# Potential development targets in spare part logistics

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**Abstract**
The study reviews development actions carried out in maintenance and spare part services. The review focuses on case studies and other real-life examples that have been reported on. It is also discussed how to identify the situations where it is practicable to emulate the found development actions. An illustrative case example is used to demonstrate how to evaluate the suitability of some of the development approaches in practice. The summary may offer ideas for companies that are in early phases of their development work, and practical guidelines for evaluating the suitability of some development actions.

**Keywords:** Spare parts, Logistics, Inventory management, Supply chain management, Development

## 1 Introduction

Maintenance outsourcing has become more common, and there are several examples in which traditional equipment manufacturers have expanded their business to maintenance (Mathieu 2001, Eronen 2004, Karjalainen 2005, Selenius 2010, Karvonen 2011). For suppliers, services in general have for long been regarded as marketing tools for increasing sales (Mathieu 2001). Providing maintenance services offers the following benefits for the equipment supplier:

- providing added value to the customer
- maintaining a deeper contact with the customer may offer
  - opportunities for innovation
  - improving the performance/durability of the equipment
  - increased sales.

However, changing the emphasis from the role of a product manufacturer to that of a service provider requires development work from the company. There are some documented examples of how spare part services and related activities have been developed in companies. These examples describe developments in both service offerings and customer relationships, as well as in spare part inventory management.

A lot of information has been accumulated about developing spare part services. This information may offer ideas and points of reference for companies that are in early phases of their development work. However, studies concerning development actions are mostly single case studies, and usually it is not discussed when and where similar development actions would be applicable and beneficial. Therefore, this paper focuses on building an analytical summary of potential development actions in the area of spare part services.

The research questions of this study are:

1. What kind of development actions in spare part services have been reported on in the literature?
2. How to identify situations in which it is practicable to emulate those development actions?

This paper presents a review of documented development actions, and assesses their wider applicability with a case example. Potential development targets are pointed out for the case company.

The rest of this paper is organized as follows: Section 2 reviews the literature concerning development efforts in maintenance and spare part services, focusing on case studies and other real-life examples. Section 3 presents an illustrative case study of pointing out potential development targets in spare parts inventory management. Finally, concluding remarks are presented.

## 2 A review of development efforts in maintenance and spare part services

From the spare part supplier's point of view, the final objective of all development efforts is increasing the profitability of the company. This can be done by increasing sales, reducing costs, or by reducing the amount of invested capital. In this section, we review real-life examples of this type of efforts found in the literature.

### 2.1 Development efforts focused on increasing sales

In general, increase in sales can be pursued by expanding the selection of services offered. We divide spare parts –related services roughly into two categories: 1) inventory services focused solely on material management and 2) maintenance-related services based on maintenance expertise. However, in practice logistic services are often marketed in connection with other maintenance services.

***Inventory services:***
Inventory services are services where the supplier takes a full or partial responsibility of an inventory of one or several items on behalf of a customer. In the literature, an often discussed model is referred to as vendor-managed inventory (VMI) or supplier-managed inventory (SMI). In VMI, the vendor is given access to its customer's inventory and demand information. Implementing a VMI solution requires that there is an established and trusted business relationship with the partners, and the material flow is substantial and continuous. In the VMI model, the customer does not place purchasing orders to the seller, even though the purchase orders may be triggered by the IT systems for legal and archiving reasons. The main tool used to operate the VMI is a demand estimate or forecast. The customer is responsible for giving the

estimate for a given period of time and using the goods according to the estimate within agreed tolerances. The customer is invoiced according to the real use or even pays according to the use without being invoiced. The supplier is responsible for maintaining an agreed level of inventory also within certain tolerances (Pohlen and Goldsby 2003). For a mathematical example of the VMI model, see e.g. Darwish and Goyal (2011).

