Contracts and Capacity Investment in Supply Chains

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Abstract. Suppliers are often reluctant to invest in capacity if they believe that they will be unable to recover their investment costs in subsequent transactions with buyers. In theory, a number of different contracts can solve this issue and induce first-best investment levels by the supplier. In this study, we investigate the performance of these contracts in a two-tier supply chain. We develop an experimental design where retailers and suppliers bargain over contract terms—and have the ability to make multiple back-and-forth offers—while also providing feedback on the offers they receive. One key result from our study is that an option contract and a service-level agreement are best at increasing first-best investment levels and overall supply chain profits. However, these same contracts also generate the largest inequity in expected profits between the two parties. We find that both of these results are driven by the bargaining tendencies of retailers and suppliers, which we refer to as “superficial fairness.” In particular, retailers and suppliers place more emphasis on negotiating the wholesale price, while partially overlooking any secondary parameter, such that final wholesale prices end up roughly halfway between the retailer’s selling price and the supplier’s production cost. We show that this bargaining behavior contributes to higher investment levels observed in the option contract and service-level agreement, along with the inequitable payoffs.

Keywords: behavioral operations • supply chain management • capacity planning and investment • incentives and contracting

1. Introduction

Firms often face the challenge of ensuring that their suppliers develop and maintain sufficient production capacity. A classic example of this involves General Motors (GM) purchasing metal car bodies from its supplier, Fisher Body (Klein et al. 1978, Coase 2006, Klein 2007). As demand increased, GM wanted Fisher to continue expanding its plants to increase capacity. However, in an example such as this, a supplier like Fisher Body may be reluctant to make investments, such as developing capacity, if it believes that its future profits will be insufficient, as a result of either low bargaining power or ex post opportunism. As a consequence, it may invest in less capacity than what would be jointly optimal (first-best). Furthermore, Cachon and Lariviere (2001), in a related capacity investment setting with forecast sharing, highlight a number of examples where suppliers are left without returns from their capacity investments, and they suggest that “suppliers may be wise to avoid spending heavily to serve assemblers” (Cachon and Lariviere 2001, p. 630).

To increase supplier capacity investment levels, theoretical research has proposed a number of solutions. Vertical integration aligns the firms’ incentives, but it can involve substantial costs and presents additional risks and challenges (Stuckey and White 1993). Long-run buyer–supplier relationships can also promote investment. However, the scope of many capacity investments, and the likelihood that market characteristics will change, can make long-run relationships difficult to maintain. Formal contracts can provide direct or indirect incentives to invest, and they have been highlighted in the operations management literature as a leading solution (e.g., Tomlin 2003, Özer and Wei 2006, Plambeck and Taylor 2007, Taylor and Plambeck 2007). In this study, we focus on contractual solutions to capacity investment problems. Specifically, we conduct a series of controlled human-subject experiments that determine whether different contractual solutions can increase supplier capacity investment levels and supply chain profits when allowing human decision makers to bargain over contract parameters and make capacity investment decisions.

While a number of papers have analyzed capacity investment problems from a theoretical standpoint, only a few experimental studies exist on the topic (e.g., Hoppe and Schmitz 2011). Many of these assume settings with deterministic demand and simplified
bargaining. In our study, we incorporate a two-stage supply chain where demand is randomly determined, and we implement a unique structured bargaining protocol that allows both a retailer and a supplier to make multiple, back-and-forth offers over contract parameters. Additionally, in our bargaining setting, subjects can send limited feedback, detailing whether they feel a particular contract parameter is too high or too low. Through this bargaining protocol we are able to not only mimic a more realistic environment but also observe how offers evolve over time and the types of feedback sent.

Using this experimental design with human decision makers, we evaluate the problem of supplier capacity investment, with the aim of answering the following research questions: (1) How do alternative contracts, many of which are equivalent in theory, perform at increasing first-best investment rates and expected supply chain profits? (2) In those contracts that are effective at inducing first-best investment rates, how are expected supply chain profits distributed between the retailer and supplier? (3) What is the behavioral driver that generates any observed differences across contracts?

We begin by theoretically investigating several contractual solutions to the capacity investment problem under two-point demand, and we show that, in theory, many of the contracts allow for various combinations of contract parameters (a price premium for higher quantities, a minimum quantity commitment, an option fee for investing in capacity, and a bonus for satisfying demand) that can generate first-best capacity investment decisions for suppliers and also equalize expected profits between the retailer and supplier. We then conduct a series of experiments directly testing these theoretical predictions and find that the contracts perform quite differently than the normative benchmarks. In particular, our first main experimental result is that the option contract, where the supplier receives a fixed option fee from the retailer that is forfeited whenever the supplier fails to invest in capacity, and the service-level agreement, where the retailer awards the supplier a bonus anytime the supplier can satisfy all of demand, both perform substantially better than the other contracts at increasing supplier investment, and thus they generate higher expected supply chain profits. However, another key result is that these same contracts, while best at inducing higher levels of first-best investment, are also tied to the most inequitable payoffs. More specifically, we observe that as certain contracts increase overall supply chain profits, these gains heavily favor the supplier.

The bargaining data from our study suggest that there are two primary reasons for these experimental results, which we collectively refer to as “superficial fairness.” In particular, (1) when retailers and suppliers bargain over multiple contract parameters, both parties, across all contracts, devote more effort toward negotiating the wholesale price while largely overlooking the secondary parameter (such as a secondary wholesale price, quantity commitment, option fee, or bonus), and (2) subjects make concessions while bargaining; that is, they first make an initial wholesale price offer that greatly favors themselves, and then each makes concessions until the final wholesale price is roughly in the middle of the supplier’s production cost per unit and the retailer’s revenue per unit. We show that these behavioral tendencies can account not only for the favorable performance of the option contract and service-level agreement, in terms of overall investment rates and supply chain profits, but also for the observed distribution of expected profits between the two parties. Furthermore, our theoretical analysis of superficial fairness also indicates when alternative contracts, such as the quantity commitment contract, may indeed perform more favorably relative to the option contract and service-level agreement.

In an effort to determine whether the results from our main study are sensitive to our experimental setting, we conduct two additional robustness studies. The first considers a slightly altered demand setting where superficial fairness, if present, should lead to increased investment rates (which we do observe). The second robustness study incorporates a slightly richer environment, by assuming that demand is continuous. In both of these robustness checks, we find support for each of our main experimental results, along with evidence of superficial fairness.

2. Related Literature

The general problem of underinvestment over a relation-specific investment, when the returns are expropriable by another party, has been extensively studied in economics. The most prominent theoretical solutions include vertical integration, contracting, and repeated interaction (e.g., Klein et al. 1978, Williamson 1979, Grossman and Hart 1986, Hart and Moore 1990, Chung 1991, Klein and Leffler 1981, Baker et al. 2002). From an experimental economics standpoint, Sloof et al. (2004), Ellingsen and Johannesson (2004), and Sloof (2008) test whether investment decisions respond to the structure of the situation as theory predicts in certain settings. Most relevant to our study are works that test the role of contracts and organizational form as solutions to capacity investment problems. In particular, Hoppe and Schmitz (2011) study whether contracts can improve decisions when renegotiation is possible. Fehr et al. (2008) and Dufwenberg et al. (2013) examine how the allocation of control rights affects results. In general, a majority of these studies focus on settings with deterministic outcomes from decisions and one-shot ultimatum offers, whereas our work...
incorporates random demand and allows for dynamic structured bargaining.

In terms of bargaining, the theoretical literature is quite rich, including process-free bargaining solutions (such as the Nash bargaining solution; Nash 1950), game-theoretic analyses of sequential bargaining games (Rubinstein 1982), and more (see Muthoo 1999 for a comprehensive summary). From an experimental perspective, studies exploring bargaining typically apply one of two extreme structures: ultimatum one-shot offers or complete free-form negotiation. The former are useful in that theoretical benchmarks are more easily derived and tested, but offers may stray from a more natural back-and-forth negotiation. On the other hand, complete free-form negotiation is attractive in capturing a more realistic bargaining process, but there is a risk of losing control in the laboratory (i.e., participants revealing personal information or making appeals to context not present in the experiment). In our study, we develop and implement a bargaining protocol that lies between these two extremes. In particular, we allow both players to make multiple offers and also permit them to send limited feedback about offers received. Thus, we attempt to mimic a more natural bargaining process while preserving the ability to observe all offers and the types of feedback sent. Both ultimatum and free-form negotiation experiments reliably show that fairness is a major concern (e.g., Guth et al. 1982, Guth and Tietz 1990, Leider and Lovejoy 2016), and therefore we expect fairness to play an important role in our setting.

