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Estimating obsolescence risk from demand data to enhance inventory control—A case study

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ABSTRACT

In this paper obsolescence of service parts is analyzed in a practical environment. Based on the analysis, we propose a method that can be used to estimate the risk of obsolescence of service parts, which is subsequently used to enhance inventory control for those parts. The method distinguishes groups of service parts. For these groups, the risk of obsolescence is estimated using the behavior of similar groups of service parts in the past. The method uses demand data as main information source, and can therefore be applied without the use of an expert's opinion. We will give numerical values for the risk of obsolescence obtained with the method, and the effects of these values on inventory control will be examined.

1. Introduction

Giving good service is considered a requirement to remain competitive throughout industry. This requirement forces manufacturers to keep a stock of service parts, because this is often the only way in which defects of the product can be repaired fast. However, obsolescence of service parts, i.e. parts on stock that are no longer used, is an important cost factor. Cattani and Souza (2003) report that scrapping of obsolete inventory can reduce profits by up to 1% each year.

In the literature, quite a few different approaches towards incorporating obsolescence in inventory models are available. Brown et al. (1964) have proposed two classes of discrete time models. The first class of models incorporates the risk of items becoming obsolete using a mortality distribution. In the second class of models Markov processes are used to model the risk of parts becoming obsolete. Moore (1971) develops a forecasting system to estimate the total requirement of consumable service parts. Furthermore, a dynamic programming inventory model is described to optimize the production runs. Ritchie and Wilcox (1977) develop a method to estimate the total requirement of service parts by using the sales data of the consumer products in which the service parts are used. Renewal theory is then used to develop an appropriate forecast for the relevant service parts. Song and Zipkin (1993) provide a continuous time framework for analysis of non-stationary demand processes. They remark that an important form of non-stationarity is the situation where demand can stop. Using the framework, provided by Song and Zipkin (1993), Song and Zipkin (1996) investigate the effects of obsolescence on the inventory policy. They show that significant savings can be made by including the risk of obsolescence in the inventory decision. Cobbaert and van Oudheusden (1996) recognize the importance of stocks becoming obsolete in inventory control. They remark however that in practice, it is only possible to find a rough estimate for the probability that the part will become obsolete in the near future. This makes approaches that have a lot of parameters hard to implement. Therefore, they propose simple methods that only need a rough estimate for the risk that the part will become obsolete in the coming period. They argue that such an estimate can be given by an expert. Teunter and Fortuin (1999) consider the final order problem under the possibility of stock disposal. A dynamic programming formulation of the problem is derived in order to find the optimal policy. Hill et al. (1999) consider an exponentially declining Poisson demand process. Dynamic programming is used to optimize the ordering process. Teunter and Klein Haneveld (2002) consider a model in which service parts can be obtained in two different ways. During a final production run, parts can be obtained at a low price. After this run the parts can only be obtained at an increased price. They find a series of order-up-to levels, which are decreasing in time, together with an optimal size for the initial order. Cattani and Souza (2003) study the effect of delaying the final order. They find that the manufacturer benefits from this delay, because it improves forecasts. On the other hand, the supplier will need an incentive to enact this delay, because an early final buy is beneficial for his turnover. Song and Lau (2004) construct an approximation for an EOQ model including obsolescence.

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The proposed solution relies on dynamic programming. Furthermore, their method requires sophisticated knowledge regarding the distribution of the time at which the part becomes obsolete. The problem of determining the final order quantity of repairable service parts is considered by van Kooten and Tan (2009). The parts cannot always be repaired, for they are sometimes condemned. The problem is modelled as a transient Markov chain. Also, an approximate model is presented that allows for more efficient calculations. Managerial insights are developed, and a sensitivity analysis is performed. Pinçe and Dekker (2009) study a model in which it is known in advance that a significant demand decrease will occur, which will cause the optimal reorder-point to decrease. Because it is assumed that only demand can take away the excess stocks resulting from this change in control policy, the shift in control is initiated before the shift in demand occurs. They derive a method to approximately determine the optimal time to shift to the new control policy.

We study an original equipment manufacturer (OEM) for which obsolescence of service parts causes problems. We concentrate on the main practical issue: quantification of the so-called risk of obsolescence. To our best knowledge, methods to estimate this risk are not available in the literature, as in the literature it is assumed that the parameters governing the process in which the part becomes obsolete are known or can be estimated by an expert. This lack of methods to estimate the obsolescence risk hampers application of models including obsolescence.