In the maintenance context, examples of VMI or similar practices can be found for consumable-type parts. E.g. a paper machine equipment manufacturer manages the inventory of consumable spare parts, e.g. scraper blades, on behalf its customers (Olli 2007). When the same product is sold for several customers, the supplier may exploit economies of scale. An example of this is the case in which a paper machine equipment manufacturer offers 24h service and fast delivery of spare parts that have been traditionally stored by the customers. This way, the supplier is able to pool the inventories of several customers in the nearby area (Eronen 2004). E.g. ABB offers an inventory management service, which automatically reports the inventory transactions to the supplier and allows the supplier to handle the replenishment process automatically (ABB, 2012).

***Maintenance services:***
A general observation is that many suppliers have expanded the selection of maintenance services that they offer to customers, as well as the selection of contract types. In this section we review examples.

Maintenance contracts can be classified into three main types (Tsang 2002):

1) *Work package contracts* can be regarded as the basic maintenance contracts. The supplier performs maintenance activities according to the customer's plan. A variant of this type of a maintenance contract is management consultancy, in which maintenance services are sourced and managed by the consultant on behalf of the client.
2) *Performance contracts* are contracts where a comprehensive range of maintenance services are awarded to a single contractor. The contract stipulates the desired performance of key outputs, such as failure rates, availability etc.
3) *Term-lease contracts* are also referred to as "facilitator types". In this mode the customer is only the user of the physical assets owned and maintained by the contractor.

Work packages may contain different types of maintenance activities, from training and consulting to direct intervention with different response times. Modern information technology (IT) enables also different types of remote services. Persona (2007) presents four case examples in which IT plays a crucial role in the services offered. 1) A wood panel manufacturer has adopted remote control and maintenance management of spare parts and continuous training of personnel through the Internet. 2) A remote maintenance company offers services for packaging machines. The company offers installation and set-up of the system, tele-control of machines, suggestions for interventions, remote training, and direct intervention. 3) A machine tools producer has created a platform that holds all maintenance data, with a client web interface. The platform provides spare part suppliers with information about customers' spare part requests. The customers are able to order spare parts and find any technical information about the machines and similar previous interventions, and the portal provides a full remote control system. 4) An engineering company has extended its services to cover the entire life cycle of plants. With the equipment suppliers and maintenance firms, the engineering company has generated a virtual enterprises network. The company has implemented an Internet portal for the network that is used for plant monitoring, preventive maintenance, equipment and system performance evaluations, training, and knowledge management.

Tsang (2002) claims that in practice, maintenance contracts tend to be task-oriented rather than performance-oriented. He suggests that this is caused by the problem that the profit motives are not shared; the contractor wishes to maximize the returns, while the client's goal is to minimize the costs, and this leads to short-term tactics. However, there are many empirical examples of long-term maintenance contracts as well.

Performance-based contracts are marketed as e.g. guarantees of response times or usability of the equipment. The elevator supplier KONE markets its long-term maintenance service with 99% or 99.5% service level, and ABB markets guaranteed on-site response time (KONE 2011, ABB 2012). The supplier may take the responsibility of the maintenance of a plant as a whole, so that it maintains also the equipment of other manufacturers. An example of this is ABB that provides overall maintenance for whole plants (Paakkonen 2009).

There are many examples of a supplier offering a service package in which the customer pays only for the use of the equipment. The term-lease contracts ease the customer's operative purchasing work, and decrease the financial risk included in the ownership of equipment. There are many examples of this: Rolls-Royce offers a Total-Care package, in which Rolls-Royce delivers "power-by-the hour", and Xerox and Canon have "pay per copy" lease and take-back programs (Baines et al. 2007). Koncranes has developed a service model in which the customer pays by the tons that are lifted by the cranes (Karjalainen 2005). The Swedish pump manufacturer ITT Flygt offers aftersales services that are priced by the energy consumption of the pumps (Öhlund and Ritzén 2002). Some forklift-manufacturers (e.g. Rocla) offer forklift leasing with additional material handling services, e.g. inventory audits and leasing workforce. Empirical examples indicate that models in which the supplier takes a greater responsibility of the whole life cycle of the product have become more common.

