Bargaining Process and Channel Efficiency

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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 in a way that should not lead to outcomes different from the ultimatum protocol. 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 we study are more efficient when participants are allowed to negotiate. The additional channel efficiency is due 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 the bargaining process is implemented has a critical effect on conclusions.

Keywords: Behavioral Operations, Supply Chain Contracts, Experimental Economics, Bargaining

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1. Introduction

Channel coordination is an important and widely studies 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. But conclusions based on laboratory experiments, such as Ho and Zhang (2008), Lim and Ho (2007), Kalkanci et al (2011), 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 contract, and others find 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 (Ho and Zhang (2008), Lim and Ho (2007)), 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, that report little if any improvement due 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.

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, and 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, the manufacturer should be able to not only coordinate the channel, but also extract the entire channel profit. In contrast, ultimatum bargaining 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 on profit distribution.

In this study we directly compare two bargaining protocols. Under the *Ultimatum Bargaining* (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 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 wholesale price (WP) contract, the manufacturer offers the wholesale price \( w \), so 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 \( \pi^*_R \), and the corresponding manufacturer profit as \( \pi^*_M \). The retailer observes 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 \( \pi_R \) and the manufacturer earns \( \pi_M \). The difference between \( \pi^* \) and \( \pi \) is in that the former is based on the optimal order quantity, while the latter is based on the actual order quantity.

We study the effect of the bargaining protocol by introducing a *Structured Bargaining* (SB) protocol that augments the UB protocol by adding a simplified bargaining stage prior to the final ultimatum stage. We call it Stage 1. Stage 1 lasts a pre-specified 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 \( \pi^*_R \) and \( \pi^*_M \), but if the retailer rejects an offer, then rather than both players earning zero, the manufacturer can make another offer to the retailer.

\(^1\) 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), Gneezy et al. (2003) among others). In our experiment Stage 1 is followed by the ultimatum stage, so the deadline effect is not pronounced.
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 (2014). The SB mechanism is intentionally simple (simpler that what a real bargaining process is likely to be). It’s only substantive different from UB is that a retailer rejection does not automatically end the negotiation. It is the effect of this feature of bargaining on contract outcomes that we are most interested in exploring.

We begin to see some of work in behavioral operations that consider the effect of the bargaining process. Leider and Lovejoy (2016) test the balanced-principal bargaining model of Lovejoy (2010) and use free form bargaining and allow communication in a supply chain involving three tiers and multiple players on each tier. Davis and Hyndman (2017) 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 (2016) 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 is allowed. Villa and Katok (2017) report on an experiment that uses free bargaining to negotiate transfer prices in their test of the Rudi et al. (2001) model. Our paper contributes to the literature by providing the most 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 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 (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 Ho and Zhang’s (2008) two-part-tariff contracts to 11% in Lim and Ho’s (2007) two-block tariff contract. 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 Ho and Zhang’s (2008) TPT contract to 80.8% in Lim and Ho’s (2007) two-block tariff contracts.

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 and 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., Biyalogorsky and Koenigsberg, 2010; Iyer and Bergen 1997; Iyer and Villas-Boas, 2003; Padmanabhan and Png 1997; and 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 about the two-part-tariff (TPT) and wholesale price (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 is the same as the first best order – 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: wholesale price (WP) and two-part-tariff (TPT). We chose the WP as one of the contracts we examine because it is the simplest contract, having only a single parameter, and 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 is 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, while others, such the block tariff, 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 the manufacturer 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.

While coordinating contracts are numerous, they all, in one way or another, induce 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 established, and we summarize in Table 1 the expressions for optimal decisions in the integrated channel, the wholesale-price contract, and the TPT contract.
Table 1. Properties of the WP and TPT contracts and the integrated channel.

<table>
<thead>
<tr>
<th>Contract</th>
<th>Channel Profit</th>
<th>Optimal wholesale price $w^*$</th>
<th>Optimal Fixed Fee $F^*$</th>
<th>Optimal order quantity $q^*$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Channel</td>
<td>$\frac{(A-c)^2}{4}$</td>
<td>$c$</td>
<td>N/A</td>
<td>$\frac{A-c}{2}$</td>
</tr>
<tr>
<td>Wholesale Price</td>
<td>$\frac{3(A-c)^2}{16}$</td>
<td>$\frac{A+c}{2}$</td>
<td>N/A</td>
<td>$\frac{A-w}{2}$</td>
</tr>
<tr>
<td>Two Part Tariff</td>
<td>$\frac{(A-c)^2}{4}$</td>
<td>$c$</td>
<td>$\frac{(A-w)^2}{4}$</td>
<td>$\frac{A-c}{2}$</td>
</tr>
</tbody>
</table>

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 non-negative profit.

