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Bargaining in Supply Chains

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We study experimentally bargaining in a multiple-tier supply chain with horizontal competition and sequential bargaining between tiers. Our treatments vary the cost differences between firms in tiers 1 and 2. We measure how these underlying costs influence the efficiency, negotiated prices, and profit distribution across the supply chain, as well as the consistency of these outcomes with existing theory. We find that the structural issue of cost differentials dominates personal characteristics in explaining outcomes, with profits in a tier generally increasing with decreased competition in the tier and increasing with decreased competition in alternate tiers. The balanced principal model of supply chain bargaining does a good job explaining our data, and it outperforms the common assumption of leader–follower negotiations. We find a significant anchoring effect from a firm's first bid but no effect of the sequence of those bids, no evidence of failure to close via escalation of commitment, and mixed results for a deadline effect. We also find an interesting asymmetry between the buy and sell sides in employed bidding strategy. All firms make predominantly concessionary offers after the initial anchor; however, sell-side firms that engage in aggressive anticoncessionary bidding successfully increase prices while not compromising closure rates. Buy-side firms achieve much smaller price changes from anticoncessionary tactics and risk reduced closure, yielding no net benefit.

Keywords: bargaining; behavioral experiments; multiechelon supply chains; efficiency and profitability
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1. Introduction

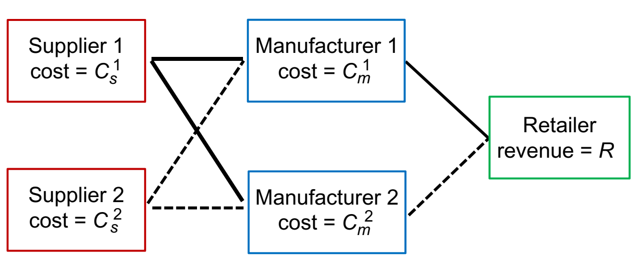
In the operations management literature, supply chain management as a field of study evolved from multiechelon inventory and control theory via the recognition of the parochial interests of each firm in the chain. That is, the coordination of the activities of multiple independent firms to maximize total social value is not automatic because of the private profitability interests of each. Firms recognize that by cooperating on material and information flows, they can create value for society, but each also wishes to capture as much of that value as possible for its private use. The mechanisms by which this tension is managed vary broadly, from detailed legal contracting to more informal relationships. Managing this issue of social value versus private gain is central to supply chain management research. Arshinder et al. (2008) catalog representative papers in this area, and Cachon (2003) reviews coordination through choosing the appropriate interfirm contract form. These, and the references therein, provide an overview of current perspectives and approaches.

Scholarly analyses of supply chains focus on issues of efficiency (are chainwide profits maximized by the choices made by the independent firms?) and distribution (how are the chainwide profits distributed along the chain?). The former is important from a social perspective (are resources appropriately allocated?), and the latter is important from a firm perspective (understanding the profitability consequences of alternative actions is necessary for decision makers). The answers to these questions remain unclear. Indeed, in many supply chain contexts of practical importance, interfirm negotiations can best be described as small-numbers bargaining, an enduringly difficult yet fundamentally important economic context. Yet we will not really understand supply chains and their efficiency and distributional characteristics without understanding how interfirm negotiations determine which firm(s) get the contract(s) and at what prices. This paper contributes to our body of knowledge by experimentally exploring these questions in the context of one common supply chain structure, but for which theory is new and no behavioral evidence yet exists.

Our experimental setup is designed to represent a market-facing firm that designs a new product and wishes to bring it to market but does not have ownership or control over all of the resources required to make that happen. The product is sufficiently new that the firm is, at least temporarily, a monopolist vis-à-vis its customers. The firm will send out a request for quote (RFQ) to multiple tier 1 suppliers. The tier 1 suppliers turn around and negotiate with their (tier 2) suppliers to get a better idea of their possible supply costs. The tier 1–tier 2 negotiations end with an understanding of what they will do if they get the contract. Once their supply costs are known, the tier 1 firms respond to the RFQ, and (potentially after some further negotiations) the supply chain forms when the market-facing firm selects a tier 1 supplier to do business with at an agreed-upon price, and the tier 1 supplier selects a tier 2 supplier to do business with at an agreed-upon price. We assume that there are sufficient economies of scale in supply that only one tier 1 and tier 2 supplier will be active in the final chain, along with the market-facing firm (and, implicitly, the suppliers to tier 2, as described below).

This situation—with the market-facing firm selecting a single tier 1 partner from several options via an RFQ and their subsequent negotiations, and the tier 1 firms behaving similarly vis-à-vis tier 2—is common in practice when the downstream tiers in the supply chain are performing product-specific activities. Somewhere upstream in the chain (in our experiments, this is after tier 2), inputs become more generic, competition becomes more perfect, and firms can source inputs at something approximating a common market competitive price. This situation, with sole-sourcing downstream and competitive markets upstream, is representative of, but not limited to, the high-tech, consumer products and services, entertainment, food, furniture, large complex engineered products, and automotive industries (see Lovejoy 2010b). The specific structure we analyze is shown in Figure 1. The solid lines denote one possible set of agreements between firms, with the dashed lines showing other possible agreements. Although the market-facing firm could be (and often is) an original equipment manufacturer, for ease of interpretation we label that firm a *retailer*, the tier 1 firms as *manufacturers*, and the tier 2 firms as *suppliers*, which intuitively signals the appropriate chain relationship of supplier to manufacturer to retailer. In our experiments there are two suppliers and two manufacturers, all with potentially different costs. We denote by c_s^1 and c_s^2 the supply costs for suppliers 1 and 2, respectively (these include their costs of upstream supply and value-adding cost). We denote by c_m^1 and c_m^2 the value-adding costs for (tier 1) manufacturers 1 and 2, respectively. Their supply costs from tier 2 will be determined by negotiations. We denote by R the revenue (net of any firm-specific value-adding

Figure 1 (Color online) Three-Tier Supply Chain Setup



Notes. Stage 1: Suppliers and manufacturers negotiate simultaneously to determine transfer prices. Each manufacturer agrees on a price with one of the suppliers. Stage 2: Manufacturers and the retailer negotiate simultaneously to determine transfer prices. The retailer agrees on a price with one of the manufacturers. The supply chain is formed with one firm in each tier.

cost) at which the retailer can sell the (indivisible) finished item on the market. Like the manufacturers, the retailer's supply cost from tier 1 will be determined by negotiations. We assume complete information about value-adding costs, which is an abstraction in many applied settings but not unreasonable in others. Firms go to great lengths to understand their suppliers' costs, because that information helps them in negotiations. In practice, these efforts include reverse engineering, cost modeling based on historical data, backing out component costs from competitors' published prices for different product configurations, direct inspection of suppliers, open books agreements, and other tactics.

1.1. Our Contribution

This paper contributes to two broad categories in the supply chain and bargaining literatures, one regarding outcomes and one regarding the process by which those outcomes are reached.

In the first category, we use our experiment to ask the following questions: (a) will the efficient firms become active in the final contracts, (b) what will the distribution of profits be throughout the chain, and (c) are these results consistent with theory? To our knowledge, this is the first time these questions have been addressed in a three-tier supply chain experiment.

In the second contribution category, we test several conventional wisdoms about the dynamics of negotiations, including framing and anchoring, escalation of commitment, concessionary versus anticoncessionary bidding, and deadline effects.

Additionally, we make a methodological contribution by studying *free-form* bargaining between firms in the supply chain. Most of the existing behavioral operations experiments that study supply chain contracting (e.g., Lim and Ho 2007, Loch and Wu 2008, Ho and Zhang 2008) use ultimatum-style bargaining; however, Haruvy et al. (2015) show that supply chain coordination improves substantially when firms can use a more flexible bargaining format. Unstructured bargaining is both more realistic and allows greater scope for structural factors such as cost differences to impact the resulting outcomes (e.g., a firm's ability to make and receive multiple offers over time provides greater opportunities to push the firms in the other tier to match offers).

1.2. Overview of Our Results

In the category of supply chain bargaining outcomes, we find that supply chain efficiency is high in all cost treatments, but, as is usual in bargaining experiments, we find a higher level of nonclosure than one would expect using purely rational economic reasoning. We find that horizontal competition significantly influences the distribution of profits within the supply chain. In general, with minor exceptions, the profits that accrue to the eventually active firm in each tier will decrease as horizontal competition in that tier increases and increase as horizontal competition in other tiers increases. Structural issues (e.g., cost structures) dominate individual characteristics (e.g., risk aversion) in determining these outcomes. The balanced principal solution (Lovejoy 2010a) explains the data quite well. The differences between treatments and the relative profits among tiers largely match its predictions; however, the point predictions assign too much profit to the retailer. In predicting the outcomes of the retailer–manufacturer negotiations, the balanced principal solution outperforms the assumption of either retailer leadership (i.e., assuming the retailer makes a "take it or leave it" offer) or manufacturer leadership with standard preference functions. This lends further support to existing evidence that, in small-numbers bargaining situations, the popular leader–follower frameworks for analysis underperform relative to more bargaining-based frameworks that predict a less extreme distribution of wealth. If, despite this, one adopts a leader–follower model in a multiple-seller, single-buyer supply chain, we find that the common agency format outperforms the more common designation of buyer as leader.

In the category of bargaining dynamics, we find a significant anchoring effect in that the first bids anchor the negotiations and the final price tends to be midway between the initial bids. However, we find no first-mover advantage, so the first bid by each party in the negotiations matters but not the sequence in which they make them. We see a significant deadline effect in stage 2 negotiations but much less so in stage 1, suggesting a more complex relationship to time in multiparty bargaining, wherein some firms can be excluded. However, we find no relationship between when a deal is struck and final prices (which we would expect to see if impatience or anxiety to close put negotiators at a disadvantage). The actual sequence of bids leading to closure largely follows an intuitive path (anchor bid followed by concessions). However, anticoncessionary tactics tend to be effective when used by sell-side firms, but much less so by buy-side firms. There also appears to be a psychological construct at play that grants the buyer a position of power unexplained by structural characteristics.

2. Experimental Design

We developed a laboratory supply chain game with free-form bargaining to study how horizontal competition affects the efficiency and distribution of profits in a multitier, $2 \times 2 \times 1$ supply chain consisting of two suppliers, two manufacturers, and one retailer. Subjects were randomly assigned to one of these three roles, which they kept throughout the experiment. The retailer needed to establish a supply chain with one manufacturer and one supplier to bring a single unit of a good to the retail market. If the retailer could form a supply chain, he received a fixed revenue R of \$40. Each supplier and manufacturer had a cost of \$5, \$15, or \$25 for their value-adding activities. To form a supply chain, the retailer needed to negotiate a transfer price for a supply contract with a manufacturer, who in turn needed to have a supply contract with a supplier. Consistent with practice (see Lovejoy 2010b), we chose to have the supply chain game begin with the negotiations between the suppliers and manufacturers, followed by the negotiations between the manufacturers and the retailer (see Figure 1).

