Discontinued Products
An Empirical Study of Service Parts Management

Luís Miguel D. F. Ferreira[1], Amílcar Arantes[2] and Cristóvão Silva[1]
[1]*Department of Mechanical Engineering, University of Coimbra, Polo II Pinhal de Marrocos, 3030 Coimbra, Portugal*
[2]*CERIS, CESUR, Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, Lisboa,1049-001, Portugal*

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Abstract: The procurement and inventory management of service parts for discontinued products has often been overlooked by companies, resulting in several problems such as stock outs, rush orders or obsolete stocks. Accordingly, the main aim of this work is to develop a methodology to deal with these issues following product discontinuation. To this end, an empirical study – based on action research principles – was carried out in a producer of household appliances, which is bound by law to provide service parts for its products for a period of 15 years after they have been discontinued. The work was developed in three stages: characterization of the company situation; definition of a procedure to eliminate obsolete stocks; and definition of a procedure to manage active service parts. The resulting methodology and respective procedures are presented and the results obtained with the implementation are discussed.

1 INTRODUCTION

Rapid technological innovation and recurrent changes in consumer preferences are decreasing product lifecycles. This places pressure on stock management, with a requirement for suitable stock levels for all service parts. Service parts are used to replace old parts that are no longer operational due to total failure or malfunction. Moreover, after a product has been discontinued, many of the service parts needed in the post product life cycle are often out of production (Inderfurth and Mukherjee, 2006).

Service parts for products like household appliances or automobiles are considered an important element of a company´s business. In some industry sectors the service parts business can represent up to 25% of the revenues and 40% to 50% of the profits of manufacturing firms (Dennis and Kambil, 2003; Cohen et al. 1999). Thus, it is important for industrial companies to guarantee the availability of service parts in order to provide the desired after-sales service level. As a result, companies are forced to stock an enormous amount of service parts.

It is often the case that many service parts for discontinued products are recognized as a major source of inventory stock-out or obsolescence. The inventory costs associated with service parts for discontinued products are much higher than those of service parts for current products. Moreover, the level of competition that exists in the market means that any stock-out of service parts cannot be tolerated, since this has a negative impact on the brand image of the company (Hong et al., 2008).

Therefore, it is important to manage service parts carefully, because production lines used for manufacturing a particular service part are likely to be discontinued, prior to demand falling to zero. Moreover, in some countries, manufacturers are required by law to provide past model service parts for several years after production has ceased. Yet, procurement and inventory management of service parts are complex subjects due to the high number of service parts involved; the intermittent nature of their demand patterns; the high responsiveness needed to minimise the downtime cost for the customer; and the high risk of stock obsolescence (Hong et al., 2008).

Hence, the main aim of this work is to develop a methodology to help manage these service part issues in the period following product discontinuation, namely: eliminating obsolete stock and managing active service parts.

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2 LITERATURE REVIEW

After-sales service is a period following on from the start of the product lifecycle and before the end of life date. When after-sales service ends, the manufacturer no longer guarantees the supply of replacement parts for the product. This period may be a legal requirement, or it may be set by the company. In some cases, it can go beyond the legal limit, in a bid to increase the service level and improve the company´s image. As it is normal that replacement parts are needed after some period of use, their demand peaks sometime after demand for the product itself. This can be seen in Figure 1 below. While this is normally the case, there may be exceptions to this rule.

The end of after-sales service may also occur unexpectedly, severely complicating the management of service parts. Where a machine is dependent on a part to continue functioning, a stock out of that part will make the machine obsolete. This means that all the other parts of that machine reach the end of the after-sales service period earlier than expected. Another source of uncertainty occurs when one part is substituted by another. An example may be when a firm manufacturing mobile phone batteries brings a new battery to market which is cheaper and lasts longer; when the consumer changes battery, they will likely choose the new model over the old model. This source of uncertainty is difficult to predict (Hong et al., 2005).

There is a considerable body of literature concerning demand forecasting and inventory management of service parts. Several documented approaches exist, ranging from relatively simple models like Croston's method (Croston, 1972) and its refinement (Syntetos and Boylan, 2001; Syntetos and Boylan, 2005) to more complex algorithms like the stochastic forecasting model presented by Hong et al (2008). This last method considers four major factors in their model to forecast service parts: product sales, the discard rate of the product, the failure rate of the service part and the replacement probability of the service part.