***Implications of expanded service offering to spare part inventory management***

In principle, the potential benefits of expanded service offering are not limited to increasing the sales only. Understanding the customer's business and the long-term nature of relationships allows better access to advance demand information. Studies about the benefits on improved information sharing of advance demand information in maintenance context are scarce, but something can be learned also from empirical studies in other contexts.

In principle, VMI or similar approaches can be expected to provide three benefits for the supplier: 1) greater demand visibility reduces demand uncertainty, which enables lower safety stocks, 2) suppliers are better able to align their production processes to customer demand (Dong and Xu 2002, Tyan 2003, Waller et al. 1999), and 3) establishment of a long relationship provides more secured sales (Vergin and Barr 1999, Xu et al. 2001). Even though modeling/simulation studies emphasize the operational benefits of VMI, empirical studies are less conclusive (Kauremaa and Småros 2009). Empirical studies suggest that the use of customer demand information is typically limited to replenishment (Kauremaa and Småros 2009, Holweg

2005). Studies concerning real VMI implementations show that whereas the buyers receive efficiency gains relating to working capital, administrative work and service levels, the suppliers do not necessarily benefit from VMI programs in operational terms. In practice e.g. large delivery lot sizes and long lead times in production are known to be factors that hinder the utilizing of improved advance demand information in planning (Kauremaa and Småros 2009). The buyer targets at ease of supply and improved operational efficiency, and the supplier chiefly at the preservation of its commercial position. Some authors (Vergin and Barr 1999, Clark and Stoddard 1996) even suggest that VMI is used primarily as a marketing tool.

In theory, taking a greater responsibility of the maintenance and inventory management of spare parts offers a greater demand visibility for the supplier, but its benefits in the maintenance context have not been extensively studied. Rather, information sharing in spare part supply chain has been presented as a potential area for further research. Kennedy et al. (2002) note that more research is needed on the benefits of information sharing between the supplier and the user. Later, Martin et al. (2010) have suggested that further research is needed in using information about the demand generation process in forecasting. The demand generation process includes e.g. the maintenance concept and the use of the equipment. The authors point out that the main obstacles are related to the availability of such information. Uusipaavalniemi and Juga (2009) have studied information-sharing practices in a steel factory's maintenance supply chain, and note the lack of other studies on the subject. Their empirical study revealed that all maintenance information is not in the systems, and much of the information-sharing is informal and depends on the persons involved, and this limits the information sharing.

We found only a couple of works that dealt with exploiting the maintenance plan data or other use-related data in spare part demand forecasting or inventory management. Ghodrati and Kumar (2005) present a case study in which information about the operation environment of pumps was used successfully in improving spare part demand forecasts. The authors define the operating environment as consisting of five factors: 1) the working environment, 2) user characteristics, e.g. operators' skills and education, 3) operating place location, 4) level of application, and 5) work time and period of operation. In the case study, the failure rates were re-evaluated, and they were noticed to be higher than the initial estimates, and to depend on the operating environment. Based on the re-evaluation, the suggested number of spare parts to be kept in stock was increased, and machine downtimes were reduced. Wang and Syntetos (2011) present an approach for linking inspection schedule information on spare part demand forecasting. However, the studies focus on single items, and the reported benefits focus on reduced downtimes. The supplier would potentially benefit from this kind of advances only in a case- or performance-based maintenance contract.

### 2.2 Development efforts focused on cost reduction

Development projects that focus on cost reduction have been discussed in the academic literature in more detail than projects that aim at increasing sales. This is probably due to the fact that this area lends itself better to the traditions of operations research.

Inventory-related costs: inventory holding costs and stock-out costs have a substantial influence on the total the spare part logistics costs. Therefore, when the demand volumes for spares change, revising inventory policies seems a sensible development action. It has been noted that empirical case studies in this area are rare, compared to other research approaches in spare parts inventory management research (Kennedy et al. 2002, Bacchetti and Saccani 2012). Still, at least 7 case studies that deal with revising and improving current spare part inventory policies could be found. All these studies have some common features. They all include a decision-making framework, and the parts are classified according to one or more criteria. Table 1 summarizes these studies. In the table it is presented which classification criteria was used, what the focus of the development work was, and what kind of benefits were achieved.