Subjects played a total of six periods of the supply chain game. In each period, subjects were randomly and anonymously matched in groups of five, consisting of two subjects with the supplier role, two subjects with the manufacturer role, and one subject with the retailer role. Suppliers (respectively, manufacturers) were randomly assigned to be supplier 1 or supplier 2 (respectively, manufacturer 1 or manufacturer 2) in each period. Subjects were also informed of each player's cost or revenue.

First, the two suppliers and two manufacturers simultaneously bargained, with the manufacturers attempting to negotiate a supply contract with a supplier. Each manufacturer negotiated separately with each supplier until reaching an agreement with exactly one of them. Each manufacturer could contract with just one supplier, but it was possible that a single supplier could end up supplying both manufacturers.

The subjects had six minutes in the first period (four minutes in later periods) to negotiate.[1] They could make numerical price offers[2] at any time and could also send chat messages. Only the recipient could see an offer or a chat message, although subjects were free to reveal that information using the chat window if they wished. An agreement was reached if a manufacturer accepted the last price offer from a supplier or if a supplier accepted the last price offer from a manufacturer. However, subjects were required to wait until two minutes had elapsed before accepting an offer.[3] If one manufacturer struck an agreement, the other manufacturer could continue to negotiate with both suppliers.

[1] We gave subjects six minutes in the first period to allow them to get comfortable with the computer interface and the bargaining procedures. The four-minute deadline in later periods was sufficient to allow most groups to negotiate without extensive time pressures while avoiding indefinite stalling.

[2] Subjects were only allowed to make or accept offers that would give them nonnegative profits.

[3] That is, during the first two minutes, subjects can make price offers and send chat messages but cannot accept an offer. We included this restriction based on earlier pilot sessions wherein we found that subjects would race to be the first to accept an offer rather than attempting to chat or negotiate. We felt that this time pressure was not reflective of typical negotiations and was not our primary focus.

At the conclusion of the supplier–manufacturer negotiations, all the subjects were shown the agreed-upon transfer prices and the new total costs for each manufacturer. The manufacturers then negotiated with the retailer for six minutes in the first period (four minutes in later periods). A manufacturer could only participate in this negotiation stage by reaching an agreement with one of the suppliers. As in the previous stage, subjects could make numerical price offers or send chat messages at any time and could accept an offer after the first two minutes. An agreement was struck when a manufacturer accepted the last offer from the retailer or the retailer accepted the last offer from one of the manufacturers.

At the conclusion of the second bargaining stage, all five subjects were informed whether a complete supply chain was formed, which firms were part of the chain, and what the negotiated prices were between the retailer and manufacturer (p_{rm}) and between the manufacturer and supplier (p_{ms}). If a subject was not part of the final supply chain, that subject's period payoff was \$0. For subjects in the supply chain, their period payoff was calculated as follows.

$$\begin{aligned} \text{Retailer:}\quad & \pi_R = R - p_{rm} \\ \text{Manufacturer:}\quad & \pi_M = p_{rm} - p_{ms} - c_m \\ \text{Supplier:}\quad & \pi_S = p_{ms} - c_s \end{aligned}$$

After the supply chain game, subjects performed two additional tasks to measure individual risk and social preferences (including selfishness, altruism, inequity aversion, and social welfare maximization; see Leider and Lovejoy 2014).

2.1. Experimental Treatments

We examined five different between-subjects cost treatments. In all cases the most efficient firms in a tier (i.e., manufacturer 1 and supplier 1) had a cost of \$5. In our base treatment we set the second firms to have a cost of \$15: hence they were at a \$10 disadvantage relative to the most-efficient firms. We then varied the level of competitiveness within a tier by increasing to \$20 or decreasing to \$0 the cost difference in either the manufacturer or supplier tier. This yielded five cost profiles, described in Table 1.

We ran 14 sessions at the University of Michigan during 2011–2012, with a total of 210 subjects participating.[4]

Table 1 **Experimental Treatments**

	Supplier costs		Manufacturer costs		
Treatment	S1	S2	M1	M2	Retailer revenue
MDiff0	5	15	5	5	40
Base	5	15	5	15	40
MDiff20	5	15	5	25	40
SDiff0	5	5	5	15	40
SDiff20	5	25	5	15	40

Participants were Michigan undergraduate students. Sessions lasted approximately 1.5 hours. Subjects earned on average \$19.53.

3. Bargaining Outcomes: Existing Theoretical and Experimental Literatures

The supplier–manufacturer negotiations over supply partner and price are 2×2 (two sellers, two buyers) bargaining situations, and the subsequent manufacturer–retailer negotiations are either 2×1 or 1×1 situations (it is 1×1 if one of the manufacturers does not secure a supply partner and so cannot enter negotiations with the retailer). Theory for this type of small-numbers bargaining is incomplete. However, there is sufficient work in some variants of this problem to warrant discussion.

With complete information, what theory exists supports the expectation that with free-form negotiations, chains with positive profit potential will form and the efficient firms will be active in the eventual supply contracts. However, 100% closure is almost never observed in experimental bargaining games, a result that is generally explained through nonpecuniary motivations such as concerns for fairness or punishment of selfish individuals.

Regarding distributional outcomes in small-numbers bargaining contexts, there are two generic approaches: noncooperative and cooperative game theory. The authors know of no theoretical results in the noncooperative literature, with either complete or incomplete information, that predict the distribution of profits in a more general supply chain with more than two tiers and more than one player per tier. Despite this, the noncooperative approach (restricted to simpler systems) dominates the extant literature, in part because it enjoys some commonly accepted solution concepts. For example, sequential or Stackelberg games, with a subgame perfect solution concept, are well regarded and familiar to researchers and readers alike. By contrast, cooperative games and bargaining theory have many proposed solution concepts but no dominant one. We refer to sequential or Stackelberg extensive-form noncooperative games as "leader-follower" or LF games. We note that these include the familiar principal–agent formats that inform the large literature on auctions (see Krishna 2002) and mechanism design (see Myerson 1981), both of which have presence and relevance in the supply chain literature.

However, it is often the case in supply chains that negotiations ensue more along the lines of our stage 1

[4] We planned to run two to three sessions in each treatment to target approximately 40 subjects and oversampled the Base treatment since it provides the baseline for both the manufacturer and supplier competition manipulations.

(2×2) context. In that setting, it is not clear who should, or can, act as the leader or whence such powers would derive. To our knowledge, there is no LF theory that informs those negotiations.[5] The lack of a theoretical prediction from the LF perspective for 2×2 negotiations prevents a comparison of our experimental results to noncooperative theory.

Among cooperative approaches, the balanced principal (BP) model (see Lovejoy 2010a) is the only extant theory that is reasonable for the stage 1 (suppliers and manufacturers) negotiations and provides testable hypotheses. The BP solution is a refinement of both the core and von Neumann and Morgenstern set solution concepts. Generalized Nash bargaining and Shapley values are ill-suited to a context where one or more actors will be shut out of negotiations (that is, by their structure these solution concepts grant each firm some value, no matter how uncompetitive it is; see Lovejoy 2010a).

The stage 2 manufacturer–retailer negotiations (which will feature either 2×1 or 1×1 negotiations) fall within a class of models that have been analyzed from the LF perspective. Being designated the leader confers substantial power and influence over the outcome of a game (the leader can anticipate the follower's reactions and craft offers to exploit that anticipatory understanding). There is no theoretical reason that the leader cannot adopt a social preference function that values gains to both parties, although standard (unilateral gains) preference functions currently dominate the literature. The coupling of standard preferences with an LF sequence tends to predict extreme distributional outcomes. For example, in our stage 2 setting, 2×1 or 1×1 LF models with standard preferences and the retailer as leader will predict that the retailer takes all of the available wealth and no manufacturer makes any profit.

However, there is a variant of the LF paradigm that, even with standard preferences, predicts less extreme outcomes. This is the "common agency" setting (see Bernheim and Whinston 1986), in which multiple leaders are allowed to make simultaneous offers to a single follower. In that case each leader's aggression in negotiations is checked by competition from other leaders, so less extreme demands are made and less extreme outcomes obtain. In our stage 2 setting with two viable manufacturers as leaders facing a single retailer as follower, the common agency prediction would be for the efficient manufacturer to get the contract from the retailer and to reap profits equal to the difference between his total costs and those of the less efficient manufacturer. If only one manufacturer is viable (for example, if only one manufacturer closes a deal with a supplier), then the situation conforms to a standard 1×1 model in which the manufacturer as leader will (with standard preferences) take all of the available surplus. In stage 2 of our experiments, we test the predictive power of the BP model, as well as both forms (retailer as leader and common agency) of the LF model.

There is an extensive history of experimental investigations of bargaining in both psychology (see Rubin and Brown 1975 and Bazerman et al. 2000 for surveys) and economics (see Roth 1995 for a survey) dating back more than 50 years. Bazerman et al. (2000) identify two major themes in the social psychology of bargaining: individual differences and structural variables. They conclude that the evidence suggests that individual differences have a small effect on bargaining outcomes and are generally outweighed by situational features (Ross and Nisbett 1991; Thompson 1990, 1998).

The early experimental economics literature heavily used free-form bargaining, particularly to test the predictions of axiomatic bargaining theories (Nydegger and Owen 1974, Roth and Malouf 1979) and Coasian bargaining (Hoffman and Spitzer 1982), as well as examining structural factors such as deadlines (Roth et al. 1988) and individual characteristics such as risk aversion (Murnighan et al. 1988). Many experiments found that under free-form bargaining agreements it was very common for outcomes to equalize payoffs (under complete information) or tokens (under incomplete information about payoffs); see Roth and Malouf (1979), Roth et al. (1981), and Roth and Murnighan (1982). Some experiments were specifically designed to mimic the structured extensive form of some LF games (see, for example, the ultimatum game by Güth et al. 1982; also see Leider and Lovejoy 2014 for a more extensive discussion and reference list). These experimentalists found that extreme offers were uncommon and were frequently rejected, whereas fairer offers were most common and were generally accepted. Frequently, the bargaining outcomes differed substantially from the LF perfect equilibrium outcome in the direction of more equitable distributions of wealth.

4. Hypotheses and Results

The various treatments in the experiments were designed to test theory-based hypotheses about efficiency and the distribution of profits in a supply chain resulting from negotiations between tiers in the chain. Most of the hypotheses are inspired by the BP theory, because it is the only extant bargaining-based theory that provides whole-chain profitability predictions. Although the first stage of negotiations is conducted with some uncertainty regarding the outcome of the second stage of negotiations, the BP predictions (which

[5] See Pratt and Rustichini (2003) for results in a related but different setting; see also the extensive literature on double auctions by, for example, Smith (1962).

are based on simultaneous joint determination of all transfer prices) are tested to see whether they extend into this more complex, but realistic, context. The second stage of negotiations is conducted with full information for all parties and benefits from both BP and LF predictions.