Wang and Syntetos (2011) presented an innovative idea to forecast demand for spare parts that relies upon the demand generation process itself, comparing it successfully with a traditional time-series method. Leifker et al. (2014) presented two approaches for dealing with the problem of extending maintenance or supply contracts for spare parts of discontinued products: one includes the use of a continuous-time dynamic program and the other makes use of a two-stage stochastic algorithm. Rego and Mesquita (2015) presented a case study on spare parts inventory management, comparing several methods using different forecasting techniques and inventory management policies by simulating with field data (10 032 spare parts references); results of the simulations allowed the recommendation of best

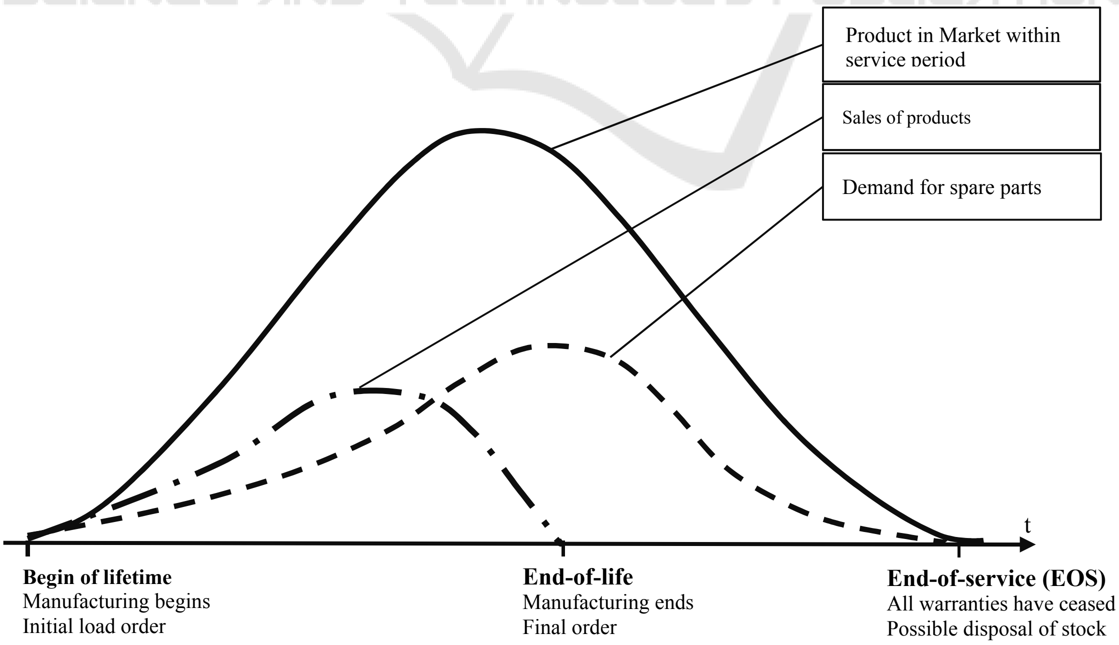

Figure 1: The lifecycle for spare parts. [Adapted from Inderfurth and Mukherjee (2006)].

policies to be followed within each spare part category. Some authors have proposed practical approaches to manage service parts for discontinued products in practice. Teunter and Fortuin (1998) present a model developed to determine the size of a final order for service parts which was implemented in an electronic equipment company, with the objective of covering the demand until all service obligation has ended. Teunter and Haneveld (1998) refer to a case study of a company that produces appliances for which they developed a model for service parts management in its final phase. The model considers an ordering policy which consists of an initial order up-to-level at time 0, the instant when the product is discontinued, and a subsequent series of decreasing order-up-to levels for various intervals of the planning horizon.

However, previous research has focused primarily on the planning and operational aspects (e.g. the determination of optimum spare parts inventory levels) and has neglected the strategic and organisational problems manufacturing companies must solve to manage their spare parts business effectively during post product life cycle. Moreover, a gap between research and practice has been identified by several authors; for a comprehensive literature review on service parts management and on the gap between research and practice we refer to Bacchetti and Saccani (2012). Here, for instance, the authors make the point that "*despite the wealth of literature on the subject, no attention has in practice been paid to proper management and control of service-parts inventory*" or that "*incremental mathematical inventory research is not likely to enhance practice*".