Our paper also draws on the extensive literature in economics and psychology on biases in bargaining (see Bazerman and Neale 1994 and Bazerman et al. 2000 for excellent surveys of the psychology literature on negotiation biases, and see Roth 1995 and chapter 4 of Camerer 2003 for surveys of the experimental economics literature on bargaining). One relevant bias is the “fixed-pie bias”—that is, the (incorrect) belief according to which negotiators focus on bargaining over how to divide a fixed surplus, failing to recognize opportunities to work together to affect outcomes. Second, they may focus on claiming value rather than on finding ways to increase joint surplus or equalize expected payoffs. Thus, we attempt to mimic a more natural bargaining process while preserving the ability to observe all offers and the types of feedback sent. Both ultimatum and free-form negotiation experiments reliably show that fairness is a major concern (e.g., Guth et al. 1982, Guth and Tietz 1990, Leider and Lovejoy 2016), and therefore we expect fairness to play an important role in our setting.

If, indeed, subjects fail to appreciate how the contractual terms work together to provide incentives, the structure and directness of the incentives under different contractual forms may be particularly important. Both theoretical (Kerr 1975, Holmstrom and Milgrom 1991, Baker 1992) and experimental (Philipson and Lawless 1997, Fehr and Schmidt 2004, Scheele et al. 2014, Al-Ubaydli et al. 2015) evidence suggests that incentives that are partial, indirect, or misaligned with the ultimate goal will likely perform worse. This intuition is often called the “foolish of rewarding A, while hoping for B” (Kerr 1975). In our setting, the option contract and service-level agreement provide the most direct incentives toward capacity investment. Hence, if negotiation biases cause subjects not to fine-tune contract parameters, these results would suggest that the contract with the most direct incentives will achieve the best performance.

From an operations management standpoint, a number of theoretical studies investigate how contracts can induce a supplier to invest in capacity for a retailer. For example, Cachon and Larivi`ere (2001) investigate an asymmetric information setting where a manufacturer can share its forecast demand information with a sole-source supplier, and the supplier decides how much capacity to invest (which is extended by Tomlin 2003 and ¨Ozer and Wei 2006). Other works include Taylor
and Plambeck (2007), who consider a classic capacity investment decision setting and derive optimal price and price with quantity contracts. We believe our work is unique to this rich literature in taking a behavioral standpoint and identifying contractual solutions to capacity investment problems with human decision makers interacting under a more natural bargaining setting.

3. Theory

One solution to the capacity investment problem is to allow the parties to negotiate a contract prior to any supplier investment decision. Here, we present a theoretical review of five contracts (wholesale price, quantity premium, quantity commitment, option, and a service-level agreement), which are used in practice (Lovejoy 2010, Plambeck and Taylor 2007, Obilcore 2007) and may induce the supplier to invest in capacity through different mechanisms. For example, the quantity premium contract can lead to first-best investment through multiple prices, whereas the quantity commitment contract makes investment attractive through a minimum order quantity by retailers.

For all contracts, assume demand follows a two-point distribution, with high demand \( D > 0 \), and difference in demand \( \delta = D - d > 0 \). High demand \( D \) occurs with probability \( p \), and low demand \( d \) occurs with probability \( 1 - p \), with \( p \in (0,1) \). The supplier \( S \) manufactures products instantaneously, begins with sufficient capacity to make \( d \) units, and can incur a fixed cost of \( K \) to increase capacity to \( D \) units. The supplier’s capacity is only useful to satisfy demand for the retailer’s \( R \) product; that is, capacity is relationship specific to the retailer.

There is full information for both parties about the model parameters. Let \( r \) represent the retailer’s revenue per unit, and let \( c = 0 \) denote the supplier’s marginal cost of production per unit. The retailer and supplier agree ex ante, before the supplier’s investment decision, to buy and sell units at a wholesale price \( w \), \( 0 \leq w \leq r \), plus any additional contract terms. We assume that investment in capacity is beneficial for the overall supply chain \( K \leq rp\delta \).

Let \( \pi_i(x) \) denote the expected profit function of party \( i \), \( i \in \{R,S\} \), in contract \( j \), \( j \in \{WP,QP, QC, OP, SL\} \), where \( x \) is the supplier’s investment decision, \( x \in \{Yes, No\} \). We will refer to any set of contract terms where it is expected profit maximizing for the supplier to invest in capacity as an incentive-compatible contract. Also, because renegotiation is not a focus of our study, we assume that renegotiation is not possible, and hence incentive compatibility depends on the initial terms of the contract.

Because fairness is likely to be a concern during bargaining, we will discuss for each contract whether fairness and incentive compatibility are jointly possible. First, we will identify the parameters that both satisfy incentive compatibility and allow for equal expected profits. Second, since the bargaining literature suggests that the wholesale price is likely to be salient and that negotiators may have biased notions of fairness, we will specifically note what is possible when \( w = r/2 \); that is, the wholesale price is at the midpoint between revenue and marginal cost. Table 1 shows the specific contractual terms required given the parameters used in the experiment.

3.1. Wholesale Price Contract

Under a wholesale price (WP) contract, the retailer and supplier agree to buy and sell units at wholesale price \( w \), where the expected profit functions are:

\[
\pi_R^{WP}(x) = \begin{cases} (r-w)d & \text{if } x = \text{No,} \\ (r-w)(d+p\delta) & \text{if } x = \text{Yes;} \end{cases}
\]

\[
\pi_S^{WP}(x) = \begin{cases} wd & \text{if } x = \text{No,} \\ w(d+p\delta) - K & \text{if } x = \text{Yes.} \end{cases}
\]

The WP contract is incentive compatible for the supplier if \( w \geq K/(p\delta) \). However, note that this is equivalent to \( w/r \geq K/(rp\delta) \), implying that as \( K \to rp\delta \), then \( w \to r \), leading to investment but requiring unequal profit shares between the two parties. Equalizing expected profits further requires that \( w/r = 1/2 + K/(2r(d+p\delta)) \). To jointly have incentive compatibility and equal expected profits requires \( rp\delta \geq (2d+p\delta)/(d+p\delta)K \) (i.e., the surplus increase from the investment has to be large relative to the cost of the investment and the amount of demand that can be covered without the investment). Additionally, note that with \( w = r/2 \), for incentive compatibility, one would need \( K/(rp\delta) \leq 1/2 \), again requiring an inexpensive investment. Equalizing expected profits is not possible with \( w = r/2 \). Our main experiment will use parameters such that \( K \) is not large enough to satisfy the conditions for equal profits or the conditions for incentive compatibility with \( w = r/2 \); however, we will conduct an additional experiment as a robustness check that uses different parameters that satisfy both conditions.

3.2. Quantity Premium Contract

A quantity premium (QP) contract states that the retailer and supplier agree to buy and sell units at wholesale price \( w_1 \), \( 0 \leq w_1 \leq r \), for the first \( d \) units and wholesale price \( w_2 \), \( 0 \leq w_2 \leq r \), for any units sold above \( d \). In this contract the expected profit functions are as follows:

\[
\pi_R^{QP}(x) = \begin{cases} (r-w_1)d & \text{if } x = \text{No,} \\ (r-w_1)d + (r-w_2)p\delta & \text{if } x = \text{Yes;} \end{cases}
\]

\[
\pi_S^{QP}(x) = \begin{cases} w_1d & \text{if } x = \text{No,} \\ w_1d + w_2p\delta - K & \text{if } x = \text{Yes.} \end{cases}
\]
The QP contract is incentive compatible when \( w_2 \geq K/(p \delta) = \bar{w}_2 \). In addition, there is a range of QP contracts that both are incentive compatible and generate equal expected profits. For this to be true, \( w_2 = ((r - 2w_1)d + r p \delta + K)/(2p \delta) \) must hold. Additionally, we must have \( w_2 \geq \bar{w}_2 \) (for incentive compatibility), as well as \( r \geq w_2 \). Therefore, the following two conditions are required on \( w_1 \): (1) \( w_2 \geq \bar{w}_2 \) if \( w_1 \leq (r(d + p \delta) - K)/(2d) \), and (2) \( r \geq w_2 \) if \( w_1 \geq (r(d + p \delta) + K)/(2d) \). Thus, a QP contract is incentive compatible and equalizes expected profits when the following two conditions are satisfied:

\[
\begin{align*}
w_2 &= \frac{(r - 2w_1)d + r p \delta + K}{2p p \delta}, \\
r(d + p \delta) + K &= \frac{r(d + p \delta) - K}{2d} \leq w_1 \leq \frac{r(d + p \delta) + K}{2d}.
\end{align*}
\]

For \( w_1 = r/2 \), the incentive compatibility condition becomes \( q \geq \frac{(r(d - p D) + 2K)/(r(1 - p))} \). Having equal expected profits requires \( q = \frac{(r(1 - p)d + K)/(r(1 - p))} \), which also satisfies incentive compatibility.