SB involves two stages. The last stage, that we call the Ultimatum Stage, is identical to the UB setting. The first stage, Stage 1, involves sequential offers by the manufacturer. 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 is $w$ to the production cost $c$, the larger is 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, so if a manufacturer makes a SB offer $#t (w_t, F_t)$ with $w_t > c$, it is always possible to follow it up with another offer $(w_{t+1}, F_{t+1})$.

\[ We conducted some sessions with “good faith bargaining” restriction, which limits manufacturers to offers that are non-decreasing in terms of retailer’s profit conditional on retailer’s profit-maximizing order. We also conducted sessions without this restriction. Qualitatively, neither behavior nor any of our conclusions are affected by this restriction, so we pooled the data for the purpose of analysis.\]
so that $w_{t+1} < w_t, F_{t+1} \geq F_t, \pi_{t+1}^R > \pi_t^R$ and $\pi_{t+1}^M \approx \pi_t^M$. In other words, any offer to the retailer that involves $w_t > c$ can be improved—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 or not 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 sometime accept Stage 1 offers?
2. Will average wholesale prices decrease during Stage 1 of SB?
3. Will SB exhibits 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 1600 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 $w_{WP} = 60$, the retailer orders $q_{WP} = 20$, which results in the manufacturer profit of 800, the retailer profit of 400, and the channel efficiency of $(800+400)/1600 = 75\%$. Under the TPT contract, the manufacturer should set $w_{TPT} = c = 20$ in equilibrium and charge $F = 1600$ to extract the entire channel profit. This

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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 retailer rejects this offer and 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.
would result in the retailer order of $q_{TP} = 40$, manufacturer profit of 1600, 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, 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 $2 \times 2$ full factorial design. We manipulate all factors between subjects. Participants play for 15 rounds, keeping their roles (Manufacturer or Retailer) for the entire session. 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 3 or 4 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.
Table 2. Experimental design and sample sizes

<table>
<thead>
<tr>
<th>Contract Mechanism</th>
<th>Ultimatum Bargaining</th>
<th>Structured Bargaining</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wholesale price (WP)</td>
<td>3 cohorts of 6</td>
<td>4 cohorts of 6</td>
</tr>
<tr>
<td>Two-Part-Tariff (TPT)</td>
<td>12 cohorts of 6</td>
<td>12 cohorts of 6&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

We conducted only three WP-UB sessions because results of WP-UB experiments are well-established in the literature (Ho and Zheng 2008, Lim and Ho 2007, Loch and Wu, 2008, Katok and Pavlov 2009) and our data replicated existing results, so there was no reason to collect more observations in this treatment. We conducted four sessions 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 is statistically significant.

In all sessions, participants arrived at the computer laboratory at a pre-specified time and read experimental instructions that describe the rules of the game, the use of the software, and the payment procedures. 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 and 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, UB sessions lasted approximately one 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.

<sup>4</sup> In six of the twelve 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 Table 7 in Appendix A.3) and all the results we report hold if we use either the data with or without this restriction. Therefore, we present the results based on the pooled data.
4. Results

4.1 Overall Negotiation Outcomes

We organize the first part of the results section to correspond to prediction in Error! Reference source not found.. We then proceed to propose a simple behavioral model that qualitatively organizes our data, and report on structural estimation of this behavioral model.

![Graphs showing negotiation outcomes](image)

(a) TPT Ultimatum Bargaining  
(b) WP Ultimatum Bargaining

(c) TPT Structured Bargaining  
(d) WP Structured Bargaining

Figure 1. Proportion of impasses and offers accepted in the two SB stages.

Figure 1 shows the outcomes of negotiations in the four treatments of our study. For UB treatments in Figure 1(a) and Figure 1(b), we show the proportion of negotiations that ended in agreement and impasse. For SB treatments in Figure 1(c) and Figure 1(d), we show the proportion
of negotiations that were successfully completed in Stage 1, in 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

Prediction 1 in Error! Reference source not found. states that manufacturers will make Stage 1 offers as well as concessions under SB. 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.

![Graphs](image)

(a) Manufacturer Concessions  (b) Bargaining Durations  (c) Average # of offers

Figure 2. Bargaining behavior under the SB protocol.

Figure 2 shows how the bargaining process evolves over the 15 periods of the experiment. The average amount manufacturers concede (Figure 2 (a)) is stable. From Figure 2 (b), the average 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 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 light of Wilcox’s finding that “serious interpretive errors can occur when the implications of stochastic choice models are ignored.” (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. 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. We note that these statistical tests are conservative.

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

Next, 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, both conditionally-optimal and actual UB orders are slightly lower than corresponding SB orders. Retailer profits, and offer efficiency, are significantly lower, while impasse rates are higher (weakly significant). As a result, overall efficiency is significantly lower. At the same time manufacturer profits are not different.

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\(^5\) 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 and TPT-UB. When comparing WP-SB to WP-UB, the difference in offer efficiency becomes significant.
Table 3. Summary of contract parameters and performance.

