9 Spare Parts Management at IBM: Capturing the Value of the Customer and Product Returns

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Abstract

In memory of Jo van Nunen as a professor at the Rotterdam School of Management, this chapter aims to provide an overview of the collaboration between the Rotterdam School of Management (RSM) and IBM. The chapter primarily reports on the research done by three Ph.D students at IBM with Jo van Nunen as promoter. Two issues that characterize the scope of the research are discussed. First, the need to systematically assess the role of the customer in the provision of maintenance services is studied. Second, the need to capture the value of returns in the management of maintenance services is considered. The chapter elaborates on the contribution of the research done in the Ph.D projects, the impact of the research results on spare parts management at IBM, and some reflections on future developments.

9.1 Introduction

In memory of Jo van Nunen as a professor at the Rotterdam School of Management, this chapter aims to provide an overview of the collaboration between the Rotterdam School of Management (RSM) and IBM. The significance of the role of Jo van Nunen in the collaboration has been made explicit when he was granted a Faculty Award from the IBM Zurich Research Laboratory in November 2007. In the last decade, three Ph.D students of Jo van Nunen have worked closely with IBM, and this collaboration continues. The research collaboration is well appreciated by the academic community; see for example the publication (Fleischmann et al., 2003).

Muhammad, Moritz, Rob: “It is fair to say that the collaboration owes its success to the tireless efforts of Jo van Nunen to keep academic researchers focused on the business perspectives, and to inspire practitioners during his entertaining speeches by outlining the possibilities of using new research ideas in industry. On several occasions, the academic corridors at RSM were shaken by his proud announcement of another successful industry application of research ideas, and at some other times, a researcher received a lecture from Jo at the same familiar pitch on how to keep industry interests in focus next to publishing in academic journals.

As Jo van Nunen very much valued the collaboration with IBM, both the successes and glitches in these projects were shared with everybody in a miles’ range - without the need for any telecommunication devices. One can hardly overstate the value of how Jo van Nunen has bridged academics and practice in this manner.”

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Ben: “Jo was around in optima forma when I was the EMEA and WW executive of Service Logistics in IBM (1995-2005). When he became aware of this leading WW service logistics role in The Netherlands, he was the first Dutch professor to poke his nose in our business. At one hand he was very impressed with the various advanced and innovative solutions we had developed to operate a “borderless” international service logistics network and at the other hand he was challenging us with many ideas for future improvements. Jo believed in market driven research and soon after he initiated PhD research in our business he addressed more and more opportunities for other research projects. Sometimes I had to perform the balancing act of the practical guy with limited resources. I am convinced that Jo tipped the jury of the Dutch Logistics Award (Nederlandse Logistiek Prijs) which resulted in this prestigious award for my IBM team in 2003. Jo with his enthusiastic and humorous approach has been always welcome for visionary service (logistics) business discussions and to share his latest “academic” jokes.”

Michiel: “I got to know Jo van Nunen as a very inspirational scientist who introduced quite some interesting and new business concepts in our thinking at IBM. In the discussions we had, always a next topic to perform research on came to life. His inspiration and drive has brought a lot of value to the IBM business and myself. An afternoon with Jo, was an afternoon to look forward to.”

Eleni: “Jo’s strong belief in industrial collaboration was evident by how he selected to spend the Faculty Award. Instead of using the award money for conference travel, as it is often done, he decided to visit the IBM Research Lab in Rueschlikon, with some of his assistants and hold a workshop with IBM Research to better understand and identify collaborative projects. From earlier discussions with IBM, he was aware that some of the topics of interest to IBM better aligned with the work of his colleagues at Technical University Eindhoven, and quite openly suggested to include them in the workshop. His openness, honesty and genuine interest to provide the best possible input to IBM, surprised his industrial partners. Jo’s humor was always well placed, kept everyone active and made the workshop a very enjoyable as well as a productive experience. The workshop led to collaborative projects between IBM and RSM as well as TUE.”

The research as described in this chapter aims to support IBM in its pioneering work to meet high customer expectations while managing service logistics operations in an efficient way. There are two important issues that have driven the research. The first issue is the need to systematically assess the role of the customer in the provision of maintenance services. Here both the use of information on the machines installed at the customer locations (Jalil et al., 2009), and the deployment of revenue management techniques in maintenance services (Jalil, 2010) play an important role. IBM is seriously considering to implement revenue management techniques in the allocation of spare parts in their network. Supported by researchers from RSM, a pilot project has been done and results are promising. A brief explanation of the main concepts used in the project will be given in this chapter. Further, the use of revenue management techniques helps to formalize the interaction with the customer in the execution of maintenance services.

