargaining" restriction, which limits manufacturers to offers that are nondecreasing in terms of retailer's profit conditional on retailer's profit-maximizing order. We also conducted sessions without this restriction. Qualitatively, neither behavior nor any of our conclusions are affected by this restriction, and therefore, we pooled the data for the purpose of analysis.

[3] Consider the setting in which $c = 20$ and $q = 100 - p$ (parameters used in our experiments). Consider an offer $w = 60$ and $F = 0$. Retailer's best reply is $q = 20$, which results in $\pi_R = 400$ and $\pi_M = 800$. Now, suppose that the retailer rejects this offer and the manufacturer follows up with $w = 40$ and $F = 300$. Retailer best reply is $q = 30$, which results in $\pi^R = \pi^M = 900$. The retailer received a concession of $900 - 400 = 500$, and at the same time, the manufacturer is also better off, earning 900 instead of 800.

[4] In 6 of 12 cohorts, the manufacturer was restricted to making offers that were not worse in terms of the optimal retailer profit than the last offer on the table. For those cohorts, this restriction was in effect in both stages. This "good faith" bargaining restriction turned out to be innocuous (see Online Appendix A.2), and all of the results that we report hold if we use the data either with or without this restriction. Therefore, we present the results based on the pooled data.

[5] We also did the same analysis for the last five rounds, and results in terms of statistical significance are very similar, except that differences in manufacturer profit are weakly significant in the last five rounds when comparing TPT-SB with TPT-UB. When comparing WP-SB with WP-UB, the difference in offer efficiency becomes significant.

[6] Under the wholesale price contract, SB wholesale prices seem to be quite stable, whereas UB wholesale prices seem to show a slight downward trend over rounds. Profits do not seem to show much trend over rounds. A plot analogous to Figure 3 for wholesale price contract is in Online Appendix A.1.

[7] We chose the bin classifications so that each has approximately the same number of observations.

[8] We also estimated a model in which we included Δ_{t-2}, which yielded nearly identical estimates for the Model 2 variables, and a positive and marginally significant Δ_{t-2} coefficient ($p = 0.096$). Therefore, the positive effect of concessions and the negative effect of the fixed fee seem to be robust.

[9] Ho and Zhang (2008) express the retailer's utility as $(p - w)\cdot(100 - p) - \lambda F$, whereas our analogous expression can be written as $(p - w)(100 - p) - F - \beta F$. Therefore, $\beta + 1 = \lambda$, and our β estimates are equivalent to λ in the 1.1 range, which is slightly lower than the estimates of Ho and Zhang (2008) of 1.37 (experiment 1) and 1.27 (experiment 2) (Ho and Zhang 2008, p. 696). This is because, unlike us, Ho and Zhang (2008) use not only retailer's accept/reject decision but also, manufacturer's offers. The evidence suggests that manufacturers make offers as if they believe that the retailers are far more sensitive to F than the retailers actually are.

[10] The TPT-UB treatment can be considered as simply a special case of $T = 1$, and solving Equation (7) for this special case yields $w_t^* = 42.91$ and $F_t^* = 360.43$, comparable with observed averages in the TPT-UB treatment of $w = 43.03$ and $F = 418.74$.

[11] w_t^* and F_t^* change as Ψ changes, but qualitatively, the pattern of offers is quite consistent. For $\Psi = 0$, wholesale prices start at 36.2, gradually increase to 40.4 by offer 9, and then, decrease consistent with our observed data to 35.6. At the same time, fixed fees start at 815 and gradually decrease to 520. For $\Psi = 600$, wholesale prices oscillate between 37 and 55 for the first nine rounds and then, gradually decrease to 35.6, in line with our data, whereas fixed fees change little throughout the negotiation but are about 100 lower than the average fixed fees that we observe. Therefore, the value $\Psi = 300$ can be considered a fitted parameter, because we cannot observe the retailer's beliefs from our data. The parameter $\bar{\pi}$ has very little effect on the results when it is below about 300. Even for $\bar{\pi} = 0$, wholesale prices oscillate between 53 and 38 for the first seven periods and then, gradually decrease to 36.6, and fixed fees are virtually unaffected. Setting $\bar{\pi}$ exceedingly high does change the dynamics. For example, for $\bar{\pi} = 600$, wholesale prices start at 24 and gradually increase to 35.6 instead of decreasing, whereas the fixed fee shows much more movement than it does in our data, starting at over 800 and gradually falling to about 300 by round 15. Therefore, the value $\bar{\pi} = 200$ can also be considered a fitted parameter.

