Chapter 2
Cost Estimation in a Capacitated Environment

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ABSTRACT
In this chapter we discuss rough-cut cost estimation in a capacitated made-to-order environment. We develop models that analyze the effects of shop workload, machine loading, and outsourcing decisions on product unit cost estimation. A comparative study of five alternative rough-cut cost estimation methods is presented. An activity based cost estimation model, which takes into account stochastic process characteristics as well as setup time, machine failures and product yields, was developed. The activity based cost estimation was found to perform better than the traditional cost estimation. We found that by taking into account the capacity and stochastic nature of the parameters, the cost estimation accuracy is improved significantly.

INTRODUCTION
Nowadays, in the global competitive market, companies’ prosperity is strongly dependent on their ability to accurately estimate product costs. This is especially true for firms operating in a make-to-order environment. For such firms, a small error in a price quote, resulting from erroneous product cost estimation, may make the difference between being awarded and losing a contract.

During the last decade, the relative weight of direct labor costs in manufacturing has dramatically diminished, while the relative weight of indirect costs has increased (Gunasekaran, Marri & Yusuf, 1999). Therefore, allocating indirect costs to products, without taking into account shop floor capacity, may lead to erroneous estimations. Despite this, most existing cost estimation models assume unlimited shop floor capacity. There are many such models in the literature. These models use information about the products, the materials and the production processes. Common approaches are:
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- Parametric cost estimation models that are based on:
  - Regression analysis (Cochran, 1976a, b; Ross, 2002).
  - Fuzzy logic (Jahan-Shahi, Shayan & Masood, 2001; Mason & Kahn, 1997).
  - Minimization of Euclidean distance between the estimated cost and its actual value (Dean, 1989).
  - Neural networks (Bode, 2000; Lin & Chang, 2002; Shtub & Versano, 1999; Smith & Mason, 1997).
- Bottom-up cost estimation models, in which the total cost is the sum of detailed components (Rad & Cioffi, 2004; Son, 1991; Stewart, 1982).
- Group technology cost estimation models that use the similarity between products from the same family (Geiger & Dilts, 1996; Jung, 2002; Ten Brinke, Lutters, Streppel & Kals, 2000).
- Hybrid cost estimation models that combine some of the models described above (Ben-Arieh, 2000; Sonmez, 2004).

Parametric, bottom-up, group technology and hybrid cost estimation models use only information about the product, the materials from which it is made, and the production processes required for its manufacture. None of the above cost estimation methods takes considers the available capacity on the shop floor. The assumption is that the available capacity is sufficient. However, in reality, one must deal with finite capacity and dynamic workloads, which may change over time.

Here we assumed that the total cost of the product is a function of the load on the shop floor (which is made up of the orders waiting to be manufactured or actually being manufactured in a certain time period). Specifically, we assumed that the cost of producing an order when the load is high is different from the cost of the same order when the load is low and most resources are idle.

It is our contention that ignoring the load on the available capacity distorts the product cost estimation and may lead to wrong decision-making.

In recent years, several researchers have suggested estimation models that consider limited capacity. However, in spite of the depth of these studies, most of these models focused on pricing and fit specific environments, such as monopolistic firms. These models were not general enough; they did not explain the relationship between the product costs and the workload. Banker et al. (2002) analyzed the issue of optimal product costing and pricing of a monopolistic firm that must commit, on a long-term basis, capacity resources. Falco, Nenni and Schiraldi (2001) developed a cost accounting model for line balancing, based on a plant’s productive capacity analysis. They tested their model in a chemical-pharmaceutical plant. Balakrishnan and Sivaramakrishnan (2001) tried to estimate the economic loss of planning capacity on the basis of limited information and of delaying pricing until more precise information about demand becomes available.

Feldman and Shtub (2006) developed a detailed cost estimation model that performs capacity planning based on a detailed schedule of work orders assuming no outsourcing, no machine failures and no product defects.

Nevertheless, outsourcing cost is an important component of the total product cost. Firms use outsourcing to reduce costs or as a solution for limited capacity. Product cost depends on a make vs. buy decision. Cost trade-off is the main approach in a make vs. buy decision (Balakrishnan, 1994; Bassett, 1991; Ellis, 1992, 1993; Levy & Sarnat, 1976; Meijboom, 1986; Padillo-Perez & Diaby, 1999; Poppo, 1998; Raunick & Fisher, 1972). In addition, strategic perspectives, such as competitive advantage and risk of dependence on suppliers, are also usually analyzed (Baines et al., 1999; McIvor et al., 1997; Venkatesan, 1992; Welch & Nayak, 1992).

There are several other areas, in addition to manufacturing, that deal with make vs. buy prob-