Multi-compartment Distribution in the Catering Supply Chain

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Multi-compartment distribution can lead to significant cost reductions and environmental savings. In the Dutch catering supply chain lead times have to become shorter, the delivery frequency needs to increase and the product and process quality must improve to meet new and strict food safety regulations (HACCP). To anticipate these market developments a high quality and efficient distribution system is necessary. Therefore, it is necessary to have knowledge and insight regarding the logistics of delivering fresh produce, other chilled products, dry groceries and frozen products in one consignment to caterers. First, the current logistic performance of the Dutch catering chain was analysed and performance indicators and logistic scenarios were formulated. Then, a model was built for the simulation of these logistic scenarios. The two most promising alternative scenarios for all supply chain partners were tested in a real-life situation. The outcome of this pilot was used to validate and refine the model.

1. INTRODUCTION

Supply Chain Management (SCM) is a concept that has gained tremendous interest in the food industry. SCM is concerned with the linkages in the chain from primary producer to final consumer with the incentive of reducing the transaction costs incurred therein. It seeks to break down barriers between each of the units so as to achieve higher levels of service and substantial savings in costs (Kearney, 1994). The concept of SCM builds on Porter’s theory of the Value Chain. The value chain identifies nine strategically relevant activities that create value and cost in a specific business (Kotler, 1994). By applying the framework called Value Chain Analysis (VCA), it is possible to assess those activities that should be improved. VCAs are designed to determine performance indicators that include the measurement of maturity profiles of each participant (van de Vorst and Simons, 1997).

In this paper, SCM in the food service sector, and in particular the catering sector, in the Netherlands is discussed. Catering is primarily concerned with the provision of meals, food and refreshments fully prepared away from people’s homes. Contract caterers are third party companies contracted to supply food management services to organisations whose main business is not catering (Squirell and Wise, 1996). The market share of the 13 largest contract caterers in the Netherlands in 1994 was 95%; they prepared lunch for about 650,000 people and had a total turnover of 1418 million guilders (Teulings and Akkermans, 1995). The caterer in this paper considered has approximately 1000 outlets. These outlets differ in size and in type of consumers. In relation to food service requirements, the greatest concerns of the caterer are on-time delivery and receiving complete orders. Food service operators need to be able to obtain small amounts of a large number of items in a short advance notice (Martin and Mawson, 1994). The distribution of small orders in this fragmented market is a costly process for wholesalers. At the moment many catering outlets do not buy products from their preferred wholesaler. The caterer
wants to decrease the number of those wholesalers, in order to decrease the purchase costs. To reach this, the flexibility of the preferred wholesaler should increase. The involved wholesaler’s core competence is the procurement and distribution of food products for caterers. The wholesaler wants to increase the drop size to decrease the distribution costs and at the same time offer a higher service level to the caterers. For optimal product quality it is interesting to distribute different product groups in different compartments (Vogels and Janssens, 1994).

In this paper, it will be shown that it is possible to combine products with different properties into one product stream within one consignment. Multi-compartment distribution of various product groups makes it possible to increase the delivery frequency and to decrease the integral costs. First, the current Dutch catering supply chain is described and a number of performance indicators are formulated. Then, some logistic scenarios are proposed and evaluated by simulation. The two most promising logistic scenarios are tested in a real-life situation. At the end, the results will be discussed.

2. DESCRIPTION OF THE CURRENT DUTCH CATERING SUPPLY CHAIN

The value chain disaggregates a firm into its strategically relevant activities in order to understand the behaviour of costs and existing and potential sources of differentiation (Porter, 1985). The value system of the catering supply chain is illustrated in Fig. 1, and consists of value chains of different firms such as supplier, wholesaler and caterer.

Porter (1985) emphasises the importance of focusing on the linkages between and among the activities in the value chain. Linkages can lead to competitive advantage in two ways: optimisation and coordination. Here we investigate the optimisation of the catering supply chain in the Netherlands. The most important results of the analysis of the logistic performance of a particular Dutch catering supply chain is presented below.

The distribution unit for fresh produce and other chilled products is a container and for dry groceries and frozen products a package. To unify this distribution unit we converted packages to containers. All product groups are distributed through the catering supply chain on trolleys.

2.1. Caterer

All outlets use standardised order forms for all product groups. These order forms are specific for each outlet. For fresh produce and other chilled products each outlet makes a demand forecast once a week and during the week changes in this forecast for the remaining days can be adjusted daily. Depending on the size of the outlet the delivery frequency of the product groups varies:

- Fresh produce and other chilled products are delivered two to six times a week.
- Dry groceries are delivered one to four times a month.
- Frozen products are delivered one to four times a month.