**Table 1: Summary of case studies about improving spare part inventory management**

| Paper | Classification method | Objective of the development work | Benefits achieved |
|---|---|---|---|
| Gelders & Van Looy (1978) | ABC analysis - demand value | Differentiating inventory models | Decreasing total inventory value (exact value not available) |
| Cavalieri et al. (2008) | Multi-criteria: (part cost, part criticality, demand variability, part specificity, supply characteristics) | Focusing attention; selecting forecasting approach (reliability based or time series); selecting stock sizing approach | Not reported |
| Porras & Dekker (2008) | Multi-criteria: (part cost, part criticality, demand volume) | Selecting approaches for determining re-order point (ROP) system variables | 6.4% savings in inventory holding costs |
| Boylan et al. (2008) | Multi-criteria: ( aspects of demand volume and variability) | Selecting forecasting method (Moving average MA vs. Exponential smoothing); selecting inventory control rules | 11.7% reduction on total inventory value (estimation, based on theoretical assumption) |
| Syntetos et al. (2009) | ABC analysis - demand value | Selecting inventory control rules (manually vs. automatically created ROPs) | Improvement in order fill rate (percentage of complete orders filled directly from stock) (79% -> 95%) |
| Paakki et al. (2011) | Multi-criteria (part cost, demand volume, demand variability, supply characteristics) | Focusing development efforts (e.g. to reduce lead times, to understand customer behavior, to revise inventory policies) | Facilitation of development work |
| Bacchetti et al. (2012) | Multi-criteria: (sales cycle phase, response lead time to customers, number of orders, part criticality, part value) | Selecting forecasting and stock-control methods and targets | Reduction of the total logistics costs (about 20%) |

**Construction of spare part classification models**

The most popular classification criteria in former spare part classification studies have been part cost and part criticality, followed by demand volume or value and supply characteristics, such as replenishment lead time or supplier availability. Also demand variability has been used in several works (Bacchetti and Saccani 2012). The availability of information may explain the classification criteria used. Typically, past sales data is easily available in modern ERP systems, but specific customer-related information or maintenance-related information is not in the same system by default. E.g. Porras and Dekker (2008) note that one important limitation of their demand set was that it did not specify whether demands were due to failures or preventive maintenance activities. The classification of part criticality is qualitative, and has been taken as provided by the case company in the studies where it has been used (Cavalieri et al. 2008, Porras and Dekker 2008, Bacchetti et al. 2012). Porras & Dekker (2008) note that there are parts that have combined criticality codes, depending on where they are installed.

Applying even a very simple classification model may offer benefit if the classification method is not yet in use in the company. Two case studies listed in table 1 apply ABC-analysis on the basis of demand value (Gelders and Van Looy 1978, Syntetos et al. 2009). Some case examples imply that ABC-classification is well known and applied in companies (Bacchetti and Saccani 2012). It has been noted that in inventory management simple rules are considered more suitable in practice than complex mathematical approaches (Huiskonen 2001, Nenes et al. 2010).

The other studies presented in table 1 apply multi-criteria classification. (Bacchetti et al. 2012) use a hierarchical approach ending in 12 different categories. In the model of Porras and Dekker (2008) the category of each item is defined by three digits. Accordingly, an item in class "*xyz*" corresponds to an item with demand class *x*, criticality class *y* and price class *z*. Paakki et al. (2011) have applied a partially hierarchical approach, ending in 18 categories. Boylan et al. (2008) build their classification on the model that Syntetos et al. (2005) developed for intermittent demand pattern classification. Originally, the scheme was developed for selecting the most appropriate forecasting method for intermittent demand. The categorization is conducted by using two factors: the squared coefficient of variation ($CV^2$) and average inter-demand interval (p). If p is less than 1.36 forecast review periods and $CV^2$ is less than 0.48, the demand can be described as smooth. If p is greater than 1.36 forecast review periods, or $CV^2$ is greater than 0.48, the SBA-method (Syntetos-Boylan Approximation) is expected to outperform the Croston method in forecast accuracy. The validity of the rules proposed is confirmed by means of the simulation of 3000 real intermittent demand data series. Unlike some other demand categorization studies, this framework pursues general validity.