This gap between research and practice is probably due to the mathematical complexity of the proposed methods and their need for data which are often not available. It is also important to mention that the adoption of simple but formalised procedures for the management of service parts during the post product life cycle can help companies achieve substantial benefits, not only by reducing costs but also by improving the company image (Botter and Fortuin, 2000).

3 RESEARCH METHOD

In this paper, the case of a company which produces household appliances is presented. In the past, the procurement and inventory management of service parts during the post product life cycle had been overlooked by the company. This resulted in several problems such as stock outs, rush orders and obsolete stock – stock of service parts for which the service contract has expired. Moreover, sometimes service part production also required components for which the original supplier was no longer operating and this would imply a time-consuming negotiation process with a new supplier.

To solve these problems, the company decided to start a project to define procedures to manage the procurement and inventory management of service parts during the post product life cycle. Moreover, it was the intention of the company managers that the procedures to be implemented should avoid using complex mathematical algorithms that users would find hard to understand as well as models that would require data which would not be easily accessible, or even available, from the company information systems.

Therefore, this study applied the principles of action research, allowing a link to be established between the company and the researchers (Middel et al. 2005). Nevertheless, two conditions need to be respected for the approach taken to fall within the field of action research. Firstly, the research objective and project plan were driven by the researcher's agenda rather than by the participating company representatives. Secondly, the project plan was motivated primarily by the development of procedures for the management of service parts during the post product life cycle and not by the aim of transforming the individual organization's practices. In any case, the focus of the research is to introduce changes in reality (Baker and Jayaraman 2012).

4 THE PROPOSAL

In this section, we present the proposal for the management of service parts during the post product life cycle. The project to define the requested procedures was developed in three stages, which are described in the following subsections: the characterisation of the company service parts; the definition of a procedure to eliminate obsolete stocks and the definition of a procedure to manage service parts.

4.1 Characterisation of the Company

In the case study company, the procurement process for service parts during the post product life cycle was as follows: when the stock for a given service part reaches its reorder level, a production order for this service part is scheduled by the logistics department. To manufacture the required service part, the necessary components are taken from stock and these can also eventually reach the reorder level. If this happens, an order for the component is placed by the company purchasing department. The size of this order is calculated to satisfy the estimated demand for the next six months, based on a simple average of the demand seen for this component since the time the product became discontinued and adjusted according to the conditions of the contract between the company and the supplier.

This stage of the project was designed to provide a clear understanding of how many spare parts were exclusively used in the post product life cycle. The company information systems held information about all the components used in the service parts of discontinued products. However, accessing the required information was difficult (for example, data about the time remaining until the end of the service contracts). In part, this information was incomplete because each component could be used in several service parts and each service part may be necessary for several products. Moreover, the data was spread over two different information systems (IS 1 and IS 2 in Figure 2).

Therefore, a support database was developed to easily access all relevant data about the components of discontinued products. This database was fed with data from both company information systems (Figure 2), and was used to identify all the necessary information for the required procurement process Using data from the first company information system (IS1), each component (Comp.) was related to the service parts (SP) where it is used. The second information system (IS2) shows how each service part was related to the final products where they are used, and for each final product (FP) the date of the last production run was recorded. Furthermore, the corresponding supplier of each component has also been identified. The result of this operation is presented in Table 1.

The information contained in the database provided a description of the discontinued product service parts and their respective components. Some of these characteristics (namely the "Time remaining to end of service") allow the parts and their components to be divided into three major groups: for