<table>
<thead>
<tr>
<th></th>
<th>Two-Part-Tariff (TPT)</th>
<th>Wholesale Price (WP)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SB: First offer</td>
<td>SB: Last offer</td>
</tr>
<tr>
<td>( w )</td>
<td>41.96 (2.36)</td>
<td>35.63* (2.05)</td>
</tr>
<tr>
<td>( F )</td>
<td>478.44 (38.02)</td>
<td>463.13 (52.20)</td>
</tr>
<tr>
<td>Optimal order ( (q^* )</td>
<td>29.01 (1.16)</td>
<td>31.32 (1.47)</td>
</tr>
<tr>
<td>Actual order ( (q) )</td>
<td>NA</td>
<td>32.02 (1.03)</td>
</tr>
<tr>
<td>Proposal retailer profit</td>
<td>428.43 (46.75)</td>
<td>600.81*** (33.63)</td>
</tr>
<tr>
<td>Proposal manufacturer profit</td>
<td>985.74 (34.99)</td>
<td>887.99* (24.59)</td>
</tr>
<tr>
<td>Offer Efficiency</td>
<td>0.8839 (0.0187)</td>
<td>0.9305* (0.0104)</td>
</tr>
<tr>
<td>Final Efficiency</td>
<td>NA</td>
<td>0.8653 (0.0196)</td>
</tr>
<tr>
<td>Impasse Rate</td>
<td>0.0574 (0.0143)</td>
<td>0.1019† (0.0176)</td>
</tr>
</tbody>
</table>

Note: Standard errors are in parentheses. Average difference between the first and the last offer according to Wilcoxon rank-sum tests: * \( p < 0.10 \), ** \( p < 0.05 \). Average difference between the last round SB and UB according Wilcoxon rank-sum tests: † \( p < 0.10 \), †† \( p < 0.05 \).

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 decrease and average TPT fixed fees increase, but the resulting profits are quite stable (Figure 3(c) and (d)).

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

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6 Under the wholesale price contract, SB wholesale prices are quite stable, whole UB wholesale prices show a slight downward trend over rounds. Profits do not show much trend over rounds. A plot analogous to Figure 3 for wholesale price contract is in Figure 6 in the Appendix A.
experiment were the same as in the TPT-UB treatment, and 48 participants (4 cohorts of 6) were included in the long TPT-UB treatment. We provide a detailed analysis in Appendix B that shows that learning in the long TPT-UB treatment lasts for the first 10-15 periods. When we compare contract performance in rounds 35-40 of the long TPT-UB treatment to rounds 10-15 of the SB treatment, we continue to see significantly lower wholesale prices (and higher efficiency) under SB.

5. Behavioral Model and Estimation

5.1. Probabilistic Choice and Reference-Dependent Utility

The purpose of the behavioral model 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.

While no behavioral model has hitherto been proposed for the dynamic framework of structured bargaining (SB) we investigate here, we can begin with a model that has been proposed for the static ultimatum bargaining (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 by 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

\[
u_R(w, F) = \pi_R(w, F) - \beta F + \varepsilon
\] (1)

where \( \beta \) 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 follows 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 0. Under the UB protocol, we specify this probability $P$ of acceptance as a logit:

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

where $\tau$ 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 $\tau$, we can say that the probability of acceptance is monotonically increasing in the expected utility to the retailer.

5.2. Reciprocal Concessions Model

SB differs from UB only by the presence of Stage 1, which gives manufacturers an opportunity to make concessions. There is evidence in the literature (Cialdini et al. 1975) that concessions increase the likelihood of agreement. This explanation is called reciprocal-concessions, and the idea is that during the bargaining process, when one side makes a concession, this activates a social norm to reciprocate. Cialdini et al. (1975) summarize the idea by observing that “…the likelihood of a concession by one party is positively related to the occurrence of a concession by another party.” (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, so 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). But 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

\[
\pi^R(w_t, F_t) = (p_t - w_t)q^*_t - F_t,
\]

For the first offer, \( \Delta_1 = 0 \), and after the first offer, the concession from Stage 1 offer \( t \) is

\[
\Delta_t = \pi^R(w_t, F_t) - \pi^R(w_{t-1}, F_{t-1}).
\] (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

\[
u_R(w_t, F_t) = \pi^R(w_t, F_t) + \sum_{i=0}^{t-1} \theta_i \Delta_{t-1} - \beta F_t + \epsilon.
\] (4)

The difference in retailer’s utility from accepting an offer under the UB and SB protocols is that in the SB, \( \Delta_t \) affects the maximization of the manufacturer because \( w_{t-i} \) and \( F_{t-i} \) \( \forall \ i = 1..t \) 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 retailer accepts offer number \( t \) be \( P_t = \Pr(\text{Accept}|w_{t-1}, F_{t-1}, w_t, F_t) \) specified as

\[
P_t = \frac{\exp(\tau u_{Rt}(w_t, F_t, w_{t-1}, F_{t-1}))}{\exp(\tau \psi) + \exp(\tau u_{Rt}(w_t, F_t, w_{t-1}, F_{t-1}))}
\] (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 \( \psi \) 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 \( \psi \) is a constant, and we will show in Section 5.5 that the value of \( \psi \) has some effect on the optimal contract parameters.

