

Stochastic Lot Sizing Problem from a Financial Perspective

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Although not immediately prevalent, lot sizing has everything to do with the use of shared resources. Setups are the representation of the inconvenient truth that different operations, to be performed on shared (and limited) resources, have to be sequenced in time in order to perform the various operations. In this way, setups are a direct consequence of shared resources. If all operations were using dedicated resources, no setups and thus lot sizing are needed. Moreover, shared resources are typically investment driven and thus expensive (as the dedicated option is totally unaffordable) so that the financial evaluation of the lot sizing decision is important. Applications of this problem setting can be found not only on the machine and departmental level, but also on the site and supply chain level.

In our research, we focus on operational queueing models that include batch-sizing. Building on these models, elements of the balance sheet and the profit-and-loss account are introduced in order to create a new financial objective function that has to be optimized as a function of the batch-size and the number of hours of overtime. We propose a new objective that measures the creation in shareholder value while taking care of the cash requirements of the company.

Operational queueing models on the one hand try to optimize pure operational measures such as lead time, work-in-process, throughput or waiting time (see for example Kuik & Tielemans, 2004, Lambrecht et al, 1998, Fowler et al, 2002). Pioneering work on the relationship between lead time, lot sizes and resource utilization has been done by Karmarkar (e.g. Karmarkar et al, 1985, Karmarkar et al, 1986). On the other hand these queueing models also often include the costs and profits related to the operations (e.g. setup cost, inventory cost, order cost) and try to optimize these cost functions (Bertrand, 1985, Zipkin, 1986, Hopp et al, 2002, Missbauer, 2002, Choi & Enns, 2004).

The minimization of lead time can lead to a competitive advantage or customer satisfaction. Tersine & Hummingbird (1995) refer to it as management of time. Some of the competitive benefits are e.g. a quicker response to changing needs, smaller variability, smaller work-in-process inventory and safety stock, planning tasks become easier. However, the bottom line effect on the firm's value is not at all clear. Even when these models take into account costs and profits, in most of the cases, capital cost is missing in the model.

We want to stress that our research differs from these cost and profit models. Models that tend to maximize profits or minimize costs often omit the impact of associated financial and cash flows and are therefore not suitable to measure the creation of shareholder value. The maximization of shareholder value is in fact one of the priorities of today's firm. The financial

models aimed at, include the elements available in the income statement and the balance sheet. The shortcoming of net income figures is that they focus on interest costs but ignore the cost of equity. Financial measures as Net Present Value, Market Value Added, Cash Flow Return On Investment or Return On Investment do measure shareholder value but they are not interesting to serve as objective for our specific operational model. The performance measure Economic Value Added on the other hand is chosen to be the new financial objective function for reasons explained below.

Other papers stress the fact that cash management is the basis for business solvency. If too many resources are tied up in inventory or accounts receivables, the company may have problems to pay its bills independent of the fact that the company is profitable. Because inflows and outflows of cash are not balanced in time, enough resources should be available during a certain period. So cash management is next to the creation of shareholder value of great importance in the financial model.

To our knowledge, very little researchers have focused on the integration between finances and operational queueing models. Yi & Reklaitis (2004) present a production planning model that simultaneous takes into account production and financing constraints for a batch-storage network. A key assumption is that there is some limited cash availability assumed. Taking into account the financial constraints decreased the optimal lot and storage sizes. A second paper is one of Guillén et al (2007). The authors derive an integrated model for supply chain management which includes budgetary constraints as well as process operations. The authors choose to optimize the change in equity in the integrated model.

An integrated operational-financial model is constructed for the stochastic lot sizing problem. Our starting point is an operational queueing model which minimizes the lead time as a function of the batch size for the single machine, single product case. This operational model with individual arrivals instead of batch arrivals is developed by Lambrecht & Vandaele (1996). Process times, setup times and interarrival times are stochastic and the environment they are working in is make-to-order. The waiting time in queue is derived using an approximation method.

This operational model is extended with a financial objective function and financial constraints. The objective function measures the creation of shareholder value through the EVA® performance measure. This choice is made because EVA® explicitly takes into account the cost of capital on the one hand and it compels management to generate returns on working capital requirements on the other hand. EVA® is short-term oriented which coincides with the tactical level decisions that have to be taken: lot size and number of hours of overtime (capacity). The extra financial constraints taken into account are related to the liquidity of the company. A minimum cash availability is necessary in order to finance the daily operations. Cash excess can be invested or money can be borrowed to reach the minimum cash level. Also included in the model is the possibility for factoring of the accounts receivables and early payment of the accounts payable.

The integrated operational-financial approach can be compared with the traditional approach where first the operations are optimized and next a financial optimization is performed with

the operational outcome used as input for the financial model. We want to show that the batch sizes that minimize the lead time, are not necessarily the same as the batch sizes that maximize Economic Value Added. The outcome should highlight the advantages of the integrated approach.

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