

Chapter 6.17

Rough–Cut Cost Estimation in a Capacitated Environment

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INTRODUCTION

Nowadays, in the worldwide competitive market, a company's prosperity is strongly dependent on its ability to accurately estimate product costs. This is especially vital 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 the acceptance and loss of 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 the shop floor capacity, may lead to erroneous

estimations. Despite this, most of the existing cost-estimating models assume unlimited shop floor capacity. There are many such models in the literature. These models use information about the products, materials, and production processes. Common approaches are the following.

- Parametric cost estimation models that are based on the following
 - Regression analysis (Cochran, 1976a, 1976b; Ross, 2002)
 - Fuzzy logic (Jahan-Shahi, Shayan, & Masood, 2001; Mason & Kahn, 1997)
 - Minimization 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 it is made of, and the production processes required for its manufacture. None of the above cost estimation methods takes into account 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.

We assume that the product total cost 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 assume 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 of the resources are idle. Therefore, ignoring the load on the available capacity distorts the product cost estimation and may lead to wrong decision making.

In recent years, several researchers suggested estimation models that consider limited capacity. However, in spite of the depth of this research, most of the models focus on pricing and fit specific environments, such as monopolistic firms. These models are not general enough as they do not explain the relationship between the product

costs and the workload. Banker, Hwang, and Mishra (2002) analyzed the issue of optimal product costing and pricing of a monopolistic firm that must commit, on a long-term basis, for capacity resources. Falco, Nenni, and Schiraldi (2001) developed a cost accounting model based on the plant productive capacity analysis for line balancing. They tested their model in a chemical-pharmaceutical plant. R. 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.

Outsourcing cost is an important component of the total product cost. Firms use outsourcing as a potential way 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 to 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, like competitive advantage and risk of dependence on suppliers, are usually analyzed (Baines, Whitney, & Fine, 1999; McIvor, Humphreys, & McAleer, 1997; Venkatesan, 1992; Welch & Nayak, 1992).

There are several other areas, in addition to manufacturing, that deal with make-vs.-buy problems. Berman and Ashrafi (1993) and Helander, Zhao, and Ohlsson (1998) presented the integer programming (IP) optimization models to facilitate make-vs.-buy decisions in component-based software development. Baker and Hubbard (2003) developed a model of asset ownership in trucking. Fowler (2004) discussed the issue of building components as opposed to buying in the development

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