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Learning Curve Effect on Materials Procurement Schedule of Multiple Sister Ships

Authors : Vijaya Dixit Aasheesh Dixit

Abstract : Shipbuilding industry operates in Engineer Procure Construct (EPC) context. Product mix of a shipyard comprises of various types of ships like bulk carriers, tankers, barges, coast guard vessels, sub-marines etc. Each order is unique based on the type of ship and customized requirements, which are engineered into the product right from design stage. Thus, to execute every new project, a shipyard needs to upgrade its production expertise. As a result, over the long run, holistic learning occurs across different types of projects which contributes to the knowledge base of the shipyard. Simultaneously, in the short term, during execution of a project comprising of multiple sister ships, repetition of similar tasks leads to learning at activity level. This research aims to capture above learnings of a shipyard and incorporate learning curve effect in project scheduling and materials procurement to improve project performance. Extant literature provides support for the existence of such learnings in an organization. In shipbuilding, there are sequences of similar activities which are expected to exhibit learning curve behavior. For example, the nearly identical structural sub-blocks which are successively fabricated, erected, and outfitted with piping and electrical systems. Learning curve representation can model not only a decrease in mean completion time of an activity, but also a decrease in uncertainty of activity duration. Sister ships have similar material requirements. The same supplier base supplies materials for all the sister ships within a project. On one hand, this provides an opportunity to reduce transportation cost by batching the order quantities of multiple ships. On the other hand, it increases the inventory holding cost at shipyard and the risk of obsolescence. Further, due to learning curve effect the production scheduled of each consequent ship gets compressed. Thus, the material requirement schedule of every next ship differs from its previous ship. As more and more ships get constructed, compressed production schedules increase the possibility of batching the orders of sister ships. This work aims at integrating materials management with project scheduling of long duration projects for manufacturing of multiple sister ships. It incorporates the learning curve effect on progressively compressing material requirement schedules and addresses the above trade-off of transportation cost and inventory holding and shortage costs while satisfying budget constraints of various stages of the project. The activity durations and lead time of items are not crisp and are available in the form of probabilistic distribution. A Stochastic Mixed Integer Programming (SMIP) model is formulated which is solved using evolutionary algorithm. Its output provides ordering dates of items and degree of order batching for all types of items. Sensitivity analysis determines the threshold number of sister ships required in a project to leverage the advantage of learning curve effect in materials management decisions. This analysis will help materials managers to gain insights about the scenarios: when and to what degree is it beneficial to treat a multiple ship project as an integrated one by batching the order quantities and when and to what degree to practice distinctive procurement for individual ship.

Keywords : learning curve, materials management, shipbuilding, sister ships
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