### 3.3. Quantity Commitment Contract

Under a quantity commitment (QC) contract, the retailer and supplier agree to buy and sell units at a wholesale price of \( w \), with a commitment that the retailer buy at least \( q \) units, \( d \leq q \leq D \), regardless of demand. If the supplier does not invest, and is therefore unable to deliver \( q \) units, then the retailer is released from the commitment and is free to order any amount. In the QC contract the expected profit functions are given by

\[
\begin{align*}
\pi_{op}^R(x) &= \frac{(r - w)d}{(1 - p)(r d - wq) + p(r - w)D} \quad \text{if } x = \text{No}, \\
\pi_{op}^S(x) &= \frac{wd}{w(q + p(D - q)) - K} \quad \text{if } x = \text{Yes}.
\end{align*}
\]

The QC contract is incentive compatible when \( q \geq (w(d - p D) + K)/(w(1 - p)) = \bar{q} \). As with the QP contract, in the QC contract, there is a range of possible contracts that are incentive compatible and that equalize expected profits. To ensure this, \( q = \frac{(r - 2w)p D + r(1 - p)d + K)/(2w(1 - p)) \) must hold. Additionally, we must have \( q \geq \bar{q} \), as well as \( d \leq q \leq D \), leading to three conditions on \( w \): (1) \( q \geq \bar{q} \) if \( w \leq (r(d + p \delta) - K)/(2d) \), (2) \( q \geq d \) if \( w \leq (r(d + p \delta) + K)/(2(d + p \delta)) \) and (3) \( D \geq q \) if \( w \geq (r(d + p \delta) + K)/(2D) \). Therefore, a QC contract is incentive compatible and equalizes expected profits between the two parties when the following conditions are satisfied:

\[
\begin{align*}
q &= \frac{(r - 2w)p D + r(1 - p)d + K}{2w(1 - p)}, \\
r(d + p \delta) + K &= \frac{(r(d + p \delta) - K)}{2d} \leq w \leq \min \left\{ \frac{(r(d + p \delta) - K)}{2d}, \frac{(r(d + p \delta) + K)}{2(d + p \delta)} \right\}.
\end{align*}
\]

For \( w = r/2 \) the incentive compatibility constraint is \( p \geq (K - rp \delta)/2 \). The requirement for equalizing expected profits is \( p = K/2 \), which also satisfies incentive compatibility.

### 3.4. Option Contract

In the option (OP) contract, the retailer and supplier agree to buy and sell units at a wholesale price of \( w \), and the retailer pays a lump sum option fee \( p_o \) to the supplier. If the supplier does not invest, he will be unable to execute the terms of the contract (i.e., unable to deliver all units the buyer has an option for) and forfeits the option fee. Note that, given our two-point demand setting, this is a special case of the more general option contract, where the retailer buys \( d \leq q_o \leq D \) options for an option fee of \( p_o \), giving the retailer the right to buy up to \( q_o \) units at a certain price \( w_o \) (and a higher price for any additional units), and if the retailer exercises more units than the supplier can deliver, the supplier must refund the option fee \( p_o \). Since this more general contract has four parameters (and would be more complex than the other contracts), our special case effectively fixes the number of options at \( q_o = D \). In a later robustness study, we investigate this more general case by incorporating continuous demand. In the OP contract the expected profit functions are

\[
\begin{align*}
\pi_{op}^R(x) &= \begin{cases} 
(r - w)d & \text{if } x = \text{No}, \\
(r - w)(d + p \delta) - p_o & \text{if } x = \text{Yes};
\end{cases} \\
\pi_{op}^S(x) &= \begin{cases} 
wd & \text{if } x = \text{No}, \\
w(d + p \delta) + p_o - K & \text{if } x = \text{Yes}.
\end{cases}
\end{align*}
\]

The OP contract is incentive compatible when \( p_o \geq (K - wp \delta) = \bar{p}_o \). Turning to the distribution of expected profits, and incentive compatibility, \( p_o = ((r - 2w)(d + p \delta)/2) \) must hold to equalize expected profits. We also must have \( p_o \geq \bar{p}_o \) for incentive compatibility, as well as \( p_o \geq 0 \), and therefore require the following conditions on \( w \): (1) \( p_o \geq \bar{p}_o \) if \( w \leq (r(d + p \delta) - K)/(2d) \), and (2) \( p_o \geq 0 \) if \( w \leq (r(d + p \delta) + K)/(2(d + p \delta)) \). Thus, an OP contract is incentive compatible and equalizes expected profits between the two parties when the following two conditions are satisfied:

\[
\begin{align*}
p_o &= \frac{(r - 2w)(d + p \delta) + K}{2}, \\
w &\leq \min \left\{ \frac{(r(d + p \delta) - K)}{2d}, \frac{(r(d + p \delta) + K)}{2(d + p \delta)} \right\}.
\end{align*}
\]

For \( w = r/2 \) the incentive compatibility constraint is \( p_o \geq (K - rp \delta)/2 \). The requirement for equalizing expected profits is \( p_o = K/2 \), which also satisfies incentive compatibility.
3.5. Service-Level Agreement
Under a service-level (SL) agreement, the retailer and supplier agree to buy and sell units at a wholesale price of \( w \), and the retailer promises to pay the supplier a lump sum bonus \( B \) any time the supplier can satisfy 100% of the retailer’s demand. Therefore, the investment decision by the supplier is unobservable to the retailer, and the supplier may receive the bonus if they neglected to invest in capacity and demand is low. In the SL agreement the expected profit functions are

\[
\pi^\text{SL}_R(x) = \begin{cases} 
(r - w)d - (1 - p)B & \text{if } x = \text{No}, \\
(r - w)(d + p\delta) - B & \text{if } x = \text{Yes}; 
\end{cases}
\]

\[
\pi^\text{SL}_S(x) = \begin{cases} 
wd + (1 - p)B & \text{if } x = \text{No}, \\
wd + p\delta + B - K & \text{if } x = \text{Yes}. 
\end{cases}
\]

The SL agreement is incentive compatible when \( B \geq (K/p - w\delta) = \bar{B} \). To equalize expected profits between the parties, \( B = (r - 2w)(d + p\delta) + K)/2 \) must hold. Furthermore, we need \( B \geq \bar{B} \) for incentive compatibility and \( B \geq 0 \), leading to the following conditions on \( w \):

1. \( B \geq \bar{B} \) if \( w \leq (rp(d + p\delta) - K(2 - p))/(2pd - (1 - p)\delta) \),
2. \( B \geq 0 \) if \( w \leq (r(d + p\delta) + K)/(2d + p\delta) \). Therefore, an SL contract is incentive compatible and equalizes expected profits between the two parties when the following three conditions are satisfied:

\[
\begin{aligned}
B &= \frac{(r - 2w)(d + p\delta) + K}{2}, \\
w &\leq \min \left\{ \frac{r(d + p\delta) + K}{2d + p\delta}, \frac{rp(d + p\delta) - K(2 - p)}{2pd - (1 - p)\delta} \right\}.
\end{aligned}
\]

For \( w = r/2 \), we need \( B \geq K/p - r\delta/2 \) for incentive compatibility. For equal expected profits, we need \( B = K/2 \). To have both incentive compatibility and equal expected profits requires the parameters to be such that \( rp\delta \geq K(2 - p) \): that is, the surplus increase from investment must be sufficiently large relative to the cost of the investment. The parameters in our main experiment do not satisfy this condition, although they are such that nearly equal expected profits are possible.

3.6. Psychological Biases
The theoretical results describe how a sophisticated designer could set the contract terms to maximize surplus and equalize payoffs. From this perspective all four of the coordinating contracts are in some sense equivalent. However, the interplay between the contractual terms can be fairly complex and/or subtle. Therefore, how might unsophisticated subjects view the coordinating contracts?

The OP contract is in many ways the least complicated and provides incentives for capacity investment, which, unlike the other contracts, do not depend on the realization of demand. Furthermore, the intuitive parameters of \( w = r/2 \) and \( p_o = K/2 \) achieve both first-best investment and equity. The SL agreement is somewhat more complex than the OP contract. While it too has incentives directly dependent on the investment decision, the impact of those incentives depends on the demand realization. The QC contract adds complexity in a different way by providing indirect incentives to invest. Similar to the SL agreement, the effect of these incentives depends on the demand realization. The retailer takes on additional risk from potentially buying “worthless” units in the low demand state. Additionally, retailers may be disinclined to set high quantity commitments if they compare outcomes in the low demand state with what they would have earned without the commitment (because of either loss aversion or regret aversion). Finally, the QP contract may be the least intuitive for subjects, as they must realize that only \( w_2 \) matters for the incentives to invest and that they should provide a price premium for high quantities.

Another way of thinking about how the contracts may differ is assuming the subjects are boundedly rational. Specifically, we often model the choices of boundedly rational individuals as involving random errors around the optimal or desired outcome (e.g., McFadden 1973, McKelvey and Palfrey 1995). In our setting, we can then compare for each contract how large a set of parameters allows for incentive compatibility (and equal expected payoffs). This essentially captures how large a choice error it would take to disrupt the desired outcomes. Note that we make a similar comparison in Table 4 in the context of superficial fairness. Aligning with our intuition from above, we see that the OP contract and SL agreement allow for the largest range of parameters for incentive compatibility under superficial fairness, while the QP and QC contracts have the smallest.