5.3 Exploring Retailer Behavior

In this section we explore retailers’ behavior in order to identify the factors that affect the likelihood that retailers accept offers. To this end, we estimate a logit model with the dependent variable 1 if an offer was accepted and 0 if it was rejected. In the baseline model (Model 1) we include only independent variables from equation (4): \( \pi^R(w_t, F_t), F_t \Delta_t \). In Model 2 we add \( \Delta_{t-1} \).
in order to check the extent to which retailers pay attention to the concession history, in addition to the latest concession.

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, while it decreases with the size of the fixed fee. The coefficient for the previous offer’s concession ($\Delta_{t-1}$) is positive, but not significant. Therefore, we conclude that equations (4) and (5) capture the main behavioral drivers, while the effect of concession history is of secondary importance.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi^R(w_t,F_t)$</td>
<td>Retailer profit from offer $t$ conditional on optimal order</td>
<td>0.0044*** (0.0003)</td>
<td>0.0044*** (0.0003)</td>
</tr>
<tr>
<td>$F_t$</td>
<td>Fixed fee from offer $t$</td>
<td>-0.0009*** (0.0002)</td>
<td>-0.0053*** (0.0004)</td>
</tr>
<tr>
<td>$\Delta_t$</td>
<td>Latest concession</td>
<td>0.0708*** (0.0008)</td>
<td>0.0072*** (0.0008)</td>
</tr>
<tr>
<td>$\Delta_{t-1}$</td>
<td>Previous concession</td>
<td></td>
<td>0.0013 (0.0009)</td>
</tr>
<tr>
<td>Constant</td>
<td></td>
<td>-4.0791*** (0.2264)</td>
<td>-4.1242*** (0.2292)</td>
</tr>
<tr>
<td>Obs. (N)</td>
<td></td>
<td>3091</td>
<td></td>
</tr>
<tr>
<td>LL</td>
<td></td>
<td>-1095</td>
<td>-1094</td>
</tr>
</tbody>
</table>

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 $\text{Accept}_t$ is an indicator variable that takes on the value of 1 if retailer accepted offer number $t$, and 0 otherwise.

$$lnL = \sum_{R} \sum_{t} [\text{Accept}_t \ln(P_t) + (1 - \text{Accept}_R) \ln(1 - P_t)]$$

(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 $\beta$ and $\tau$ 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 $\beta$ and $\tau$ estimates are the same for UB and SB, and $\beta$ estimates are positive. We also conclude that the behavioral model provides a much better fit than the model with noise only.

<table>
<thead>
<tr>
<th>Table 5. Estimates for Equation (5) for SB and UB separately</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>$\tau$</td>
</tr>
<tr>
<td>$\beta_{SB}$</td>
</tr>
<tr>
<td>$\beta_{UB}$</td>
</tr>
<tr>
<td>$\theta_\ell$</td>
</tr>
<tr>
<td>$N$</td>
</tr>
<tr>
<td>$-2\ln L$</td>
</tr>
<tr>
<td>AIC</td>
</tr>
<tr>
<td>BIC</td>
</tr>
</tbody>
</table>

Notes: Standard Errors are in parenthesis; *** p<0.01. BIC formula: $BIC = -2\ln L + k\ln(N)$; For the reference dependent model $k=40= 4$ parameters + 36 individual intercepts for SB, $k=38=2$ parameters + 36 individual intercepts for UB. For the noise only model $k=37$.

Our estimates of the $\beta$ parameter, which captures the aversion to the fixed fee, is close to the analogous estimate in the Ho and Zhang (2008)\(^7\). The interpretation of the positive and

\(^7\) Ho and Zhang (2008) express the retailer’s utility as $(p - w)(100 - p) - \lambda F$, while our analogous expression can be written as $(p - w)(100 - p) - F - \beta F$. Therefore, $\beta + 1 = \lambda$, and our $\beta$ estimates are equivalent to $\lambda$ in the 1.1 range, which is slightly lower than the Ho and Zhang 2008 estimate of 1.37 (experiment 1) and 1.27 (experiment 2) (see p. 696).
significant estimate of \( \theta_t \) is that retailers derive utility from receiving concessions in addition to the utility they derive from profit.