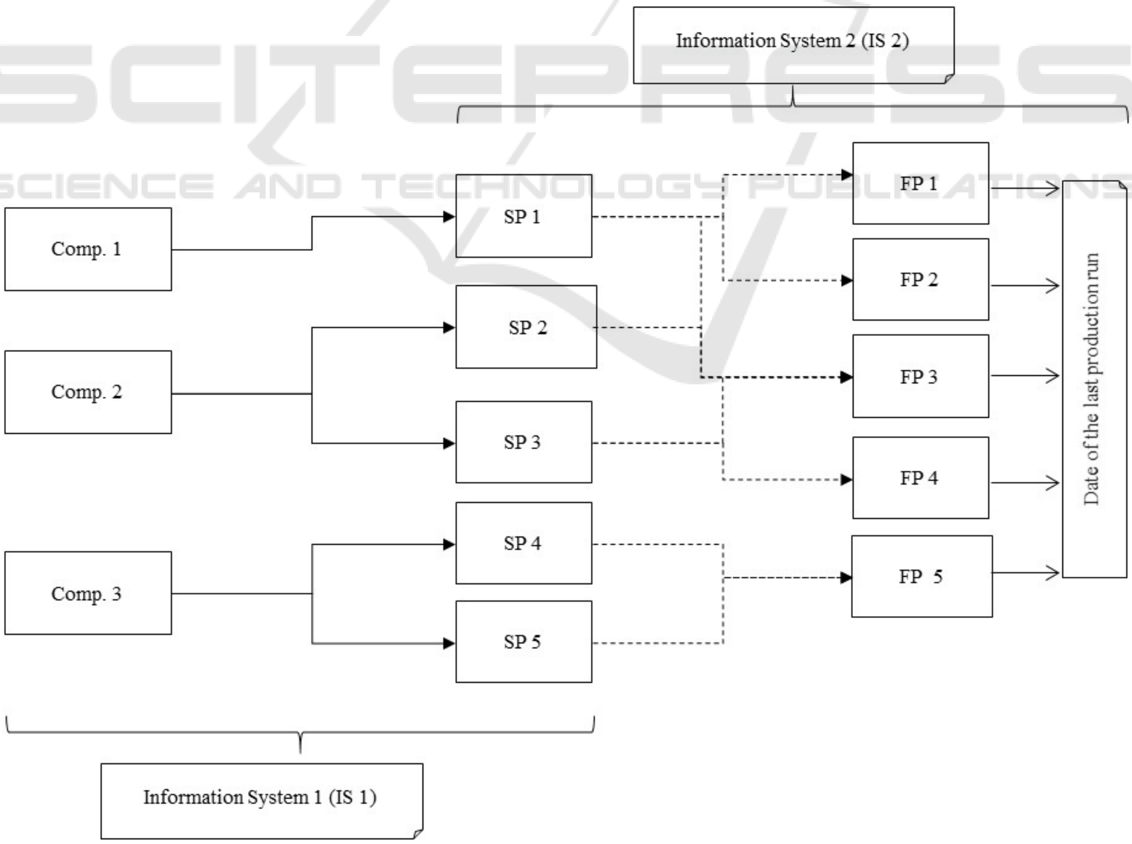

Figure 2: Data collection from the company information systems.

Table 1: Component information.

Compo-nent	Time to end service(years)	Stock (units)	Stock (€)	Supplier
…	…	…	…	…
C10	5	1524	480	XYZ
C11	1	149	30	?
…	…			
Cn	-2	46	202	ABC
…	…	…	…	…

the first group, the company is no longer required to provide support; for the second group, the company is required to provide parts and components within the 15-year limit; and for the third group, no end-of-service date exists (this represents around 50% of the components listed). The complete listing of Table 1 showed that the company manages approximately 1300 components, exclusively used in service parts for discontinued products.

These 1300 components are required in around 1800 service parts for discontinued products (there are more service parts than components as each component can be used in various parts). In turn, these parts are used in 6530 end products (appliances). The 1300 components represent 14% of the total number managed by the company and 9% of the company stock value. Three percent of these components representing obsolete stock. Another conclusion from analysing Table 1 was that approximately 50% of the components had no active supplier assigned.

This represents a major difficulty for the management and procurement of those components, because if a stock-out of one of these components occurred, the company would have to start a negotiation process with a new supplier, meaning long lead times. The lack of an active supplier could be due to two reasons: the usual component supplier has ceased trading or a long time has passed since the company has placed an order with the supplier who, due to production changes, is not able or not willing to supply that component anymore.

4.2 A Procedure to Eliminate Obsolete Component Stocks

The previous project stage identified some obsolete components stocks. A procedure to eliminate these stocks was required. The stock of these components could simply be sold as scrap; nevertheless, they could still be valuable as components for the production of service parts of discontinued products, despite the fact that the company has no obligation to do so.

In the past, if the company received an order for a service part which was no longer active (covered under the post product life cycle period) and for which there was no available stock, the client was informed that the company was no longer required to provide this service part and the stock out was not considered a service-level failure by the company. Nevertheless, it is clear that this situation could reflect badly on the company. To avoid these kinds of problems a procedure to eliminate obsolete stocks was defined, as shown in Figure 3.