The BP solution to a multitier bargaining chain is unique if the difference in value-adding costs between the two most efficient firms in tier k, call this Δc_k, is nonincreasing as we move upstream in the chain (as k increases; see Lovejoy 2010a). We use five treatments (cases) to feature different combinations of Δc in the manufacturer and supplier tiers, as shown in Table 1. In all cases the revenue to the retailer (net of value-adding costs) equals 40. This experimental structure necessarily includes cases where Δc increases going upstream (that is, cases where Δc in the supply tier is greater than Δc in the manufacturing tier, as in treatments MDiff0 and SDiff20), which admit nonunique BP solutions. However, it is still possible that all BP solutions share some testable attributes, as we describe below.

4.1. Supply Chain Formation

With complete information and positive potential profits, current economic theory based on self-interested behavior would predict 100% closure, as discussed above. The hypothesis that the probability of closure $p = 1$ is clearly rejected as soon as we have any nonclosure, which we do have here. So not all negotiations will close even when complete information and positive profits are available. In our experiments a key contingency seems to be asymmetry of bargaining power, where in stage 2 of the negotiations, 91% of the 2×1 chains close, but only 73% of the 1×1 chains close (this situation obtains when there is a breakdown in stage 1 of the negotiations, resulting in one of the manufacturers having no supplier under contract). Overall, 89% of all trials ended up with a complete supply chain. So closure is significantly more likely than nonclosure in all cases, as expected. However, the probability of closure for the chain overall is significantly reduced when at least one of the manufacturers fails to close on a supply contract in stage 1. This cannot be because the failed manufacturer is intransigent, because that manufacturer is not active in the stage 2 negotiations. Rather, it appears to be the symmetry of power in 1×1 stage 2 negotiations, relative to asymmetry in 2×1 negotiations, that drives failure to close. Further analysis would be required to confirm this. For the remainder of this paper, all results (proportions, etc.) are computed for completed chains only.

4.2. Supply Chain Efficiency

By a repeat of the above arguments on closure, existing economic theory with complete information would predict that the efficient firms will be active in the final chain. If any efficient firm is excluded from a proposed contract, that firm can always make a more attractive offer to a member of its opposite (supplier or buyer) tier. In our multitier setting, however, there are two different ways to perceive efficiency. The first is ex ante efficiency, which means that the low ex ante (before stage 1 negotiations) value-adding cost firms are active in the final chain. However, it is possible that a manufacturer with lower ex ante costs has higher costs ex post if he bargains poorly and pays a substantially higher input price to his supplier. Ex post manufacturer efficiency would mean that the lowest-cost (ex post) manufacturer gets the contract from the retailer; ex post whole-chain efficiency means that the ex post efficient manufacturer and supplier are both active in the final chain.

4.2.1. Ex Ante Efficiency. We test hypotheses regarding ex ante efficiency by looking for significant statistical evidence that efficiency occurs at a rate greater than one would expect from random formation. For example, to test ex ante efficiency among suppliers, we let x denote the fraction of completed chains in which the ex ante efficient supplier is active and test H_0: $x = 0.5$ against the alternative H_A: $x \neq 0.5$.[6] For ex ante efficiency in the whole chain, we adopt as our null hypothesis independent random selection of firms in each tier. In cases where these are unique (MDiff and SDiff both greater than 0), we would expect 1/4 of them to be globally efficient, so letting x denote the fraction of completed chains that contain the ex ante efficient firms in both the supplier and manufacturer tiers, we test the null hypothesis H_0: $x = 0.25$ against the alternative H_A: $x \neq 0.25$.

The results are that the ex ante efficient suppliers are chosen with at least 80% probability in all treatments, and ex ante efficient manufacturers are chosen with at least 75% probability. In all cases efficiency is significantly higher than random selection would imply ($p \leq 0.01$). Whole-chain efficiency is at least 60% in all treatments, significantly higher than with random selection ($p < 0.01$). There are no significant differences between treatments in the frequency with which the efficient supplier is selected. The MDiff20 treatment has significantly higher manufacturer efficiency than the other three treatments with different manufacturer cost differences[7] ($p < 0.01$) and similarly has higher joint efficiency ($p < 0.01$).

[6] We conservatively use two-sided tests throughout our analysis. Unless otherwise indicated, we use tests of proportions for statistical tests involving binary outcomes, and we use Wilcoxon rank-sum tests for statistical tests involving continuous outcomes.

[7] We do not use the MDiff0 treatment in any of the statistical tests for ex ante manufacturer efficiency, since every chain is efficient trivially. Similarly, we do not test for the ex ante supplier efficiency of the SDiff0 treatment.

4.2.2. Ex Post Efficiency. After the stage 1 negotiations close, the total cost (input price plus value-adding cost) is known for each manufacturer, giving the stage 2 manufacturers–retailer negotiations clean theoretical predictions.

In stage 2 if there is just one viable manufacturer in a chain that closes, then efficiency is trivially ensured. We exclude these trivial cases from our analysis. Similarly to ex ante efficiency, we test hypotheses regarding ex post efficiency by looking for significant statistical evidence that ex post efficiency occurs at a rate greater than one would expect from random formation. For example, with two viable manufacturers, we test that the fraction of times the efficient manufacturer is active significantly exceeds 0.5 (as before, we conservatively use a two-sided test). The results are that both the ex post efficient manufacturer and the ex post efficient manufacturer–supplier pairs are significantly ($p < 0.01$) active in the final chain.

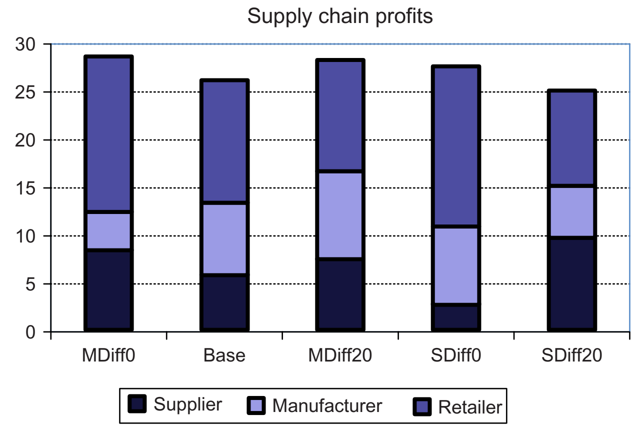
There were some differences among treatments. The MDiff20 case was significantly more likely to result in the efficient manufacturer being chosen relative to the other cases ($p < 0.01$ for all). This might be expected, since the efficient manufacturer has the strongest bargaining advantage in this case. Also, in the whole-chain test MDiff20 is modestly statistically different than MDiff0 ($p = 0.06$) and Base ($p = 0.05$). Interestingly, SDiff20 is not as impactful as MDiff20, attesting to the importance of the manufacturer–retailer negotiations in the second stage of bargaining.

In summary, we expect the ex ante efficient firms to be active in the final supply chain, even though the first-stage negotiations feature bargaining with incomplete information. In the second stage of negotiations, featuring complete information bargaining, we expect the more efficient supplier–manufacturer pair to be active. There were some significant treatment effects, with a strong manufacturer value-adding cost advantage being more highly related to efficient outcomes than a strong supplier advantage.

4.3. Effect of Competition on Profit Distribution

Our experiments investigated how profits will be distributed along the supply chain, whether this depends on the level of horizontal competition in each tier, and whether the results conform to theory. Figure 2 plots the average profits earned by each tier of the supply chain in each treatment. It is clear that there is substantial variation in the profit distribution between the treatments. Retailers tend to consistently capture the largest share of the profit (earning between 40% and 60% of the total profit). Supplier and manufacturer profits vary widely across treatments, with suppliers earning between 10% and 40% and manufacturers earning between 15% and 30%. Additionally, note that even when two firms in a tier have equal costs and are therefore

Figure 2 (Color online) Supply Chain Profit Distribution



highly competitive, the winning firm still earns positive profits. Hence, it does not appear that firms are bargained down to their reservation price.

4.3.1. Comparative Statics. The balanced principal model predicts the outcomes shown in Table 2. A bracketed interval means that the BP solution is not unique. In those cases, every profit profile between the end points is a BP solution, with the end points preserving a total surplus of 30 (profits sum to 30). So, for example, in MDiff0 all (supplier, manufacturer, retailer) profit distributions, $\lambda \times (0, 0, 30) + (1 - \lambda) \times (10, 0, 20)$ as λ ranges from 0 to 1, are BP solutions.

Several predicted trends in tier-specific profits as a function of horizontal competition (in the same and alternative tiers) are robust to nonuniqueness issues. For example, retailer profits can be expected to be decreasing (or at least nonincreasing) as Δc in the manufacturing tier increases, because the prediction interval for MDiff0 is everywhere (except for a single point) above the predictions for the Base and MDiff20 treatments. Table 2 shows the theory-driven predictions of tier-specific profits as a function of horizontal competition. Our specific hypotheses and results are as follows (note that we test each claim using a Cuzick's nonparametric test for trends):

Table 2 BP Profitability Predictions for Each Treatment and Tier

Treatment	Supplier profit	Manufacturer profit	Retailer profit
MDiff0	[0, 10]	0	[20, 30]
Base	5	5	20
MDiff20	5	10	15
Predicted trend as mfg ΔC increases	No prediction	Increases	Decreases
SDiff0	0	5	25
Base	5	5	20
SDiff20	[5, 15]	5	[10, 20]
Predicted trend as supp ΔC increases	Increases	Stays the same	Decreases

- Supplier profits increase with less supplier competition: supported ($p < 0.01$).
- Manufacturer profits increase with less manufacturer competition: supported ($p < 0.01$).
- Manufacturer profits do not change with less supplier competition: not supported. Manufacturing profits decrease significantly as horizontal competition in the supply tier decreases.
- Retailer profits decrease with less supplier competition: supported ($p < 0.01$).
- Retailer profits decrease with less manufacturer competition: supported ($p < 0.01$).

We also tested the single "no prediction" outcome from theory by testing for any significant trend (in any direction) of supplier profits as a function of horizontal competition in the manufacturing tier. The result was no statistically significant effect on supplier profits as a function of manufacturing competition ($p = 0.4$).

