Preface

Inventory control has emerged as a leading application of operations research. The Survey of Current Business reported that the dollar value of inventories in the USA alone exceeded $1.3 trillion at the end of 2010. Cost-effective control of inventories can cut costs significantly, and contribute to the efficient flow of goods and services in the economy. Many techniques can be brought to bear on the inventory management problem. Linear and nonlinear programing, queueing, and network flow models, are some examples. However, most inventory control packages are based on the methodology of inventory theory. Inventory theory is an important subfield of operations research that addresses the specific questions: when should an order be placed, and for how much?

Inventory theory had its roots in the well-known EOQ formula, first discovered by Ford Harris nearly 100 years ago (Harris 1915). Harris, working as a young engineer at the Westinghouse Corporation in Pittsburgh, was able to see that a simple formula for an optimal production batch size could be obtained by properly balancing holding and set-up costs. The EOQ formula, first derived by Harris, is amazingly robust – it still serves as an effective approximation for much more complex models. After Harris's work, the development of inventory theory was largely stalled until after World War II. The success of operations research in supporting the war effort was the spur needed to get the field off the ground. It seems that the newsvendor model of inventory choice under uncertainty was developed around this time, although it appears that the fundamental approach of balancing overage and underage costs under uncertainty was really first derived by Edgeworth (1888) in the context of banking.

Serious research into stochastic inventory models began around 1950. An early landmark paper was Arrow, Harris, and Marschak (1951). They were the first researchers to provide a rigorous analysis of a multiperiod stochastic inventory problem. Three significant books on the theory stimulated substantial interest in inventory theory research: Whitin (1957), Arrow, Karlin, and Scarf (1958), and Hadley and Whitin (1963). The 1960s saw an explosion of papers in inventory theory.

None of the books or hundreds of papers on inventory control written up to this time addressed an important class of problems. In every case, a tacit assumption was made that items stored in inventory had an infinite lifetime and unchanging utility. That is, once placed into stock, items would continue to have the same value in the marketplace in perpetuity. In truth, there is a very large class of inventories for which this assumption is wrong. These include inventories subject to decay, obsolescence, or perishability.

Let us define our terms. Decay (or exponential decay) means that a fixed fraction of the inventory is lost every planning period (this has also been referred to as age independent perishability). In continuous time, this translates to the size of the inventory decreasing at an exponential rate. Very few real systems are accurately described by exponential decay. For example, suppose the local grocery store discards an average of 10% of its production each day due to spoilage. In actuality though, some days it will not have to discard any product and some days it will have to discard much more than 10%. Assuming a 10% loss each day is a convenient approximation of a more complex process. Exponential decay has been proposed as a model for evaporation of volatile liquids, such as alcohol and gasoline. But how often are these substances stored in open containers, so that they would be subject to evaporation? Radioactive substances (such as radioactive drugs) are one example of true exponential decay. However, inventory management of radioactive substances is a rather specialized narrow problem. While exponential decay has been proposed as an approximation for fixed life perishables, there are better approximations.

A related problem is that of managing inventory subject to obsolescence. What distinguishes obsolescence from perishability is the following. Obsolescence typically occurs when an item has been superseded by a better version. Electronic components, maps, and cameras are examples of items that become obsolete. Notice that in each case, the items themselves do not change. What changes is the environment around them. As a result of the changing environment, the utility of the item has declined. In some cases, the utility goes to zero, and unsold items are salvaged or discarded. However, it is often the case that utility does not decrease to zero. Declining utility can result in declining demand and/or decreasing prices. For example, older electronic items, such as a prior generation of PDAs or hard drives, continue to be available for some time, but are typically sold at reduced prices. From a modeling perspective, the point at which an item becomes obsolete cannot be predicted in advance. Hence, obsolescence is characterized by uncertainty in the useful lifetime of the product.

Finally, we come to perishability. We assume the following definition of perishability throughout this monograph. A perishable item is one that has constant utility up until an expiration date (which may be known or uncertain), at which point the utility drops to zero. This includes many types of packaged foods, such as milk, cheese, processed meats, and canned goods. It also includes virtually all pharmaceuticals and photographic film. This writer's interest in this area was originally sparked by blood bank management. Whole blood has a legal lifetime of 21 days, after which time it must be discarded due to the buildup of contaminants. When uncertainty of the product lifetime is assumed, the class of items one can model is substantially larger. For example, perishable inventory with an uncertain lifetime can accurately describe many types of obsolescence.

Considering the large number of perishable items in the economy, why was this important class of problems ignored for so long? The short answer is that the problems are difficult to analyze. Interestingly, Pete Veinott, a major figure in inventory theory, wrote his doctoral thesis (in the early 1960s) on various deterministic models for ordering and issuing perishable inventories, but never published this work. When this writer inquired why, he said that the notation was so complex and awkward, and he preferred putting the work aside and move on to other problems (Veinott 1978). Van Zyl's (1964) important work on the two period lifetime case with uncertain demand remained largely unknown, as it was never published in the open literature. (This author became aware of Van Zyl's work after completing his doctoral thesis on the subject).

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