5 Demand Management in E-grocery at Albert.nl

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5.1 Introduction

The prototypical example of demand management is revenue management. The goal of revenue management is to maximize revenues if the supply capacity is constrained. Pricing and inventory allocation are the main levers to achieve this goal. The core idea is to segment the market, differentiate the product offering in a flexible way, and to prioritize service to the most profitable segments. Revenue management originated in the airline sector but has since been adopted by many other industries, including hospitality, car rental, and advertising.

Jo van Nunen has always been truly excited about the opportunities for Revenue Management in areas beyond the classic hotel and airline sectors. Jo van Nunen’s motto that “companies should seduce their customers to behave in a way that enables cost-efficient supply” reflects his strong belief in the potential of demand management to increase profitability in supply chain management.

With his genuine enthusiasm about the topic, he managed to seduce the management team of e-grocery Albert.nl to start a collaboration with the Rotterdam School of Management on Demand Management Opportunities in E-Fulfillment. With Jo van Nunen’s active support, the project has been successful in many ways. The research introduced many new optimization problems that are both scientifically challenging as practically relevant. Jo van Nunen also helped to generate much interest from outside the academic community, with a publication in the Wall Street Journal (Agatz, 2008) and coverage on national television (Vakwerk 2008, RTL7) as some of the highlights. Inspired by Albert.nl, Jo van Nunen regularly promotes demand management practices to practitioners in various sectors ranging from urban logistics (van Nunen, 2006, Quak, 2008), automotive logistics, short sea shipping (van Nunen, 2008) and spare part logistics (see Chapter 9).

Unlike a traditional revenue management setting which fixes operations prior to order in-take, demand management has a significant cost impact in e-grocery, as the location of the customers impacts the costs of delivery. Consequently, demand management in e-grocery translates to profit management rather than revenue management. This chapter describes the past and ongoing research on demand management in collaboration with e-grocery Albert.nl. In particular, it discusses the work of two PhD students of Jo van Nunen, namely Niels Agatz and Evsen Korkmaz. We first elaborate on the planning tasks at Albert.nl in Section 1.2. In Section 1.3 we explain the success of the implementation of differentiated pricing at Albert.nl. In section 1.4 we take the cost perspective of demand management and elaborate on the core project of the PHD thesis of Niels Agatz (Agatz, 2009), the Time Slot Management Problem.
In section 1.5 we explain the ongoing research at Albert.nl that specifically focuses on demand management as a way to exploit the difference in order size and corresponding revenue between customers. In 1.6 we give an outlook on future research in this area.

5.2 E-grocery at Albert.nl

On November 5, 2001, Albert.nl was launched as a fully Internet-based home delivery channel of Albert Heijn, a subsidiary of retail multinational Royal Ahold. Ahold also owns Peapod, a major U.S. e-grocer. Albert.nl primarily targets well-educated, service-oriented consumers; time-starved double-income families with young children; customers that are (temporarily) not able to go out for grocery shopping; and customers dissatisfied with regular grocery shopping. These groups account for approximately 75% of sales. The remaining 25% comes from small businesses without professional catering services, including child-care centers, professional services firms, advisory firms and IT firms. These types of customers are harder to acquire, but they generally order more frequently and in bigger order volumes than individual consumers do. Albert.nl offers approximately 9,000 stock keeping units (SKUs), including fresh groceries such as meat, milk and fruit; similar to a mid-sized regular Dutch supermarket.

The assortment is tailored to the specific needs of online consumers, which means there is a relatively big share of large volume and non-perishable items. Additionally, the assortment includes products from two other subsidiaries of Royal Ahold: Etos (health and beauty care) and Gall and Gall (wine and liquor). The product prices are identical to those in the conventional stores, plus a time-dependent delivery fee, varying between € 4.95 and € 7.95. Albert.nl provides home delivery in two-hour delivery slots. The time slots partly overlap and span from 8am – 2pm from Monday to Saturday and 4pm – 9pm from Monday to Friday. There are no deliveries on Sundays. To allow the company enough time for order picking and transportation, customers must place orders at least 16 hours before the requested delivery slot. Specifically, orders have to be placed before noon (midnight) to be delivered during the next morning (afternoon) shift. The minimum order size is € 60. Payment for groceries and associated delivery fees is due at the time of delivery.

Albert.nl operates a 4,500-square-meter dedicated distribution center or Home Shopping Center (HSC) in Rotterdam and a 6,000-square-meter HSC in de Meern, near Utrecht. In comparison, a conventional Dutch supermarket ranges between 800 and 3,500 square meters, and a conventional Albert Heijn distribution center ranges between 20,000 and 25,000 square meters. The company owns a fleet of 75 dedicated delivery vans and has approximately 700 employees. Occasionally, additional delivery vans are rented by the company to respond to peak-hour demand. The HSCs are supplied by the Albert Heijn warehouse in a similar fashion as the regular stores. They receive three deliveries per day with an order lead-time of one day. Note that this lead-time is longer than the lead-time that Albert.nl quotes to its own customers.