Fig. 1. The current value system of the Dutch catering supply chain consists of the value chains of suppliers, a wholesaler, a caterer and the final consumers.
The total flow of goods subsequently consists of approximately 65% fresh produce and other chilled products, 25% dry groceries and 10% frozen products.

2.2. Wholesaler

Fresh produce and other chilled products are distributed regionally from five distribution centres scattered throughout the Netherlands. There is no inventory at these distribution centres (DCs) at all. All fresh produce and other chilled products from different suppliers are cross-docked at these DCs. Dry groceries are delivered from one central distribution centre to all catering outlets. For dry groceries the wholesaler has inventory for two weeks at the distribution centre. The frozen products are delivered directly to the catering outlets by the supplier of the wholesaler. The lead time, from ordering till receipt, of fresh produce and other chilled products is 24 hours and the lead time of dry groceries and frozen products is 48 hours.

2.3. Suppliers

The supplier of fresh produce collects orders at a catering outlet level. The transportation of these goods to the DCs of the wholesaler is board out to the wholesaler. Other chilled products are delivered in the precise daily amount required by the DCs. The supplier of dry groceries is a business unit of the wholesaler, but in the model we defined it as a separate supplier and wholesaler.

2.3.1. Cost-calculation of the current value system.

The value chain provides the basic tool for cost analysis. According to Porter (1985) each value activity uses and creates information, such as buyer data (order entry) and performance parameters (testing). More precisely, logistic activities within a firm can be divided into:

1. Flow of goods (transportation, material handling and transformation)
2. Flow of information (information exchange regarding orders, deliveries, transportation etc.)
3. Management and control (inventory management, planning, sales and after-sales service).

For the cost-calculation of the current Dutch catering supply chain we calculated only the costs of the flow of goods and the flow of information. We assumed that the costs of management and control will almost be the same in the logistic scenarios, so we did not include these costs in our analysis.

The following activities are separated to calculate the costs of the flow of goods (the firm where the process takes place is enclosed in brackets):

- Order collection by the supplier (supplier)
- Transportation from suppliers to the Distribution Centre (wholesaler)
- Collection of the goods from various suppliers and route formation at the Distribution Centre (wholesaler)
- Transportation from the Distribution Centre to the catering outlets (wholesaler)
- Goods reception at the catering outlet (caterer)

In the flow of information the following activities are separated:

- Order generation and packing slip reception (caterer)
- Order entry and generation, packing slip reception and shipping (wholesaler)
- Order entry and packing slip shipping (supplier)

The flow of information in the catering supply chain which consists of orders and of packing slips is illustrated in Fig. 2.

The caterer generates an order and that is sent to the wholesaler. The wholesaler enters this order. The shipment from the wholesaler to the caterer, is composed from the specific order and
the packing slips are checked against the shipment. The same process occurs between the wholesaler and the supplier.

3. PERFORMANCE INDICATORS AND LOGISTIC SCENARIOS

As a result of the inventory of the Dutch catering supply chain, a number of logistic scenarios have been formulated. In order to measure the performance of these scenarios, some performance indicators have been defined.

3.1. Performance indicators (PIs) of the catering supply chain

A performance indicator is a variable indicating the effectiveness and/or efficiency of a part or the whole of the processes or systems compared to a given norm/target or plan (Fortuin, 1988). We assessed the logistic performance of the flow of goods and the flow of information in the catering supply chain with the following direct indicators of logistic performance (Reijnders and Pleijster, 1991):

- Lead time
- On-time delivery
- Delivery frequency
- Load utilisation rate
- Travel distance
- Inventory level

Most of these direct indicators are already measured in the separate firms of the catering supply chain, but now they will be measured for the total catering supply chain. So all firms get insight into the logistic process of the total catering supply chain. As a financial indicator (Reijnders and Pleijster, 1991) we use the total cost per container. This financial indicator is new for all firms into the catering supply chain, but is an aggregation of recently used indicators in the separate firms.

The main goal is to decrease the total cost per container and to increase the customer service over the total supply chain for various product groups. The PIs will measure the effectiveness and the efficiency of the logistic scenarios to reach this goal. The PIs are defined and presented in order of their importance in Table 1.

<table>
<thead>
<tr>
<th>Table 1. Performance indicators</th>
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<td>Total cost per container</td>
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<td>Lead time</td>
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<td>On-time delivery</td>
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<td>Delivery frequency</td>
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<td>Load utilisation rate</td>
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<td>Travel distance</td>
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<td>Inventory level</td>
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The total costs per container determine the integral cost of the total catering supply chain. The total costs per container depends on the following PIs: lead time, inventory level, delivery frequency, load utilisation rate and travel distance. As a result of the lead time and the inventory level the freshness of the products can be determined. The integral environmental costs are related to the travel distance and the service level is related to the on-time delivery.