**Use of classification models**

The classification models work as a basis for development actions. The use of item classification can be divided into three types:

1. Focusing the attention in general

At its simplest, classification can be used for focusing the attention on a specific group or groups of items. In Syntetos et al. (2009), the manual work of selecting ROP-system parameters focuses on the parts with the greatest sales volume. The importance of focusing the attention is emphasized also in the works of Cavalieri et al. (2008) and Paakki et al. (2011).

2. Forming heterogeneous groups for comparing stock control methods with the simulation approach

In four studies, a simulation approach has been used to compare the suitability of different inventory control methods (Cavalieri et al. 2008, Porras and Dekker 2008, Boylan et al. 2008, Bacchetti et al. 2012). Several examples can be found about applying this approach also in other than spare part contexts, (e.g. Azadeh et al. 2011, Inaba 2012). An inventory control method is composed by a criterion that specifies the conditions under which a new order should be issued, and a reference point for the quantity to be ordered. However, simulation requires that there is enough data available to allow reliable conclusions. Cavalieri et al. (2008) do not discuss the issue of data availability. Bacchetti et al. (2012) consider 3 observations about the demand as a minimum requirement for applying a simulation approach. Also items with 18 months from the last order have been classified as dismissed and excluded from the simulation approach. Porras and Dekker (2008) address the issue of very low demand and mention that the items for simulation were selected from a larger group, but do not explicitly describe the selection criteria. In the work of Boylan et al. (2008) data sets from different companies were used, but the simulation approach was not applied for all of them due to the lack of inventory-related data or great variation in demand variability and order intervals over time.

3. Supporting judgment-intensive managerial decisions

Two studies deal with providing improvement suggestions without using the simulation approach. Bacchetti et al. (2012) offer some suggestions for the item groups that are not considered suitable for applying the simulation approach. For low-demand spare parts the suggested approach is using a causal forecasting method which is based on the demand rate of a similar component, employed on similar product models with a longer demand history. For dismissed items, make-to-order (MTO) or a periodic control with order-up-to level on the assumption of Poisson distributed demand is applied. In Paakki et al. (2011), the simulation approach is not applied at all, but qualitative suggestions about further development work are made for different item categories. One of the suggestions is revising the inventory policies, for which the simulation approach is a potential approach. Other suggestions are e.g. understanding customer behavior and reducing lead times, which are more time-consuming efforts, and managerial judgment plays a greater role in their implementation. Therefore, it is more difficult to quantify the potential benefits of these efforts. The benefit of this approach is that some practical suggestions to the case company can be given, even if the data is too “difficult” to be analyzed with simulation. In addition, the suggestions are not limited only on changing inventory control parameters.

# 3 An illustrative case example on defining potential development targets in spare part logistics

In this section we discuss the generalizability of the development approaches presented in former case studies. We demonstrate how the data of a case company lends itself to similar approaches that have been applied in other studies.

## 3.1 Introduction of the case company

The case company is a large global equipment manufacturer that seeks to expand its spare parts and maintenance business. The equipment is mostly customer-specific installations to basic industry. The total sales value is around 100 M€, of which the share of service business is 30% and growing. The spare parts in question are non-repairable parts by default.

The company has several stocking points globally. Stocks are kept in connection with the production units and some of the sales units that also offer maintenance services to customers. Currently the information sharing between the units is limited, so that there is no direct access to the inventory records or plans of the sales units.

The current inventory policy in the case company is such that items with 3 or more orders per year are classified as "items with repeating demand". For those items, a re-order point system is applied, and Economic order quantities are calculated based on two-year average demand volume, and provided as a guideline for the replenishment decision. However, some items are kept in stock despite a lower demand rate, if short lead times have been promised to the customers and cannot be achieved without keeping stock.  A simple ABC-classification according to yearly demand value is in use, and for high value parts inventory control parameters are used.