After registration at the Albert.nl website, the customer gets a personal account. Upon login, before actually creating an order, the customer reserves a two-hour delivery slot. Customers can choose from a menu of partly overlapping time slots, up to 3 weeks in the future. After reserving their time slot, customers can search products and put together their order. Customers can use the search engine to find particular items or browse by department, e.g. vegetables, nonperishable and dairy. A picture and additional product information such as food value is provided for each product item. Customers can specifically browse the weekly special offers. It is also possible to make personal shopping lists. Additionally, the customer can find items from previous orders and items previously purchased in the regular Albert Heijn supermarket. The information on the items bought in the regular store is available to the e-grocer through the Albert Heijn loyalty card, the so-called Bonus card.

The Albert Heijn website provides product and menu suggestions to stimulate additional purchases and increase the order volume. Albert.nl differentiates its delivery service per zip code. The number of weekly time slots offered in each zip code is based on the expected demand density. A zip code with low (potential) demand receives only a few weekly delivery slots in an attempt to concentrate that demand, whereas high demand regions are assigned more delivery slots.
On an operational, day-to-day level, Albert.nl sets order limits per time slot for each HSC, based on the available fulfillment capacity and time constraints. The fulfillment capacity is based on order-picking and delivery capacity, which both involve physical constraints (warehouse size, fleet size) as well as corresponding staffing levels. In the short term, the capacity is essentially fixed as the company plans its required staffing levels (order-pickers and delivery couriers) several weeks before delivery, based on sales forecasts. This is necessary as delivery requires well-trained personnel, which essentially limits the options for using temporary employment and thus flexibility in the short-term. The order limits are set in a way to promote a balanced distribution of demand over the slots. If the order limit is reached for a particular slot, it is closed for customers in the entire delivery region and turns “grey” on the website. The fulfillment operations are organized around two shifts per day, which correspond with the morning and evening booking deadlines.

These so-called cut-off times serve as deadlines for order placement. After the cut-off time, when all the orders for the given shift are known, commercial routing software determines the corresponding delivery routes. The routing software takes time windows, dwell times and vehicle capacities into account. The dwell times at the customer are estimated based on the order volume in terms of number of crates and the characteristics of the customer’s home, in particular whether it is in a high-rise or a low-rise. The route planning also calculates vehicle speeds for different road types and adjusts speeds throughout the day to account for rush hour congestion. The accuracy of these estimates is very important as it has a direct impact on the timeliness of the deliveries. Based on the planned delivery routes, another commercial software package determines efficient order-picking routes through the warehouse. These routes are determined in such a way that the heaviest items come first so that the smaller, more delicate items will not be crushed.

The warehousing operation is relatively low tech. The orders are picked manually in batches of about seven customers. The order picker receives the pick locations of the items and the corresponding amounts on a hand-held portal. With an average of 67 SKUs per customer order, the picking process is quite labor-intensive. The process is organized in five different product flows: bulk, high-value, perishable, deep-frozen and non-perishable. The five flows are picked in parallel and grouped together by delivery vehicle. The order is packed in plastic folding crates. The frozen items are transported in a cooler with dry ice and are stored in the deep-frozen area until delivery.

A typical delivery route serves between 10 and 20 customers. The driver delivers the ordered goods to the customer’s home, right up to the kitchen table. This also applies to upstairs apartments. The driver has a mobile PIN device which allows the customer to pay using his or her debit card. The driver will take back deposit bottles and folding crates if necessary.

If Albert.nl cannot deliver the order, or must make an additional delivery because no one is at the delivery address to receive and pay for the order at the specified time, the customer will be charged an additional fee of € 3 for delivery or a € 10 cancelation fee.

5.3 Price Differentiation

Since its beginning, Albert.nl has consistently experienced annual sales growth rates of about 30%. However, some delivery time slots proved more popular than others. As a result, demand imbalances increased. While there was typically a lot of unused fulfillment capacity on Tuesday and Wednesday, insufficient capacity was available for Monday morning and Friday evening. Due to these imbalances, many delivery vehicles were used for only a few hours each day. To counterbalance the popularity differences between the time slots and decrease the corresponding operational inefficiencies, Albert.nl decided to introduce a differentiated delivery fee. Instead of a flat € 6.80 delivery charge for all time slots, the prices for delivery were made dependent on the time and day of the slot, ranging from € 4.95 to € 7.95. The extremely busy slots on Monday morning and Friday afternoon, for example, were assigned the highest fee (€ 7.95), while the unpopular 12noon – 2pm slots got the lowest (€ 4.95), see Exhibit 5. Furthermore, Albert.nl added a new overlapping time slot from 8am to 10am, to provide the customer with more choices in the morning and possibly alleviate the busy 9am-11am slot. All of these changes took place in August 2005.
The price differentiation turned out to be a big success as it smoothed the demand, reducing the ratio between the busiest to the least busy window in terms of number of customers visited from 3:1 to 1.5:1. This allowed the company to further grow its sales without having to invest in additional peak-capacity. Moreover, the additional demand in the middle of the day helped increase the utilization of the physical delivery capacity by allowing more drops per route.

