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On the use of installed base information for spare parts logistics: A review of ideas and industry practice

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ABSTRACT

Demand for spare parts is often difficult to forecast using historical data only. In this paper, we give an overview of installed based management and provide several ways in which installed base information can be used to support forecasting. We discuss cases where installed base information is used in forecasting at four companies and list the issues involved. Moreover, we review some models to illustrate the potential value of the installed base information and conclude that forecasts of spare parts demand and return can be made considerably more timely and accurate using installed base information.

1. Introduction

It is well known that spare parts management is difficult because the parts can be expensive, their demand is highly erratic and intermittent, yet their shortage costs can be very large (see, e.g. Aberdeen Group, 2003). Moreover, spare parts typically carry high obsolescence risk due to their specific functionalities. Consequently, service logistics companies often have difficulties in striking the right balance between inventory holding, stock-out and obsolescence costs while offering competitive service contracts.

Much could be gained if demand for spare parts could be better forecasted. Although there is a wide literature on time series forecasting, these methods are not always successful. First of all, parts and products exhibit a lifecycle pattern with an initial growth, maturity and a final decline phase. Secondly, actual customer demand may depend on the specific context, including which systems the customer employs, which type of contracts he has, how the products have been maintained and what the actual states of his systems are. As a result, it makes sense to consider demand forecasting using all available information on the so-called installed base and we will refer to this with the term *installed base forecasting*. Although this idea seems straightforward, it is not that easily realized in practice as much information needs to be maintained and often companies do not have access to it. Moreover, the scientific research on installed base forecasting is limited and the notion is pretty scarce in the operations literature.

One could say that installed base forecasting is a kind of causal forecasting, in the sense that the forecast is not only made on the historic demand data but also on data about installed base aspects that trigger demand.

The idea to relate forecasts to the installed base was already mentioned in the forecasting of new product adoption by Brockhoff and Rao (1993) and was later followed by marketing researchers. For spare parts it was mentioned briefly by Cohen et al. (1990), as a kind of updating of forecasts, however, without further analysis. Auramo and Ala-Risku (2005) discuss installed base information for service logistics, but the main focus is on getting the installed base information from various sources. Jin and Liao (2009) discuss inventory control in case of stochastically growing installed base with the assumption that the data is available. Jalil et al. (2010) highlight the potential economic value of installed base data for spare parts logistics. They also discuss various data quality issues that are associated with the use of installed base data and show that planning performance depends on the quality of the data along various dimensions. They discuss an implementation with IBM. Colen and Lambrecht (Forthcoming) discuss the case of a capital goods manufacturer that is transitioning from a product oriented to a service oriented company. The case highlights the importance of installed base forecasting for service oriented operations management. From these studies,

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we conclude that the scientific literature lacks a good overview on what installed base forecasting is, how it can be used and what its pros and cons are. In this paper, we try to fill this gap by giving an overview of ideas and by relating them to the industry practice.

The remainder of the paper is organized as follows. In Section 2, we define the concept of installed base, indicate what kind of installed base data is relevant and how it can be collected. Moreover, we also discuss the actual practice of installed base forecasting, as observed with a number of companies, which participated in a project on service logistics. We also discuss the obstacles with maintaining good quality data. In Section 3, we indicate how installed base information can be used to make better forecasts and how that affects spare parts stocks. In Section 4, we analyze the value of installed base forecasting. First we make a comparison with black-box forecasting and secondly, we assess the value of install-base forecasting in case of a planned demand drop. Next we consider the effect of errors in the installed base data. We finish the paper with overall conclusions on installed base forecasting.

2. The installed base and the demand for spare parts

2.1. The installed base and the service network

2.1.1. Definition of installed base

The installed base is usually defined as the whole set of systems/products a company has sold and which are still in use (see Longman, 2007). Here we would like to elaborate on this definition and make explicit that the original equipment manufacturer (OEM) need not be the organization, which provided the after sales services. Therefore, we define the installed base as the whole set of systems/products for which an organization provides after sales services.

