Chapter 4

OPERATIONAL RESEARCH METHODS FOR EFFICIENT WAREHOUSING

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Abstract The design and operation of a warehouse entail many challenging decision problems. We begin by providing definitions as well as qualitative descriptions of two actual warehouses. This will then set the stage for an overview of representative operational research models and solution methods for efficient warehousing. Problems which will be exposed can be classified into three major categories: throughput capacity models, storage capacity models, and warehouse design models. We conclude by identifying future research opportunities.

1. Introduction

Be they associated with grocery distribution, manufacturing or health care, warehouses are ubiquitous and come in almost all shapes and sizes. So it is certainly of considerable practical interest to identify methods for improving their design and operation, and these span the entire spectrum of analytical models (optimization and queuing) and simulation models. Problems which are surveyed here can be classified into three major categories: throughput capacity models, storage capacity models, and warehouse design models. Note that warehouse location models and container terminals (which serve as temporary buffers for inbound and outbound containers) are respectively examined in the chapters entitled “Facility Location in Supply Chain Design” and “Models and Methods for Operations in Port Container Terminals,” in this book.

Throughput capacity models are comprised of order picking policies, akin to vehicle routing problems and which can be further subdivided between picking and batching policies, as well as storage assignment policies and dynamic control policies. Storage assignment policies attempt to match incoming product with available storage locations. Objective
functions assumed in the study of these policies include the minimization of material handling cost (or equivalently, the maximization of throughput), as well as the minimization of material handling costs plus inventory holding and reordering costs.

Storage capacity models either find the optimal warehouse size or else maximize space utilization. Meantime, questions such as rack orientation, space allocation and overall building configuration are the purview of warehouse design models. Previous surveys on the use of operational research methods in warehouses were conducted by Ashayeri and Gelders (1985), who concluded that the most practical approach to studying the complexities of a warehousing system is to combine analytical and simulation models, and by Cormier and Gunn (1992), who pointed out that, while warehouses are usually part of a larger supply chain, studying the tradeoffs between all the latter’s constituents poses both significant modelling and organizational challenges. The most recent such surveys are by Van den Berg and Zijm (1999) and Rouwenhorst et al. (2000).

Figure 4.1 is an attempt to categorize the various warehousing decision models and proposes a second classification based on a strategic, tactical and operational decision framework. Note that strategic decisions have a significant impact on long-term profitability and do not recur frequently, hence justifying the use of sophisticated analytical and simulation models. On the other hand, operational decisions tend to recur on a daily basis, or even more frequently for that matter, so that the main concern is in having algorithms which yield consistently good solutions quickly.

![Figure 4.1. A taxonomy of warehousing decision models.](image-url)