5.5. Manufacturer’s Behavior

We would like to model the manufacturer as a fully rational expected-profit maximizer, who is aiming to maximize his expected profit and is reacting to the retailer’s response function. In our 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, so as a simplification, let us assume that the maximum number of offers is \( T \). Then the manufacturer’s optimization problem at time 1 is:

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

(7)

Where \( P_t \) is defined in equation (5) and \( \pi_t^M = (w_t - c) \left( \frac{A - w_t}{2} \right) + F_t \).

An important issue we must consider is manufacturer’s beliefs about retailer’s behavioral parameters (\( \beta, \theta \) and \( \tau \)). 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 \( \beta \) because, Ho and Zhang (2008) showed that there is a one to one relationship between the wholesale price the manufacturer offers under the TPT contract, and the manufacturer’s belief about retailer’s loss aversion, namely:

\[
\hat{\beta} = \frac{w - A}{2w - (A + c)} - 1
\]  

(8)

Using equation (8) and the data from our TPT-UG treatment, we compute manufacturers’ belief about the retailer’s loss aversion to be \( \hat{\beta} = 0.67 \) (standard error is 0.195)\(^8\). In general, manufacturer’s optimization problem in equation (7) does not have a closed form solution, but

\(^8\) We computed average \( w \) for each participant in the role of manufacturer in the TPT-UG treatment. Given our parameters, equation (8) is not valid for \( w < 60 \), so we removed three participant who did not satisfy this restriction and used equation (8) to compute \( \beta \)’s for the remaining participants and averaged them.
there is a closed form solution for the wholesale price in the last period, $w_T$ (see Appendix for details):

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

(9)

Solving for the other variables requires deriving the first order conditions. As an illustration, we includes the FOC derivations for the last period fixed fee, $F_T$. (See Appendix B for the derivation).

There is no further insight that can be gained from analytical derivations for earlier periods $t < T$, so we omit them, and instead solve the problem numerically. We present computational results for the case of $\beta = 0.67$ and parameters $\theta_t$ and $\tau$ come from Table 5.\textsuperscript{9} 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 because 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 $\Psi$ denotes the retailer’s belief about what would be his expected utility from potential future offers if offer $t$ is rejected).\textsuperscript{10}

In Figure 4 we display a distribution of the lengths of negotiations that we observe in our data. The distribution of lengths appears nearly Normal for the range of $T = 1$ to $T = 15$, with

\textsuperscript{9} The TPT-UG treatment can be considered as simply a special case of $T = 1$, and solving equation (8) for this special case yields $w_1^* = 42.91$ and $F_1^* = 360.43$, comparable to observed averages in the TPT-UG treatment of $w = 43.03$ and $F = 418.74$.

\textsuperscript{10} $w_t^*$ and $F_t^*$ change as $\Psi$ 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 9 rounds, and then gradually decrease to 35.6, in line with our data, while fixed fees change little throughout the negotiation, but are about 100 lower than the average fixed fees we observe. So, the value $\Psi = 300$ can be considered a fitted parameter since 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 7 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, while 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. So, the value $\bar{\pi} = 200$ can also be considered a fitted parameter.
only about 15% of negotiations having many more offers. Therefore, we solved the problem for \( T = 15 \).\(^{11}\)

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 over-estimates the retailers’ sensitivity to the fixed fee.

![Figure 4. Distribution of the lengths of negotiations observed in our data.](image)

\(^{11}\) The WP-SB treatment is a special case of \( F = 0 \), and solving equation (8) for that special case results in a sequence of wholesale prices that start at \( w_6^* = 60 \) and declines to \( w_{15}^* = 49.43 \), which is comparable to observed wholesale prices that decline from \( w_1 = 57.4 \) to \( w_T = 50.41 \).
The behavioral model that we propose is one in which the retailer dislikes the fixed fee in the TPT contract, and likes concessions. While 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. While 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 finally arrive at a compromise solution. So 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. Manufacturer also treats the problem with indefinite end as if it was a finite, although a 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. But the model we propose is parsimonious, trackable, and sufficiently realistic to capture several important features of the real bargaining process (aggressive initial offers and multiple concessions), 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 ultimatum bargaining (UG) protocol has been commonly used in laboratory studies that tested analytical models of channel coordination. One contribution of our paper is to compare the UG protocol to the structured bargaining (SB) protocol and show that the protocol under which bargaining is implemented 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 UG protocol, making it a useful step in exploring the effect of bargaining on contract performance.\textsuperscript{12} While we cannot claim that a bargaining mechanism that allows manufacturers to make concessions is the true mechanism responsible for the treatment effect we observe, it is both, intuitively plausible and is consistent with our data.

\textsuperscript{12} It is important to emphasize that the SB protocol we investigate here is neither a positive 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 UG protocol. Both protocols are abstractions of a very complex and nuanced process, but SB allows manufacturer to make concessions, which is a feature that is likely to be important to reaching agreements in many bargaining situations.
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 appears 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 UG 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 to two different quantity discount contracts. Like our study (as well as the previously-cited studies of a deterministic demand setting by Ho and Zhang (2008), Lim and Ho (2007) and Katok and Pavlov 2013), as well as others cited in the review article by Chen and Wu (2018)) they find that coordinating contracts do not improve efficiency. But a bargaining process that would allow the buyer and the seller to share some of their private information will likely reverse this conclusion.