Finally, concerns with the true fairness of the contract (as captured by social preference models such as in Fehr and Schmidt 1999 and Bolton and Ockenfels 2000) do not suggest that the coordinating contracts should perform differently. If the supplier does not invest, the two parties will only have equal expected payoffs if \( w = r/2 \). By contrast, when the supplier invests, all four contracts can equalize expected payoffs for a range of parameters. Therefore, concerns about fairness should only further increase the supplier’s incentives to invest in all four coordinating contracts.

4. Experimental Design
Our experimental design included five treatments, one for each contract, consisting of 10 rounds. In each round, a participant was first assigned the role of retailer or supplier, who was then randomly matched,
To help subjects keep track of the contract offers, we provided them with two tables, one that displayed all of the proposed offers and one that displayed all of the received offers, along with any feedback. The bargaining stage in each round lasted up to four minutes. If either party chose to accept a contract proposal at any time, the bargaining stage ended for that dyad. If an agreement was not reached within the allotted time, both parties earned a profit of zero. By utilizing this type of bargaining structure, we are able to capture some of the features existing in more realistic negotiations while maintaining our ability to directly monitor the bargaining dynamics.

From our experimental parameters and the theory outlined in Section 3, one can calculate contract parameters necessary for incentive compatibility, along with conditions that generate equal expected payoffs. This information is shown in Table 1, which depicts our experimental design, number of participating subjects (228 total), and contract details. Note that it also includes conditions in which a wholesale price of 5 = $/piece is incentive compatible and equalizes expected profits.

We ran all treatments at the Laboratory for Experimental Economics and Decision Research at Cornell University, where participants were mostly students. Subjects first read the instructions themselves. Following this, we then read the instructions out loud and answered any questions. Roughly 30 minutes were spent reviewing the game. We recruited participants through an online system where cash was the only incentive offered. Subjects were paid a $5 show-up fee plus an amount based on their performance. Average compensation for the participants was just over $26, which was based on the profits from all 10 rounds. Each session lasted approximately 80 minutes, and the experimental interface was programmed using z-Tree (Fischbacher 2007).

5. Results

In this section we first summarize the outcomes: investment rates, incentive compatibility, expected profits, and contract parameters. We then detail the bargaining dynamics, including offers made and feedback sent. Because each treatment was composed of reasonably

### Table 1. Experimental Design, Number of Participating Subjects, and Contract Details

<table>
<thead>
<tr>
<th>Contract</th>
<th>Participants</th>
<th>Incentive compatibility</th>
<th>Equalize expected profits</th>
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</thead>
</table>
| WP       | 48           | $w \geq 7.00$           | $w_1 = (18.5 - 2w_1), 4.25 \leq w_1 \leq 5.75$ | $w_2 = 8.5$ | $-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quad-\quarter
large cohorts of 14–18 subjects, we use the individual subject as our main unit of statistical analysis. Unless otherwise noted, we use nonparametric Wilcoxon rank-sum tests comparing treatments to one another, and all regressions include clustered standard errors at the subject or subject-pair level. Also, as mentioned, whenever a supplier’s best response is to invest in capacity (i.e., it is expected profit maximizing for the supplier to invest), we refer to this as incentive compatible.

5.1. Outcomes
Retailer-supplier dyads successfully reached an agreement at similar rates across all five treatments (see Table 2) and an overall grand average of 88.86%, with the exception of the WP contract, which yielded an agreement rate of 81.25%. Thus, we focus on outcomes conditional on agreements.

Figure 1(a) depicts the average investment rates for each of the five contract treatments, given an agreement. As one can see in Figure 1(a), the WP contract leads to an investment rate of 35.38%. However, a different result emerges for the remaining contracts. The QP, QC, and OP contracts and the SL agreement generate higher investment levels than in the baseline WP contract treatment, where these differences are significant in all but one comparison, between WP and QP (p = 0.120 for WP versus QP, p = 0.034 for WP versus QC, and p < 0.01 for WP versus OP and WP versus SL). The OP contract achieves the best investment rate, 86.85%, and the SL agreement achieves the second best, 71.01%, both of which are significantly higher than the remaining contracts (all p’s < 0.01). If we compare the OP contract and SL agreement with each other directly, the OP contract’s investment rate is significantly higher than that for the SL agreement (p < 0.01).

The favorable investment rates of the OP contract and SL agreement appear to persist over time, as observed in Figure 1(b). To formally check for any experience effects, we ran five logit regressions with clustered standard errors, with the supplier investment decision as the dependent variable and the decision period as the independent variable. The coefficient on the period variable was not significantly different from zero in any of the five regressions (smallest p equal to 0.288).

Table 2 provides a summary of additional results. Beginning with incentive compatibility rates, one can immediately recognize a difference between the OP contract and SL agreement, compared with the remaining contracts. That is, 91.55% of agreements in the OP contract and 72.78% of the agreements in the SL agreement were incentive compatible, compared with roughly half in the QC contract and only a minority in the WP and QP contracts. Thus, the favorable investment rates of the OP contract and SL agreement are partially because of their ability to generate incentive-compatible agreements. Furthermore, the incentive-compatible agreements under OP and SL also give much stronger incentives to invest. To support this, we calculated for each incentive-compatible agreement the average difference in expected payoff from investing or not investing (i.e., the average value of the incentive compatibility inequality). For WP, QP, and QC, even when contracts were incentive compatible, the payoff difference from investing was quite small (0.79, 0.99, and 3.94, respectively). By contrast, OP and SL contracts had substantially larger payoff differences from investing: 20.93 and 12.45.

Turning to retailer and supplier expected profits, in Table 2, there appears to be a correlation between investment rates and distribution of expected profits. For instance, the WP contract, while yielding a relatively low level of investment, provides the most equitable payoffs between the retailer and supplier: suppliers make roughly 3.63 more in expected profits than

### Table 2. Summary of Experimental Results for Each Contract, Outcomes Conditional on Agreement

<table>
<thead>
<tr>
<th>Contract</th>
<th>Agreement %</th>
<th>IC %</th>
<th>Retailer</th>
<th>Supplier</th>
<th>Chain</th>
<th>w/w₁</th>
<th>w₂/q/p₁/B</th>
<th>Terms</th>
<th>Messages</th>
<th>w/w₁</th>
<th>w₂/q/p₁/B</th>
</tr>
</thead>
<tbody>
<tr>
<td>WP</td>
<td>81.25%</td>
<td>12.82%</td>
<td>50.84</td>
<td>54.47</td>
<td>105.31</td>
<td>5.61</td>
<td>—</td>
<td>72.25</td>
<td>—</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[2.70]</td>
<td>[3.80]</td>
<td>[1.62]</td>
<td>[1.36]</td>
<td>[0.78]</td>
<td>[0.11]</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QP</td>
<td>89.58%</td>
<td>21.86%</td>
<td>49.75</td>
<td>56.74</td>
<td>106.49</td>
<td>5.79</td>
<td>5.43</td>
<td>21.83</td>
<td>9.40</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[2.23]</td>
<td>[4.01]</td>
<td>[1.51]</td>
<td>[1.45]</td>
<td>[0.68]</td>
<td>[0.13]</td>
<td>[0.16]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>QC</td>
<td>92.08%</td>
<td>51.58%</td>
<td>49.50</td>
<td>58.24</td>
<td>107.74</td>
<td>5.29</td>
<td>14.34</td>
<td>28.06</td>
<td>9.79</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[1.85]</td>
<td>[4.21]</td>
<td>[1.65]</td>
<td>[1.83]</td>
<td>[0.65]</td>
<td>[0.10]</td>
<td>[0.31]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OP</td>
<td>88.75%</td>
<td>91.55%</td>
<td>42.98</td>
<td>70.05</td>
<td>113.03</td>
<td>5.19</td>
<td>27.55</td>
<td>25.04</td>
<td>19.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[2.61]</td>
<td>[3.52]</td>
<td>[3.72]</td>
<td>[3.79]</td>
<td>[0.38]</td>
<td>[0.14]</td>
<td>[2.45]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SL</td>
<td>93.89%</td>
<td>72.78%</td>
<td>43.54</td>
<td>67.11</td>
<td>110.66</td>
<td>5.09</td>
<td>25.90</td>
<td>18.86</td>
<td>17.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>[1.81]</td>
<td>[4.55]</td>
<td>[2.09]</td>
<td>[1.89]</td>
<td>[0.69]</td>
<td>[0.16]</td>
<td>[1.81]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes. Standard errors across subjects are reported in square brackets. “Chain” refers to the overall supply chain. For terms and messages, w₁ and w₂ pertain to QP, q pertains to QC, p₁ pertains to OP, and B pertains to SL.
retailers. As we move down the table, to those contracts that lead to higher investment rates, this difference in expected profits only increases, to 6.99 in the QP contract, 8.74 in the QC contract, 27.07 in the OP contract, and 23.57 in the SL agreement. Furthermore, the average payoff difference is significantly more supplier favorable for OP and SL than for the other three contracts (all \( p < 0.01 \)). These data suggest that contracts that increase overall supply chain profits largely favor the supplier.