Examples are the set of computers Dell has sold under its name, the airplanes manufactured by Airbus, the power plants positioned in remote locations by Wärtsilä, etc. The installed base of these systems/products need maintenance and spare parts in order to continue functioning. Thus, OEMs have maintenance or service contracts with the user either directly or through intermediate parties.

Although our exposition will be valid both for products sold in a consumer market (e.g. consumer electronics) and for equipment sold in an industrial market, in the sequel, we will mainly focus on the industrial equipment, as the cost of maintenance, repair and overhaul (MRO) services are highest in the industrial market.

2.1.2. Service network

The installed base is served by means of a service network consisting of stock locations keeping inventory of spare parts to either directly serve the customer or to replenish the next tier of forward stock locations, i.e., stock locations nearer to the customer. Proximity to the customer is mainly driven by the requirement of short delivery lead times especially when equipment down time costs are substantial. Cohen et al. (1997) discuss general spare parts networks and state that usually two or three level networks are used, like continental distribution centers, regional distribution centers, and forward stock locations and/or consignment stocks at customer sites.

Demand for spare parts at an individual customer is usually low and erratic, so pooling of stocks is economically attractive but also increases lead times. In the case when spare parts inventory is pooled, emergency transports are used to satisfy urgent demand. Typically, service contracts require 2 h, 4 h, 8 h to next business day deliveries. To avoid high inventory costs, companies stock almost all parts at continental distribution centers, and use limited stock assortment at regional and forward stock locations. For a good stocking decision at a forward stock location, it is important to know accurately the characteristics of the installed base (e.g. size, age, location of equipment) in the neighborhood. In the special case where stock locations are dedicated to a particular customer, the assortment will be in agreement with customer requirements. For stock locations serving several customers, the assortment will not reflect all customer requirements.

2.1.3. Maintenance concept

The demand for maintenance and spare parts services also depends on the deployed maintenance concept. We may distinguish between reactive maintenance and various categories of proactive preventive maintenance, for an overview see Murthy and Blischke (2005). Observe that from the maintenance policy and the state of the install base (like the age and number of flying hours) the demand for spare parts for preventive maintenance can be predicted. For example, if an airplane goes into a major overhaul, like a D-check, then a lot of spare parts will be needed. Condition-based maintenance also provides detailed data about the state of the install base.

2.2. Main issues in spare parts logistics

2.2.1. Lead times

It is well-known that (long) lead times make spare parts management difficult. If spare parts are always available within one day, then one does not need to do sophisticated planning. In the following, we distinguish between the make-to-stock and make-to-service (order) situations, and as a consequence, between transport and manufacturing lead times. The transport lead time is the time needed to bring a part from a depot/stock location to a customer, and these lead times range from hours to weeks, depending on the transport mode chosen and distance. The transport lead time is important for deciding on the stocking location of the spare part if the customer wants a very fast service (which can be up to 2 h). The manufacturing lead time refers to the time it takes to source or produce a part according to the requirements, and bring it to the service network. Manufacturing lead times can be much longer (up to two years), as the manufacturing of a spare part might require production of new molds or special set-ups to start production. Moreover, sub parts (also called piece parts) needed to make the part may also have long lead times.

In Europe as well as in the US, there are efficient express companies, able to deliver parts to main cities within 24 h (but not to all cities, and often not to islands). A single central stock location for the whole continent may be enough even when there are hundreds or thousands of customers. In this case of make-to-stock, the main concern is to determine the number of spare parts to be kept on stock to satisfy demand within the manufacturing lead time. Hence, a forecast of the spare parts demand within this lead time is needed.

However, if down time costs are high, spare part delivery lead times of a day are usually not acceptable. In that case one has to balance the stock out (downtime) costs with the inventory holding and obsolescence costs. When stock out costs prevail, one can store the parts close to the customer using regional depots or forward stock locations, or even at the site of the customer. These stocks can be re-supplied from a central stock. In this case forecasts are required only within a very short transportation lead time, but for a very small region.

2.2.2. Demand characteristics

The demand for spare parts is usually intermittent, erratic and slow moving. As a result, little data is available to perform