Therefore, a managerial take-away from our study is that an effective bargaining process should present opportunities for the bargainers to guide the evolution of contract parameters towards efficiency. How contract parameters evolve, and what is the best bargaining process to enable evolution towards an efficient outcome, depends 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 towards efficiency. Davis and Hyndman (2017) 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 sub-optimal newsvendor problem solution. And it is likely that in settings with asymmetric information, such as Kalkanci et al.
(2011), a bargaining process that facilitates some information sharing would improve the efficiency of the quantity discount contract.

Appendix: Optimal Contract Parameter Characterization at the end of the time horizon

In period $t=T$ (terminal period), supplier maximizes w.r.t $w_T$ and $F_T$:

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

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 $u_t = \pi^R + \sum_{i=0}^{t-1} \theta_i \Delta_{t-i} - \beta F_t$ per equation (4).

Let us to rewrite retailer’s utility from offer $T$ as $u_T = (1 + \theta_T)\pi^R - \theta_T \pi^R_{T-1} - \lambda_T F_T + Past Goodwill$ by denoting $\lambda_T = 1 + \theta_T + \beta$ and $Past Goodwill = \sum_{i=0}^{T-2} \theta_i \Delta_{T-i}$. Also, the supplier profit from offer in period $T$ is $\pi_T^F = (w_T - c)\left(\frac{A-w_T}{2}\right) + F_T$.

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:

$$\frac{\partial Z_T}{\partial w_T} = \pi_T^F P_{RT} \frac{\partial u_{RT}}{\partial w_T} + P_T \frac{\partial \pi_T^F}{\partial w_T} = 0$$

$$\frac{\partial Z_T}{\partial F_T} = \pi_T^F P_{RT} \frac{\partial u_{RT}}{\partial F_T} + P_T \frac{\partial \pi_T^F}{\partial F_T} = 0$$

Combining the two:

$$\frac{\partial u_{RT}}{\partial w_T} \frac{\partial u_{RT}}{\partial F_T} = \frac{\partial \pi_T^F}{\partial w_T} \frac{\partial \pi_T^F}{\partial F_T}$$

Where $\frac{\partial u_T}{\partial w_T} = (1 + \theta_T)\frac{w-A}{2}$; $\frac{\partial u_{RT}}{\partial F_T} = -(1 + \theta_T + \beta)$; $\frac{\partial \pi_T^F}{\partial w_T} = \frac{A+c-2w_T}{2}$; $\frac{\partial \pi_T^F}{\partial F_T} = 1$

So: $(1 + \theta_T)\frac{w_T-A}{2} = -\lambda_T \frac{A+c-2w_T}{2}$

Which comes out to: $w_T = \frac{\lambda_T (A+c)-(1+\theta_T)A}{2\lambda_T - (1+\theta_T)}$ and can be rewritten as equation (9).

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

$$1 + \exp(\tau u_{RT}) = \tau \lambda \pi_T^F.$$
Note that the *Past Goodwill* constant is important. It changes the $u_T$ and therefore the $F_T$ determined above.

Incidentally (not needed in the computation but used for verification), prior to combining the FOCs, the FOC wrt $w$ is:

$$
\frac{\partial z_T}{\partial w_T} = \tau \pi \frac{r}{2} Pr_T (1 - Pr_T) \frac{w_T - A}{2} + Pr_T \frac{A + c - 2w_T}{2} = 0
$$
Acknowledgments

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References


On-Line Appendix

A.1 The effect of learning and additional repetitions

We observe little learning under the wholesale price contract, as can we show in Figure 6 below.

![Graph showing average wholesale price (w) over periods for SB and UB treatments.](image1)

(a) Wholesale prices (w)

![Graph showing average profit over periods for SB and UB treatments.](image2)

(b) Manufacturer Profit ($\pi_M$)

![Graph showing average profit over periods for SB and UB treatments.](image3)

(c) Retailer Profit ($\pi_R$)

Figure 6. Average contract parameters and profits over rounds under the WP contract.

In contrast, we observed a substantial amount of learning under the TPT contract, as we report in Figure 3 in the main body of the paper. Here we further explore the effect of additional repetition on the TPT contract.

Each round under SB involves multiple decisions, while each UB round involves one decision. In order to test a conjecture that improvement under SB can be attributed to repetitions, we conducted an additional TPT-UB treatment, in which participants played for 40, rather than 15 rounds. The procedures were identical in all other regards.
Figure 7. Average contract performance over periods (vertical bars represent standard errors).