Regarding supply chain profits, note that they are directly tied to investment rates and that all contracts earn a minimum profit of 100. Therefore, at the risk of some repetition, all but QP generate significantly higher supply chain profit compared with the WP contract (\( p = 0.120 \) for WP versus QP, \( p = 0.034 \) for WP versus QC, and \( p < 0.01 \) for WP versus OP and WP versus SL). And the OP contract and SL agreement both significantly outperform the remaining contracts (all \( p < 0.01 \)).

Table 2 also delineates the average contract parameters for agreements in each treatment. Starting with the WP contract, the average agreed-upon wholesale price was 5.61, below the required threshold for incentive compatibility (\( w \geq 7.00 \)). A similar result exists in the QP contract, where the average wholesale price was 5.79 but the secondary wholesale price was only 5.43, lower than the condition for incentive compatibility (\( w_2 \geq 7.00 \)). The QC contract performs better in this regard, in that the average quantity commitment was 14.34, which, given the observed wholesale prices, is higher than the average quantity commitment required for incentive compatibility (not depicted; \( q \geq 13.97 \)). In the OP contract and SL agreement, given the observed wholesale prices, the option fee and bonus are far above the thresholds for incentive compatibility: 27.55 in the OP contract (not depicted; \( p_r \geq 9.03 \)) and 25.90 in the SL agreement (not depicted; \( B \geq 19.06 \)).

Last, in Table 2, the average wholesale prices for all contracts are roughly halfway between the retailer’s revenue per unit \( r = 10 \) and the supplier’s cost of production \( c = 0 \). Keeping this in mind, recall from Section 3 that the QP, QC, and OP contracts and the SL agreement can all lead to first-best investment while equalizing expected profits. Specifically, this is possible when \( 4.25 \leq w \leq 5.75 \) in the QP contract, \( 4.625 \leq w \leq 5.75 \) in the QC contract, and \( w \leq 5.75 \) in the OP contract (in the SL agreement, \( w \leq 4.5 \) is necessary, but \( w = 5 \) can also lead to relatively equitable expected profits). Returning to Table 2, the average observed wholesale prices for these contracts are within, or near, all of these ranges, suggesting that the secondary parameters may be partly responsible for the inequity we observe in certain contracts. For instance, consider the OP contract. Recall from above that the option fee necessary to induce investment and lead to equal expected profits, given the observed wholesale prices, is \( p_r = 9.03 \). Yet the average option fee in our experiment is 27.55.

### 5.2. Bargaining Dynamics

Turning to the bargaining dynamics, the right side of Table 2 shows the number of messages sent per subject for each contract parameter. As one can see, there were more messages sent about the wholesale price than about the secondary parameter, particularly in the QP and QC contracts. This effect is weaker in the SL agreement, which may be because the SL agreement is the only contract where the secondary parameter is potentially paid even if the supplier does not invest (and demand is low). Also, in Online Appendix A we show that this tendency for more messages to be sent about the wholesale price persists over time, such that subjects did not appear to take a sequential approach to bargaining.

In Figure 2 we provide two arrow plots that illustrate the types of feedback sent for the QP and QC contracts. In these plots the vertical axis represents the wholesale price, \( w \) or \( w_1 \), and the horizontal axis represents the secondary parameter, \( w_2 \) or \( q \). The origin of the arrows illustrates a contract offer, rounded, and the length of the arrows depicts the frequency with which messages were sent about a parameter. Longer (shorter) vertical arrows suggest that many (few) messages were sent about the wholesale price, longer (shorter) horizontal arrows indicate that many (few)
messages were sent only about the secondary parameter, and longer (shorter) arrows in a straight diagonal suggest that many (few) messages were sent equally about both parameters. Consistent with Table 2, most of the arrows are vertical and relatively long, implying that feedback frequently focused on the wholesale price being too high (down arrow) or too low (up arrow). It also appears that a vast majority of the messages focused on driving the wholesale price to about 5 (in the OP contract and SL agreement, not depicted, similar effects persist but are not as strong).

We now turn to how offers evolved over time. In Figure 3, we provide two sunflower density plots for the SL agreement, which depict the contract proposals during the bargaining stage at different moments in time (similar patterns exist for the QP, QC, and OP treatments). Specifically, the figure on the left shows the density of offers during the first minute of bargaining, and the figure on the right shows the density of offers during the fourth minute of bargaining. The vertical axis denotes the wholesale price $w$, and the horizontal axis represents the bonus $B$. One can immediately notice that during the first minute of bargaining, there is considerable dispersion of offers for both parameters. However, during the final minute, wholesale prices converge to about 5, whereas the bonus continues to exhibit considerable variability (a similar pattern emerges if one looks at the first and last two minutes). This suggests that subjects responded to the plethora of messages about the wholesale price but gave relatively less attention to the secondary parameter.

5.3. Superficial Fairness

Thus far, one primary result is that the OP contract and SL agreement generate not only higher levels of incentive-compatible agreements and investment but also highly inequitable payoffs. With regard to the bargaining dynamics, we observe that retailers and suppliers tend to (1) place more emphasis on bargaining over the wholesale price and (2) settle on a price that is roughly halfway between the retailer’s revenue per unit and

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Notes. Each circle represents a single observation. Each line on a lightly shaded hexagon represents one observation. Each line on a darkly shaded hexagon represents six observations.
the supplier’s cost of production per unit. Here, we provide further support for these bargaining tendencies and discuss how these two bargaining anomalies, which we collectively refer to as “superficial fairness,” contribute to our experimental results.

There is a vast literature that shows that when two parties negotiate over a parameter with salient end points, they often make concessions and come to an agreement that is roughly in the middle (Roth and Malouf 1979, Roth and Murnighan 1982). Indeed, in our experimental data, retailers and suppliers tend to start with an initial offer that strongly favors themselves and eventually settle on a wholesale price that appears more equitable. Specifically, the average midpoint, between the retailer’s and supplier’s first wholesale price offers, ranges from 5.01 in the SL agreement to 5.73 in the QP contract, and the wholesale price for accepted offers is significantly correlated with the midpoint of the initial offers, in all treatments (p ranges from 0.377 in OP to 0.695 in QP, all p’s < 0.01).

The corresponding concession pattern for the secondary parameters, however, is not as strong. While the secondary parameters for the accepted contract and the midpoint of the initial offers are significantly correlated, the strength of the correlation is relatively weaker than those for wholesale prices (p between 0.183 in SL to 0.527 in QP, p < 0.01 for all). Also, importantly, the secondary parameters for accepted contracts significantly differ from the midpoint of initial offers in each treatment, other than QP (signed-rank tests: p = 0.473 in QP, all others: p < 0.01).

To determine what contributes to accepting an offer, Table 3 reports the results of regressing subjects’ acceptance of an offer using logit regressions with subject-pair clustered standard errors. An indicator variable, ISIC, is equal to 1 if the offer is incentive compatible. Because some studies suggest that things such as inventory risk can influence outcomes (e.g., Davis et al. 2014), Risk Difference is a risk allocation measure, where we first calculated the absolute difference in profits if demand is high or low, for both the retailer and supplier (conditional on the correct investment choice), and then took the absolute difference between the parties. This variable will be high if either the retailer or the supplier is bearing the majority of the payoff uncertainty and will be zero if they have equal payoff uncertainty. Similarly, in line with standard models of fairness (Fehr and Schmidt 1999, Bolton and Ockenfels 2000), Inequality captures the payoff inequality by taking the absolute difference between the parties’ expected profits (conditional on the correct investment). Finally, \( w \in [4.5, 5.5] \) is an indicator variable equal to 1 if the wholesale price is between 4.50 and 5.50, capturing the superficial fairness of the offer (we obtain qualitatively similar results if we use alternative measures of superficial fairness, such as expanding the range to \( w \in [4, 6] \)).

