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Supplier-Manufacturer Relationships Under Forced Compliance Contracts

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Today, many retailers are adopting lean strategies to improve efficiency (see Abernathy et al. 1999). Manufacturers that supply lean retailers must fulfill orders accurately, rapidly, and efficiently, despite demand volatility, by appropriately structuring their production and transportation processes. The outsourcing of transportation has become common; in this case a contract might be struck that specifies how much capacity a logistics provider guarantees to the manufacturer. Given that the demand for transportation services varies day by day in the “lean-retailer” context, the contract must take into account the manufacturer’s risk of not fulfilling the retailer’s demand if the transportation requirements exceed the agreed upon capacity and the logistics provider’s risk of not using all of the committed capacity. The use of electronic spot markets for transportation has become prevalent and offers one means to mitigate these risks—the transportation provider can sell unused capacity while the manufacturer can secure additional transportation services when the logistics provider’s promised capacity is insufficient. In this paper we analyze a contract in this context and its capability to mitigate the effects of demand and spot-price uncertainties, as well as how each party, and the supply chain in total, benefits from the contract.

We analyze a contract for options for nonstorable products or services, such as transportation, between a single supplier and a single manufacturer in the presence of a spot market, where the supplier has limited capacity and the manufacturer must fulfill periodic stochastic demand from a downstream supply-chain link, such as a lean retailer, in full. We assume

that the quantity of goods desired by the manufacturer is always available on the spot market at some price, that the spot-market price is exogenous, and that neither the supplier nor buyer is of sufficient size to have a perceptible effect on it.

We model our problem as a two-stage Stackelberg game in which the supplier is the leader. At stage one, the supplier offers the manufacturer a contract for options with a reservation price and an exercise price. In response, the manufacturer purchases a certain number of options from the supplier, after which the supplier determines the total quantity of goods or services to make available to the manufacturer or the spot market. At the beginning of the second stage, demand and spot price are realized. After observing this information, the manufacturer decides how many options to exercise with the supplier and how much to purchase on the spot market. The manufacturer can view the spot market as an alternative source of the product: If the spot market price is below the supplier’s exercise price, then the manufacturer buys only from the spot market; otherwise, she buys from the spot market only if the reserved capacity is insufficient to satisfy the demand in full. After the manufacturer’s order is filled, we assume that the supplier can sell all his excess inventory to the spot market at some price, which may or may not be profitable. We assess the effectiveness of such a contract in coordinating the channel, how the optimal policies are set, and how the value of the contract is shared between the parties.

Several papers analyze whether forward options can coordinate the channel and ensure incentive compatibility for both players, or whether additional

mechanisms are needed. Barnes-Schuster et al. (2000) investigate a two-period model with a single supplier acting as a leader and a single buyer, in which the buyer can purchase a certain number of options as well as place a firm order each period. Cachon and Lariviere (2001) consider a similar model (where the buyer acts as a leader) and analyze two different compliance regimes (voluntary compliance and forced compliance) and two different information sharing cases (full information and asymmetric information).

Modeling the presence of the spot market in conjunction with a contract for forward options is an important extension of the literature. Spot markets have not often been included in supply-chain contracting models, although many commodities are traded on spot markets, which are used by suppliers to clear excess production and by customers for supply when contracted quantities fall short of requirements. Among the papers we found, Wu et al. (2002) and Spinler et al. (2002) are the closest to ours. The setting in Wu et al. (2002) is similar to ours: It includes options on the capacity, a Stackelberg game in which the supplier is a leader, and a spot market. These authors assume that the demand is deterministic and a function of the spot price which is, in turn, state contingent. Spinler et al. (2002) analyze a model that is very similar to that of Wu et al. (2002), but with an additional assumption that both the demand and the production cost are state contingent. In contrast to these papers, we assume stochastic demand that is independent of the spot price. Also, neither Wu et al. nor Spinler et al. require the buyer to satisfy all demand as we do in this paper, but rather determine the quantity that maximizes the indirect utility of the buyer. As a consequence, some results that we present here are different. For example, we show that the exercise price is set at the level such that the probability that the spot price would exceed the exercise price is very small; Wu et al. conclude that the exercise price will be equal to the production cost. In addition, we assess contract effectiveness and analyze incentive compatibility for the supplier and the manufacturer.

By analyzing a contract for options in a spot-market setting, we simultaneously extend two streams of literature—We apply a contract for options to a new

setting and assess the effect of spot markets under a new contractual setting. We also add to the research on spot markets by developing a model that is appropriate when the buyer (the manufacturer in our model) supplies a lean customer with varying demand and is able to gauge the effect of stochastic demand.

We show that the manufacturer's cost function is convex and provide a closed-form expression for the optimal reservation quantity. We provide non-restrictive conditions under which the supplier's profit function is unimodal in the forward and exercise prices, and show analytical expressions for the optimal contract terms.

We demonstrate, using centralized and decentralized cases as benchmarks, that while the contract significantly improves the overall system performance, it cannot guarantee channel coordination. Nonetheless, we show that the contract always brings value into the supply chain and can decrease the gap between centralized and decentralized system profit by as much as 99% in the best scenario. The supplier, who is the leader, benefits most from the contract, but is unable to extract all the additional profit from the channel.

A supplier must be competitive (i.e., the supplier's expected revenue from selling to the spot market must be nonnegative) and have sufficient capacity for a contract to be incentive compatible for the manufacturer. A noncompetitive supplier minimizes his exposure to the unattractive spot market by setting a high reservation price, which induces the manufacturer to reserve a small quantity that provides her little value. Even if competitive, a supplier with insufficient capacity will not offer the manufacturer an attractive contract.

With a competitive supplier of sufficient capacity, the contract is most attractive when the spot-market margin is large because it allows the spot market to be circumvented. Although the supplier benefits most in this circumstance, the manufacturer can reduce her cost significantly when spot-price variability and demand uncertainty are high. In fact, with a large spot-market margin, the percentage improvement in each party's position is comparable under high coefficients of variation of both spot price and demand—These are perhaps the most viable contract conditions,

when both parties are highly motivated to enter into a contract.

We can succinctly summarize the optimal strategy for the competitive supplier, who is motivated to offer an incentive-compatible contract to the manufacturer. Specifically, the exercise price should be set sufficiently low to virtually guarantee that the manufacturer will exercise the options, and the reservation price should be set to balance the trade-off between immediate (Stage 1) revenue from capacity reservation and the future (Stage 2) revenue from the exercise of options and sales to the spot market. The advantage of selling to the manufacturer rather than the spot market is small when the spot-market margin is small, and so the supplier sets a higher reservation price to increase immediate revenue. When the spot-price margin is high, the supplier sets the reservation price lower to encourage the manufacturer to buy a

large number of options to increase future revenue from the exercise of the options.

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