In this situation, clients are informed which service parts have reached the end-of-service period. Clients are informed that if they wish they may place a final order for these service parts. If the stock components for the of end of life service parts is sufficient to cover the client's final order, the order is delivered. If the stock of components is not sufficient to cope with the service part production, an order for the required components is placed. After the final client orders, if some service parts or components remain in stock, they are then sold as scrap. This procedure is now scheduled for the beginning of each year for all service parts which have reached their end-of-life date the previous year.

This procedure allows obsolete stock to be removed, including both spare parts and the components which they alone use, given the direct link between the two. In addition, the warehouse space allocated to these parts and components becomes available for other stock. Finally, and most importantly, this approach ensures customer satisfaction (service level), given that the customer is warned in advance of the service part's end-of-life. They are provided with the opportunity to make a last order, guaranteeing a fixed quantity and with a lead time of around one month. It was also decided that this procedure would be carried out at the start of each year, covering the service parts which had reached their end-of-life during the previous year.

4.3 A Procedure to Manage Active Service Parts

This last stage of the project defined a procedure to improve the management process of active service parts. The main objective of managing service parts is to establish a component ordering procedure which ensures an adequate inventory level. The availability of components to produce service parts is vital to the company. Long lead times are associated with component orders and this is not acceptable to the end customer who is waiting for their household appliance to be repaired.

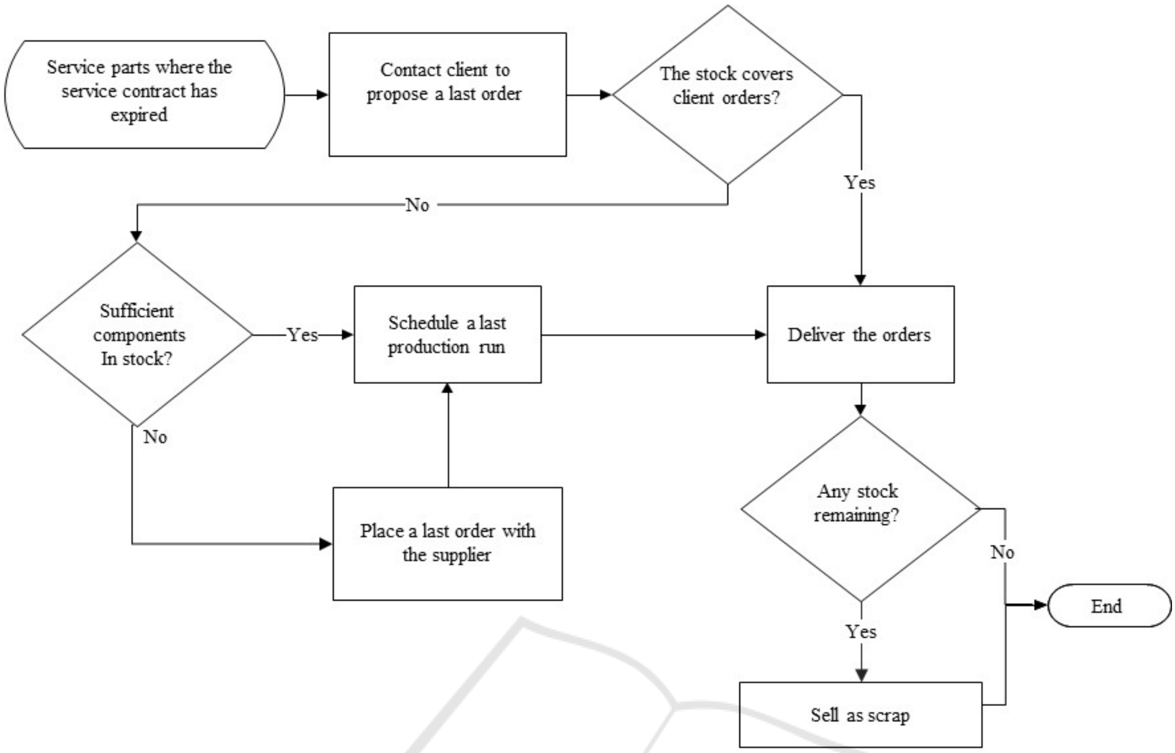

Figure 3: Flowchart showing the procedure to eliminate obsolete stock.