In Table 3, in all contracts, offers are significantly more likely to be accepted if the wholesale price is superficially fair. And the magnitude of the effect is considerable—increasing the likelihood of acceptance by between one-third and two-thirds of the base rate probability (QP: 32%, QC: 66%, OP: 59%, and SL: 52%). By contrast, subjects do not appear to favor offers that are incentive compatible. Similarly, subjects do not seem to reject offers that are objectively unequal in either expected profits or risk allocation, the former of which is consistent with our data in that contracts with highly unequal expected profits are accepted. Finally, while not depicted, we note that there is no

**Table 3.** Logit Regressions of Accepting an Offer, for the QP, QC, and OP Contracts, and the SL Agreement

<table>
<thead>
<tr>
<th></th>
<th>QP</th>
<th>QC</th>
<th>OP</th>
<th>SL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>ISIC</td>
<td>−0.612***</td>
<td>−0.639***</td>
<td>−0.0324</td>
<td>0.0719</td>
</tr>
<tr>
<td></td>
<td>[0.257]</td>
<td>[0.257]</td>
<td>[0.263]</td>
<td>[0.264]</td>
</tr>
<tr>
<td>Risk Difference</td>
<td>0.00384</td>
<td>0.00261</td>
<td>0.00359</td>
<td>4.02e−05</td>
</tr>
<tr>
<td></td>
<td>[0.00893]</td>
<td>[0.00893]</td>
<td>[0.00345]</td>
<td>[0.00352]</td>
</tr>
<tr>
<td>Inequality</td>
<td>−0.00437</td>
<td>0.00238</td>
<td>−0.00772</td>
<td>0.00135</td>
</tr>
<tr>
<td></td>
<td>[0.00404]</td>
<td>[0.00467]</td>
<td>[0.00373]</td>
<td>[0.00373]</td>
</tr>
<tr>
<td>( w \in [4.5, 5.5] )</td>
<td>0.428***</td>
<td>0.812***</td>
<td>0.782***</td>
<td>0.748***</td>
</tr>
<tr>
<td></td>
<td>[0.180]</td>
<td>[0.190]</td>
<td>[0.195]</td>
<td>[0.211]</td>
</tr>
<tr>
<td>Time</td>
<td>0.0115***</td>
<td>0.0115***</td>
<td>0.00916***</td>
<td>0.00921***</td>
</tr>
<tr>
<td></td>
<td>[0.00121]</td>
<td>[0.00122]</td>
<td>[0.00123]</td>
<td>[0.00123]</td>
</tr>
<tr>
<td>Constant</td>
<td>−3.514***</td>
<td>−3.830***</td>
<td>−3.330***</td>
<td>−3.907***</td>
</tr>
<tr>
<td></td>
<td>[0.229]</td>
<td>[0.252]</td>
<td>[0.247]</td>
<td>[0.277]</td>
</tr>
</tbody>
</table>

Notes. Logit regression with standard errors clustered at the subject-pair level. The dependent variable is the contract acceptance decision; ISIC is a binary variable equal to 1 when an offer was incentive compatible, Risk Difference denotes the absolute difference in payoff risk between the retailer and supplier, Inequality denotes the absolute difference in average payoffs between the retailer and supplier, \( w \in [4.5, 5.5] \) is a binary variable equal to 1 when the offered wholesale price was between 4.50 and 5.50, and Time shows the time in the round.

***p < 0.01; **p < 0.05; *p < 0.10.
corresponding preference for offers near the middle value of the secondary parameter, which can directly contribute to the distribution of expected profits. (In separate regressions, the coefficients on an indicator variable for the secondary characteristics are not significant in any treatment.)

This emphasis on the wholesale price, combined with concessions, can account for the rates of incentive compatibility we observe and also, qualitatively, the differences in expected profits. As previously highlighted in Section 3, when both contract parameters are unconstrained, the QP, QC, and OP contracts, and the SL agreement, have considerable flexibility at inducing the supplier to invest in capacity and equalize expected profits. However, if one of the two parameters is restricted to a particular value, and the secondary parameter is overlooked, then the performance of these contracts may differ. Specifically, if the average wholesale price in all contracts is \( w = 5 \), then the proportion of the contracting space for the secondary parameter that will lead to incentive compatibility, or favor the supplier over the retailer, greatly differs across the contracts. For example, in the QC contract, the quantity commitment parameter must be between 10 and 20, where the requirement for incentive compatibility is \( q \geq 14 \), and the requirement for a supplier earning strictly more than the retailer (given investment) in expected profits is \( q \geq 17 \). This implies that 60% of the quantity commitment parameter space leads to incentive-compatible outcomes and that 30% leads to the supplier earning more in expected profits. Table 4 shows the results from applying this approach to each of the coordinating contracts (focusing on the individually rational contract space for the OP contract and SL agreement). As one can see, the ordering of incentive compatibility rates and inequity of expected profits is consistent with that which exists in the experimental data.

We can also investigate more generally how the various contracts likely perform (in terms of efficiency and profit distribution) in the presence of superficial fairness. Specifically, we consider the size of the incentive-compatible outcomes and that 30% leads to the supplier earning more in expected profits. Table 4 in the presence of superficial fairness. We can also investigate more generally how the various contracts likely perform (in terms of efficiency and profit distribution) in the presence of superficial fairness. Specifically, we consider the size of the incentive-compatible regions for various contractual forms.

<table>
<thead>
<tr>
<th>Contract</th>
<th>Requirement</th>
<th>% region* (%)</th>
<th>( n_q \geq n_r ), given invest</th>
<th>% region* (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>QP</td>
<td>( w_2 \geq 7.00 )</td>
<td>30</td>
<td>( w_2 \geq 8.5 )</td>
<td>15</td>
</tr>
<tr>
<td>QC</td>
<td>( q \geq 11 )</td>
<td>60</td>
<td>( q \geq 17 )</td>
<td>30</td>
</tr>
<tr>
<td>OP</td>
<td>( p_r \geq 10 )</td>
<td>87</td>
<td>( p_r \geq 17.5 )</td>
<td>77</td>
</tr>
<tr>
<td>SL</td>
<td>( B \geq 20 )</td>
<td>73</td>
<td>( B \geq 20 )</td>
<td>73</td>
</tr>
</tbody>
</table>

*In OP and SL, these numbers reflect the region of the individually rational contracting space.

Note that by focusing on the effects of superficial fairness, we are giving a somewhat conservative prediction for the performance of the OP contract and SL agreement. For example, in some treatments we observed the overperformance of OP or SL (e.g., from many subjects investing even when the contract was not incentive compatible) or the underperformance of other contracts (e.g., many subjects in WP not investing even when the contract was incentive compatible) that cannot be explained by superficial fairness alone. We focus on superficial fairness to analyze the effect of our primary behavioral factor.

Given that \( w = r/2 \), we define two terms that will be common across the contracts. Define \( \Theta = K - (r/2)p\delta \), which represents the additional incentives that the secondary term in the contract must provide, given the incentives that the wholesale price is already generating. Note that \( \Theta \in (0, K/2) \). Additionally, define \( \Gamma = (r/2)(d + p\delta) \), which denotes the amount of the surplus (conditional on investment) given to each party by the wholesale price (i.e., not counting the cost of investment \( K \), or the payoff effects of the other terms of the contract). Note that \( \Gamma > K/2 \). We can then reformulate the incentive compatibility constraints as shown in Table 5 and calculate the fraction of the (individually rational) contract space that would be incentive compatible.

Given these incentive-compatible regions, we can identify the parameters where one contract has a larger incentive-compatible region than another, and therefore when we might expect one contract to lead to greater investment and supply chain profits. The parameter conditions are summarized in Proposition 1, with the details provided in Online Appendix B. As one might expect from our results, the OP contract has the (weakly) largest incentive-compatible region. This is quite intuitive, as it is the contract form that provides the most direct incentives to invest. The relative performance of SL and QC tend to depend on the model parameters, with SL performing better when \( p \) is large and QC performing better when \( p \) is small. Again, this
makes sense because the incentives in SL come from the risk of losing the bonus B if the supplier does not invest and demand is high, which is more likely when \( p \) is larger. By contrast, QC provides incentives by increasing the minimum order when demand is low. This incentive matters more when the likelihood of low demand is greater (i.e., \( p \) is low). QP generally performs the worst, as it has at most 50% of the contract region as incentive compatible. Only when the incentive problem is small (i.e., \( \Theta/K \) is large) does QP perform well compared with SL or QC.

**Proposition 1.** For superficially fair contracts \((w = r/2)\), the following conditions describe the relative size of the (individually rational) incentive-compatible (IC) regions:

1. The OP contract has a strictly larger IC region than SL and QP for all parameter values. The IC region for OP is strictly larger than QC if \( \delta \leq 2 \Gamma/(r(1-p)) \); otherwise, they are equal.
2. The SL contract has a strictly larger IC region than QC if \( \delta < 2p \Gamma/(r(1-p)) \); otherwise, QC is larger. The likelihood of high demand \( p > (\sqrt{5} - 1)/2 \) is sufficient to satisfy this condition. The SL contract has a strictly larger IC region than QC if \( \Theta/K < \Gamma/(\delta) \); otherwise, OP is larger.
3. The QC contract has a strictly larger IC region than QP if \( \delta > 2 \Gamma/(r(1-p)) \) or if \( \delta \leq 2 \Gamma/(r(1-p)) \) and \( \Theta/K < (1-p)/(2p) \).