Once the role of the customer in the execution phase is made explicit, it is possible to optimize execution decisions using decision support tools. It is also possible to use the formalized description of the execution phase to further analyze its implications for the planning phase, which is one of the main topics in the current Ph.D research of Harold Tiemessen (Tiemessen, 2011).

The second issue is the need to capture the value of returns in the management of spare parts. In the Ph.D research of Moritz Fleischmann (Fleischmann, 2000), the opportunities of re-using parts from end-of-use machine returns were recognized and analyzed. The opportunity of repositioning spare parts that were taken to the customer location but not used in the delivery of maintenance services, has recently been studied in the Ph.D research of Muhammad Jalil (Jalil, 2010).

This chapter describes the research done during the three Ph.D projects and the content is organized around the two topics described above. We first briefly describe planning and execution of service logistics at IBM in Section 9.2. In Section 9.3, the role of the customer in service logistics is explained. Some of the techniques discussed there are coined revenue management approaches, i.e. which aim to manage the demand for products and services in such a way that the supply can be done more efficiently. In Section 9.4, the research on reverse logistics in the context of spare parts management is outlined. A more elaborate account on the management of reverse logistics and closed-loop supply chains as an emerging field to which Jo van Nunen has contributed are given in the Chapter of Closed Loop Supply chains in this book. In Section 9.5, we draw conclusions and give an outlook on future research avenues. The references provided in this chapter are limited and biased towards the output from the projects discussed. However, within the references provided, more comprehensive literature surveys can be found.

9.2 Service Logistics and Spare Parts Management at IBM

In this section, we provide an overview of the service logistics management at IBM with an emphasis on the management of spare parts. At IBM, maintenance services are usually provided on a customer call basis. The client agreement specifies, amongst other things, the response time of the maintenance services (including parts delivery time) and, depending on the type of contract, compensation for untimely delivery of services. The planning of service levels in the network requires a careful balance between managing operational costs and meeting ever increasing customer expectations (Draper & Suanet, 2005). There is significant variety in the required service levels among customers and installed machines, based on customer expectations, criticality of parts, etc.

The design of the spare parts network and the planning and execution of spare parts delivery at IBM represents the state of the art. The spare parts network at IBM is designed in such a way that timely service can be provided against minimum operational costs (Candas, 2007). In the EMEA (Europe, Middle East, and Africa) region, each country has a Central Stock Location, and a number of Field Stock Locations (Jalil, 2010). The EMEA central hub is positioned in Venlo, the Netherlands, and it constitutes with the stock locations a two- or three-echelon network, where the central stock location is either positioned at an echelon level between the central hub and the field stock locations or at the echelon level among the field stock locations below the central hub. Although each customer has a primary stock location from which spare parts are delivered, there is the possibility to service a customer from various stock locations. IBM has developed a method to decide from which stock location a customer needs to be serviced, given the amount of stock in the network and the required spare part delivery time.
Also the planning of stock levels in the network takes into account the flexibility in delivering spare parts to the customers (Cohen et al., 2000; Erke et al., 2003). The field stock locations are replenished from the central hub location and the central stock locations.

We discuss the planning and execution of spare parts delivery in more detail in Section 9.3, where we focus on the use of installed base data and revenue management techniques. We discuss the management of returns at IBM in Section 9.4.

9.3 Role of the Customer in Planning and Execution of Spare Parts Management

During the execution of service logistics, while interacting with the customer, relevant information about the position and status of the equipment and preferences of the customer becomes available. However, the planning of stock levels in the spare parts networks requires forecasts of customer demand, including anticipation of where spare parts need to be delivered together with the associated part delivery time. This requires the management of data on the whereabouts of installed machines and the type of maintenance agreements under which these machines need to be serviced.