The predictions of the BP theory are largely supported for tierwise profits as a function of horizontal competition in the same and alternative tiers. The exception is the prediction of indifference in the manufacturing tier as a function of competition in the supply tier. The intuition behind the theoretical prediction is that because the efficient supplier can contract with both manufacturers during the first stage, the two manufacturers should be able to strike the same agreement with the supplier. Therefore, whether the supplier ought to be able to capture a large or a small profit, this should add the same amount to the cost of both manufacturers, and therefore the cost difference between the manufacturers should be preserved. However, our experimental outcomes differ from this prediction. Manufacturers make more than predicted (also see Table 6) when supplier competition is high in SDiff0 and Base but the same as predicted when competition is low in SDiff20, whereas retailers make less than predicted with high competition. Suppliers, by contrast, make approximately the predicted amount in each case. Hence, the departure from theory in the effect of supplier competition on manufacturer profits is not a function of the supplier–manufacturer negotiations but of the subsequent manufacturer–retailer negotiations wherein the retailer bargains less aggressively than predicted. In summary, the BP predictions for the effect of tierwise competition are generally supported, the sole exception being where a remote tier drives the results and does so by bargaining less aggressively than anticipated.

4.3.2. Regression Analysis. As a further test of the prediction that tierwise profits (π) are driven by Δc_m and Δc_s, we ran three regressions with (supplier, manufacturer, retailer) profit as dependent variables and indicators for manufacturer and supplier cost differences being 10 or 20:

$$\pi = \alpha + \beta_1 I_{[\Delta c_m=10]} + \beta_2 I_{[\Delta c_m=20]} + \beta_3 I_{[\Delta c_s=10]} + \beta_4 I_{[\Delta c_s=20]} + \beta_5 Period + \epsilon.$$

We included data from all five treatments together in the same regression. We included the period in the regression to account for any learning or fatigue effects over time. Recall that BP theory (see Table 2) predicts that supplier profits will increase as horizontal competition in the supplier tier decreases (Δc_s increases), with no prediction as a function of Δc_m; manufacturer profits will increase in Δc_m and remain the same in Δc_s, and retailer profits will decrease as either Δc_m or Δc_m increases.

The regression results are shown in Table 3. The period has no significant effect, so there is no evidence of learning or fatigue effects over time. Supplier profits increase significantly as the horizontal competition in the supplier tier decreases (i.e., as SDiff goes from 0 to 10 and from 10 to 20). Supplier profit does not exhibit a monotonic pattern with respect to manufacturer costs: profits decline significantly compared with the Base case if MDiff = 10 but by less and not significantly if MDiff = 20. These results are consistent with BP predictions. (Recall that BP had no prediction for the influence of MDiff because of nonuniqueness issues.)

Manufacturer profits increase significantly as manufacturer competition declines (i.e., profits increase with MDiff), as predicted by theory. Manufacturer profits decrease significantly when SDiff = 20 and decrease, albeit not significantly, when SDiff = 10. Recall that

Table 3 Tier-Level Profit Distributions

Variable	(1) Supplier	(2) Manufacturer	(3) Retailer
MDiff = 10	−2.649***	3.544***	−3.393**
	(0.834)	(0.893)	(1.226)
MDiff = 20	−0.971	5.161***	−4.579***
	(0.652)	(0.643)	(0.973)
SDiff = 10	2.999***	−0.612	−3.842**
	(0.956)	(1.145)	(1.513)
SDiff = 20	6.961***	−2.764***	−6.730***
	(1.086)	(0.837)	(1.245)
Period	−0.310*	0.00543	0.283**
	(0.158)	(0.175)	(0.108)
Constant	6.603***	4.601***	19.05***
	(1.180)	(0.957)	(1.776)
Observations	218	218	218
R^2	0.261	0.177	0.306
MDiff 10 = 20?	$p = 0.03$	$p = 0.12$	$p = 0.39$
SDiff 10 = 20?	$p = 0.00$	$p = 0.02$	$p = 0.04$

Notes. Standard errors clustered at the session level are reported in parentheses. Dependent variables are supplier profit, manufacturer profit, and retailer profit.
*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

theory predicts constant manufacturing tier profits in these treatments as a function of SDiff, so theory is not challenged when SDiff = 10 but is challenged when SDiff = 20.

Retailer profits decreased significantly with lower levels of horizontal competition in either upstream tier (with MDiff = 20 yielding retailer profits significantly below the Base case, but only directionally lower than MDiff = 10). These outcomes are consistent with theory. Interestingly, retailer profits are hurt more by decreased competition in the supply tier than by decreased competition in the manufacturing tier (compare the effect of SDiff going from 10 to 20 to the effect of MDiff going from 10 to 20). This highlights the importance of competitive realities in remote tiers of a supply chain, and the importance of the stage 1 (tier 1 to tier 2) negotiations to the profits of the retailer.

4.4. BP Prediction: Whole-Chain Profit Profile

One of the predictions of the multitier BP theory is the relative distribution of profits throughout the chain; i.e., who gets the available surplus? Even in the nonunique cases there are profitability patterns that are robust to the range of predicted outcomes. For example, in the MDiff0 case the predicted supplier profits are in the range [0, 10], the predicted manufacturer profit equals 0, and the predicted retailer profit is in the range [20, 30]. All of these outcomes satisfy the inequalities $M \leq S < R$. We test this by considering the space of strict inequalities,[8] in which there are six possible events ($M < S < R$, $S < R < M$, etc.). We test the null hypothesis that the population proportion of outcomes with the BP predicted ordering significantly exceeds what one would expect from random outcomes. For example, let x equal the proportion of outcomes in the MDiff0 treatment with the predicted ordering $M < S < R$. We test the null hypothesis H_0: $x = 1/6$ against the alternative H_A: $x \neq 1/6$. For the Base and SDiff20 treatments, there is no strict three-tier ordering predicted by theory, but there are predicted pairwise orderings. For example, for SDiff20, BP predicts $M \leq S$ and $M < R$. Again using a sample space of all possible three-tier strict orderings, the two pairwise results in SDiff20 occur simultaneously in two of the six orderings, so the natural null hypothesis is $x = 1/3$ if the outcomes were random (and likewise for the Base case outcomes). Proceeding similarly for the remaining treatments, Table 4 shows the hypotheses and relative frequencies under random selection. The results of these tests are shown in Table 5.

The predicted profit profile occurred in approximately two-thirds of the outcomes for three cases

Table 4 Whole-Chain Profit Profiles

Treatment	Supplier profit	Manufacturer profit	Retailer profit	Profit order tested	Relative frequency
MDiff0	[0, 10]	0	[20, 30]	M < S < R	1/6
Base	5	5	20	S < R & M < R	1/3
MDiff20	5	10	15	S < M < R	1/6
SDiff0	0	5	25	S < M < R	1/6
SDiff20	[5, 15]	5	[10, 20]	M < S & M < R	1/3

Table 5 Results of Whole-Chain Profit Profile Hypothesis Tests

Treatment	BP order	% match order	Null: random	Obs random?
MDiff0	R > S > M	71.79	1/6	$p < 0.01$
Base	R > S & R > M	66.04	1/3	$p < 0.01$
MDiff20	R > M > S	20.83	1/6	$p = 0.44$
SDiff0	R > M > S	65.12	1/6	$p < 0.01$
SDiff20	R > M & S > M	45.71	1/3	$p = 0.15$

Table 6 Profitability Point Predictions

	Predicted			Median experimental outcome		
Treatment	Supplier	Manufacturer	Retailer	Supplier	Manufacturer	Retailer
MDiff0	[0, 10]	0	[20, 30]	9.00	3.40***	17.00***
Base	5	5	20	5.00	7.00***	12.50***
MDiff20	5	10	15	8.25***	10.00	11.00***
SDiff0	0	5	25	2.00***	9.00***	17.00***
SDiff20	[5, 15]	5	[10, 20]	8.00	5.00	10.00

***Indicates that the median outcome is significantly different from the point prediction at $p < 0.01$ (using a rank-sum test); all other p-values are >0.10.

(MDiff0, Base, and SDiff0)—a significantly higher frequency than random ordering would predict ($p < 0.01$ for each). For MDiff20 and SDiff20, however, although the predicted pattern occurred directionally more often than the null hypothesis, the differences were not statistically significant. For MDiff20 the strong bargaining position of the manufacturer seemed to disrupt negotiations in both stages; the retailer earned more than the manufacturer (as predicted) in only 52% of chains, and the manufacturer earned more than the supplier in only 63% of the chains. For SDiff20 there were a large number of cases where the supplier and manufacturer earned equal profits.[9] If we include these ties, a majority of the outcomes match the BP order.

4.4.1. Point Estimates for Profitability.

The BP predictions for profits to each tier and the median experimental outcomes are shown in Table 6. Although the median outcomes are consistent with BP's predicted relative profit profiles, the point predictions are significantly different from the experimental outcomes in more than half the data. In general, we find that retailer

[8] This is more conservative and simplifies identifying the relevant null hypothesis. If we allow for ties where BP predicts and use the same null hypothesis probabilities, all our results are the same except that SDiff20 now matches the BP order 54% of the time ($p = 0.01$).

[9] As described in the footnote above, this is consistent with the BP prediction but not accounted for in the conservative test.

profits are generally lower than predicted, manufacturer profits are sometimes higher than predicted, and supplier profits are sometimes higher than predicted.

As described above, retailers bargained less aggressively than theory predicts in the majority of cases, lowering their profits. This leaves more for the manufacturers and suppliers, and both do as well or better than predicted in all cases. We will return to this point below.

In summary, the BP predictions for the profit profile (the ordering of profits) across the three tiers of the supply chain were directionally supported in our experiments with statistical significance in two-thirds of the cases. The exceptions were MDiff20 and SDiff20, where strong bargaining positions in those tiers seemed to have a disruptive effect. By contrast, BP's point predictions for firm profits deviate from the data in many cases. This is due to a general feature of retailers bargaining less aggressively than theory suggests, leaving more surplus for the manufacturers and suppliers to divide among them. So the profile is maintained, but upstream tier profits tend to be higher than predicted.

Horizontal competition is a significant driver of the profits in any tier. The regression results suggest that retailers are hurt by decreased competition in either upstream tier (losing between one-fifth and one-third of their profit), both manufacturers and suppliers are helped by decreased competition in their own tier (doubling their profits in the best case), suppliers show mixed effects of decreased competition in the manufacturing tier, and manufacturers are hurt by decreased competition in the supplier tier. All of these are consistent with theory except the last one, as discussed above.

