How to get a bigger bang for your buck

Improving the effectiveness of spare parts car inventories for Douwe Egberts Coffee Systems

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Summary

Douwe Egberts is one of the leading companies in the international market for coffee and tea. A special division called Douwe Egberts Coffee Systems International provides complete coffee solutions to the out-of-home market, involving the supply and maintenance of a large variety of coffee machines to companies from various sizes in various countries around the world. This research focuses on the Dutch division, simply referred to as *DECS*.

DECS employs around 200 field service engineers, divided over multiple teams, who are responsible for the installation and maintenance of the installed base. Each engineer has a company car containing a limited stock of spare parts, to provide technical service to customers located in a specific geographical area. These car stocks are managed according to a *base stock level policy with periodic review*, and are replenished from a central warehouse in Venlo. Keeping an inventory of each item in the engineer's car is very costly, regarding the size of the assortment and the relatively large fraction of slow moving spares. Engineers thus have to decide which items to stock, and the number of units to stock per item, in order to provide good service to the customers in their own customer portfolio while keeping the inventory value as low as possible. Service is measured in terms of the first visit fill rate, i.e., the fraction of demand that is fulfilled within the first customer visit.

Recent performance scores showed that not all engineers succeed in finding this trade-off, and that they need support on *how to get a bigger bang for their buck*. Therefore, DECS aims to provide the engineers with more effective support on managing their car inventories by giving a periodic advice about the type of items to include in their car stock, and the base stock levels to define per item. As no fundamental research is conducted yet on how to construct an inventory advice that is adjusted to the engineer's customer portfolio composition, we formulated the following research goal:

To create an optimization tool that can be used periodically for determining the optimal car inventory composition and the associated base stock levels per field service engineer, such that total costs are minimized for a range of predefined target first visit fill rates, while taking individual customer portfolios into account.

Here, total costs are defined as the costs for inventory and supply of spare parts. By involving a range of predefined target first visit fill rates, DECS' management team is provided with a better understanding of the additional inventory investment needed for a certain service level. This can be useful in making informed decisions about the target service level that should be defined in the future. Furthermore, this tool can provide a better insight in the causes of bad performance scores, since it allows for comparing engineer's current item collection with the collection that is optimal for their customer portfolio composition.

Recent studies on spare parts inventory control often incorporate the possibility of sharing inventory among various stock locations by means of lateral transhipments (*inventory pooling)*, as this is proven to be an effective strategy in improving companies' logistical performances, while reducing total cost. We also incorporate this in our research to determine whether this could be beneficial for DECS. As a result, we studied the following two inventory pooling scenarios:

- *No pooling*; which implicates that no inventory sharing is allowed between engineers, and engineers can only use their own car stock to fulfil item demand in the first customer visit.

- *Partial pooling*, which implicates that engineers from the same team are allowed to share inventory to fulfil item demand in the first customer visit. For this pooling scenario, only one of the team members acts as a supplier of inventory (the *main*), which implicates that all other team members (the *regulars*) travel to this 'team captain' to obtain the required item(s) in case they do not have the item(s) available in their own car stock. In this scenario, expensive fast or mid moving items (for which high holding costs are incurred) are typically allocated to the main's car stock instead of to all engineers in the team, which may result in a lower total inventory in the team.

Demand for spare parts is often assumed to occur according to a Poisson process. In order to test whether this also holds for DECS, we perform a Chi-square test on historical item usage data. Unfortunately, results indicate that actual item demand does not follow a Poisson distribution. Further tests indicate that no other probability distribution sufficiently fits the historical item usage data. As we need a probability distribution to model item demand for our optimization tool, we will follow the assumption of Poisson demand despite these test outcomes and will evaluate the consequences by using cases from practice.

The optimization process consists of two steps: *evaluation*, that involves the first visit fill rate calculation for specific base stock levels, and *optimization* that involves finding the base stock levels that minimize the total costs while the target first visit fill rate is attained. We test two evaluation techniques: *Erlang evaluation* and *Poisson evaluation.* The Erlang evaluation is often used in comparable studies where inventories are controlled by *continuous review* (implicating that replenishment actions are triggered directly after item usage), and is based on modelling the changes in inventory level as an Erlang loss queue. For this queuing model, item demand is assumed to follow a Poisson distribution and arrives in quantities of one at a time. As DECS actually uses periodic review (implicating that replenishment actions are triggered after a fixed time interval) and items are sometimes demanded in quantities larger than 1, we develop the *Poisson evaluation* that is also based on the assumption of Poisson item demand. In this evaluation technique, first visit fill rates are calculated as the fraction of demand that arrives between two replenishment moments, which can be fulfilled with a specific base stock level. For the optimization step, we use a *greedy procedure* that iteratively increases the base stock level of that combination of item and engineer that gives the *biggest bang per buck*, i.e., the largest ratio of increase in distance to the target first visit fill rate over cost increase, until all engineers have attained their target first visit fill rate.