Together with RSM, IBM assessed the need to invest in the quality of their installed base data (Jalil et al., 2009). In particular, the adding value of accurate data on the position of machines at the zip code level in terms of better planning performance was studied. First of all, the value of having the correct data available at the zip code level was considered. This corresponded with the adding value of the new planning system implemented by IBM that was able to make use of such detailed data. Stock levels were planned in the spare parts network, while taking into account that customers at specific locations could be served from various stock locations within the required part delivery times. The performance of stock planning by using the zip code level data was compared with the baseline situation, where the stocks were planned by using aggregated stock location level data. The results indicate that the planning performance significantly improves by using the accurate zip code level data. However, the expectation of obtaining completely accurate data is unrealistic in most of the practical settings. Installed base data quality also varies in practical settings. In this research, the impact of having erroneous data was studied by considering relevant error scenarios. Some of these scenarios represented errors that were made evenly throughout the installed base. Such errors could be caused by mistyping zip codes etc. Other error scenarios had a specific structure and could result in uneven redistribution of machine locations in the installed base. A typical example would be the case in which the locations of all machines of a customer are erroneously assumed to be at the purchasing department of that specific customer, while the customer has business locations with machines throughout the region. The stock plans based on the erroneous data result in higher costs when the network stock needs to be allocated to the customers at their actual locations. The results were mixed, however. In most cases, errors made evenly throughout the network had little or no impact on the planning performance. In contrast, some of the errors with a specific structure and an uneven redistribution of the installed base had a considerable negative impact. The study highlighted the fact that improvements of installed base data quality can be very beneficial, but that the nature of the data errors is very important, next to other factors, such as installed base size.

Installed base data can be used not only to enhance planning, but also to support the execution of spare parts delivery. In particular, the value of delivering a spare part from the network to a customer can be compared with the anticipated value of delivering the part to another, more beneficial, customer in the future. Also, one can compare the supply of a spare part from different stock locations while anticipating future demand at the zip code level. In the spirit of the revenue management approach, Jalil (2010) developed a Markov Decision Process formulation defining value as a function of the network stock throughout the service horizon. Upon arrival of customer demand, the option to use an item from the network stock to serve the customer is compared with the option to serve the customer using an emergency shipment from outside the network. For each customer, the service price, penalty for not serving the customer in time, and delivery costs are specified. In this manner, a revenue management approach is used to decide on delivering spare parts to customers. A number of execution heuristics are compared on a representative IBM installed base situation. The revenue management approach outperforms the greedy approach presently used at IBM. It should be noted that the greedy approach is already quite advanced, as outlined in the study (Jalil et al., 2009).

Inspired by this study and other factors, IBM decided to start an internal project in which the revenue management approach is incorporated in a decision support tool. Goal of the tool is to provide accurate estimates on the direct delivery cost, the direct dissatisfaction cost, and the (expected) future cost for every warehouse with stock at hand that can fulfill the actual service request. The big advantage of such a tool is that it shows to the user that a certain allocation decision with low immediate delivery cost might bring a high risk (and thus high expected cost) of running into troubles in the near future. At the same time, the decision responsibility remains at the human operator of the tool as the mathematical model cannot take into account all expert knowledge that can be important in some circumstances.

This project builds upon theoretical work (Jalil, 2009). However, the large scale industrial setting requires some structural changes in the solution approach in order to capture the multi echelon nature of the network, and the continuous replenishment policies at the local warehouses. Furthermore, dissatisfaction functions (one per contract type) are used to calculate the (virtual) cost in case a service request is satisfied beyond contract time. In the project, the dissatisfaction functions have not only been used to translate service performance into a monetary unit but also as an instrument to steer the simulated service levels in any desirable direction.

The general idea is to send out the part from the warehouse that minimizes the sum of direct delivery and direct dissatisfaction cost plus the expected optimal cost-to-go. In this project two different approaches have been developed and implemented to approximate the optimal cost-to-go. The first method uses an average demand pattern together with a greedy allocation rule to estimate arrival times of future replenishment orders. These estimated replenishment orders are then used to solve a linear program that represents the n-step look-ahead problem decision problem.
The second method is a one-step look-ahead rollout algorithm where the cost-to-go is determined using Monte Carlo simulation. Both methods have been tested on representative IBM data and give promising results. Further study is needed to decide which method is best suitable to be used in real-life (Tiemessen, 2011).

Besides the valuable project results, this pilot study has also spurred many new research ideas. One of these ideas is to do a structural analysis of revenue management techniques in spare parts supply while incorporating replenishments during the forecast horizon. Another interesting idea is to study the alignment between execution (real-time demand allocation) and planning (determining appropriate base stock levels) in spare parts supply. In the IBM project presented above the base stock levels were considered as fixed inputs, but they can also be optimized. Intuitively, it is clear that the optimal base stock levels depend on the real-time demand allocation policy and vice versa.