The process for acquiring the components used to manufacture the service parts for end products which are still current is relatively simple as this depends on the demand (for spare parts). However, when there is intermittent demand for service parts, forecasting methods are used so that inventory levels can be properly managed.

In the past, the company used the average service part demand over the previous six months to forecast the demand for the next six months, whenever the component reorder point was reached. The forecast demand for the next six months would help anticipate the component procurement process and the service part production, thus avoiding long lead times for the final client. In this respect, two distinct situations are possible: (1) service parts with components for which there are active suppliers and (2) service parts with components for which there are no active suppliers. In both cases demand forecasting is important to guarantee an effective procurement process and efficient inventory level management. Additionally, in the second case forecasting is also important to help the purchasing department negotiate with potential new suppliers.

At the beginning of the project the company considered that the forecasting method used was not the most effective. Thus, in order to identify which forecasting method to use for managing service parts it was decided to study the demand patterns (using available data from a seven-year period).

The service parts were classified according to their demand patterns as: slow moving, intermittent, erratic and lumpy, as proposed by Syntetos et al. (2005). This classification was made considering the values calculated using: inter-demand interval (IDI) and the squared coefficient of variation of the demand sizes (CV^2).

Considering that the company had asked to avoid complex algorithms that would be difficult for the user to understand and considering the available data, three demand forecasting models were tested: the Croston Model (Croston, 1972), the SBA model (Syntetos and Boylan, 2005) and the simple average in use by the company.

As proposed by the authors, demand for slow moving components should be forecast by the Croston method and the others by the SBA model. Using historical data, the accuracy of these models was compared with the result obtained using the simple average procedure in place in the company. The comparison of the models was made comparing the forecasting errors, considering the mean absolute percentage error (MAPE). Table 2 presents the inter-demand interval (IDI) and the squared coefficient of variation of the demand sizes (CV^2) for three randomly selected service parts.

The forecasting errors obtained for each component are presented in Table 3. It is clear that there is no forecasting method tested which outperforms the others for all the cases. Thus, it was decided to keep the simple average procedure, already in place in the company. This decision is in accordance with the findings of Sytentos et al. (2015).

Table 2: Demand patterns of three randomly selected service parts.

	SP. 1	SP. 2	SP. 3
IDI	2.35	1.02	1.94
CV^2	1.25	0.37	2.7

Having identified the forecasting model to be used, the support database developed during this project (referred to in the previous section) was used to elaborate a list of all the components with no available supplier. For these components, a single average of the past demand (since time 0) was used to estimate their future demand till the end of their service life. This list was sent to the purchasing department who was responsible for initiating contacts to find potential suppliers for those components.

The demand estimate based on past demand helped the purchasing managers negotiate with the selected suppliers. To avoid the same problem in the future (where components have no supplier available), a simple procedure represented in Figure 4 was implemented in the company.

Table 3: Performance of the forecasting models.

Service Parts	Forecasting model	MAPE
1	SBA (α = 0.10)	43%
	Average	42%
2	Croston (α = 0.17)	76%
	Average	96%
3	SBA (α = 0.15)	202%
	Average	203%

The database developed during this research project allowed an historical record to be created, comprising demand data for the service parts. At the beginning of each year, the list of components is checked to identify all components where demand existed last year. For these components, all suppliers are contacted to verify if they are still able to deliver the required component. If not, the purchasing department will be required to initiate contacts to find a new supplier.

For the components with available suppliers the procurement process in place in the company will be as follows. Whenever the reorder point is attained, an order to satisfy the demand for the next six months will be made, considering the simple average of the past six months' demand.

5 RESULTS

This project allowed the company to make the management of spare parts during the post product life cycle more efficient and reliable, anticipating some of the problems usually felt. To achieve this objective, several procedures were developed to support the procurement decisions for these spare parts, according to the time period remaining that the company has to assure the availability of spare parts.

The comparison of forecasting methods showed that a simple six-month average could produce adequate results to define the order quantity for service parts. The procurement and inventory management procedures for service parts described were implemented in the company and have been used on an ongoing basis.

