Market price uncertainty, risk aversion and procurement: Combining contracts and open market sourcing alternatives

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ABSTRACT

We evaluate the implications of concurrent utilization of "contracts" and "open market" arrangements by a risk averse buyer in continuous procuring of a standardized product of known demand over a specified time period. The buyer being risk averse is concerned about the magnitude and uncertainty of expenses. The contract price is deterministic and the market price is stochastic. Cases when the two price processes are exogenous, and when the contract price is endogenously linked to volume of procurement and market price are examined. Models are developed to determine the optimal pattern of procurement from the two arrangements for specified price, risk aversion and contract duration parameters. The study finds that optimal procurement from market increases with contract price premium but decreases with degree of risk aversion and market price uncertainty. Usefulness of alternate forms of contracts when contract and market alternatives are used concurrently is discussed. Application of the models to hypothetical datasets compares the relative usefulness of alternate forms of integrating contract and market alternatives, and of complete reliance on "contract" or "market" alternatives.

1. Introduction

'Contracts' and 'open market' arrangements are the two principal modes of sourcing. However, when price is the principal procurement criterion as in case of a standardized product with well-defined performance attributes, it is difficult to assess which of mode of sourcing is more effective. Contractual procurement avoids price uncertainty and ensures certainty of supply, but presents the risk of lock-in at a higher price (Joskow, 1987). Lock-in refers to the obligation to buy from the contract regardless of the expected market price. The risk due to lock-in is especially high when the contract duration is long. In contrast, open market procurement offers the opportunity to buy at a lower price at certain times, but exposes the buyer to price uncertainty. The absence of a clear advantage of one over the other raises the question, 'what is the optimal sourcing arrangement in a dynamic market with uncertain prices when the risks of contractual lock-in and market price uncertainty are of concern'? Due to the advantages and disadvantages of both alternatives, it may be useful for a risk-averse buyer to use both contract and market modes of procurement while accounting for the relative price dynamics of the two alternatives over the decision horizon (Cohen and Agrawal, 1999).

The emergence of electronic markets has encouraged simultaneous utilization of contract and open market procurement arrangements in many industries including automotive, electricity, electronic components, chemicals, and semiconductor (e.g., Kleindorfer and Wu, 2003). Our conversation with procurement executives at Raymond's Inc. and Stanley Black & Decker reveals that simultaneous utilization of contract and open market procurement has been effective in managing the risks of input price volatility for many commodity products. According to a senior procurement executive of Stanley Black & Decker:

"The spot prices of various input commodities could sometimes fluctuate over a wide range (e.g., between −9% and 100%) during a month. Writing a long-term contract with firm price and quantity guarantees can therefore be risky. The company, keeping in view the market price trend typically writes a contract with firm pricing for at least 12 months but without any commitment on the purchase quantity. We provide the supplier non-binding (quarterly) forecasts of the quantities of products anticipated to be purchased in any quarter during the contract duration. Actual purchase quantities from the contractual supplier are based on purchase orders that are issued time to time while comparing contract prices with the (likely) open market prices. Depending on the market conditions, contract

and open market price comparisons may be carried out on a bi-weekly, monthly, quarterly or half-yearly basis. Each purchase order specifies the quantity to be supplied in shipments that arrive at a much shorter interval i.e., daily or weekly basis to match the timing of demand. Thus the actual supply of goods resembles just-in-time delivery i.e., supply occurs almost continuously compared to the issue of purchase orders at certain intervals. The difference between the anticipated requirement and contractual purchase is procured from the open market simultaneously at the prevailing market prices that fluctuate continuously between two successive contractual purchase orders. Typically, Stanley Black & Decker procures about 20–30% of its input requirements from the open market. Since the dual mode procurement without strong quantity commitments is a well-established practice by the company, the contractual supplier does not offer resistance when the purchased quantities are adjusted across purchase orders. We expect our supplier to understand the nature of uncertainty we are dealing with. However to compensate the supplier for absorbing some of our risks, the company may include some price premium over the expected market prices while deciding the contract prices."

The above comments indicate, the rationale for simultaneous utilization of contract and market alternatives can be explained by the 'risk averse' behavior of procurement managers. The firm sources inputs using contracts and spot market multiple times in a procurement epoch based on purchase orders that are decided at the beginning of procurement epochs. Since the market prices could fluctuate randomly after the procurement rates are decided, it is difficult to assess whether contract or spot market would be advantageous over the procurement epoch. In the above context, a key decision would be to identify the optimal proportion of procurement from contract and/or open market arrangements while considering the potential market price uncertainty through the procurement epochs. Our discussion with the managers at Stanley Black & Decker suggests that these optimal decisions are difficult to make when the market prices are uncertain.