We can also look at how the incentive-compatible contracts distribute expected profits within the supply chain and whether it is generally true that the efficient contracts such as OP and SL typically favor the supplier. With a superficially fair wholesale price, and assuming that the contract is incentive compatible, all of the contracts yield expected payoffs with a similar form:

\[ \pi_R = \Gamma - T, \quad \pi_S = \Gamma + T - K. \]

Here, \( T \) denotes the expected transfer between the retailer and the supplier conditional on investment, given the coordinating terms of the contract. Specifically, \( T = (w_2 - r/2)p \delta \) for OP, \( T = (q - d)(1-p)(r/2) \) for QC, \( T = p \delta \) for OP, and \( T = B \) for SL. One thing to note is that additional incentives beyond the minimum necessary to ensure incentive compatibility will favor the supplier. Additionally, as we specified above, contracts with larger incentive-compatible regions (OP and SL for many parameters) have more scope for such larger transfers. This is consistent with what we saw in our experimental results, where the average contracts under OP and SL were both substantially beyond the minimum to be incentive compatible and also heavily favored the supplier. We can more concretely identify for each contract how much of the incentive-compatible region will give the supplier a larger expected payoff. First, note that the supplier will have a larger expected payoff whenever \( T > K/2 \). Table 5 reports what fraction of the incentive-compatible region will satisfy this condition. We can identify the parameters that will ensure that a contract has a greater share of its incentive-compatible region that favors the supplier. This is formalized in Proposition 2.

**Proposition 2.** For superficially fair contracts \((w = r/2)\), the following conditions describe the relative proportion of the IC regions that give a larger expected profit to the supplier than to the retailer:

1. The SL contract has a strictly larger supplier-favorable proportion of the IC region than OP, QC, and QP for all parameter values.
2. The OP contract has a strictly larger supplier-favorable proportion of the IC region than QC if \( \delta < 2 \Gamma/(r(1-p)) \); otherwise, they are equal. The OP contract has a strictly larger supplier-favorable proportion of the IC region than QP for all parameter values.
(3) The QC contract has a strictly larger supplier-favorable proportion of the IC region than QP if \( \delta > 2\Gamma/(r(1 - p)) \) or \( p < \frac{1}{2} \).

When a larger share of the incentive-compatible region for a contract is associated with supplier-favorable outcomes, we can expect that the average outcomes will favor a supplier for that contract. Therefore, these results suggest that the observation in our data that suppliers tend to earn significantly more than retailers under the OP and SL contracts will apply more generally. Additionally, note that for the wholesale price contract, a superficially fair wholesale price is not incentive compatible. If the supplier does not invest, then the retailer and supplier earn equal profits. If he does invest, then the retailer will have strictly larger expected profits. Therefore, OP and SL will also tend to be more supplier favorable than WP.

What effect would adding concerns for “true” fairness (in the sense of inequity aversion or other outcome-based fairness concerns) have on the predicted performance of the various contracts? For example, suppose that firms refused to accept a contract where the difference in expected profits was larger than some threshold—that is, requiring that \( |2T - K| < F \) for some \( F > 0 \). For large \( F \), this will rule out the portion of the contract space that is associated with large transfers. Note that the incentive compatibility constraints for all the contracts can be rewritten as \( T \geq \Theta \) (except SL, where it is \( T \geq \Theta/p \)), so excluding large transfers only eliminates incentive-compatible contracts. For OP and SL, this will exclude contracts with large \( p \) and \( B \), respectively, shrinking their incentive-compatible regions to be more similar to those of the other contracts. For sufficiently small \( F \), all the contracts will have very similar contract regions of intervals centered around the payoff-equalizing point. Therefore, incorporating true fairness will tend to mute the differences between contracts and thus cannot explain the pattern of results we see in our data.

6. Robustness Checks

To investigate the robustness of our results, we conducted two additional experimental studies. One evaluates a scenario where a superficially fair wholesale price should, in theory, induce investment in the WP contract, and the other considers continuous demand.

6.1. Alternative Two-Point Demand

In the first robustness study, we ran one treatment of the WP contract (42 subjects), one treatment of the OP contract (40 subjects), and one treatment of the SL agreement (36 subjects), with one subtle difference compared with the main study: the probability of high demand occurring was increased from 1/2 to 7/10, thus making a superficially fair wholesale price of \( w = 5 \) incentive compatible for the supplier. All other parameters and experimental protocols remained the same. Conducting these treatments helps determine (a) whether the favorable performance of the OP contract and SL agreement, from a supply chain perspective, persists in an alternative setting; (b) whether there continues to be a wider distribution of expected profits in the OP contract and SL agreement, relative to the WP contract; and (c) whether investment levels in the WP contract increase relative to the main experiment, providing evidence in favor of superficial fairness.

In these treatments, agreement rates were 83.81% (WP), 89% (OP), and 82.78% (SL). There is only one weakly statistically significant difference among these, between WP and OP (rank sum: \( p = 0.096 \)). Therefore, we report outcome results conditional on an agreement, and all tests between treatments are Wilcoxon rank sum.

Figures 4(a) and 4(b) illustrate the average investment rates for each of the three contracts, overall and over time. As one can see, the OP contract and SL agreement yield significantly higher investment rates than the WP contract (\( p < 0.01 \) for WP versus OP, \( p = 0.036 \) for WP versus SL, and \( p = 0.115 \) for OP versus SL). Comparing these data with the main experiment, we observe a significant improvement in investment rates, especially in the WP contract. In the WP contract, average investment rates nearly double, from 35.38% previously to 68.18% (\( p < 0.01 \)). In addition, there are marginal gains for investment rates in OP and SL compared with the main study (93.82% versus 86.85% previously in OP, \( p = 0.044 \); and 84.56% versus 71.01% in SL, \( p = 0.069 \)).

Table 6 provides summary statistics for the two-point robustness study. Focusing on incentive compatibility, there is a similar pattern to the main experiment, as OP and SL have higher rates than WP (98.31% in OP, 99.33% in SL, and 80.11% in WP, both tests versus WP: \( p < 0.01 \)). Comparing these incentive compatibility rates with the original experiment, we observe a considerable improvement, particularly in the WP contract, where rates increased from 12.82% previously to 80.11%. This result is in line with superficial fairness, as \( w = 5 \) is now incentive compatible. Also similar to the main experiment, we find that, conditional on incentive compatibility, OP and SL provide much stronger incentives to invest. The average payoff difference from investing was 34.88 in OP and 27.91 in SL, compared with 1.36 in WP.

Turning to the distribution of expected profits between retailers and suppliers in Table 6, it appears that the OP contract and SL agreement continue to generate inequitable payoffs, despite their favorable performance from a supply chain perspective. As in the main experiment, the difference in expected profits for the supplier relative to the retailer was significantly more...
supplier favorable in the OP and SL contracts relative to the WP contract (both \( p \)'s < 0.01). In terms of the supply chain, because investment is directly tied to supply chain profit, OP and SL outperform WP (\( p < 0.01 \) for WP versus OP, \( p = 0.036 \) for WP versus SL, and \( p = 0.115 \) for OP versus SL).

Wholesale prices are similar to those in the main study: 5.86 versus 5.61 previously in the WP contract, 5.23 versus 5.19 previously in the OP contract, and 5.24 versus 5.09 previously in the SL agreement. There is a small difference in the option fee for OP, which increases to 32.60 from 27.55 previously, whereas the bonus in the SL agreement is similar to the main experiment (25.18 versus 25.90 previously). Last, in terms of bargaining dynamics, the number of messages sent favored the wholesale price.

### 6.2. Continuous Demand

In the second robustness study, we consider continuous demand. To this end, we implemented the same experimental protocols as in the main study, but demand was uniformly distributed from 10 to 20, and the cost of increasing supply capacity by one unit, \( k \in [10,20] \), was 3.5 (thus, an investment of 35 would increase capacity from 10 to 20). Under this continuous demand scenario, we explored the WP, QC, and OP contracts and the SL agreement (42, 32, 34, and 40 subjects, respectively).

We provide the theoretical details under continuous demand in Online Appendix C. However, we note here that under our continuous implementation, the first-best investment level was 16.5, with expected supply chain profit increasing from 100 (no investment, \( k = 10 \)) to 121.125 (\( k = 16.5 \)). The WP cannot lead to this first-best investment, whereas QC, OP, and SL can all generate first-best investments and equalize expected profits. Also, we note that the level of complexity under continuous demand, particularly for OP and SL, increases considerably compared with two-point demand. For instance, the OP contract now consists of three terms: an option fee \( p_o \) paid by the retailer for the option to buy up to \( q_o \) units at wholesale price \( w_o \) (any additional units are purchased at an increased wholesale price \( w \), which we fix in our experiment, \( w = 1.2w_o \)). If the supplier cannot satisfy all of the options, then the option fee is returned, and the two parties transact under a single wholesale price at \( w_o \). Therefore, given the additional complexity under continuous demand, we provided subjects with a decision support tool during negotiations and when making capacity decisions. During bargaining they could enter potential contract terms into this tool and see each party's expected profits for each level of investment. They could also use this tool for any offers they received while bargaining.