[12] The WP-SB treatment is a special case of $F = 0$, and solving Equation (8) for that special case using a procedure identical to the one that we used for TPT results in a sequence of wholesale prices that start at $w_1^* = 60$ and decline to $w_{15}^* = 49.43$, which is comparable with observed wholesale prices that decline from $w_1 = 57.4$ to $w_T = 50.41$.

[13] It is important to emphasize that the SB protocol that we investigate here is neither a positive description nor a normative description of actual bargaining. That is, we do not propose that our SB protocol is a perfectly accurate reflection of the manner in which channel partners negotiate. It is merely a protocol that is closer to real bargaining than the UB protocol. Both protocols are abstractions of a very complex and nuanced process, but SB allows the manufacturer to make concessions, which is a feature that is likely to be important to reaching agreements in many bargaining situations.

[14] The new parameter λ_t is in effect just accounting for the parameter β. There is an F_t inside π_t^R, and that F_t is multiplied by $(1 + \theta_t)$. By setting $\lambda_t = 1 + \theta_t + \beta$, we are cancelling that redundant term and leaving only β as a multiplier on F_t.

References

Becker-Peth M, Katok E, Thonemann UW (2017) How to benefit from manufacturer-retailer negotiations: An example of the buyback contract. Working paper, University of Cologne, Cologne, Germany.

Biyalogorsky E, Koenigsberg O (2010) Ownership coordination in a channel: Incentives, returns, and negotiations. *Quant. Marketing Econom.* 8(4):461–490.

Bolton GE, Karagözoğlu E (2016) On the influence of hard leverage in a soft leverage bargaining game: The importance of credible claims. *Games Econom. Behav.* 99(2016):164–179.

Cachon GP (2003) Supply chain coordination with contracts. *Supply Chain Management: Design, Coordination and Operation*, Handbooks in Operations Research and Management Science, vol. 11 (Elsevier, Amsterdam), 227–339.

Chen KY, Wu Y (2018) Buyer-supplier interactions. Donohue K, Katok E, Leider S, eds. *The Handbook of Behavioral Operations* (Wiley, New York), 459–488.

Cialdini RB, Goldstein NJ (2004) Social influence: Compliance and conformity. *Annual Rev. Psych.* 55:591–621.

Cialdini RB, Vincent JE, Lewis SK, Catalan J, Wheeler D, Darby BL (1975) Reciprocal concessions procedure for inducing compliance: The door-in-the-face technique. *J. Personality Soc. Psych.* 31(2):206–2015.

Davis AM, Hyndman K (2018) Multidimensional bargaining and inventory risk in supply chains: An experimental study. Management Sci. 65(3):1286–1304.

Davis AM, Leider SG (2018) Contracts and capacity investment in supply chains. *Manufacturing Service Oper. Management* 20(3): 403–421.

De Bruyn A, Bolton GE (2008) Estimating the influence of fairness on bargaining behavior. *Management Sci.* 54(10):1774–1791.

Desai P, Koenigsberg O, Purohit D (2004) Strategic decentralization and channel coordination. *Quant. Marketing Econom.* 2(1): 5–22.

Fern EF, Monroe KB, Ramon AA (1986) Effectiveness of multiple request strategies: A synthesis of research results. *J. Marketing Res.* 23:144–152.