4.5. A Comparison of BP and LF Supply Chain Models

There is no predictive LF model for our stage 1 (2×2) negotiations. However, in stage 2 we will have either a 2×1 or 1×1 model, for which both BP and LF solutions are available. Which model is more predictive of outcomes? LF models need to identify a leader (i.e., somebody endowed with the ability to make "take it or leave it" offers), and leadership can reside either in the manufacturing tier or the retailer tier. If we declare the retailer the leader with a standard unilateral preference function (case RL), the subgame perfect equilibrium is for the retailer to declare a price infinitesimally larger than the full cost of the (ex post) most efficient manufacturer, capturing all of the available value. If we declare the manufacturing tier as the leader where each firm has a standard preference function (case ML), there are two possibilities. If there is only one viable manufacturer (a 1×1 bargaining system), the sole manufacturer will capture all of the value, leaving the retailer with nothing. If there are two viable manufacturers (a 2×1 bargaining system), we have a complete information common agency problem (Bernheim and Whinston 1986), which has the subgame perfect solution of the (ex post) efficient manufacturer getting the contract for a price equal to the full cost of the competitor, thereby capturing the full Δc_m. The BP solution is for the efficient manufacturer to get the contract but get only one-half of Δc_m in the 2×1 case and one-half of the total surplus in the 1×1 case. Figure 3(a) shows the mean absolute error between these model predictions and experimental results for manufacturer profits. (Examining retailer profits yields the same comparison, except in cases where the inefficient manufacturer is chosen, reducing the total surplus from what the three models predict. To account for that, we also examine the manufacturer's profit share, which yields similar results; see Figure 3(b).) Rigorously, we used a pairwise, two-tailed Wilcoxon signed-rank test for the equality of medians with the following results. BP is more accurate than RL in all treatments ($p < 0.01$ for all); BP is statistically indistinguishable from ML in all cases except MDiff20, when BP is unambiguously better ($p < 0.01$); and ML is better than RL ($p < 0.01$) except in MDiff20 and SDiff20, for which ML and RL are indistinguishable. Hence, we find that the BP model is equal to or better than any LF model in all treatments. Interestingly, using a standard principal–agent style of model with a retailer principal is the worst among these alternatives. If researchers want to adhere to LF models of some sort, these results suggest the common

Figure 3(a) (Color online) Model Error: Manufacturer Profit

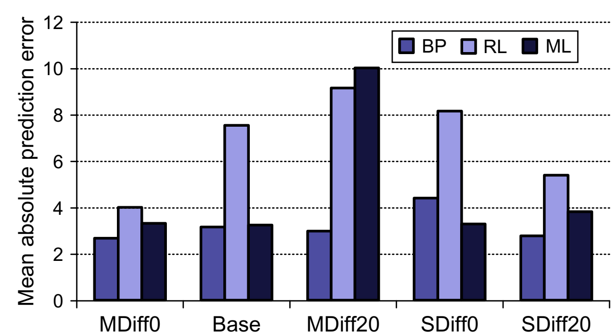
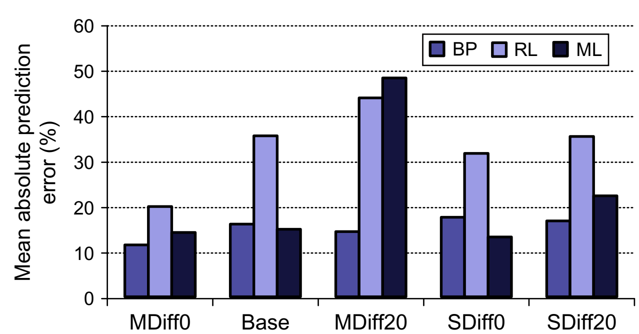


Figure 3(b) (Color online) Model Error: Manufacturer Profit Share



agency format (ML) is superior to the single-leader format (RL).

4.5.1. Best Estimate for Profits as a Function of Competitive Context. We noted above that there is at least one situation where the manufacturer gets more than is theoretically predicted. We can generalize our prediction for the profit to the active manufacturer in stage 2 negotiations to $\alpha\Delta c_m$ in the 2×1 case, and $\alpha(r - c_1)$ in the 1×1 case, for some $\alpha \in [0, 1]$. The BP model sets $\alpha = 0.5$, a standard preference RL model would set $\alpha = 0$, and a standard preference ML model would set $\alpha = 1$. Table 7 presents the regression results for estimating the best-fitting α for our data. Columns (1) and (2) report the estimates for fitting α to manufacturer profit levels, and columns (3) and (4) fit manufacturer profit shares (to account for surplus changes caused by selecting the inefficient manufacturer). Columns (1) and (3) fit a single α for all five treatments, whereas columns (2) and (4) fit a separate α for each treatment. The best-fitting α is not statistically different from the BP prediction of 0.5 for either profit levels or profit shares, and the point estimates are numerically very close. Similarly, the treatment-specific estimates of α are not significantly different from the BP assumption in two of the five treatments for both profit levels (MDiff0 and MDiff20) and profit shares (MDiff20 and SDiff20). In the other cases we find that the best fit gives somewhat more profit to the manufacturer, as we would expect from our previous analysis. By contrast, both the RL assumption of $\alpha = 0.0$ and the ML assumption of $\alpha = 1.0$ can be rejected for each profit measure, both overall and for each treatment.

Table 7 Best Empirical Fit of α

	(1)	(2)	(3)	(4)
Variable	Manufacturer profit		Manufacturer profit share	
α	0.573*** (0.0489)		0.566*** (0.0454)	
α(MDiff0)		0.493*** (0.0191)		0.579*** (0.0107)
α(Base)		0.732*** (0.0333)		0.746*** (0.0457)
α(MDiff20)		0.470*** (0.0389)		0.467*** (0.0387)
α(SDiff0)		0.746*** (0.0907)		0.702*** (0.0948)
α(SDiff20)		0.591*** (0.0322)		0.610*** (0.0760)
Observations	218	218	218	218
R-squared	0.787	0.822	0.782	0.813

Notes. Standard errors clustered at the session level are reported in parentheses. Dependent variables are manufacturer profit in columns (1) and (2) and manufacturer profit share in columns (3) and (4).
*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

4.6. Personal Characteristics

We also examined what effect (if any) negotiator personal characteristics (risk aversion or social preferences) have on the distribution of profits in a supply chain. Although we found a few significant coefficients in a series of regressions, there did not appear to be overall consistent patterns, and the estimated effects were small compared with the effects of competition (which are as much as six times as large; see Leider and Lovejoy 2014). Hence, it appears that the effects of individual characteristics are small compared with structural factors (consistent with the social psychology literature discussed in §3.3).

5. Bargaining Dynamics

We have so far analyzed bargaining outcomes and which factors are important in driving those outcomes. Our data also allow us to investigate aspects of "bargaining dynamics," participant behaviors during the bargaining process that affect outcomes (closure rate, the timing of closure, and/or the negotiated prices). There is a rich literature on bargaining dynamics: see Kagel and Roth (1995), Bazerman and Neale (1992), and Bazerman and Moore (2013) and references therein. We have already discussed (see §4.1) failure to close, which has more presence in our (and other) experiments than would be predicted by theory. Here, we look at some additional issues suggested by the literature: anchoring and the efficacy of bidding first, escalation of commitment as a failure mode, deadline effects on the timing of offers, and the effect of impatience. We also look at the consistency of the intuitive process of converging via alternating concessions with our observed data, and we note some interesting behaviors that arise in our asymmetrical, multilateral setting that one would not see in bilateral negotiations.

Throughout, we relate bids and results to the *zone of possible agreement* (ZOPA), which is defined as the available surplus in a negotiation. We will refer to the retailer and the retailer's revenue as R; to suppliers 1 and 2 and their costs as S1 and S2, respectively, with the cost of S1 $\leq$ S2; and to manufacturers and their costs as M1 and M2, with value-adding costs for M1 $\leq$ M2. The ZOPA in stage 1 is the interval [S1, R − M1]. The ZOPA in stage 2 is the interval from the lower of the two manufacturers' supply costs (after contracting with suppliers) to the revenue R. We will refer to a ZOPA interchangeably as being the relevant interval and/or its width, relying on context to aid interpretation.

5.1. Some Summary Statistics and Observations

In the first bargaining stage between suppliers and manufacturers, there were on average 5.5–7.6 offers involving manufacturer 1 and 5.3–7.6 offers involving manufacturer 2. In both cases there are significant differences between treatments (Kruskal–Wallis test: $p < 0.01$ and $p = 0.02$), with SDiff0 having the most

Table 8 **Stage 1 Bargaining Offers**

Panel A: Offers with manufacturer 1								
	S1 first offer		S2 first offer		M1 first offer		Avg accepted offer	
Treatment	Price	% of ZOPA	Price	% of ZOPA	Price	% of ZOPA	Price	% of ZOPA for M1
MDiff0	15.34	34	19.79	1	13.63	71	15.64	65
Base	15.48	35	20.86	2	10.84	81	13.77	71
MDiff20	16.02	37	20.15	3	12.09	76	14.20	69
SDiff0	11.39	21	11.19	21	7.06	93	8.15	90
SDiff20	20.32	51	28.30	18	12.66	74	17.74	58
Panel B: Offers with manufacturer 2								
	S1 first offer		S2 first offer		M2 first offer		Avg accepted offer	
Treatment	Price	% of ZOPA	Price	% of ZOPA	Price	% of ZOPA	Price	% of ZOPA for M2
MDiff0	15.63	35	19.78	2	13.68	71	15.42	65
Base	14.92	50	20.63	0	11.00	70	12.91	60
MDiff20	16.25	56	20.96	6	10.88	71	13.08	60
SDiff0	10.84	29	10.18	29	8.14	84	8.61	82
SDiff20	19.26	71	28.21	21	13.49	58	15.65	47

offers in both cases. In the second stage of bargaining between manufacturers and the retailer, there were 5.8–6.8 offers, with no significant differences between treatments (Kruskal–Wallis test: $p = 0.90$).

In the first bargaining stage between suppliers and manufacturers (see Table 8), the buying tier (manufacturers) asks for the substantial majority of the available surplus (between 71% and 79% by M1 and between 58% and 84% by M2), and the selling tier asks for less (between 21% and 51% and between 1% and 21% for S1 and S2 negotiating with M1, respectively; and between 29% to 71% and between 0% and 29% for S1 and S2 negotiating with M2, respectively), with S1 bargaining with M2 the only case where the supplier asks for more than the manufacturer. Interestingly, in many cases the supplier asks for approximately one-third of the overall surplus, consistent with an equal split among the three tiers. These initial offers are close together; those involving manufacturer 1 leave between 5% and 25% of the ZOPA contested, whereas initial offers involving manufacturer 2 leave between 6% and 29% contested. These initial offers tend to anchor the negotiations (investigated further below), with final accepted offers tending to be near the midpoint of the original offers.

The offers are generally consistent with competitive realities for the buyer and stronger seller. For example, M1's most aggressive offers are in SDiff0 and least aggressive offers are in MDiff0, and S1's most aggressive offers are in SDiff20 and least aggressive offers are in SDiff0. However, the weaker seller follows a less "rational" approach, being almost as aggressive in SDiff20 as in SDiff0.

