A General Model for Inventory Management with Dual Sources: Trading off Lead Time and Cost Differences

ABSTRACT

Manufacturing companies and retail chains often have access to two alternative supply sources for component parts, product modules, finished goods or supply materials. One source is typically low cost but has long lead times, whereas the other provides quicker response but at a higher price. When designing its procurement process, the purchaser may select one of the two sources as its exclusive supplier. Alternatively, it may opt for a dual sourcing strategy which procures from both sources. In the latter case, the challenge is to determine how much of the total procurement volume to allocate to the two sources and how inventory information should be used to make these allocation decisions, dynamically. The same dilemma arises when a firm has two (or more) assembly plants in different parts of the world, with different costs and lead times to service its customer base.

The above strategic dilemmas arise, first and foremost when firms decide on offshoring strategies. Offshore outsourcing/production has become increasingly popular in the past two decades. Lower Total Landed Cost (TLC), i.e., the aggregate of labor, material, working capital, freight and customs costs, is the main driver for offshore sourcing. Other benefits include process efficiency, quality, better availability of skilled people, and lower foreign corporate tax rate. According to a recent PricewaterhouseCoopers' survey (PwC 2010), the share of products that are sourced from offshore locations ranges from 51% and 75%, in different European and American countries and it has been projected to grow at more than 10% annually in the next five years. However, the cost savings of the offshore options reduce inventory flexibility, in the sense that deliveries take longer. Longer lead times, in turn translate into a need for larger safety stocks, under a given targeted service level, or inferior service levels under given inventory investments. In contrast, onshore procurement in the local market
is fast but typically incurs higher costs. How to trade-off between onshore production and offshore outsourcing is the focus of this research.

While the field of operations management has developed a rich arsenal of planning models to support single supplier systems, relatively little is known in settings where there are two or more supply sources, that are differentiated by their lead times and costs. This applies in particular to the structure of an optimal sourcing strategy. Identifying this structure under the combined complexities of fixed order costs and capacity limits for individual orders placed in each period, is the main objective of our research. Unlike traditional inventory planning models, we also allow for inventory decreases, through salvaging or return policies, again associated with fixed and variable adjustment costs.

The potential for efficiency improvement, in this area, is extensive. In a recent paper by Allon and Van Mieghem (2010a), the authors propose and analyze a specific class of heuristic sourcing rules. Their work was motivated by a $10 billion US manufacturer of wireless transmission components with two assembly plants, one in China and another in Mexico. The Chinese plant was considerably cheaper in terms of its variable manufacturing costs, but had order lead times considerably longer than those from Mexico. See also Allon and Van Mieghem (2010b) and Van Mieghem and Allon (2015). The authors identify a heuristic dual sourcing strategy which in their application saves up to 20% over the best single sourcing strategy. To appreciate the impact of such savings, in the retail industry the purchasing costs amount to 85% of the cost of goods sold. This means that gross profit margins increase from 15% to 32% when the sourcing costs can be reduced by 20%. This leads to an even higher increase in net income.

Our base model considers a multi-period planning problem for a single product with two supply sources. Each source has its own variable cost rate, fixed cost per order, lead time and capacity limit for each period’s order. Procurement from both suppliers incurs a fixed cost representing administrative, production setup costs or fixed shipping costs per order, and there are limits on the order size for any order placed with either of the suppliers, arising from the suppliers’ production or shipment capacity. Additional costs include standard inventory carrying and backlogging costs, where we assume that all
shortages can be backlogged. Leftover inventory at the end of each period can either be carried over to
the next period incurring a inventory holding cost, or be salvaged immediately, incurring a fixed cost
independent of the amount salvaged. Demands are assumed to be independent across time. We show that
the optimal cost-to-go functions satisfy a novel convexity structure, termed $(C_1K_1, C_2K_2)$-convexity. We
derive structural results for the optimal solution, based on which we are able to characterize the optimal
sourcing and salvaging decisions.

We show that an optimal policy first determines the size of an order with the expedited supplier, or
the size of any salvage quantity, based, exclusively, on the regular full inventory position. Thereafter,
any order with the regular supplier is determined as a function of the adjusted inventory position.
Moreover, the dependence of the optimal order sizes and/or salvage quantity, on the period's starting
inventory position follows a relatively simple structure. The above results apply to the special case where
the lead times of the two suppliers differ by a single period. However, our structural results suggest
effective heuristics for general lead time combinations.

We evaluate our heuristics in a comprehensive numerical study. We focus on how various model
primitives impact on the benefits of dual sourcing. For example, we show that the cost savings due to
dual sourcing may be as large as 30%. For a given price differential, the benefits of dual sourcing grow
as the lead time difference increases.

REFERENCES


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