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The OM Triangle

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Abstract. A key contribution of OR/MS models is to gain insights into trade-offs facing operations managers. One such trade-off involves capacity, inventory, and variability: while the firm would like to tolerate high levels of variability and run at full capacity utilization with virtually no inventory, this is not plausible. The standard G/G/1 queueing model is used to illustrate and gain insight into the trade-off between these three competing goals. In cases where better information can be used to reduce the variability in services or in arrivals, this insight can be expressed as an inter-relationship between capacity, inventory, and the third parameter of information (rather than variability). Adopting the terminology of Lovejoy (1998), this inter-relationship is referred to as the OM triangle. As discussed herein, it is the manager's job to find her firm's optimal position with regard to the OM triangle.

Keywords: queueing theory, capacity, inventory, waiting time, lead time, information, tradeoff.

The OM Triangle: Instructor's Note

1. Introduction

Many popular texts in operations management lack simple examples that illustrate the tradeoff between capacity, inventory, and variability. This key insight is derived herein from queueing theory; more specifically, from the G/G/1 queueing model.

While queueing theory provides sound theoretical background for the derivation of the inter-relationship between these three parameters, the goal of this note is not to teach queuing theory. Instead, it is to bring out qualitative insights that can be used as a guide in managerial decision making. Students should not get lost in the calculations and thereby miss the insights that the theory has to offer. One of these insights is that capacity, inventory, and variability reduction are, in a sense, substitutes. For example, if you reduce variability, you can get by with less capacity and/or less inventory.

In a queueing setting, variability can be found in arrivals and/or in services. These two types of variability can expressed, for example, by the coefficients of variation in interarrival times and in service times.

In some cases, variability in arrivals and in services can be reduced by the judicious acquisition and use of *information* (broadly defined). For example, rather than taking all patients as walk-ins, a doctor's office might get information from patients as to their ailments, and then make appointments to smooth out the arrivals. Another example on the demand side is given by Womak et. al (1991), who discuss how new cars in Japan are sold by sales personnel who go door-to-door, thereby gaining the consumer pulse and allowing the firm to reduce the variability in demand.

Likewise, information may in some cases also be used to reduce variability in service times. A simple example might be a sophisticated Department of Motor Vehicles (DMV) office, which pre-screens customers as to the service needed and then routes each customer to the appropriate server (so that while there are differences in service times between servers, each server experiences little variation in service times). The example of automobile manufacturing again offers a more elaborate example. Spear and Bowen (1999, p. 98) describe the Toyota production system (TPS) as follows:

> …all work is highly specified as to content, sequence, timing, and outcome… The requirement that every activity be specified is the first unstated rule of the system… most managers outside of Toyota and its partners don't take this approach to work design and execution – even when they think they do.

In other words, Toyota first generates precise information as to how every operation is to be performed, and then provides employees with that information and expects them to execute accordingly. If a process is executed the same way every time, the variability in the process is greatly reduced. In other words, information is key to the TPS, and has helped Toyota develop a lean manufacturing system with virtually no inventory and lesser capacity cushion.

In these types of situations, where information can be used to reduce variability, the tradeoff between capacity, inventory, and variability can equivalently be expressed as one between capacity, inventory, and information. Lovejoy (1998) calls the inter-relationship between these latter three parameters the OM triangle. The contribution of this teaching note is to more explicitly show how the OM triangle stems from queueing theory, and to get students to think about how they as (future) managers might themselves manage the tradeoff between capacity, inventory, and information.

2. Teaching Experience

Following this instructor's note is a note that can be included in a course pack or handed out to students. Earlier versions of the note have been used successfully in core operations courses at both the undergraduate business and MBA levels. The note is flexible in that if a purely qualitative treatment is