We successfully constructed an optimization tool for both scenarios and verified these, using both evaluation techniques in small scope test cases (comprising only 10 items and 4 engineers). Results indicate that both test tools work as expected, and that the total inventory investment in an engineer team is indeed lower for the partial pooling scenario than for the no pooling scenario. In order to determine whether the first visit fill rate that is predicted by the optimization tool can also be attained if the suggested base stock levels would be used in practice, we constructed a validation model. This validation method requires less time than results validation, which implicates testing base stock levels in practice for a considerable period of time. Ideally, this validation model calculates the first visit fill rate based on historical item usage data. As we concluded that this data does not follow a Poisson distribution for DECS, it cannot be used for the validation process. Therefore, we randomly generate item demand from a Poisson distribution, and use this instead. Results indicate that both tools are valid and will generate a reliable inventory advice if all model assumptions are satisfied. The two evaluation techniques give comparable results, however base stock levels are higher with the Erlang evaluation and allocation of items to main and regulars also differs. Furthermore, we monitored computation times for the full scope tools and found that the partial pooling tool requires considerable computation time (probably weeks), even if a team comprises only 2 engineers. Fortunately, the full scope no pooling tool generates a solution per engineer within a few seconds. Next to that, we could see that the Poisson evaluation requires longer computation times than the Erlang evaluation technique.

As we cannot use DECS' historical item usage data in our validation model to determine the first visit fill rate that will be attained in practice, it is difficult to give a good estimate of the benefits of using the base stock levels from the tools. As the assumption of Poisson item demand is not satisfied, it is possible that the base stock levels from the tools are too low to attain the target first visit fill rate in practice. In addition, we cannot determine which evaluation technique is most suitable for DECS. Regarding the fact that base stock levels are lower with the Poisson evaluation than with the Erlang evaluation, and that the base stock levels from the tools are most likely too low to attain the target first visit fill rate in practice, we suggest using the Erlang evaluation.

In order to get an indication of the possible benefits, we compared the item collection that an engineer currently uses with the item collection that results from the no pooling tool in terms of item availability (whether the requested items were included in the item collection or not) and inventory value. We used the no pooling scenario as it resembles the current way engineers are expected to fulfil item demand. Results from this comparison indicate that using the no pooling tool could result in a decrease in inventory investment of up to 60%, while realizing a comparable item availability. Note that the actual cost reduction could be lower as the suggested base stock levels will probably be too low in practice, and an additional inventory investment is needed to attain the target. Therefore, further testing in practice is needed in order to determine the effect of using the suggested tools while not all model assumptions are satisfied. We recommend DECS to focus on the no pooling scenario first, regarding the computation speed of the tool and the fact that this resembles how engineers currently work. Once these tests indicate that it is advantageous to use the optimization tool in terms of cost and first visit fill rate benefits and this provides effective support for the engineers, we suggest DECS to follow a phased implementation plan. The first phase involves the use of the inventory advice for a few engineers and definition of a business process which states the tasks and responsibilities for all parties involved. The second phase involves nation wide implementation, and the third phase focuses on integration of the tool in the IT systems present.

Further research is needed to find an explanation for the differences between the tool outcomes that are found with the Erlang evaluation and with the Poisson evaluation technique. Next to that, the optimization tool can be extended in order to incorporate the inventory at the central warehouse, such that both echelons are included in the optimization process. Another possibility to extend the tool is to incorporate the fixed order quantities that DECS currently uses for some items. We did not yet take these into account in our study. Finally, we did not specify stock-out costs for DECS as these are hard to quantify, and used a service level constraint instead. We recommend DECS to perform further research to quantify these costs in order to determine which costs can be considered relevant. This provides a better understanding of the financial effects of item unavailability, which could be revealing as the extent of these effects can be a basis for simultaneously expanding the budget for spare parts inventories and increasing the target first visit fill rate to a certain level.