5.4 Demand Management: Cost Perspective

When deciding which delivery options, i.e. which time slots, to make available to which customers, the e-grocer has to anticipate the impact on the delivery costs. Agatz et al. (2008b) address the problem of assigning specific time slots to zip codes given a set of service requirements, the Time Slot Management Problem (TSMP). The assignment needs to facilitate cost-effective routing of delivery vehicles. To facilitate further analysis, two fundamental assumptions are made: (1) the total demand is known for each zip code, and (2) the total demand is divided evenly over the set of offered time slots, irrespective of the number of time slots offered. Historical data supports the validity of these assumptions. Two different modeling approaches are presented: continuous approximation and integer programming. Continuous approximation relies on simple formulas to approximate routing distances based on problem characteristics, such as vehicle capacity and demand density. Daganzo [2005] approximates the distance between two consecutive stops of a route through a region with a slowly varying demand density $\delta$ by $k/\sqrt{\delta}$ where $k$ is a dimensionless constant that is independent of the region shape.

The paper uses similar concepts to estimate the expected total distance traveled in a day for a given time slot schedule. The approach does not rely on detailed data of individual customer orders, but on concise summaries of “local” data.

For example, the expected distance traveled per zip code for an offered time slot is estimated based on the density of adjacent zip codes that also offer that time slot. The expected total distance traveled is then approximated by aggregating over all zip codes and offered time slots. The key assumption of the continuous approximation approach is that the demand density is slowly varying over time and space. The original continuous approximation approach divides the delivery route into two components: (1) the stem distance to the delivery region and (2) the distribution distance between consecutive stops in the delivery region. In our setting, we distinguish between four components of a delivery route:

- distance between stops within the same zip code within the same time slot;
- distance between stops in different zip codes within the same time slot;
- distance between stops in two consecutive time slots
- distance between the delivery region and the depot.

Given the evaluation of a time slot schedule, local search is used to improve the schedules.

The integer programming approach is based on a combination of two cost approximations. Consider a delivery vehicle. The cost incurred by that delivery vehicle is viewed as consisting of two parts. The first part consists of the costs incurred during a particular time slot, which is determined by the “cluster” of zip codes visited during the time slot. The second part consists of the costs incurred by moving from one time slot to the next. The former costs are approximated by identifying a “seed” zip code for the cluster and considering the distance of each zip code in the cluster to the seed zip code. The latter costs are approximated by considering the distance between the seed zip codes of the clusters visited in subsequent time slots.

The computational studies on real-life data demonstrate the viability and the merits of these methods. The results show that a more dynamic and differentiated demand management approach can lead to
considerable cost savings. The reduction of vehicle-miles per order corresponds to considerable environmental benefits.

5.5 Demand Management: Revenue Perspective

In order to calculate profitability of each customer, one should know both the cost of serving and the revenue on the very individual level. However, determining both the cost and revenue precisely is a challenging task within an online grocery retailing environment. As mentioned in the previous section, cost calculation is not trivial due to the dynamic structure of routing. Similarly, to assess the revenue that would be gathered from each customer is also troublesome, because of two main reasons: (1) while reserving the delivery time slot, the information on basket size and profitability is not known in advance; (2) due to the sustainability targets, the long term value of customers is extremely important for albert.nl. However, such long-term customer life-time value is not easy to calculate, especially in non-contractual settings as is the case for albert.nl where customers stop ordering without declaring that they are no longer active. As stressed by Ribbink et al (2004), customer loyalty is crucial for online retailing and building customer loyalty is at least as important a concern as focusing on transactional metrics. Here the need emerges for analyses that incorporate both long and short-term concerns. Due to these practical and strategic reasons, it is necessary to calculate the long-term value of each customer and offer incentives on delivery service depending on this value. This approach serves both to favour the loyal customers and to exploit the demand management by increasing the long-term value with the pricing and service allocation levers.

Long-run profitability of a customer is generally named Customer Life-time Value (CLV). CLV is defined as the expected present value of all future profits over the lifetime relationships of a customer with the firm. It is a critical metric from both operational and marketing perspectives (Gupta et al, 2006).

There are different modelling approaches on CLV such as use of Recency-Frequency-Monetary value (RFM), econometric approach and probabilistic approach. Estimating the future behavior of customers in online grocery environment has two dimensions.

Since this is a non-contractual setting, it is important to first estimate whether the customer is still active and if so, to predict his future purchase pattern. Even though the probabilistic modelling of customer behavior has been extensively investigated (Schmittlein et al, 1987; Reinitz and Kumar, 2001; Fader et al, 2005), there is still need for further research on the CLV at the individual level which is not elaborated enough.

The results from the probabilistic modelling of customer behavior can serve as inputs for both CLV calculation and the final part of the ongoing PhD project on designing a decision support system for dynamic pricing of delivery service.

5.6 Summary

This chapter reflected on the research collaboration between the Rotterdam School of Management and Albert.nl. Jo van Nunen played a prominent role in the launch, funding and continuation of this collaboration, which sparked many academically challenging and practically relevant research opportunities. This combination exemplifies the kind of research that Jo has always promoted with full conviction and contagious enthusiasm.

References