The implemented procedures led to a 4% reduction in stock outs, raising the service from a level of 95% to 99%. The improvement essentially resulted from a set of formal procedures that guarantee the existence of suppliers for any service parts components in the post product life cycle. This avoided extremely long lead times from a negotiation process which does not meet the expectations of final clients.

Another result of this project was a 10% reduction of the inventory value of service part components in. This was mainly due to eliminating obsolete stock, which also helped increase warehouse efficiency.

6 CONCLUSION

This paper demonstrates how an action research project can provide performance improvements in the management of service parts used in the post product life cycle. Simple, but formal procedures are

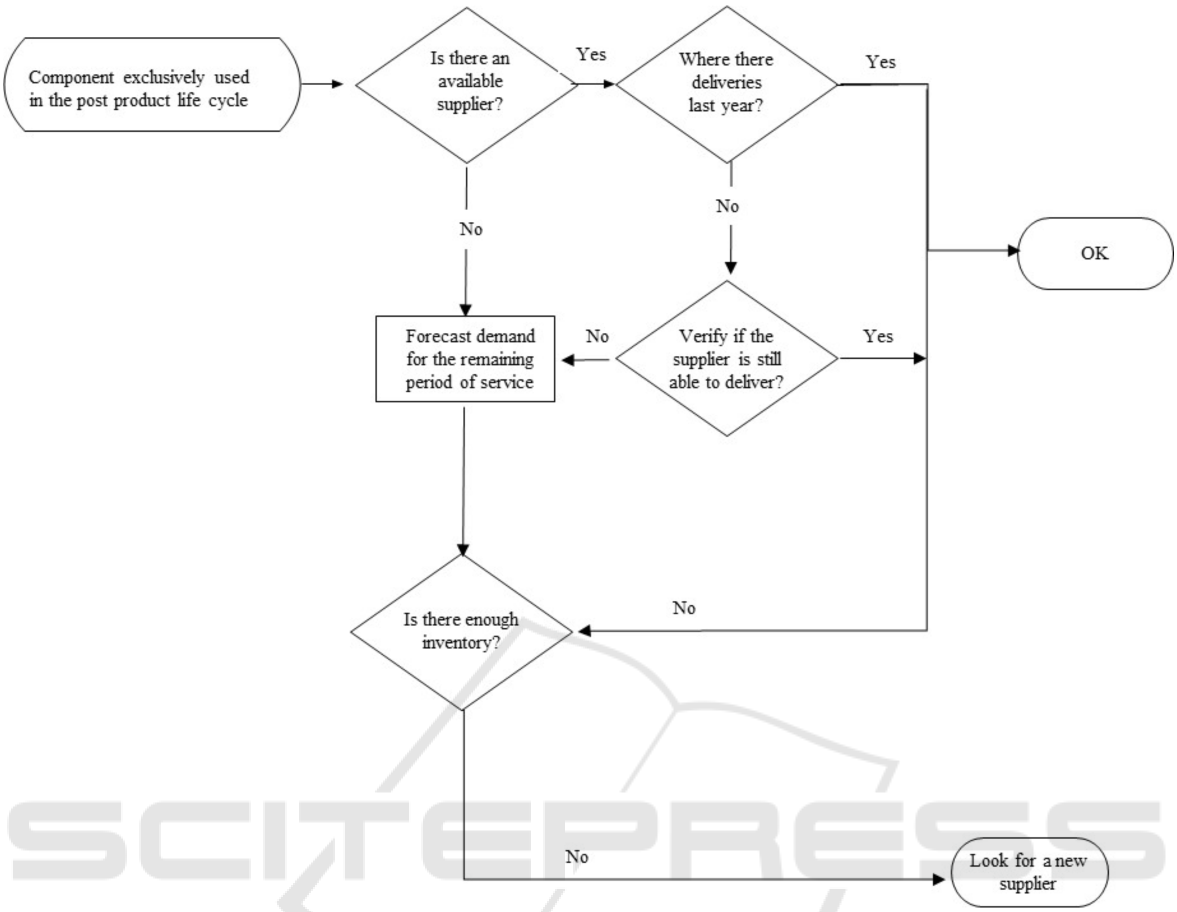

Figure 4: Procedure to guarantee the availability of suppliers.

employed to eliminate obsolete stocks and to manage active service parts. The simplicity of the developed procedures was important for their acceptance in the company, since it is well known that most managers feel uncomfortable if they are unable to understand the models that support the results. Moreover, available methods described in the literature often require data which is not available in most companies.