We see similar behaviors in second-stage bargaining between manufacturers and the retailer (see Table 9). Again, the buyer's (retailer's) first offers are quite aggressive, claiming between 70% and 88% of the ZOPA, with the most aggressive offers in MDiff0 and least aggressive in MDiff20. By contrast, M1's initial offers tend toward approximately equal splits. Also, sellers are acting rationally given competitive realities, with M1's aggressiveness increasing with the difference in real costs and M2's aggressiveness decreasing with that difference.

Again, the initial offers tend to anchor the negotiations, so subjects are only bargaining over 20%–40% of the remaining contracting space. Table 10 reports the average offers of each firm in stage 2, as well as the average accepted offer. Both manufacturers and

Table 9 **Stage 2 Bargaining Initial Offers**

			M1 first offer		M2 first offer		Retailer first offer	
Treatment	M1 total cost	M2 total cost	Price	% of ZOPA	Price	% of ZOPA	Price	% of ZOPA
MDiff0	20.66	20.35	26.45	26	26.73	31	21.52	88
Base	18.98	28.04	28.98	47	32.83	24	22.83	82
MDiff20	19.22	38.10	32.02	62	40.07	11	25.52	70
SDiff0	13.16	23.70	26.57	49	30.46	26	21.35	72
SDiff20	22.74	30.65	31.89	50	35.94	38	26.44	81

Table 10 Stage 2 Bargaining Average Offers

Treatment	M1 avg offer	M2 avg offer	Retailer avg offer	Avg accepted offer: Price	Avg accepted offer: % of ZOPA for R
MDiff0	25.28	25.67	21.40	23.70	75
Base	28.88	32.52	24.01	27.32	61
MDiff20	31.11	40.44	25.55	28.41	56
SDiff0	24.79	28.69	21.97	23.31	63
SDiff20	31.36	34.67	27.31	30.06	58

retailers on average make relatively small concessions compared to their initial offers, and accepted agreements are approximately halfway between the initial offers of the retailer and manufacturer 1 (as well as being at approximately the midpoint of the average offers). With the initially more aggressive offers by the retailer, the average agreement gives the retailer between 55% and 75% of the possible surplus.

5.2. Bargaining Dynamics in the Literature and in Our Experiments

Here, we further investigate some specific bargaining dynamics issues discussed in the literature and testable with our data.

5.2.1. Framing and Anchoring. Final agreements tending to be midway between the initial offers can be interpreted via framing and anchoring. *Framing* refers to how a negotiator perceives or interprets a deal. This goes beyond the actual price paid and puts that price into a more complex cognitive context. There are a number of ways that negotiations can be framed. An individual may evaluate an offer as favorable or unfavorable based on prior experience of accepted offers, for example. Alternatively, an individual may consider structural factors such as the total available surplus along the chain, any individual firm's costs, or nonstructural inputs like the initial bid. In this subsection we focus on that final way to frame a negotiation, it being anchored at a specific price so that any outcome is perceived not on its own terms but relative to the anchor price.

Kahneman and Tversky (1981) note that the same outcome can be perceived as a gain or a loss, depending on the reference point or anchor it is compared to and that these effects can influence behaviors in negotiations. So it is often recommended in negotiations that one offer a first bid that establishes an aggressive position, because that establishes an anchor, and then anything less (even modestly) is perceived by the other as a favorable outcome. Galinsky and Mussweiler (2001) show that whoever makes the first offer does better but that this advantage is reduced if the opponent focuses on the structural aspects of the negotiations rather than that anchor bid. There is also an argument that in a context of incomplete information one should let the opponent bid first because it will reveal some information (after correcting for the anticipated aggressiveness). None of these conventional wisdoms has been previously tested in our supply chain context.

Table 11 shows the results of regressing the final price paid against the initial bids of each firm (as well as the total costs for manufacturers 1 and 2 in the second-stage negotiation). In stage 1 negotiations between M1 and the suppliers, we find a significant impact of the initial offers from both the buyer and the low-cost seller on final prices, and buyer and seller initial offers are equally influential on final price. For

Table 11 Effect of Initial Offers on Final Price

	M1–S bargaining		M2–S bargaining		R–M bargaining	
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Buyer's First Offer	0.458***	0.410***	0.673***	0.635***	0.231***	0.239***
	(0.130)	(0.121)	(0.0835)	(0.0844)	(0.0634)	(0.0594)
Seller 1's First Offer	0.448***	0.408***	0.172***	0.141**	0.249***	0.257***
	(0.103)	(0.0977)	(0.0544)	(0.0547)	(0.0758)	(0.0751)
Seller 2's First Offer	0.0980*	−0.0119	0.0681**	0.0193	0.0587	0.0465
	(0.0464)	(0.0383)	(0.0241)	(0.0349)	(0.0544)	(0.0609)
Seller 1's Total Cost					0.149**	0.0862
					(0.0624)	(0.0723)
Seller 2's Total Cost					0.120*	0.156*
					(0.0622)	(0.0900)
Treatment controls	No	Yes	No	Yes	No	Yes
Constant	−0.415	3.344**	1.335	3.325**	1.308***	1.211***
	(1.023)	(1.257)	(0.951)	(1.295)	(0.216)	(0.176)
Observations	179	179	158	158	164	164
R^2	0.668	0.699	0.734	0.748	0.070	0.056

Notes. Standard errors clustered at the session level are reported in parentheses. The dependent variable is the agreed-upon price.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

Table 12 Effect of Making the First Offer on Final Price

	M1–S bargaining		M2–S bargaining		R–M bargaining	
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Buyer Made First Offer	−0.236	−0.315	0.0517	0.403	−0.702	−0.170
	(1.330)	(0.824)	(0.937)	(0.592)	(0.680)	(0.667)
Treatment controls	No	Yes	No	Yes	No	Yes
Constant	13.69***	15.73***	12.90***	15.26***	26.69***	23.74***
	(1.016)	(0.437)	(1.060)	(0.408)	(0.364)	(0.665)
Observations	236	236	231	231	220	220
R^2	0.000	0.352	0.000	0.270	0.004	0.297

Notes. Standard errors clustered at the session level are reported in parentheses. The dependent variable is the agreed-upon price.
$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

stage 1 negotiations between M2 and suppliers, we see significant but unequal influences of the initial offers by the manufacturer and low-cost seller. In stage 2 we again find a significant and equal impact of the initial offers from both the buyer and the low-cost seller on final prices. In the second-stage negotiation there is also an effect of the manufacturer's total costs; however, this may reflect actual bargaining power rather than anchoring, since the coefficients change substantially when we include treatment dummies.

So, at least for the advantaged player within a tier, one's first bid has a significant effect on outcome. But is it advantageous to bid first? Table 12 reports the results of regressing the agreed-upon price on an indicator for the buyer making the first offer. We find no significant effect on the final price, and the estimated coefficient in the specification with treatment controls is of small magnitude. Hence we find no first-mover advantage or disadvantage.

5.2.2. Escalation of Commitment. One source of inefficiency in negotiations is a failure to close even when closure can be beneficial to both parties and to society, and we see failure to close more frequently in experiments than would be anticipated by theory. One possible contributing mechanism (see the discussion in Bazerman and Moore 2013) is "escalation of commitment," meaning the (seemingly irrational) allegiance to an initial (but untenable) position, once one has signaled that that position is firm. In our context, this would be signaled by refusal to retreat from an extreme initial offer, even if that meant nonclosure.

To test for this, we construct for each firm a measure of its "concession," specifically the difference between its initial and final offer (measured as a percentage of the ZOPA). A larger concession then indicates that a subject changed their offer by a larger amount compared with their initial offer. We then regress an indicator for a closed agreement on the concessions of each firm, as well as the initial offers. The results are reported in Table 13. In columns (1) and (2) we report the results for stage 1 bargaining where manufacturer 1 is the "buyer" and the suppliers are the "sellers," and in columns (3) and (4) we report the corresponding results with manufacturer 2 as the "buyer." Columns (5) and (6) report the results for second-stage bargaining with the retailer as the buyer and the manufacturers as the sellers. Concessions generally have the anticipated directional effects but are either not significant or marginally significant in both stage 1 and stage 2 bargaining. That is, we see no evidence of closure inefficiencies as a result of escalation of commitment in our negotiations.

5.2.3. Convergence via Concessionary Offers. One intuitive impression of negotiations is of parties starting at different initial offers and then making a sequence of concessions as the negotiations converge to an agreement. Although subjects were not required to make monotonic offers (they could choose to rescind a generous offer and replace it with a less generous offer), we might intuitively expect bargainers to take turns making concessions. Indeed, in our experiments this is the norm. Almost all follow-up offers from manufacturers in the first stage are concessions (89% of offers for manufacturer 1, 87% for manufacturer 2), and almost all manufacturers who make more than one offer only make concessions (84% for manufacturer 1 and 82% for manufacturer 2). We find similar results for sell-side firms. Almost all offers from suppliers are concessions (88% of offers for supplier 1, 91% for supplier 2), and almost all suppliers make only concessionary offers (85% of supplier 1's and 86% of supplier 2's). In the second stage, 95% of follow-up offers by retailers are concessions, and 93% of retailers only make concessionary offers. Similarly, 89% of offers from both manufacturers 1 and 2 are concessions in the second stage, and almost all manufacturers make only concessionary offers in stage 2 (78% of manufacturer 1's and 76% of manufacturer 2's).