Fischbacher U (2007) z-Tree: Zurich toolbox for ready-made economic experiments. *Experiment. Econom.* 10(2):171–178.

Gneezy U, Haruvy E, Roth AE (2003) Bargaining under a deadline: Evidence from the reverse ultimatum game. *Games Econom. Behav.* 45(2):347–368.

Gode DK, Sunder S (1993) Allocative efficiency of markets with zero-intelligence traders: Market as a partial substitute for individual rationality. *J. Political Econom*. 101(1):119–137.

Güth W, Schmittberger R, Schwarze B (1982) An experimental analysis of ultimatum bargaining. *J. Econom. Behav. Organ.* 3(4):367–388.

Hale JL, Laliker M (1999) Explaining the door-in-the-face: Is it really time to abandon reciprocal concessions? *Comm. Stud.* 50: 203–210.

Ho TH, Zhang J (2008) Designing pricing contracts for boundedly rational customers: Does the framing of the fixed fee matter? *Management Sci.* 54(4):686–700.

Iyer AV, Bergen ME (1997) Quick response in manufacturer-retailer channels. *Management Sci.* 43(4):559–570.

Iyer G, Villas-Boas MJ (2003) A bargaining theory of distribution channels. *J. Marketing Res.* 40:80–100.

Iyer G, Narasimhan C, Niraj R (2007) Information and inventory in a distribution channel. *Management Sci.* 53(10):1551–1561.

Kalkanci B, Chen K-Y, Erhun F (2011) Contract complexity and performance under asymmetric demand information: An experimental evaluation. *Management Sci.* 57(4):689–704.

Katok E, Pavlov V (2013) Fairness in supply chain contracts: A laboratory study. *J. Oper. Management* 31:129–137.

Katok E, Tan L (2017) Procurement in the presence of supply disruptions. Working paper, University of Texas at Dallas, Dallas, Texas.

Leider S, Lovejoy WS (2016) Bargaining in supply chains. *Management Sci.* 62(10):3039–3058.

Lim N, Ho T-H (2007) Designing price contracts for boundedly-rational customers: Does the number of blocks matter? *Marketing Sci.* 26(3):312–326.

Loch CH, Wu Y (2008) Social preferences and supply chain performance: An experimental study. *Management Sci.* 54(11): 1835–1849.

Lovejoy WS (2010) Bargaining chains. *Management Sci.* 56(12): 2282–2301.

McKelvey RD, Palfrey TR (1995) Quantal response equilibria for normal form games. *Games Econom. Behav.* 10(1):6–38.

Ochs J, Roth AE (1989) An experimental study of sequential bargaining. *Amer. Econom. Rev.* 79(3):355–384.

O'Keefe DJ, Hale SL (1998) The door-in-the-face influence strategy: A random-effects meta-analytic review. Roloff ME, ed. *Communication Yearbook* (Sage, Thousand Oaks, CA), 1–33.

Padmanabhan V, Png IPL (1997) Manufacturer's return policies and retail competition. *Marketing Sci.* 16(1):81–94.

Roth AE (1995) Bargaining experiments. Kagel JH, Roth AE, eds. *The Handbook of Experimental Economics* (Princeton University Press, Princeton, NJ), 253–348.

Roth AE, Xing X (1994) Jumping the gun: Imperfections and institutions related to the timing of market transactions. *Amer. Econom. Rev.* 84(September):992–1044.

Rudi N, Kapur S, Pyke DF (2001) A two-location inventory with transshipment and a local decision making. *Management* 47(12): 1668–1680.

Villa S, Katok E (2017) Negotiating transshipments prices for improving supply chain coordination. Working paper, University of Texas at Dallas, Dallas.

Wilcox NT (2011) Stochastically more risk averse: A contextual theory of stochastic discrete choice under risk. *J. Econom*. 162(1):89–104.