Inventory Control and Delivery Time Quotation in Assembly Supply Chains

In a business environment where the customers are highly time-sensitive, it is critical for a company that aims at providing high-quality products or services to deliver orders in a timely manner. Such entities are usually required to provide an accurate estimate of the order delivery time and to keep the delivery schedule reliable.

A salient example is the outsourcing of home/business-building improvement projects via the internet. There are online platforms, such as HomeAdvisor, which help customers seek qualified contractors for those projects. A customer with certain specific requirements for a project can visit the online platforms and fill out a set of questions, in which the customer will be asked to provide the desired completion time. Next, the platform leads the customer to matching contractors, where the customer obtains information on the contractors' quotations for the completion time of the project. In this example, a contractor's capability of quoting short project delivery times is important, but even more important is the contractor's ability to keep the delivery times reliable as the online platforms show past customer reviews of each contractor. An important factor in how successful a contractor will be in keeping short and reliable delivery times is the availability of key parts or modules that the contractor will have to use to complete the customer order.

Consider another example that is the use of modular buildings for government projects. Typically, government agencies will hire contractors through the so-called GSA Schedule Contracts, which “are indefinite delivery, indefinite quantity (IDIQ), long-term contracts under the General Services Administration's Multiple Award Schedule (MAS) Program . . . They contain pre-negotiated prices, delivery terms, warranties, and other terms and conditions which streamline...
the buying process."¹ The customers here are the agencies seeking contractors through GSA, who will grant a modular building contractor future projects at the pre-negotiated prices.

Having provided the context, we now provide an overview of our model. The model consists of a specialty contractor (or contractor, she), who attempts to attract businesses from customers, and multiple suppliers, each of whom (he) produces and stores a key module involved in completion of an order for the contractor. The contractor provides a delivery quotation before or upon arrival of a customer inquiry. If the two parties reach an agreement, the contractor needs to deliver the order before the promised date. A failure to meet the promised date would cause a penalty for the contractor. The penalty could be a goodwill cost and/or take monetary form.

According to the example of the GSA Schedule Contracts, the contractor must provide a pre-announced uniform delivery time quotation, without knowing each customer's specific delivery time requirement; while according to the example of the online outsourcing of home improvement projects, the contractor is able to provide a customized delivery time quotation based on real-time conditions such as the specific timeline of the customer. We refer to the former as the uniform quotation policy, while refer to the latter as the adaptive quotation policy.

We assume that potential customers arrive according to a Poisson process and each module supplier employs a base-stock inventory control policy. According to the classical inventory management literature, e.g., Rosling (1989) and Zipkin (2000), the suppliers of those items can make replenishment decisions independently, which is the independent S-policy, or they can coordinate their replenishment decisions, which is the modified S-policy.

This study makes three major contributions to the existing literature, summarized as follows:

¹http://gsa.federalschedules.com/gsa-schedule/gsa-schedule-faq/
(1) To the best of our knowledge, this is the first study of an inventory system in which the suppliers make inventory decisions and the contractor provides delivery quotations. This is a challenging problem for which the optimal solution is not known in the literature.

(2) We devise analytical and simulation algorithms to identify the optimal inventory decisions and quotations. When the suppliers employ the independent S-policy, we propose a simulation algorithm based on an important observation that the multiple-supplier system can be converted into an equivalent one-supplier system, which makes the algorithm efficient. When the suppliers employ the modified S-policy, we propose a Dynamic-Programming-based heuristic, akin to Clark and Scarf's algorithm (1960), using a technique of converting an assembly system into an equivalent serial system employed by some previous studies (e.g., Rosling 1989 and Zipkin 2000).

(3) We compare different inventory policies, i.e., the independent S-policy versus the modified S-policy, and different quotation policies, i.e., the uniform quotation policy versus the adaptive quotation policy. We find that the loss of efficiency of using the independent S-policy (compared to the modified S-policy) is on average less than 2.5%, while the loss of efficiency of using the uniform quotation policy (compared to the adaptive quotation policy) is about 20%-30%.

References:

