Chapter 2
High Level Inventory Network Modeling Approaches

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ABSTRACT

Over the last several decades, practitioners have used the Square Root of N (SQRTN) and the Portfolio Effect models to develop estimates of the change in finished goods inventory investment that will result from potential consolidations of existing supply chain networks. The relative simplicity of these two models has made them commonly used tools of consultants and practitioners. However, what is often overlooked or ignored in practice is that these models may or may not provide accurate projections, and that there are limitations to the range of problems which these models can address. In this paper, we evaluate the accuracy of projections made by the SQRTN and portfolio effect models under a variety of network conditions, and we provide guidance on when and how practitioners can both use and supplement these models. Our evaluations are based on the results of simulation studies which we conducted for this paper as well as many years of inventory management practice in private industry.

INTRODUCTION

The ability to rapidly estimate the implications of potential supply chain infrastructure and policy alternatives on inventory investment requirements represents an important decision support capability to have readily available within a firm. For example, inventory investment is an important component (and cost) of most manufacturing and distribution network strategic studies. At the same time, our observation is that in practice, inventory investment often receives the least "rigorous modeling" attention of the typical major cost components of large-scale network studies. Other key cost components of manufacturing

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and distribution network studies such as one-time location, start-up and closing costs, the optimal level of automation and other technologies to employ, fixed and variable production and warehousing costs, and freight, duties and transport related costs often receive more intense analysis – particularly in studies performed by industry practitioners and consultants[1].

The purpose of this chapter is to present and evaluate from a practitioner's perspective some simple rules of thumb for inventory modeling approaches that one can employ in network studies – *based on the authors' experience in private industry*. These approaches consist of a combination of statistically based methods as well as practical techniques to complement the statistical models.

Another contribution or objective of this chapter is to provide guidance to practitioners on the relative accuracy of some commonly used inventory models. We will offer this perspective through a series of simple illustrative inventory modeling simulations.

Over the last several decades, a significant body of research has developed on two related inventory models; namely, the *square root of N* model (Maister, 1976) and the *portfolio effect* model (Zinn, Levy, & Bowersox, 1989). A key contribution of these two models is that they are cleverly simple (i.e., require minimal inputs), yet when used appropriately, they can provide reasonable "high level" estimates of potential finished goods inventory investment changes resulting from network infrastructure and/or policy changes. The relative simplicity of these two models has made them commonly used tools of consultants and practitioners. This is particularly the case with the square root of N model, which as is well known, and as we will illustrate shortly is extraordinarily straightforward. *However, what is often overlooked or ignored in practice is that there are significant limitations to the range of problems to which one can apply the square root of N model*. In this chapter, we will illustrate some straightforward examples of when to use the square root of N (SQRTN) model or the portfolio effect model, and when more sophisticated models should be considered[2].

The remainder of this chapter is organized as follows. The next section provides a short review of selected literature on inventory modeling. Following, we will introduce the SQRTN model and the original portfolio effect model to provide context for the rest of the chapter. In the next section, we then review key distribution network attributes and firm specific inventory planning process attributes that one should weigh in determining the appropriate inventory modeling approach. This will lead to a discussion of when to employ certain "complementary" non-statistical inventory analysis techniques that go hand-in-hand with the use of the SQRTN and portfolio effect models. We will then provide illustrative examples of when and how to use the SQRTN model and the portfolio effect models. The chapter concludes with a description of how to put these statistical and non-statistical techniques together to generate an overall distribution network inventory evaluation.

LITERATURE REVIEW

The SQRTN model dates back over 35 years ago to Maister (1976) who noted that his work, for the first time, provided a model based on a mathematical proof which could estimate the impact on inventory investment of consolidating multiple field warehouses into one central facility serving an entire market area. Maister pointed out that others (e.g., Brown, 1962; Heskett, Ivie, & Glaskowsy, 1974; Starr & Miller, 1962); had previously discussed the impact of consolidating warehouses, but had not offered mathematical verification of this impact. As discussed shortly, Maister articulated that the "total inventory in a system is proportional to the square root of the number of locations at which a product is stocked".