However, we do see some evidence of anticoncessionary behaviors (that is, a seller's follow-up offer is lower, or a buyer's follow-up offer is higher, than the previous offer), and these tactics have very different efficacy between buyers and sellers. Table 14

Table 13 Escalation of Commitment and Bargaining Closure

	M1–S bargaining		M2–S bargaining		R–M bargaining	
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Buyer's Concession	0.146		0.247		0.100	
	(0.133)		(0.207)		(0.129)	
Seller 1's Concession	−0.224		−0.0381		0.413*	
	(0.417)		(0.0529)		(0.220)	
Seller 2's Concession	0.0302		−0.0838		−0.0218	
	(0.0597)		(0.0557)		(0.0941)	
Total Concession		0.0315		0.0352		0.144
		(0.0847)		(0.0575)		(0.124)
Buyer's Initial Claim (% ZOPA)	−0.204*	−0.186*	−0.175	−0.148	−0.359	−0.296*
	(0.113)	(0.0923)	(0.127)	(0.123)	(0.225)	(0.175)
Seller 1's Initial Claim (% ZOPA)	−0.375	−0.371*	−0.355	−0.327	−0.415*	−0.260
	(0.225)	(0.208)	(0.233)	(0.244)	(0.212)	(0.160)
Seller 2's Initial Claim (% ZOPA)	−0.00907	−0.0481	0.221	0.160	0.0537	0.0823
	(0.135)	(0.127)	(0.157)	(0.111)	(0.0775)	(0.0780)
Constant	1.262***	1.241***	1.197***	1.176***	1.308***	1.211***
	(0.147)	(0.123)	(0.138)	(0.144)	(0.216)	(0.176)
Observations	186	206	171	197	164	164
R^2	0.170	0.159	0.076	0.053	0.070	0.056

Notes. Standard errors clustered at the session level are reported in parentheses. The dependent variable is an indicator for a bargaining agreement.
*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

reports the results of regressing the final price on an indicator for anticoncessionary behavior. In columns (1) and (2), this indicator equals 1 if the sell-side firm makes at least one anticoncessionary offer, whereas in columns (3) and (4), the indicator equals 1 if the buy-side firm makes an anticoncessionary offer. Columns (1) and (3) use stage 1 bargaining; columns (2) and (4) use stage 2 bargaining. We find that in both stages when the sell-side firm makes anticoncessionary offers, this significantly increases the final price—by more than \$3 in stage 1 and almost \$2 in stage 2. For anticoncessionary buy-side firms, there is some reduction in price in stage 1; however, this is only marginally significant, and the effect is one-third as large as for sell-side firms. There is no change in final price for stage 2. We also run similar regressions testing for an effect on closure rates. For buy-side firms, we find evidence that anticoncessionary offers reduce closure rates in first-stage negotiations by 13% ($\beta = -0.131$, $p < 0.01$), but we do not find a similar reduction in closure rates in the second stage ($\beta = 0.031$, $p = 0.89$). For sell-side firms, we find no significant effect on closure in either stage, and in both cases the coefficient is very close to zero (stage 1: $\beta = -0.046$, $p = 0.27$; stage 2: $\beta = -0.001$, $p = 0.99$). Hence, using an aggressive strategy of making anticoncessionary offers is clearly beneficial for the sell-side firms: it raises the average price without leading to more impasses. Anticoncessionary strategies by buyers are ineffective or come at a cost in reduced closure with only a small price benefit. These effects approximately offset each other, leaving the buyer no better off.

Table 14 Anticoncessionary Offers and Prices

	Stage 1 bargaining	Stage 2 bargaining	Stage 1 bargaining	Stage 2 bargaining
Variable	(1)	(2)	(3)	(4)
Sell Side Is Anticoncessionary	3.136***	1.786**		
	(0.994)	(0.636)		
Buy Side Is Anticoncessionary			−1.138*	0.634
			(0.541)	(1.599)
Negotiation Involving M2	−0.814**		−0.596	
	(0.334)		(0.365)	
Treatment controls	Yes	Yes	Yes	Yes
Observations	239	144	238	86
R^2	0.452	0.407	0.363	0.328

Notes. Standard errors clustered at the session level are reported in parentheses. The dependent variable is the agreed-upon price (conditional on coming to agreement). Columns (1) and (3) report results for the first-stage negotiations between the manufacturers and the suppliers (we pool together negotiations involving both manufacturers). Columns (2) and (4) report results for the second-stage negotiations between the retailer and the manufacturers. *Sell Side Is Anticoncessionary* is an indicator variable that equals 1 if the sell-side firm that is part of the final agreement made at least one anticoncessionary offer. *Buy Side Is Anticoncessionary* is an indicator variable that equals 1 if the buy-side firm made at least one anticoncessionary offer to the sell-side firm that was part of the final agreement. *Negotiation Involving M2* is an indicator variable that equals 1 if the agreement is between manufacturer 2 and one of the suppliers.
*$p < 0.1$; **$p < 0.05$; ***$p < 0.01$.

To understand this further, a random sample of 60 cases (30 each for buyer-side and seller-side anticoncessionary tactics) was selected and qualitatively examined for motives and behaviors. That is, the sequences of bids and chat exchanges were inspected for revealed logic. This resulted in identifying five logics for anticoncessionary bidding, categorized as follows (the definitions are followed by the percentage of anticoncessionary behaviors explained, for sellers and buyers):

Threat. The archetype for a threat was a steady worsening in offered bids, signaling to the other to accept now or get even less in the future (60% of the sample for sellers and 40% for buyers).

Mistake. Sometimes the anticoncessionary bid was claimed to be a mistake. In these cases, the firm typically quickly offered another bid (13.3% for sellers and 16.7% for buyers).

Intervening bid. This was only possible in the stage 1 2×2 negotiations. Sometimes a negotiator would announce that an intervening bid in his or her parallel negotiations (with the other supplier, for example) changed the landscape, hardening that negotiator's position (3.3% for sellers and 23.3% for buyers).

Being nice. Sometimes the opponent actually invited an anticoncessionary bid, even though such a bid was not favorable to him or her. From the chats there seemed to be two justifications for this. The first was a sense of fairness that outweighed the desire for private gains, and the opponent invited bids that divided things relatively evenly. The second was strategic, made in hopes of strengthening the potential chain's position in negotiations with the retailer. In both cases, the chats invited and/or supported an anticoncessionary bid (10% for sellers and 6.7% for buyers).

Playing around. The first 120 seconds of exchanges was relatively riskless because nobody could accept bids during that initial chat period, and some negotiators saw this as an opportunity to signal that business does not have to unfold as usual. This is suggested by one or a few unexpected bids and then recovery to more standard bargaining sequences (0% for sellers and 3.3% for buyers).

The remaining cases in the sample were unexplained. Also, there are possible hybrid logics among these that can neither be confirmed nor ruled out by the data. For example, a clear threat means that there is surplus that the bidder was willing to concede (perhaps to be fair), but the more the opponent delays, the less nice the bidder will be. The usual caveats apply when one is trying to infer internal logics from external data.

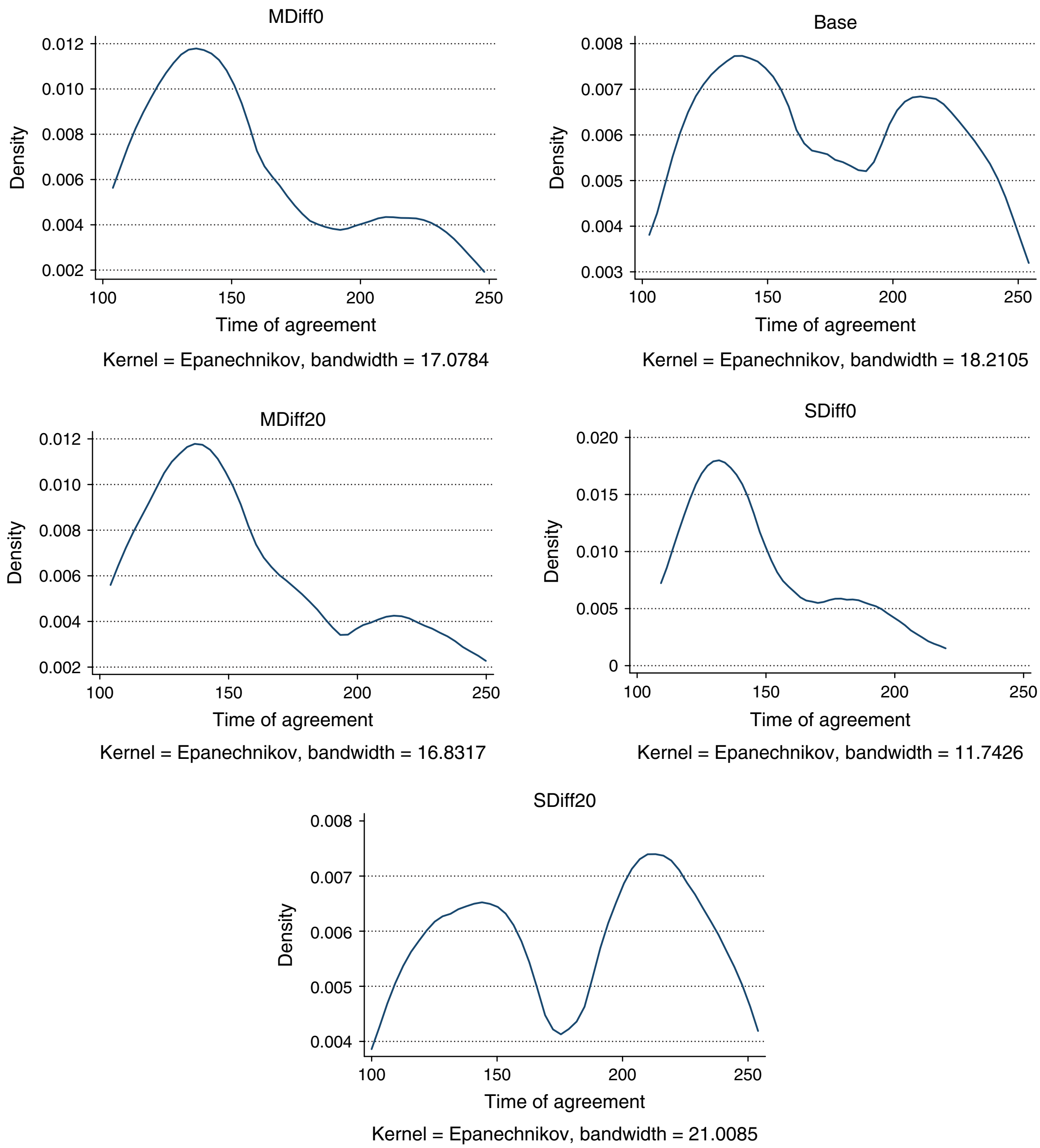
The modal anticoncessionary behaviors are conscious threats, so anticoncessionary bids appear to be strategic tactics consciously employed by negotiators. Intuitively, one might think of two possible motives. The first would come from a position of strength where offering descending bids is a credible threat. The second is from a position of weakness, where one wishes to inject some irrationality into a system that is rationally disadvantageous. The qualitative analysis of the bids and chats could not unambiguously unravel these; however, if either were dominant, we should see some treatment effects (based on positions of strength or weakness). We do not see evidence of this. Buyer anticoncessionary behavior appears evenly across treatments, and almost half of all instances of seller anticoncessionary behavior are in the MDiff20 treatment, which features moderate to low competition in both tiers. So there does not appear to be one pure motive for or logic behind anticoncessionary tactics that is tied to strength of position. In summary, anticoncessionary behavior appears to be consciously employed in a threatening manner and to have significant beneficial effects for the sell side, but not the buy side. A further refinement of what contingencies suggest this tactic will require further research.

5.2.4. Deadline Effect. Roth et al. (1988) observed a high concentration of agreements in the final 30 seconds of their bargaining experiments. The most common interpretation of this is that negotiators will probe for advantage as long as there is time remaining but realize more acutely the need to close as time is expiring. Those results, however, were for bilateral bargaining where any one party could unilaterally keep the negotiations open. In our setting, firms face the possibility of being closed out of the deal, which may inject pressure to close sooner rather than delay. Do we see a deadline effect in our setting?