The company markets maintenance services, such as shutdown services including mechanical demolition, rebuilds, industrial cleaning solutions, equipment maintenance, material handling services, and technical services. Inventory-related services are under continuous development. Areas of development include e.g. productization spare part availability, and simplifying the order-delivery process for items that the customer orders repeatedly. The maintenance services are offered by the sales units that also sell the equipment and spare parts, and these sales units form the biggest share of the total customer base that order parts from the central stocks.

## 3.2 Data analysis

In the case company, sales data from 2 years was available in the ERP-system, so it was possible to analyze the demand patterns of items. We selected data from one product line for the analysis. There are 1783 stock-keeping units (SKUs) in this product line. Obsolete items had been currently removed from this data set.

Table 2 presents an overview of the case data. We analyze first the prerequisites for applying the most common approach in former case studies, which is comparing different inventory control methods using simulation. This approach assumes that the nature of the demand of the SKUs is somewhat permanent, and inventory control decisions can be made on the basis of past demand, and thus enough data about past demand is needed. The number of demand events is a criterion applied by Bacchetti et al. (2012). Using their criteria and excluding SKUs that have less than three orders, we conclude that simulation cannot be used for 373 items. Both Bacchetti et al. (2012) and Boylan (2008) use average demand interval (ADI) as a classification criterion, with 1.36 forecast review periods as a cutoff value. Boylan et al. (2008) exclude the items that cannot be categorized due to great variation in demand intervals or demand variability over time. However, the exclusion process is not explicitly described in their paper. We have used the following approach: we measured ADI from both 2010 data and 2011 data. If an SKU switched across different categories defined by the cutoff-value of 1.32 months, or ADI could not be determined for another time period, it was concluded that the item could not be categorized reliably by ADI. Altogether, the simulation approach seemed unsuitable for two thirds of the SKUs, which represents 47% of the total sales volume.

**Table 2: Overview of case company data**

| | Number of SKUs | Share of total sales value | Comment |
|---|---|---|---|
| Total | 1783 | 100% | |
| <3orders in the data set | 373 | 2% | Not enough data for applying the simulation approach |
| ADI crosses the cutoff-value (1.36) between 2010 and 2011 | 573 | 36% | SKU could not be reliably categorized by average order interval |
| ADI could not be determined for 2010 or 2011 | 601 | 9% | SKU could not be reliably categorized by the average order interval |

In general, traditional stock control-methods such as the re-order-point system of periodic control are known not to suit well for lumpy demand. To demonstrate the lumpiness of demand profiles of the SKUs as a whole, the framework of Syntetos et al. (2005) can be applied ( Figure 2). The demand data has been analyzed on the monthly level. Only two of the 1783 SKUs have a $CV^2$ less than 0.49, and 337 items have a p less than 1.36. Thus, the majority of demand can be described as erratic or lumpy. The problem is that there is no “best practice” for the inventory control for lumpy items (Boylan et al. 2008). The more items there are in the lumpy area, the less reason there is to assume that changing inventory control parameters will lead to cost reductions in total inventory costs.

