Optimizing the Assignment of Goods to a Retail Distribution System Within Coop Supermarkets

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ABSTRACT

National organization of Dutch supermarkets Coop, can realize big savings by allocating products of their current portfolio to the most cost optimal distribution system. In this paper a model is described that provides insight in the costs per product. Also it compares the costs per distribution system, in order give a advice for the most cost optimal distribution system. The costs per individual product in the total supply chain are defined as a combination of the purchase price and the logistic costs. It turns out that the differences in purchase prices that the suppliers enquire per distribution system are most defining for the allocation of products to distribution system. When optimizing the allocation of the current portfolio, it becomes apparent that a reallocation of 937 products saves around €XX million euro on an annual base. By taking into account the principles of the game theory, the cluster to which a product belongs turns out to be a big influence when determining the costs. In other words, the costs of a product in a cluster are affected by the costs of the other products in that cluster. Coop can realize savings in the purchase costs by relocating products to their most optimal distribution system, and taking the cluster of the product into account.¹

Subject headings: supply chain, distribution system, cost reduction, Delft System Approach, Game Theory, Retail

1. INTRODUCTION

Coop Netherlands is a national organization of Dutch co-operative supermarkets. Coop has a market share of over 3 percent in the Dutch grocery market and a turnover of more than 1 billion euro. In September 2014 Coop reorganized the supply chain by shutting down two of their three distribution centers and acquiring one in Gieten. This resulted in one center for nonperishable goods in Gieten and one for perishable goods in Deventer.

Coop distributes by using three distinct systems:

- Storage at a distribution center (DC): goods from different suppliers are stored in one of the aforementioned distribution centers and are transported to the customer (the supermarket) when ordered (56%)
- Cross-Docking (XD): the distribution center receives goods that are already assigned to a customer, sorts them directly and transports them to the supermarkets (18%)
- Direct Delivery (RL): the supplier delivers the goods directly to the ordering customers (supermarkets) (26%)

Due to the logistic reorganization Coop realized that a motivation of distributing goods via one of the three distinct distribution systems is lacking. This paper presents research subject to the development of a model to calculate the costs for new and current products in order to allocate the products to the right form of distribution system. This allocation is done on the basis of minimizing the cost over Coops complete supply chain. This research done is looking for an answer on the question of:

What product specific variables cause costs in the distribution systems and need to be considered when determining the most optimal distribution system for current and future products?

¹The most optimal system is determined by minimizing the costs

This paper is organized by first explaining the methodology of the research. After this, the establishment of the model is clarified. This included a discussion on the requirements and constraints of the model, the cost function dependent variables, the needed input and the desired output. This is followed by the explanation of the models that are developed, including validation and verification of the model. These two models are implemented and examined by exposing them to three different cases: the ideal situation, the results when used on one supplier and the results if subject to the principles of the game theory. The results of these case studies are described and discussed, resulting in conclusions and recommendations.

2. METHOD

Because of large variation in product types, distribution systems, suppliers and customers, it is hard to indicate general costs for products. Therefore a model was created, determining the costs per specific product. Using these individual costs per product an analysis is done with an adaption of the model to be able to evaluate the ideal situation. In the ideal situation all the goods are allocated to the most optimal system.

The development of the model is done following the Delft System Approach, where the development is seen as a system with desired output, requirements, performance, a black-box in which the calculations are done and the needed input (Veeke and Ottjes 2008). A schematic overview of the approach of the development is shown in Figure 1. The outcomes of the Delft System Approach were the starting point of the model.
2.1. Requirements

As the requirements of the model, the following points are indicated:

- The model determines the costs per product per distribution system.
- The model recommends an optimal distribution system for each product based on minimization of the total costs per product.
- The model gives insight in the current status of the regular assortment of Coop.
- The model gives advice on how to rearrange the assortment in order to reach the optimal situation and the model determines the costs in the most optimal solution.

2.2. Performance

The models performance can be said to be the models match with reality. The better the model corresponds to reality, the better its performance. In order to measure the performance of the model a validation (external validity of the model) and verification (internal consistency) is done. If both are found to be fully satisfied it can be said that the models outcome can be trusted.

Validation is done by comparing the model to the exploitation. Summing up all the individual costs of the regular portfolio and sorting them per expenditure category is taken as the models result. Now observing the deviation from the exploitation, gives the validity of the model. The deviation of the model and the exploitation is less than 5%, so it is concluded that the model is valid (it represents reality).