At this moment, IBM is using an advanced and patented algorithm (Erke et al., 2003) to calculate optimal base stock levels under the assumption that requests are fulfilled from the closest warehouse in the network with stock at hand. This assumption is very much in line with the logic that is applied nowadays in real-life. Based on the promising results of the pilot project there is however a good chance that IBM will move to a smarter allocation policy that uses actual stock levels and actual remaining lead times of outstanding replenishment orders. Experiments have already shown that this smart allocation policy leads to higher service levels and thus there might be an opportunity to reduce some of the base stock levels and still meeting all service measure constraints. This will be investigated further in the Ph.D. thesis of Harold Tiemessen (Tiemessen, 2011).

9.4 Reverse Logistics and Spare Parts Management

In this section, we discuss a number of ways of how reverse logistics has been incorporated in the management of spare parts at IBM. A traditional reverse logistics element in spare parts management concerns the return and repair of defective parts from the field. This entails a loop of parts flows. More recently, electronics manufacturers such as IBM also face reverse logistics flows of used products. This includes end-of-lease returns, but also end-of-life products taken back as a customer service or due to environmental legislation. One of the projects initiated by Jo investigated the option of exploiting these product returns as a source of spare parts (Fleischmann et al. 2003; Fleischmann et al., 2005).

The longer economic and technical life cycles of spare parts, as compared to full products, make the dismantling of returned machines and the harvesting of spare parts a potentially attractive alternative to the refurbishment of the complete product. Dismantling is a rather cheap source of parts. The main costs concern a thorough testing of the disassembled parts. This tends to be much cheaper than the procurement of new parts. This holds especially at the later stages of the product life cycle, when regular procurement sources may no longer be available. Dismantling also tends to be cheaper than the repair of defective replacement parts, as parts harvested from returned machines need not be defective, thus implying a higher yield.

These cost advantages of the dismantling option are counterweighed by a number of challenges. In particular, the availability of returned equipment for dismantling is hard to forecast, even for end-of-lease returns. Therefore, this option entails a significant level of uncertainty and thus the risk of either undersupply or oversupply of recoverable spare parts.

The core of the aforementioned project was to develop an approach to overcome these challenges and thereby make dismantling available as a regular parts supply source. Fleischmann et al. (2003) report on a simulation study on this issue. The results show that the achievable procurement cost savings due to dismantling largely outweigh the costs for higher safety stocks due to the increasing level of uncertainty. They also suggest that available parts should be tested immediately, rather than establishing a separate stock of untested harvested parts.

The question of whether to re-use returned equipment at IBM for refurbishment or for sourcing of spare parts has recently been explored further by Ferguson et al. (2008). The authors propose revenue management techniques to support the disposition of the returned machines.

In his Ph.D thesis, Jalil (2010) elaborates on the repositioning of spare parts returns in the service logistics network by using a revenue management approach. It is assumed that with a certain probability, a spare part is not used during maintenance; therefore it shall be placed back in the network inventory. Following the concepts of integrating the forward and reverse channels by Fleischmann et al. (2001), integrated approaches are compared to the independent approaches. Results depict that the integrated approaches perform significantly better than independent approaches. Within integrated approaches, similar to the study (Jalil et al., 2009) as discussed in Section 1.3, a revenue management approach is compared with the greedy method. The revenue management approach accounts for the full integration by considering the forward and reverse decisions jointly. The greedy approach only considers partial integration by accounting for the forward decision during reverse decision; while the forward decision is made in independence of reverse decision. The comparison reveals that the performance of partial integration is quite comparable to the full integration while being less computationally intensive. This is in contrast with the findings for the forward delivery of spare parts, where the observation is that the revenue management approach performs significantly better than greedy approach.

9.5 Conclusions and Outlook

This chapter reflects on the research collaboration between RSM and IBM and it in particular provides an overview of the related Ph.D research projects in which Jo van Nunen acted as promoter. Two main issues, the need for better understanding the role of the customer and capturing the value of product returns, have been highlighted. Jo van Nunen has advocated the research on these topics. In particular, his motto that the "customer must be seduced to request products and services in such a way that the supply can be optimized" addresses the integration of supply and demand management, as embodied by the revenue management approach. In the context of spare parts management at IBM, there are several opportunities to develop this further. In the execution of spare parts delivery, the actual demand of the customer need not be aligned with the contract specifications. An incentive scheme where customers are "seduced" to request under- or over-servicing with respect to their fixed contracts, could further enhance customer satisfaction in an efficient way. Here the opportunity to control the return of spare parts or the use of recovered items can be incorporated as well; this could relate to the replacement of a defective part which is redundant, the replacement of a part whose condition has been monitored, etc.

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