3.2. Logistic scenarios

In the logistic scenarios developed all product groups will be transported via the wholesaler’s distribution centres of fresh produce and other chilled products. The delivery frequency varies among the logistic scenarios. All catering outlets in a specific route will be supplied via the same scenario. The lorry has three different compartments: one for fresh produce and other chilled products (2–4°C), one for dry groceries (ambient temperature) and one for frozen products (−18°C). These logistic scenarios are represented in Table 2.

For example, in scenario (3,1,1) the fresh produce and other chilled products will be delivered three times a week and both the dry groceries and frozen products once a week, e.g., (3,1,1). Every delivery day the wholesaler delivers the whole packet of product groups to a specific number of outlets. For example, on Monday the first three outlets in a route get dry groceries and frozen products, on Wednesday the second three, and so on.

The service level in scenario (6,6,6) is very high, all product groups will be delivered six times a week. By simulation of this scenario we will demonstrate the effects of such a high service level for the total supply chain. Scenario (6,1,1) is nearly similar to the current scenario. The only difference is that the distribution of the various product groups is now combined and that the delivery frequency of each product group is a little higher. The delivery frequency for fresh produce and other chilled products decreases in the scenarios (3,1,1) and (3,3,3). In scenario (3,3,3) the delivery frequency from dry groceries and frozen products is increased, so the service level for these product groups also increases. By simulation of these logistic scenarios we will gain insight into the possibilities of multi-compartment distribution and into the effects of multi-compartment distribution on the total integral costs and the service level.

4. SIMULATION MODEL

Following Slats et al. (1995) the performance of a logistic scenario is mainly indicated by how it is handling dynamic aspects. Discrete event simulation is the most suitable tool to analyse dynamic aspects. Moreover, simulation makes it easier to decide on the redesign of the total supply chain. The logistic scenarios represented in Table 2 are tested by dynamic simulation using a model built with the software tool ARENA (Pegden et al., 1995).

The simulation model describes the behaviour of the catering supply chain from the stock of the suppliers to the sales at the catering outlets. The behaviour of the catering supply chain is measured by the formulated performance indicators. The simulation model is constructed by identifying activity components that influence these performance indicators. There is no route planning included in the model, because all outlets of the caterer are close to each other: the average distance between two outlets is 2.9 km. When a specific outlet in the route does not have any order on a specific day, the lorry drives almost the same distance. The Poisson distribution is used to model random variations in order of their sizes. For some process activities a
stochastic delay is included in the model. The simulation model is validated by a pilot of the most profitable scenarios. A sensitivity analysis is carried out for the simulation time and the performance indicators.

An example of an activity component is the transportation from suppliers to the distribution centre. From the current situation input parameters are determined and the output variables are identified which influence the performance indicators. The activity component ‘transportation from suppliers to the distribution centre’ is represented in Table 3

Per activity component scores on the PIs can be determined from all output variables. For example, the sum of the output variables total distance per week from the activity component ‘transportation from the suppliers to the DC’ (see Table 3) and from the activity component ‘transportation from the DC to the catering outlets’ results in the score on the Performance Indicator Travel distance.

5. RESULTS OF THE SIMULATION

The results of the simulation can be split in the analysis of the current logistic scenario, the analysis of the alternative logistic scenarios and the pilot of the most profitable scenarios.

5.1. Analysis of the current logistic scenario

As a result of the inventory exercise it is found that about 65% of the total logistic costs are generated by the flow of goods and about 35% is generated by the flow of information. It is interesting to see that the costs of the information flow are rather high. This is partially the result of the assumption we made in the simulation model that the number of order and deliver moments should be equal. In Section 2 we explained that once in a week a demand forecast is made for fresh produce and other chilled products. In the real-life situation not all catering outlets adjust this demand forecast daily.

For the current scenario of fresh produce and other chilled products, the PI on-time delivery is represented in Fig. 3. In this figure the difference between the actual delivery moment and the target moment for each outlet on the route is plotted for each day of the week. For good performance the delivery moments must be in a time range of 15 minutes of the target moment.

In the current scenario for fresh produce and other chilled products, the lorry arrives more often late than early at the catering outlets. On Friday the lorry arrives at almost all outlets quite early and on Monday, Tuesday and Wednesday the lorry is, at least at one outlet, late by more than 15 minutes.