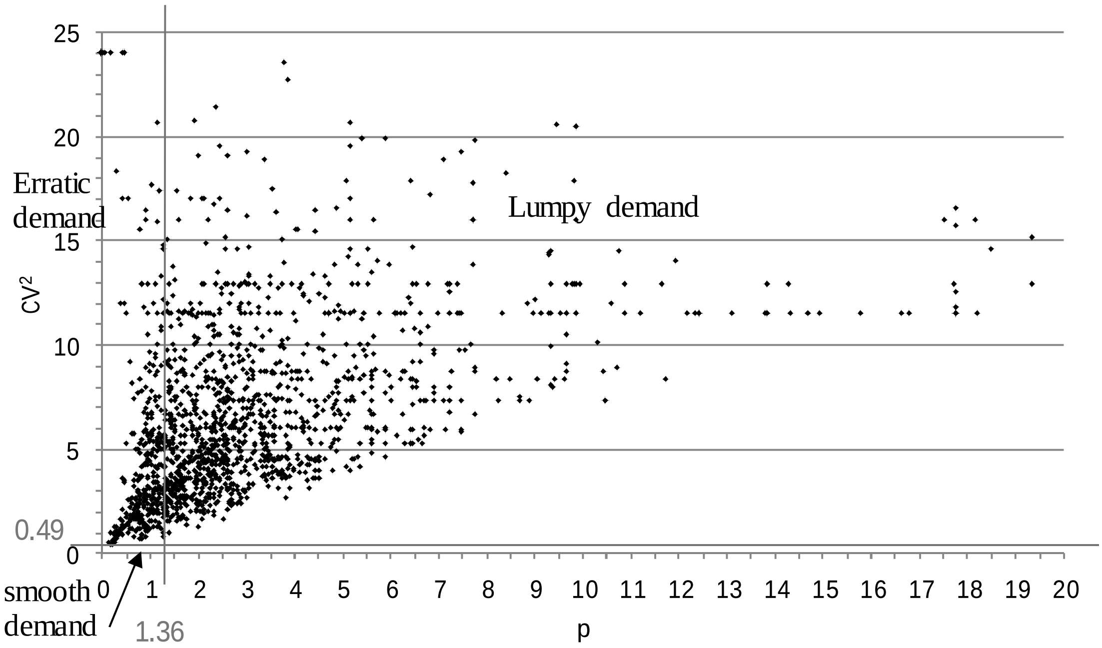


**Figure 1: Demand patterns in the case company**

The other classification approach presented in section 2.3 was grouping items to support judgment-intensive managerial decisions. This approach has been discussed in past studies to a lesser extent. Here we present examples of the possibilities of this approach in the case company.

Many of the case company items do not lend themselves for sophisticated statistical analysis. However, they may still be categorized on the basis of contextual information, e.g. customer knowledge. This qualitative customer information includes e.g. knowledge on the duration of customer relationships and the type of customer business. In the industrial context, the number of customers is typically lower and the duration of customer relationships longer than in the consumer environment. In the case company, 21% of the SKUs are sold to only one or two customers, 73% are sold to less than 10 customers, and 98% for less than 50 customers. Only 0.4% are sold to more than 100 customers. Therefore, some “difficult” demand patterns may be explained by such customer-related issues as stock-keeping policies, changes in the installed base, and even by preventive maintenance. In general, the prerequisites and motives for sharing explanatory demand information are better in situations where there are considerable, repetitive sales to a customer.

It is relevant to sort out the items that have the most “difficult” demand, but where the demand patterns can be potentially explained by the customers’ inventory replenishments or preventive maintenance. These items could be potentially managed better with a partial MTO or advance order –policies than traditional reactive inventory control.

Figure 3 presents an example of quick analysis of the case company’s customer base. It shows how the total sales are distributed to individual customers. It can be seen that there are a few customers that clearly dominate the sales. In this case, these customers are internal customers, representing the sales units of the company, and they are easily identified as long-term customers. In the case company, the largest customers hold stock for some of the items.

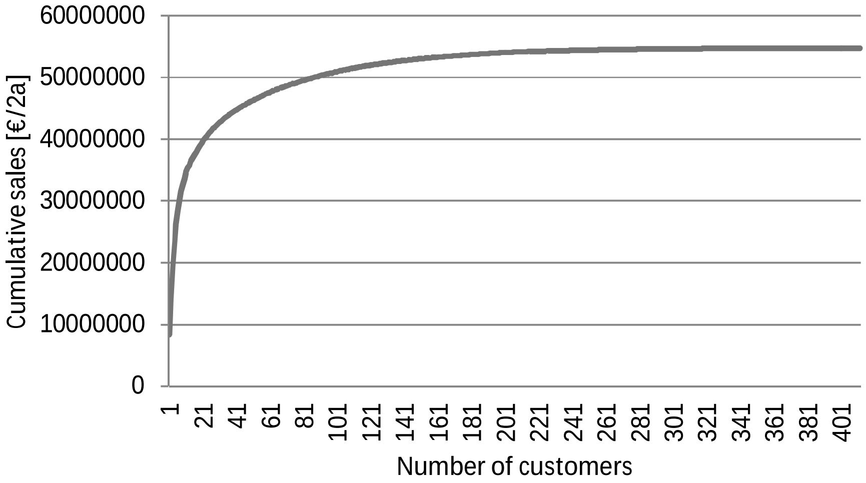


**Figure 2: A quick analysis of the customer base**

In this environment, increasing the visibility in the supply chain is an area of development that has already been identified, but the actual development work  lacks focus. Item classification can be used to support the decision of selecting pilot SKUs for enhanced information sharing.