Figure 7 (a) – (c) plots average wholesale prices, fixed fees and offer efficiency over periods. The figure shows that under ultimatum bargaining, the learning due to repetition takes place at the start of the session, and after period 15 there is very little additional learning that takes place. To demonstrate this formally, we calculated average wholesale price, offer efficiency, and total efficiency for periods 1-10, 11-20, 21-30 and 31-40, and display these averages and the corresponding standard errors Figure 7 (d). We computed standard errors using session averages as the unit of analysis. The table also reports the results of a matched pair t-test that compares averages between adjacent blocks.
Analysis in Figure 7 (d) shows that learning is evident at the start of the session (differences between periods 1-10 and periods 11-20 are highly significant) but tapers off after the first 10-20 periods. No learning is evident in the second half of the session.

We next compare the performance of the TPT contract under the UB and SB protocols at the end of the session after the learning has tapered off. For this comparison we conducted three regressions (with clustered standard errors at the individual level) in which the independent variable is the bargaining protocol indicator variable (UB = 1 if the observation is from the UB treatment and 0 if it from the SB treatment). We used data from the last 5 periods of the session (Periods 36-40 for TPT-UB-Long and Periods 11-15 for TPT-SB). We report results in Table 6.

<table>
<thead>
<tr>
<th>Independent Variable</th>
<th>Wholesale Price</th>
<th>Fixed Fee</th>
<th>Offer Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>UB = 1 if UB and 0 if SB</td>
<td>3.57* (2.00)</td>
<td>106.37 (68.82)</td>
<td>-0.017** (0.008)</td>
</tr>
<tr>
<td>Constant</td>
<td>31.44*** (1.25)</td>
<td>542.96*** (37.07)</td>
<td>0.949*** (0.005)</td>
</tr>
<tr>
<td>R²</td>
<td>0.015</td>
<td>0.013</td>
<td>0.063</td>
</tr>
<tr>
<td>N (Groups)</td>
<td>360 (72)</td>
<td>360 (72)</td>
<td>360 (72)</td>
</tr>
</tbody>
</table>

Note: * p<0.1, ** p<0.05, *** p < 0.01

The variable UB captures the average difference between UB and SB protocol during the last 5 periods of the session. We see that all differences except the fixed fee are significant. Wholesale prices are higher by 3.57 under UB, and offer efficiency is about 1.7% lower. Since we showed that learning under UB tapers off well before the last 5 periods, this analysis demonstrates that the improved performance under SB cannot be fully explained by increased repetition alone.
A.2 Predictions of the Noise-Only Model

Figure 8 displays a comparison between dynamics implies by the noise-only model (i.e \( \tau = 0.007, \beta = 0, \theta_t = 0 \forall t \), and our data. We can see that, absent behavioral parameters of the retailer, manufacturers set the wholesale price at the coordinating level of 20, and make concession in terms of the fixed fee—contrary to the dynamics we observe in our data.
A.3 The Effect of Good Faith Restriction (TPT-SB Treatment)

Overall, in the six TPT-SB sessions without the good faith restriction there were 1376 concessions made, and of those 119, or about 8%, violated the restriction. These violations did not have any significant effect on average contract parameters, profits, orders, efficiency metrics, or rejections. Table 7 shows the averages for the first and last offer broken down by treatments with and without the restriction.

Table 7. Means, Standard Errors, and comparisons of sessions with and without the good faith restriction.

<table>
<thead>
<tr>
<th></th>
<th>Good Faith Restriction (first offer)</th>
<th>Good Faith Restriction (last offer)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Wholesale Price ((w))</td>
<td>42.46 (3.96)</td>
<td>41.49 (2.83)</td>
</tr>
<tr>
<td>Lump Sum ((F))</td>
<td>450.65 (59.35)</td>
<td>506.22 (50.28)</td>
</tr>
<tr>
<td>Retailer Profit ((\pi_R))</td>
<td>455.86 (73.56)</td>
<td>400.99 (62.51)</td>
</tr>
<tr>
<td>Manufacturer Profit ((\pi_M))</td>
<td>939.23 (43.71)</td>
<td>1032.38 (50.72)</td>
</tr>
<tr>
<td>Order ((q))</td>
<td>31.64 (1.59)</td>
<td>31.31 (1.88)</td>
</tr>
<tr>
<td>Optimal Order ((q^*))</td>
<td>28.77 (1.98)</td>
<td>29.26 (1.42)</td>
</tr>
<tr>
<td>Offer Efficiency</td>
<td>0.87 (0.03)</td>
<td>0.89 (0.02)</td>
</tr>
<tr>
<td>Overall Efficiency</td>
<td>0.87 (0.02)</td>
<td>0.88 (0.03)</td>
</tr>
<tr>
<td>Rejection Rate</td>
<td>0.06 (0.02)</td>
<td>0.05 (0.02)</td>
</tr>
</tbody>
</table>

Note: \(H_0\): no difference due to good faith restriction.
A.4: Compendium Instructions

Welcome

You are about to participate in a decision-making experiment. If you follow these instructions, you can earn a considerable amount of money. Your earnings depend on your choices as well as the choices of others. In the end of the session, your profit, expressed in the experimental tokens, will be converted to US dollars at rate 600 tokens for one US dollar and added to the show-up fee of $5. You will be paid in cash.