Verification of the model is done by reviewing the behavior of all the different variables in the cost function. These influences are compared to reality to see if they correspond. It turned out that the behavior of all variables in the model correspond to reality, which means that internal consistency of the model is verified, leading to a confirmation of the fact that the model can be used to indicate savings.

2.3. Black box

The black box represents the system that determines the costs. In order to calculate the costs per product a cost function is derived and shown in equation 1.

\[
\sum_{i=DC, XD, RL} C_{n,i} = C_{p,i} + C_{h,i} + C_{t,i} + C_{d,i} + \text{A7} (\text{it represents reality})
\]

The function shows that the logistic costs are determined per type of cost \((p, h, t, d)\) and per distribution systems. The following variables are used:

- \(C\): Cost
- \(n\): type of expense
- \(p\): personnel expenses
- \(h\): warehousing expenses
- \(t\): costs of transport from DC to the supermarkets
- \(d\): costs due to spoilage
- \(i\): type of distribution system, DC, XD and RL
- \(\text{A7}\): the purchase price per distribution system

A segregation per distribution is done, because the costs are likely to differ: the system cuzes have higher handling cost, whereas the other requires higher investment of the supplier. All logistic costs are shown in Table 1, only \(C_{i, RL}\) is missing. All logistic costs in RL are assumed to be zero, because these costs are nearly zero for Coop.

### Table 1 Cost equations

| \(C_{p,i}\) | \(C_{p,DC} = €0.25\) |
| \(C_{p, XD} = €0.25\) |
| \(C_{h,i}\) | \(C_{h, DC} = \epsilon + \iota \left( \frac{|X_4|}{X_5} \right) \) |
| \(C_{h, XD} = €0.03\) |
| \(C_{t,i}\) | \(C_{t, DC} = €0.30\) |
| \(C_{t, XD} = €0.30\) |
| \(C_{d,i}\) | \(C_{d, DC} = (cd + b)_\text{A7} \left( 1 - \frac{X_3X_4}{X_5} \right) \) |
| \(C_{d, XD} = €0.00\) |

Where:

- \(C_{p,i}\) is the personnel cost for DC and XD which are determined by taking the average amount of time for handling per distribution system times the average wages. These cost do not vary between products and are fixed cost.
- \(C_{h,i}\) is the warehousing cost and is dependent on both fixed values (i.e., \(e, f, h, i, g\)) and the variables:
  - \(X_3\), the amount on an order
  - \(X_5\), the amount of distributed goods
  - \(A_4\) the capacity of a pallet
- \(C_{t,i}\) is the transport cost which is assumed to be equal for each type of product and equal for each type of system (both DC and XD).
- \(C_{d,i}\) is the spoilage cost which is dependent on fixed values (i.e., \(a, b, c, d\)) and the variables:
  - \(X_3\), the amount on an order
  - \(X_5\) the amount of goods distributed
  - \(A_6\) the perishable date
  - \(A_7\) the purchase price

All formulas are extended by the purchase price of the product \(A_7\), which varies per supplier per distribution system. The equations consist of fixed values, static variables and dynamic variables.

- A fixed value is a value that is fixed for all the different costs and over time. These values vary only when Coop changes its strategy. These values are represented by small letters; an example is the amount of days the distribution center is at work.
1. Static variables are variable per product but fixed for one specific product. The static variables are represented by a capital letter A followed by a number. An example of a static variable is the perishable date.

2. Dynamic variables vary for specific products and are represented by a capital letter X followed by the number 3 or 5. An example of such a variable is the amount of goods ordered per week.

2.4. Input

The input of the model is twofold: 1. distribution system specific input, 2. product specific input. The first type of input is determined by taking the average performance of the current process. The second type of input is dependent on the product, and of the distribution system. This type of input is only known for the current distribution system. For the theoretical future distribution system the data is missing so an assumption is done, based on the available data of 55% of the products.

2.5. Output

Two types of analyses are done. The first analysis is a calculation the costs per individual product and is called the calculation. On base of the total costs per distribution system, the model gives an advice of the most optimal distribution system for that specific product. The second analysis is done to give an insight in the current costs of the regular assortment and gives an understanding of how to reduce costs. This analysis is called the evaluation.