In this study, we examine these issues while accounting for the risk aversion characteristic of procurement managers. We first propose a model to derive the optimal procurement policy across multiple procurement epochs when the contract duration, and the contract and market prices remain exogenous. Subsequently, we examine how the optimal policy changes when the contract price allows volume discount. The model is used to analyze the usefulness three alternate types of contracts: fixed quantity contract that does not adjust procurement quantity during the entire contract duration, recurrent contracts that allow review and readjustment of procurement quantity in each procurement epoch without any minimum quantity commitment, and recurrent contracts with a minimum quantity commitment allowing readjustment of quantities only above the minimum quantity. Our study is distinct from past sourcing studies (e.g., Li and Kouvelis, 1999; Secomandi and Kekre, 2014) dealing with uncertain prices in that we examine the issue of optimal 'risk-averse' sourcing when the market price is non-stationary, the product is procured continuously (and not just one time at a pre-specified time in the decision horizon) to match the demand rate in a procurement epoch, and contract and market alternatives are used concurrently while allowing procurement quantities to readjust at the beginning of procurement epochs. Essentially, our model applies when the rates of procurement are decided with respect to unknown market prices at the beginning of procurement epochs.

Our results indicate that: a) the optimal policy could involve simultaneous procurement from contract and open market alternatives, b) for a specified decision horizon and initial prices, the optimal quantity to procure from market decreases with the degree of risk aversion and market price uncertainty, and it increases with the contract price premium, and c) volume discount by the contractual supplier may not always eliminate market procurement.

To the best of our knowledge, finding a) is distinct, because, past studies (e.g., Li and Kouvelis, 1999; Secomandi and Kekre, 2014; Goel and Gutierrez, 2011) have found simultaneous utilization of the two alternatives useful only when supply from one alternative is affected by capacity unavailability, or storage, transportation and/or high transaction cost related concerns. Finding b) is somewhat intuitive; however, past studies (e.g., Martinez-de-Albeniz and Simchi-Levi, 2006; Cohen and Agrawal, 1999) have not provided a closed form solution for the pattern of relationships among the price parameters, decision horizon and procurement policy. The result in c) helps understand the interaction between contract and spot market prices in a novel way. A key contribution of our findings lies in analytical quantification of the influence of risk aversion and price dynamics on contractual and open market sourcing over time.

We demonstrate how the model works using hypothetical dataset. Application of the model for alternate forms of contracts illustrates that the model can be useful when risk aversion, quantity re-adjustment intervals and contract and market price parameters are known. For the example risk aversion, quantity re-adjustment times, and contract and market price parameters, we find: a) recurrent contracts offer greater opportunities for lowering expenses than other alternatives and the advantage is relatively greater when the market price variability is higher because of the potential opportunity to procure more from market when market prices are favorable, and b) minimum quantity commitment contract has higher cost advantage over fixed quantity long-term contracts because of the opportunity to readjust the procurement quantity based on emerging prices. The analysis illustrates how in a given context for specified parameter values, the model can be used to design appropriate souring arrangement.

The rest of the paper is organized as follows. In the following section, we review the literature on procurement strategy under contract and uncertain market price dynamics. Next, we describe the problem context and formulate models for deriving the optimal strategy. Finally, we illustrate how to use the model for deriving managerial insights and suggest directions for future research. Proofs to various propositions and corollaries and detailed derivations are given in appendices.

2. Literature review

Extant research on combined spot and contract purchasing has characterized problems in terms of decision maker's risk attitude (i.e., risk neutral or risk-averse), spot price characteristics (i.e., stationary or non-stationary), contractual flexibility (i.e., quantity flexibility or option contracts) and decision horizon (i.e., single period or multiple periods). We discuss past works based on these attributes. Concern for uncertainty in costs or payoffs differentiates a "risk averse" decision maker from a "risk neutral" one. From a modeling perspective, 'risk neutral' objective concerns with optimization of expected expense or profit; in contrast, the 'risk-averse' objective optimizes expected utility, described as a function of magnitude and uncertainty of expense or profit.

First, we review some key risk neutral sourcing studies that investigate issues similar to ours. In a deterministic demand, non-stationary price and two supplier context, Li and Kouvelis (1999) used stochastic dynamic programming to obtain the optimal timing of placing an order to satisfy the demand at the end of the contract duration when sourcing occurs from one of the alternatives (unless there is a capacity constraint with the supplier). Based on numerical studies the study found that time flexibility in placing the order is useful to the buyer when market price uncertainty is higher. Bonser and Wu (2001) also applied stochastic dynamic programming approach in two phases to investigate the use of long-term contract and spot sourcing in a multi-period fuel procurement problem for electric utilities. Our model has similarity to their model in terms of deciding the minimum contract purchases first and subsequent finalization of