**Table 6. Summary of Results for the Two-Point Demand Robustness Study, Outcomes Conditional on Agreement**

<table>
<thead>
<tr>
<th>Contract</th>
<th>Agreement %</th>
<th>IC %</th>
<th>Expected profit</th>
<th>Terms</th>
<th>Messages</th>
</tr>
</thead>
<tbody>
<tr>
<td>WP</td>
<td>83.81%</td>
<td>80.11%</td>
<td>59.89</td>
<td>63.97</td>
<td>123.86</td>
</tr>
<tr>
<td></td>
<td>[3.32]</td>
<td>[4.22]</td>
<td>[3.02]</td>
<td>[2.65]</td>
<td>[1.72]</td>
</tr>
<tr>
<td>OP</td>
<td>89.00%</td>
<td>98.31%</td>
<td>48.31</td>
<td>84.52</td>
<td>132.84</td>
</tr>
<tr>
<td></td>
<td>[3.26]</td>
<td>[1.08]</td>
<td>[4.75]</td>
<td>[4.96]</td>
<td>[1.33]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SL</td>
<td>82.78%</td>
<td>99.33%</td>
<td>52.82</td>
<td>76.78</td>
<td>129.60</td>
</tr>
<tr>
<td></td>
<td>[3.29]</td>
<td>[0.69]</td>
<td>[4.04]</td>
<td>[4.20]</td>
<td>[1.57]</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Notes.** Standard errors across subjects are reported in square brackets. “Chain” refers to the overall supply chain. For terms and messages, \( p_o \) pertains to OP and \( B \) pertains to SL.
When making capacity investment decisions, suppliers could see the expected profits for each level of investment given the agreed-upon contract.

Regarding results, agreement rates in WP, QC, OP, and SL were 90.48%, 94.38%, 90%, and 86.5%, respectively, with only one significant difference of comparisons (QC versus SL rank sum $p = 0.010$). Thus, we report outcomes conditional on an agreement, and all hypothesis tests are Wilcoxon rank sum. Figures 5(a) and 5(b) depict the average investment level for each contract under continuous demand, overall and over time. As one can see, there is a somewhat familiar ranking. That is, OP and SL generate significantly higher investment levels than WP and QC ($p < 0.01$ for WP versus OP, WP versus SL, QC versus OP, QC versus SL, $p = 0.094$ for WP versus QC).

Table 7 provides a summary of additional results for the continuous robustness treatments. As with the main study and first robustness experiment, it appears that the contracts that perform best at generating investment also yield fairly uneven expected profits between the retailer and supplier. Specifically, under continuous demand, the supplier expected profit exceeds that of the retailer by 2.24 in the WP contract, 3.47 in the QC contract, 7.56 in the OP contract, and 16.99 in the SL agreement. These differences are generally larger in SL and OP relative to the WP contract ($p < 0.01$ for WP versus SL, $p = 0.093$ for WP versus OP). Also, the supplier profit is significantly higher in OP and SL compared with the WP contract (both $p$’s $< 0.01$). This observed payoff inequality is especially interesting given that both parties could see their expected profits under various contracts using the decision support tool during bargaining and when making the investment decision.

Turning to supply chain profits, the QC contract, OP contract, and SL agreement all lead to significantly higher profits compared with the WP contract (all $p$’s $< 0.01$). When comparing the coordinating contracts with one another, the OP contract significantly outperforms the QC contract ($p < 0.01$) and marginally outperforms the SL agreement ($p = 0.059$). However, there is no difference in supply chain profits between QC and SL, despite SL generating higher investment. This is because suppliers often invested more than the first-best level of 16.5 in the SL agreement, and it partially explains why suppliers earn considerably more than retailers in the SL agreement.

Table 7. Summary of Results for the Continuous Demand Robustness Study, Outcomes Conditional on Agreement

<table>
<thead>
<tr>
<th>Contract</th>
<th>Agreement %</th>
<th>Expected profit</th>
<th>Contract terms</th>
<th>Messages</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Retailer</td>
<td>Supplier</td>
<td>Chain</td>
</tr>
<tr>
<td>WP</td>
<td>90.48%</td>
<td>[2.12]</td>
<td>[0.88]</td>
<td>[0.94]</td>
</tr>
<tr>
<td>QC</td>
<td>94.38%</td>
<td>[1.61]</td>
<td>[1.11]</td>
<td>[1.29]</td>
</tr>
<tr>
<td>OP</td>
<td>90.00%</td>
<td>[2.76]</td>
<td>[1.52]</td>
<td>[1.66]</td>
</tr>
<tr>
<td>SL</td>
<td>86.50%</td>
<td>[2.50]</td>
<td>[1.91]</td>
<td>[1.96]</td>
</tr>
</tbody>
</table>

Notes. Standard errors across subjects are reported in square brackets. “Chain” refers to the overall supply chain. For contract terms and messages, $q$ pertains to QC, $p$, and $w$, pertain to OP, and $B$ pertains to SL.
With respect to contract terms and bargaining dynamics, in Table 7 we see a pattern consistent with the salience of superficial fairness. Specifically, wholesale prices are about, or slightly above, the superficially fair focal value of \( w = 5 \). Additionally, for the contracts with multiple parameters, more messages were sent about the wholesale price than about any alternative parameters.

7. Conclusion

In this study, we conduct an experimental investigation of capacity investment problems with bargaining. We compare five contracts that, in theory, can provide sufficient incentives and generate first-best investment in capacity by the supplier: wholesale price, quantity premium, quantity commitment, option, and service-level agreement. Furthermore, four of these contracts not only can provide proper incentives for first-best investment but also can equalize expected profits between the two parties. We find, however, significant differences in the performance of these contracts when we allow human decision makers to bargain over contract terms and make investment decisions. In particular, the option contract and service-level agreement significantly outperform the other contracts in terms of first-best investment levels and thus supply chain profits. These same contracts also generate the greatest inequity between the two parties in terms of expected profits; the gains they generate largely favor the supplier.

In our experiment, we introduce a form of bargaining that puts some structure on the communication but leaves the offer process unstructured. This allows us to observe the bargaining dynamics over time. These data indicate that subjects have preferences for what we refer to as “superficial fairness.” That is, subjects focus heavily on negotiating the wholesale price and eventually agree on a wholesale price that is near the middle of the contracting space while paying less attention to the secondary term. These biases significantly distort the incentives provided by the quantity premium and quantity commitment contracts. By contrast, the option contract and service-level agreement have incentives that are robust to an overemphasis on superficially fair wholesale prices, in terms of first-best investment. However, these contracts are also more susceptible to superficial fairness in terms of an unequal distribution of payoffs.

The tendency to focus on bargaining over one salient term is not uncommon in the literature—often because of negotiators using sequential agendas that make joint gains hard to find (Mannix et al. 1989) or focusing on distributing value rather than finding integrative solutions—the “mythical fixed pie” (Bazerman and Neale 1994). This behavior has also been observed in practice. For instance, Devlin et al. (2014) conduct interviews with fashion retailers and suppliers negotiating buyback contracts and find that wholesale prices charged are similar regardless of the presence of a buyback, as if the buyback amount is largely overlooked. Nevertheless, while we believe that this type of bargaining behavior is useful in organizing the data, undoubtedly many other dynamics occur during the bargaining process that may drive particular results.

It is important to recognize that there are settings where the option contract and service-level agreement may not always be preferred. For instance, if the parties are overly concerned about equitable payoffs, our experimental results suggest that traditional wholesale price, quantity premium, and quantity commitment contracts may be favored. As another example, if the supplier’s investment decision is unobservable, then the option contract is not even implementable. Furthermore, our theoretical analysis of superficial fairness suggests that in a two-point demand setting, if the option contract is not available for whatever reason, various parameters may affect which contract is preferred. For example, if the likelihood of high demand is large, the service-level agreement and quantity premium contract may perform favorably, whereas if the likelihood of high demand is small, the quantity commitment contract may perform well at inducing first-best investment.

We believe that there are several opportunities for future research in this area. One direction would be to extend our work in a repeated setting. As mentioned previously, relational incentives in a long-term relationship is a common solution to capacity investment problems. It would also be interesting to extend our setting and results to incorporate renegotiation.

One limitation of our study is that subjects had a fixed amount of time to bargain over parameters. While we believe our contractual setting was relatively simple compared with negotiations in practice—most supply chain contracts would be significantly more complicated and face far greater uncertainty and ambiguity—we recognize that many supply chain negotiations would likely involve more time and some additional level of calculations for each offer (although we provided decision support in our continuous demand treatments). However, while this may be a limitation to our study, we believe that ours is one of the first to allow both parties to make back-and-forth offers while also allowing them to provide limited feedback, as opposed to a setting with only one-shot ultimatum offers. Thus, we believe that our work takes an important step toward understanding a more realistic bargaining setting, but we admit that more work is necessary to fully understand capacity investment decisions and bargaining.

From a managerial standpoint, while we investigate a capacity investment context for the supplier, our
results can also apply to smaller-scale settings, where a supplier must make a relationship-specific investment. For instance, a start-up may need to invest in training, software, or hiring specialized personnel to serve a potential buyer. In these situations, our results suggest that contracts similar to the option or service-level agreement may generate greater levels of investment by the supplier and lead to higher supply chain profits, but they may favor the supplier as well.

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