The procedures implemented during the project make use of a forecasting method. To choose the forecasting method three well known models were tested: the Croston model, the SBA model and a simple six-month average of past demand. It was found that no method outperforms the others, therefore it was decided to maintain the six-month average already in use in the company.

The implementation of the procedures has allowed the company to improve the service levels of service parts for past product life cycle.

The action research model used in the development of the procedures to manage spare parts for the post product life cycle contributed both to achieving practical results in the field and to developing new knowledge. This was achieved through the active participation of both researchers and company employees, which characterises the action research model.

REFERENCES

Bacchetti, A. and Saccani, N., 2012. Spare parts classification and demand forecasting for stock control: Investigating the gap between research and practice. *Omega*, vol. 40, no. 6, pp. 722-737.

Baker, T. and Jayaraman, V., 2012. Managing information and supplies inventory operations in a manufacturing environment. Part 1: An action research study. *International Journal of Production Research*, vol. 50, no. 6, pp. 1666-1681.

Botter, R and Fortuin, L., 2000. Stocking strategy for service parts: a case study. *International Journal of Operation and Production Management*; vol. 20, pp. 656-74.

Croston, J.D., 1972. Forecasting and stock control for intermittent demands. *Operational Research Quarterly*, vol. 23, pp. 289-303.

Cohen, M.A., Zheng, Y.S. and Wang, Y., 1999. Identifying opportunities for improving Teradyne's service-parts logistics system. *Interfaces*, vol. 29, no. 4, pp. 1-18.

Dennis, M.J. and Kambil, A., 2003. Service management: building profits after the sales. *Supply Chain Management Review*, vol. 7, no. 1, pp. 42-48.

Hong, J. S., Koo, H., Lee, C. and Ahn, J., 2008. Forecasting service parts demand for a discontinued product. *IIE Transactions*, vol. 40, No. 7, pp. 640-649.

Inderfurth, K. and Mukherjee, K. 2006. Analysis of spare part acquisition in post product life cycle. Otto von Guericke University. *FEMM* Working Paper 2006/006.

Leifker, N.W., Jones, P.C. and Lowe, T.J., 2014. Determining Optimal Order Amount for End-of-Life Parts Acquisition with Possibility of Contract Extension. *The Engineering Economist*, vol. 59, no. 4, pp.259–281.

Middel, R., Coghlan, D., Brennan, L. and McNichols, T., 2006. Action research in collaborative improvement. *International Journal of Technology Management*, vol. 33, no. 1, pp. 67-91.

Nagarur, N., Hu, T. and Baid, K., 1994. A computer based inventory management system for spare parts. *Industrial Management & Data Systems*, vol. 94, pp. 22-28.

Rego, J.R. and Mesquita, M.A., 2015. Demand forecasting and inventory control: A simulation study on automotive spare parts. *International Journal of Production Economics*, vol. 161, pp.1-16.

Syntetos, A. A. and Boylan, J. E., 2001. On the bias of intermittent demand estimates. *International Journal of Production Economics*, vol. 71, no. 1/3, pp. 457-466.

Syntetos, A. A. and Boylan, J. E., 2005. The Accuracy of Intermittent Demand Estimates. *International Journal of Forecasting*, vol. 21, pp. 303-314.

Syntetos, A. A. and Boylan, J. E. and Croston, J. D., 2005. On the Categorization of Demand Patterns. *Journal of the Operational Research Society*, vol. 56, pp. 495-503.

Teunter, R. H. and Fortuin, L., 1998. End-of-life service: A case study. *European Journal of Operational Research*, vol. 107, no. 1, pp. 19-34.

Teunter, R. H. and Fortuin, L., 1999. End-of-life service. *International Journal of Production Economics*, vol. 59, pp. 487-497.

Teunter, R.H. and Haneveld, W.K. Klein, 1998. The 'final order' problem. *European Journal of Operational Research*, vol. 107, no. 1, pp. 35-44.

Wang, W. and Syntetos, A.A., 2011. Spare parts demand: Linking forecasting to equipment maintenance. *Transportation Research Part E: Logistics and Transportation Review*, vol. 47, no. 6, pp. 1194-1209.