The demand model on which we will concentrate is relatively simple; we use a so-called sudden death demand model with an exponentially distributed demand lifetime. For this model we describe a method that can be used to estimate the expectation of the demand lifetime using demand data.

The remainder of this paper is organized as follows. In Section 2, we will make qualitative observations of the obsolescence problem at the company. This discussion will serve as the primary motivation for our method. In Section 3, we give further motivation for the method by analyzing demand data of service parts. In Section 4, we give an extensive modelling discussion. We then describe the method, and give ideas on how it was implemented. In Section 5 we will draw conclusions, and give suggestions for future research.

2. Obsolescence of service parts

This study will focus on obsolescence of service parts used in technologically complex products, with a relatively high price, a long life-cycle, and which consist of a very large number of parts that may possibly need replacement. Examples of such long life cycle products include baggage handling systems, automobiles, aircrafts, rolling stock (e.g. train carriages) and machines for chip fabrication.

The research we report on was performed as part of a study carried out at such an OEM. The products manufactured by the OEM typically consist of a very large number of parts ($>30\,000$) that can in principle be replaced. A product type is in production for a period of around 10 years. Individual products have a life-cycle that spans around 30 years. After the product goes out of production, the installed base remains more or less constant over a period of multiple decades.

The study assessed the stocking policy for service parts in use at the company. This policy is based on a forecast for future demand, based on past demand data. This demand forecast is subsequently used as input for an inventory model, which gives recommendations for reorder point and order quantity to the inventory controllers. The general goal of the study was to improve the forecast and inventory model, in order to improve the recommendations to the inventory controllers. One aspect of the improved model resulting from the study, that contributed towards achieving this goal, is including obsolescence risk in the model. In this article, we concentrate on this aspect of the improved model.

2.1. Dead stock

One important concern of the company is dead stock. A significant fraction of the inventory value is tied up in stocks for non-moving parts, i.e. parts that were not used in recent years. While not being used, dead stock still ties up capital and increases warehouse costs, without contributing to the overall service level. When there is no demand, most often the only method to get rid of stocks is scrapping them. Dead stocks may thus be costly regardless of how we handle them. Preventing, or at least controlling, the build-up of dead stocks is thus important to be able to control costs. To be able to control the build-up of dead stocks, it is of importance to gain an understanding of the underlying drivers of the build-up of dead stock.

In consultation with the managers and inventory controllers of the company, we found that further built-up of dead stock mainly results from drops in demand. When a part is demanded during the time interval on which a forecast is based, the forecasted demand for that part is positive. This may trigger the model to stock, or restock, the part. When the forecasted demand does not occur, and instead, no demand occurs in the following years, the stock on the part has become dead stock, at least in the sense that is has not moved for some years. After these years, the part either starts moving again, or it remains dead. In the former case, the costs are much lower than in the latter case. It is therefore important to distinguish between a period of no demand that results from a temporary demand variation, and one that results from a permanent demand decrease.

According to the management and inventory controllers, both temporary demand variation and more permanent demand decreases (and increases) occur in practice, and we will identify reasons for both temporary and more permanent demand fluctuations. We will refer to permanent demand changes as demand non-stationarity.

Let us first further discuss temporary demand deviations. Temporary demand variations typically arise from variations in the time between overhauls of individual pieces of equipment, from variation in the wear and tear of individual parts in the product, and from variations in the number of accidents and incidents. Without sources of non-stationary demand, on a longer term a constant installed base results in a constant number of overhauls, part breakdowns, accidents and incidents. However, even without non-stationarity, statistical variation makes that on the short term part usages vary. Temporary demand deviations are the only variations typically taken into account in standard demand models, such as compound Poisson demand and i.i.d. normal demand in particular, and any stationary demand model in general.

While demand non-stationarity can cause obsolescence, which is a major cost factor for service parts inventories, demand non-stationarity is not taken into account in most models. In Section 4, we will propose an inventory model that does take non-stationarity into account. The form of non-stationarity that will be the focus of this model is sudden-death obsolescence. In the following, we will first discuss some underlying reasons for non-stationarity in general, that were identified at the company.