3. RESULTS AND DISCUSSION

The model is exposed to three cases: the ideal situation, a study of all the products of one supplier and criticizing the model using a theory. This section ends with the sensitivity per analysis.

3.1. Exposure to the cases

Case 1: The ideal situation — When running the model for all the products of the current assortment, the costs per head of expense are calculated and the most optimal distribution system is indicated. When adding the costs per head of expense of the most optimal solution per product, an insight in the costs for the ideal situation is constructed and shown in Figure 3.

<table>
<thead>
<tr>
<th>Current situation</th>
<th>Ideal situation</th>
<th>Savings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Personnel costs</td>
<td>€</td>
<td>€</td>
</tr>
<tr>
<td>Transport costs</td>
<td>€</td>
<td>€</td>
</tr>
<tr>
<td>Warehousing costs</td>
<td>€</td>
<td>€</td>
</tr>
<tr>
<td>Spoilage</td>
<td>€</td>
<td>€</td>
</tr>
<tr>
<td>Total costs</td>
<td>€</td>
<td>€</td>
</tr>
<tr>
<td>Total purchase</td>
<td>€</td>
<td>€</td>
</tr>
<tr>
<td>Total costs</td>
<td>€</td>
<td>€</td>
</tr>
</tbody>
</table>

Table 2

Ideale verdeling

In the columns the different situations are shown, whereas the third column indicates the savings. A red font indicates an increase in costs and a black font a decrease of costs. As a result the model determines an ideal solution that saves about €XX million, which is 6.5% of the total expenses. This is composed by an increase of logistic costs, while saving purchase costs. In the ideal situation XX products change from XD and RL to the DC.

Case 2: The products of Berkhout & Langeveld — To check the results with reality, a case study is done. In this case all XX products of meat supplier Berkhout and Langeveld are studied. In this case savings of around €XX (4.7%) are indicated by allocating XX products from XD to the DC. This reallocation is in line with the results found in case 1. But as a consequence XX products remain XD. In reality this would lead to a non-profitable situation. So, the model has determined a theoretical optimum which is unfit for practical use. Implementing the game theory will examine this matter.

Case 3: Implementing the game theory — The game theory focuses on situations where there 2 or more persons are playing a game in which they want to maximize their profit while taking the strategies of the opponents into account (McCain 2010). In practice allocating all products from one supplier to one distribution system, results in an advantage for the supplier, which could be rewarded by the supplier. This situation could be seen as a cooperative N-persons game, a form of the game theory, where the products are cooperating to obtain the most optimal result. Applying these principles to find the optimum, not only a new optimum is found, but also another optimal division of the articles.

3.2. Sensitivity

The sensitivity is tested by looking at the influence of the variables on the results of the two different analyses. It turns out that the influence of the variables in the calculation analyses cannot be generalized. This is due to the difference in coherence between the variables and cost per product. It turns out that the influence of the purchase price (A_{7,i}) is around 10% for average products with average total costs. Otherwise the sensitivity of the variables is dependent of the cost-scenario, where the amount to be ordered (X_3), the minimum obliged order (A_1 or A_8) and THT (A_6) are the most sensitive variables.

The influence on the results of the evaluation model is caused by the assumptions on the purchase price in the different distribution systems (assumption to determine A_{7,i}). Changing this assumption with 25%, results in a change 23% in the outcome. This means that the savings determined are between €XX million and €XX million and results in an allocation difference of XX products. However the behavior of the costs (increase and decrease) and allocation does not change.

4. CONCLUSIONS

A verified and validated model is developed that can be used to find potential savings in the total supply chain of Coop. By assigning products with low logistic costs to the DC distribution system big savings in purchase costs can be realized. Implementation of the principles of the game theory shows that the cost per product is dependent of the cluster in which the product is part. Analyzing the clusters leads to a more practical solution.
It is recommended to use the model to not only allocate new products but also evaluate the current situation at Coop. In order to enable this analysis it is advised to collect all the variables, also when information is not useful for calculations in the current distribution system. When answering the main question of the research:

What product specific variables cause costs in the distribution systems and need to be considered when determining the most optimal distribution system for current and future products?

The most optimal system is determined by minimizing the costs.

It turns out that the costs are influenced by three different types of variables:

- distribution system specific input
- product specific input
- the clusters in which the product is part

For Coop the opportunities to save money in the total supply chain are substantial when cooperation between departments is refined and data is better managed and used.

REFERENCES