The answer is yes, with some caveats. Agreement times during both stages are bimodal, with a large fraction of agreements struck shortly after agreements become possible at 120 seconds, and then (typically) another mode toward the deadline. In stage 1 the deadline effect is not strong, with a significant difference between the last 30 seconds and previous 30 seconds in only two treatments for agreements involving manufacturer 1 (Base: $p = 0.04$, SDiff20: $p < 0.01$) and only one treatment for manufacturer 2 (MDiff20: $p < 0.01$). Hence, anxiety to close may be significant in stage 1, leaving subjects reluctant to push negotiations to the deadline.

However, there is a substantial deadline effect in stage 2. Figure 4 shows the distribution of agreement times in periods 2–6 (so as not to mix period lengths; see Footnote 1). In each treatment except SDiff0, at least 25% of agreements are made in the last 30 seconds, with more than 50% of agreements closing in the last half-minute in the SDiff20 treatment. This is between two and five times as many agreements closing than in the previous 30 seconds. A test of proportions shows a significant increase in these four treatments (MDiff0: $p = 0.02$, Base: $p = 0.04$, MDiff20: $p = 0.06$, SDiff20: $p < 0.01$).

Figure 4 (Color online) Agreement Times by Treatment During Second-Stage Bargaining



5.2.5. Timing of Closure. One feature of our bargaining context (relative to simple bilateral bargaining) is the pressure to close a deal so as not to be left out (only one manufacturer is chosen by the retailer, and one supplier is chosen by each manufacturer). As alluded to above, one might anticipate that this context would generate faster closure times, consistent with an anxiety-to-close interpretation driven by competitive realities. In addition, it is intuitive, and a feature of some analytical models (see Muthoo 2002 and references there), that impatience (as a personality trait) is disadvantageous in negotiations. If a negotiator feels that he or she has to reach a deal sooner rather than later, whether because of personality traits or structural reality, she is unlikely to get the most out of the negotiations. We cannot disentangle personality traits from structural characteristics in driving a desire for earlier closing times, but we can test whether early closing times are related to structural characteristics and/or outcomes.

In stage 1 the earliest closing treatments for both manufacturers were MDiff0 (M1: 133 seconds, M2: 137 seconds) and MDiff20 (M1: 131 seconds, M2: 143 seconds). The latest closing treatment for manufacturer 1 was the Base treatment (155 seconds), whereas the latest closing treatment for manufacturer 2 was SDiff20

(164 seconds). In stage 2 negotiations, we find that in periods 2–6 (with four-minute bargaining periods) the average closure time for the Base (175 seconds) and SDiff20 (179 seconds) treatments is significantly later than for the MDiff0 (158 seconds) and SDiff0 (147 seconds) treatments ($p = 0.07$ and $p = 0.01$ for Base versus MDiff0 and SDiff0; $p = 0.05$ and $p = 0.02$ for SDiff20 versus MDiff0 and SDiff0). The MDiff20 treatment (159 seconds) is not significantly different from any treatment. These do not consistently line up with a structural interpretation. We would expect that the pressure to close would be greatest when the cost differences are smallest. However, if we regress closing times in stage 2 on the absolute difference in total cost between the two manufacturers, although the sign is positive (as anticipated), it is not significant ($\beta = 0.815$, $p = 0.170$). If we include treatment dummies, the effect of the cost difference is positive and significant ($\beta = 1.996$, $p = 0.028$). However, the treatment dummies for closure time are still fairly large, so the pressure to close is not fully explaining the treatment differences. In summary, we see no consistent relationship between closing time and structural characteristics in our experiments.

Regardless of what is driving closing time, is it related to outcomes? Table 15 reports the results of regressing the share of the ZOPA that the buying firm earns under the agreement on the time of the agreement, where we track separately cases where the buying firm accepts a selling firm's offer and where a selling firm accepts a buying firms offer. We find no evidence for an impatience or anxiety effect for either firm: early agreements and late agreements yield very similar outcomes. We also find similar results using price rather than surplus share as the dependent variable. So even if there was some feature driving a desire for earlier closing times, they do not appear to significantly affect outcomes.

5.3. Bargaining Dynamics Discussion

As is usual in bargaining experiments, we find a higher level of nonclosure than one would expect using purely rational economic reasoning. We find no evidence that escalation of commitment is the reason, but otherwise, we are unable with our data to identify the cause. The literature suggests issues of fairness and/or emotional concerns not typically part of economic models.

We find a significant anchoring effect in that the first bids anchor the negotiations and the final price tends to be midway between the initial bids. However, we find no first-mover advantage. So each party should consider its initial bid carefully, but it does not matter in which sequence negotiators offer their initial bids.

We see a significant deadline effect in stage 2 but much less of one in stage 1 negotiations, suggesting that, with horizontal competition on both sides, the desire to bargain to the end is tempered by a countervailing desire to close. However, we find no relationship between when a deal is struck and final prices. (We would expect such a relationship if impatience or anxiety to close put negotiators at a disadvantage.)

The actual sequence of bids leading to closure largely follows an intuitive path, featuring an initial anchor bid and then concessions (price increases for buyers, price decreases for sellers) leading to eventual closure. However, sell-side firms that use an aggressive strategy of making anticoncessionary bids (15%–20% of firms) benefit significantly, raising the final price without reducing the closure rate. There is no equivalent benefit for the buy side: any benefit to prices is offset by a reduction in closure. Although a mixture of motives can lead to anticoncessionary tactics, the modal behavior is a threat that things could get worse if the other firm is not more accommodating.

Another interesting buy-side versus sell-side asymmetry appears in our data. The original anchor bids and the lack of extreme reactions to them clearly indicate

Table 15 **Effect of Agreement Timing of Buying Firm's Share**

	M1–S bargaining		M2–S bargaining		R–M bargaining	
Variable	(1)	(2)	(3)	(4)	(5)	(6)
Time Accepted by Buyer	−0.000366	9.17e–05	−0.000991	−0.000186	−0.000313	−4.37e–05
	(0.000503)	(0.000363)	(0.000793)	(0.000505)	(0.000371)	(0.000373)
Time Accepted by Seller	−0.000172	0.000220	−0.000459	0.000143	−0.000464	−0.000311
	(0.000525)	(0.000306)	(0.000709)	(0.000514)	(0.000335)	(0.000326)
Treatment controls	No	Yes	No	Yes	No	Yes
Constant	0.762***	0.690***	0.779***	0.645***	0.695***	0.647***
	(0.0906)	(0.0486)	(0.107)	(0.0811)	(0.0580)	(0.0674)
Observations	195	195	192	192	181	181
R^2	0.009	0.440	0.046	0.362	0.016	0.220

Notes. Standard errors clustered at the session level are reported in parentheses. The dependent variable is the fraction of the ZOPA allocated to the buyer in the agreement.

$^{*}p < 0.1$; $^{**}p < 0.05$; $^{***}p < 0.01$.

that both sides perceive the buy side to be in a stronger position than the sell side. The buy side demands a larger fraction of the possible surplus than the sell side, and that remains true through closure. This makes sense in the second stage, where the monopolist retailer really is in a strong position. However, the justification for this behavior is not clear in the first stage of negotiations in MDiff0 and SDiff20, where the low-cost seller should be in a strong position. There appears to be a psychological construct at play that grants the buyer a position of power unexplained by the costs alone. We cannot diagnose this further with our data, but we can suggest some possibilities. Stage 1 has the feature that no party knows how the retailer will behave, and the buyer has to carry that burden into stage 2. It may also be that in the more complex multilateral context of stage 1, boundedly rational negotiators fall back to intuitive, but not necessarily relevant, framings that give the buyer power they do not structurally deserve. Either way, negotiations in realistic supply chain contexts open up new questions that one may not encounter in more conventional bilateral bargaining experiments.

6. Summary and Conclusions

Central questions in the study of supply chain performance are those of efficiency (is the total profit maximized?) and distribution (who gets the potential profits in the chain, driven by what contingencies?). In this paper we study these and other questions in the context of a three-tier, $2 \times 2 \times 1$ (suppliers $\times$ manufacturers $\times$ retailer) supply chain with varying levels of horizontal competition in the manufacturer and supplier tiers. Bargaining unfolds in a manner sympathetic to many real supply negotiations between a market-facing firm and its tier 1 suppliers and between tier 1 and tier 2 suppliers. Despite its sympathy with industrial reality, to the authors' knowledge, this is the first experimental study of a supply chain with more than two tiers and horizontal competition within tiers.

We find that chains form with high probability and supply chain efficiency is high across all treatments. Profits are influenced by the degree of horizontal competition in each tier, in a manner that is largely consistent with the balanced principal model of supply chain negotiated prices. Specifically, profits in a tier will generally increase with less competition in the tier, and decrease with less competition in other tiers. A firm's profits can depend significantly on competitive realities in a remote tier. Deviations from predicted outcomes tended to be in the direction of more equitable distributions of wealth, where one of the parties (the retailer primarily) does not extract all of the value that it theoretically could demand.

There is no alternative theoretical prediction for our stage 1 negotiations known to the authors, but stage 2 negotiations can benefit from leader–follower (LF) as well as BP predictions. Our results augment existing experimental evidence that outcomes tend to be less extreme than standard preference LF models would predict and more aligned with bargaining model predictions. In our experiments, the BP model outperforms both types of standard preference LF model (with either the retailer or the manufacturing tier in the role of leader). Restricting attention only to LF models in $n \times 1$ settings, the popular (and somewhat intuitive) tendency to declare the 1 player the leader is not as aligned with our experimental outcomes as the alternative common agency assumption (with the n-firm tier as the leader).

The BP model predicts that when there are two viable manufacturers negotiating with a single retailer, the efficient manufacturer will get the contract and enjoy profits equal to $0.5\Delta c_m$. We generalize this to assuming profits equal to $\alpha\Delta c_m$ and estimate the best α from our experimental data. Pooling all treatments, α is not significantly different from 0.5 (its best-fitting estimate equals 0.57), but in specific treatments the best α can differ significantly from 0.5. When this happens, it is in the direction of more equitable distributions of wealth (the retailer does not bargain as aggressively as predicted).

The cost profile in the chain dominates personal negotiator characteristics (risk aversion, altruism, etc.) in influencing outcomes. This is consistent with current conventional wisdom that structural characteristics dominate interpersonal differences in these settings. We see a more dramatic deadline effect in stage 2 negotiations than in stage 1, suggesting that this effect can be mediated by a more complex bargaining context. The bargaining strategies that individuals use have significant impact on bargaining outcomes. The initial offers that both the buying and selling firms make serve as anchors that significantly affect the final price agreement. Additionally, sell-side firms who choose to make anticoncessionary offers achieve significantly higher prices without compromising closure rates. Finally, buy-side firms seem to be granted a degree of deference that is not uniformly supported by the cost profiles, which may be a cognitive feature worthy of further research.

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