5.2. Analysis of the alternative logistic scenarios

The performance of the logistic scenarios as summarised in Table 2 is measured by the performance indicators of Table 1. For example, scores with respect to the PIs total cost per container and travel distance will be described in more detail. The PI total cost per container is the sum of the costs per container of the flow of goods and of the costs per container of the flow of infor-
The score for the PI ‘cost per container of the flow of goods’ for the logistic scenarios is shown in Fig. 4.

The current scenario for the flow of goods is set at 100%. The other scenarios are compared with this current scenario. The cost per container of the flow of goods increases in scenario (6,6,6) with +15% and in scenario (6,1,1) with +4%, and decreases in scenarios (3,1,1) and (3,3,3) with −14% and −10%, respectively. In all alternative scenarios the costs of the activities transportation from suppliers to the DC and route formation are rather constant. The costs of the activities order picking, transportation from DC to caterers and goods receiving at the catering outlet varies between the alternative scenarios. A similar figure can be developed for the costs of the flow of information.

Another example of a PI, travel distance per week is shown in Fig. 5. The travel distance from the suppliers to the DC is almost constant in all scenarios, because the same volume of products has to be transported, regardless of the delivery frequency. The travel distance from the DC to the caterer decrease significantly in scenarios (3,1,1) and (3,3,3). More kilometres have been made in scenarios (6,6,6) and (6,1,1) because the delivery frequency increases in these scenarios. Analysis shows that about 40% of reduction in kilometres in the scenarios (3,1,1) and (3,3,3) is caused by the declining delivery frequency and about 60% by multi-compartment distribution.

![Fig. 4. The costs per container of the flow of goods are decreasing in scenarios (3,1,1) and (3,3,3).](image-url)
The simulation also resulted in scores for the other PIs. Analysing these scores, the scenarios (3,1,1) and (3,3,3) appear the two most profitable scenarios. Hence, these scenarios have been tested in a real-life situation.

5.3. Pilot of the most profitable scenarios

During two periods of six weeks, the scenarios (3,1,1) and (3,3,3) have been tested in a real-life situation. The pilot of scenario (3,1,1) was tested, using a lorry with three different compartments, which delivers fresh produce and other chilled products three times a week and the dry groceries and frozen products once a week to each outlet. During the pilot of scenario (3,3,3) all product groups were delivered three times a week. For the whole logistic process – flow of goods and flow of information – data was registered. The results of the pilot are almost the same as the results of the simulation. The results of the PI total costs per container from the pilot and the model are compared, which is shown in Fig. 6.

In Fig. 6 the flow of goods and the flow of information is distinguished. It is observed that the difference between the results of the pilot and the model are marginal, both for the flow of goods and the flow of information.

Another important result of the pilot is the decreasing travel distance in both scenarios. The total emission of NO\textsubscript{x}, CH\textsubscript{4}, VOC, CO, N\textsubscript{2}O and CO\textsubscript{2} also decreases by 30–40%.

![Travel distance per week per scenario](image)

Fig. 5. The travel distance per week decreases in scenarios (3,1,1) and (3,3,3).

![Total costs per container, results model and pilot](image)

Fig. 6. The results of the model and the pilot are almost the same for the PI total costs per container.
6. DISCUSSION AND CONCLUSION

Discrete event simulation is an effective tool to predict favourable logistic scenarios. Out of the results of the simulation and the pilot we found that the benefits of multi-compartment distribution depend on:

- The size of the catering outlets; how smaller the outlet, how more economical multi-compartment distribution is.
- The current load utilisation rate for fresh produce and other chilled products; how lower the load utilisation rate of fresh produce and other chilled products in the current situation, how more economical multi-compartment distribution is.
- The proportion of the three product groups (fresh produce and other chilled products, dry groceries and frozen products) in the route; the smaller the proportion of dry groceries and frozen products, the more economical combined transportation is.

When the ordering process is computerised, the costs of the flow of information shall decrease and so the difference between scenario (3,1,1) and (3,3,3) shall be smaller. Then the best logistic scenario – (3,1,1) or (3,3,3) – for a specific route in the catering supply chain depends on the size of the catering outlets in the route.

Multi-compartment distribution is positive for all supply chain partners. At the moment scenario (3,1,1) was found to be the most profitable scenario. The integral costs were as low as possible, the quality of all product groups is maintained and the environmental savings are large. The caterer has daily fewer delivery moments of the wholesaler by an increased deliver frequency of dry groceries and frozen products. The drop size of the wholesaler is increased, which means more efficient deliveries. The proportion of products bought by the catering outlet from not preferred wholesalers appeared to be less than before multi-compartment distribution. So the turnover of the wholesaler increases and the purchase costs are decreasing for the caterer. Multi-compartment distribution is a means to anticipate the developments in the Dutch catering supply chain.

REFERENCES