Potential selection criteria for the pilots are:
1. The demand is highly lumpy (infrequent and volatile) or it cannot be classified.
2. The number of customers is low.
3. Access to customers' inventory records, planning information and forecasts is possible (the customers are internal or long-term customers)

The information deeded for this type of classification is easily available from the ERP. In practice, the cutoff-values for the criteria need to be determined so that a suitable number of items are selected, and the classification is well understood and accepted by the managers. From this pre-sorted group, it is easier to select the potential pilots by using managerial judgment. In this case, managerial understanding is needed in determining e.g. whether the demand profile is such that it causes difficulties to production or purchasing. This depends on the lead times, which are currently not always documented in the ERP system. In addition, from the managers' point of view, the ease of implementation of information sharing depends highly on such issues as the organizational culture in the customer's unit.

## 3.3 Discussion

This section provided an overview on the maintenance and spare part services of a case company, and evaluated how the development approaches found in the literature fit the company's situation and needs. Other companies' service offerings and contract types provide a reference point, but specific development areas were not pointed out for the case company on the basis of them. However, some more general approaches could be found for revising inventory policies.

In the case company, the simplest classification model, ABC-analysis was already applied, so it was assumed that in order to improve the current practice, a more detailed classification was necessary. In general, finding out a current classification practice is recommendable in the beginning of a development project.

A common approach in inventory research is comparing alternative inventory control methods with simulation. For a considerable number of items, this approach was unsuitable for the case company due to a low number of orders and discontinuity of demand patterns. Metrics similar to the ones used in this case example can be applied in other companies in order to assess the applicability of the simulation approach.

Other potential uses of classification methods have been discussed less in the literature. In this case, classification could be used also for finding out SKUs for which extended information sharing with the customer is a potential development target. This is a subject that has been presented as an area for further research in the literature, but specific research approaches have not been suggested. We suggest that in order to find out the practical relevance of the subject it should be studied in a practical context, and part classification can be used to point out the most potential contexts.

## 4 Conclusions

This paper has focused on building an analytical summary of potential development actions in the area of spare part services, summarizing both what kind of development actions in spare part services have been reported in the literature, and how to identify situations in which it is practicable to emulate those development actions.

One of the aims of this paper was to review the literature on development actions in spare part services. The development activities reported in the literature can be roughly divided into two: the development of new services, and refining the old activities. Empirical examples imply that several equipment manufacturers have expanded their selection of maintenance-related services and longer-term contract types. The most detailed descriptions can be found about revising spare part inventory policies. Typically, in these studies it is presented how spare parts are classified into distinct groups in order to focus the attention on the most important items, to compare different inventory control methods with simulation, or to otherwise support managerial decision making.

Another aim was to assess the wider applicability of the development approaches presented in the literature. For this purpose, a case example was used. It was demonstrated how the applicability of development approaches depend on the company's current planning practices and the nature of the demand.

This paper offers a quick view on the development actions in spare part services, focusing on spare part inventory management. As such, it may offer ideas for companies that are in early phases of their development work. Empirical experience indicates that defining the targets for development projects is often time-consuming, and the projects usually concern several people. Describing the company situation according to the characteristics presented in the analytical summary may help the different parties in achieving the same level of understanding of the company's situation, and thus help saving time in the early phase of the development work.

The main limitation of this study is that it is based on a relatively small number of cases. In general, it is difficult to get access to internal development actions of companies, and therefore it is difficult to evaluate how well the presented summary covers the development actions that are taken currently in companies. The summary can be improved when data from more development projects has accumulated.

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