The Experiment

In this experiment you will be assigned into one of two roles -- a manufacturer or a retailer. Your role is currently displayed on the screen in front of you. Half the people in this room are assigned into each role and these roles will remain fixed for the duration of the experiment. The experiment will last 15 periods. In each period, a manufacturer and a retailer are matched. The matching will change every period.

The manufacturer

A manufacturer produces a product at cost 20 tokens per unit. The manufacturer proposes a wholesale price, which is paid per unit, and a lump sum, which is to be paid by the retailer regardless of the number of units ordered. If the retailer accepts the proposal, then the manufacturer will earn the number of units the retailer orders, multiplied by the \((\text{wholesale price} - \text{cost})\) plus the lump sum that the retailer pays. If the retailer rejects the proposal, the manufacturer can make another proposal (unless negotiations reached “Impasse” stage; see below).

The retailer

The retailer evaluates the manufacturer’s proposal and determines if the proposal is acceptable. If so, the retailer decides on the order quantity to buy from the manufacturer at the wholesale price. The retailer may reject the manufacturer’s proposal and await a new proposal (unless negotiations reached “Impasse” stage; see below).

Participant Earnings

If a proposal is accepted, the retail price will be:

\[ \text{Retail Price} = 100 - \text{Order Quantity} \]

The retailer’s profit is then:

\[ \text{Retailer’s Profit} = (\text{Retail Price} - \text{Wholesale Price}) \times \text{Order Quantity} - \text{Lump Sum} \]

The manufacturer’s total profit from the trade is:

\[ \text{Manufacturer’s Profit} = (\text{Wholesale Price} - 20) \times \text{Order Quantity} + \text{Lump Sum} \]
The Impasse stage

If no proposal is acceptable to the retailer within 5 minutes, the parties will enter an impasse stage. The manufacturer makes one final offer. The retailer can either accept the proposal or declare an impasse. If the retailer decides to declare an impasse, no trade takes place and each party earns zero profit in this period.

The Interface

Your computer screens, as shown below, have a “Calculate” button that allows both manufacturers and retailers to try different choice scenarios without actually submitting a decision.

Below is a screenshot of the calculator interface available to the manufacturer and the calculator interface available to the retailer.
The manufacturer’s interface allows manufacturers to try different combinations of wholesale price and lump sum without actually making an offer.
After the manufacturer submits an offer, it appears on the retailer’s screen and the retailer can then try different order quantities before reaching a decision.
For a manufacturer, the calculator will assume the order quantity maximizes retailer’s profits and show both parties’ profits assuming that the retailer orders this amount.
You can use the “Calculator” button as much as you need. Whenever you are ready to submit your decision, click on the “Submit” button.

Example 1.

Suppose the manufacturer offers Wholesale price = 40 and Lump Sum = 333.
Suppose the retailer accepts the offer and orders 50 units. Then
Manufacturer’s profit = (40 – 20) x 50 + 333 = 20 x 50 + 333 = 1000 + 333 = 1333
When the retailer re-sells these 50 units on the market, the market price is
Retail Price = 100 – 50 = 50.
The retailer’s profit will be
Retailer’s profit = (Retail Price – Wholesale price) x Order Quantity – Lump Sum
\[(50 - 40) \times 50 - 333 = 10 \times 50 - 333 = 500 - 333 = 167.\]

**If no trade takes place**
If the retailer does not accept the contract, each party earns nothing and the game proceeds to the next period.

**Example 2.**

Suppose the manufacturer offers Wholesale price = 80 and Lump Sum = 1000. If the retailer accepts the offer and orders 10 units. Then

- Manufacturer’s profit = \((80 - 20) \times 10 = 60 \times 10 = 600 + 1000.\)

When the retailer re-sells these units on the market, the market price is

- Retail price = 100 – 10 = 90.

The retailer’s profit will be

- Retailer’s profit = \((\text{Retail price} – \text{Wholesale Price}) \times \text{Order Quantity} – \text{Lump Sum} = (90 – 80) \times 10 – 1000 = 10 \times 10 – 1000 = 100 – 1000 = – 900.\)

Thus, for the retailer, accepting this contract and ordering 10 units results in a loss. If no trade takes place

In fact, it turns out that at wholesale price = 80, the retailer’s best order quantity should be 10. However, given the lump sum = 1000, it is simply not possible for the retailer to make profit with this contract. If the retailer rejects this offer, no trade takes place and each party earns zero profit.