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Solving the last mile issue: reception box or delivery box?

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Abstract *One of the biggest challenges in B2C e-commerce is the so-called "last mile", the home delivery service for the customer. Particularly in electronic grocery shopping it is difficult to combine profitability and high service level. The authors' simulations suggest that the unattended reception of goods reduce home delivery costs considerably, by up to 60 percent. Unattended delivery has not been widely used because it requires investments and commitment from the customer. The two main approaches to unattended delivery are the reception box concept and the delivery box concept. The reception box is a refrigerated, customer-specific reception box installed at the customer's garage or home yard. The delivery box is an insulated secured box equipped with a docking mechanism. The reception box concept results in more effective home delivery transportation and the delivery box concept in smaller investment to achieve unattended receipt. This article assesses these two different concepts. The cost savings in transportation are analysed using simulation. The operational cost savings are compared to the respective investments required to calculate the payback period. Both concepts proved to be feasible but which one works better is not only a question of financial justification. The possible additional value to customers and overall suitability to the market must also be considered.*

Introduction

Home delivery logistics in e-commerce generally, and in the electronic grocery business (e-grocery) in particular, has been one of the key factors leading to large losses for pioneering companies. The situation today is that there is not yet a proven operations model for the home delivery service (Tinnilä and Järvelä, 2000). Examples of the issues challenging the B2C e-grocers are tight delivery time windows, preservation temperature regulation and the growing number of small orders to be delivered all the way to customers at home (Witt, 1999; Brooksher, 1999). This is the "last mile issue" of e-commerce (Dagher, 1998; Guglielmo, 2000; Jones, 2000; Laseter *et al.*, 2000; McKinnon and Forster, 2000; Reda, 1998).

The logistical services created for e-grocery have been started by means of trial and error. In most cases home delivery transportation is an additional service provided using third-party service providers. The home delivery service providers use several different delivery concepts and service levels defined by e-grocers. By service levels we mean, for example, the delivery time window offered for the customer, that is how long the customer has to stay at home waiting for the delivery.

Webvan[1], the leading e-grocery company in the USA, started out in June 1999 with a home delivery concept based on 30-minute delivery windows and attended reception (Himelstein, 1999; Guglielmo, 2000; Perman, 2000). In December 2000 the company's daily operations were still unprofitable and Webvan announced[2] that it would make the transition to 60-minute delivery windows to reduce the cost of operations. The bigger time window will allow better vehicle routing optimisation, but customer service will suffer, as customers need to attend and awaiting the deliveries for one hour instead of half an hour.

Vehicle routing problems with time windows have been investigated by a number of operations researchers (e.g. Solomon, 1987; Desrochers *et al.*, 1992; Bramel and Simchi-Levi, 1996). However, this research has mostly been aimed at the development of routing algorithms. In the context of last mile physical distribution, the routing tools have been used for example in research on city logistics (Taniguchi and Van Der Heijden, 2000; Kohler, 1997). This research has focused on co-operation of various freight forwarders delivering goods to the shops in the inner city. Previous studies of the effect of unattended reception on home delivery efficiency (Kallio *et al.*, 2000; Kämäräinen *et al.*, 2001; Punakivi and Saranen, 2001) have compared various home delivery solutions using simulations and mathematical calculation models. Analyses have been made of the standard home delivery concepts with attended reception and of a concept with reception boxes at the customer's home yard (Kämäräinen *et al.*, 2001; Punakivi and Saranen, 2001; Saranen and Småros, 2001). The results show that unattended reception is the optimal service concept from the perspective of cost efficiency in home delivery transportation. Unattended reception allows for greater operating efficiency without sacrificing the service level, but requires investments in reception solutions at the consumer end. The interesting issue is to analyse what level of investments these cost savings justify from the e-tailer's, or distribution service provider's, point of view.

Streamline, the pioneer in developing unattended reception solutions, had to close its business because it was unable to generate the volumes needed to justify the investments (Peapod, 2000; Nasdaq, 2000). A substantial part of the investment was for fixed reception boxes in consumers' garages. Thus, even though the customer-specific reception boxes enable value-added services like vendor managed inventory (Småros and Holmström, 2000; Småros *et al.*, 2001; Feare, 1999) for customers and considerable cost savings in the e-grocer's home delivery operations, the investments involved with the reception boxes are very high. The problem is that an operating concept based on reception boxes leads to a low growth rate because the installation of the boxes for new customers is costly and slow. In this sense the operating concept with attended reception would be better for a company aiming for fast growth in the e-commerce market. On the other hand, a concept with unattended reception is better when reaching for repetitive purchasing customers and stable demand of goods.

Trying to identify the optimal operating concept, one question arises: "How to combine operational effectiveness, high service levels and fast growth in the home delivery business?" One alternative that has not yet been fully explored is a solution based on secured delivery boxes (e.g. Homeport[3]), with the possibility to reach the same operational cost level as in the solution with fixed customer-specific reception boxes. In the delivery box solution an insulated box containing the goods is delivered to the customer and attached securely in a locking device bolted on the building wall. The empty boxes are collected on the day following delivery or later. The secured delivery box solution potentially enables a faster growth rate and higher flexibility of the investments because of a smaller investment required per customer. The drawback is the additional cost of collecting the empty boxes.

This article investigates existing home delivery service concepts and presents simulation results of the differences in operating cost levels of the attended receipt solutions compared to the unattended receipt solutions. The payback times for investments for unattended receipt are then analysed based on the differences in operating efficiency between attended and unattended reception. The operating efficiency is calculated utilising a simulation model of the different home delivery service solutions and demand derived from grocery shopping POS data from a specific area of metropolitan Helsinki, Finland. The model estimates the costs, working time and vehicles needed to fulfil customer demand using the different home delivery solutions in the selected test area of metropolitan Helsinki.

Simulation settings and data used

The simulation results to be presented in this article have been obtained using RoutePro (as used by CAPS[4]), a routing software from CAPS Logistics. RoutePro algorithms utilise digital maps of the selected area, enabling different road type usage exacting simulation outcomes such as working hours and the number of vehicles needed. In the simulation model, each scenario is constructed in two steps. First, orders are generated, then they are routed using the routing software.

In this analysis the routing is limited by the volume of orders, the vehicle characteristics and by the two time windows included in each order file. The delivery time window, specified by “drop-off start” and “drop-off end”, depends on the type of reception. If reception or delivery box solutions are used, the delivery time window equals the delivery hours. With concepts requiring attended reception, the delivery hours of each order are divided into time windows defined by the service concept and the actual time of purchase from traditional grocery shopping POS data. The pick-up time window, which describes when the orders have to be loaded into the vehicle at the distribution centre, is determined in the order file by using “pick-up start” and “pick-up end”. The delivery is assumed to be available for pick-up at the last possible ordering time for the respective delivery time window. Figure 1 presents an example of the relationship between the time windows in the order file. The service concept specifies the latest possible arrival time for each order. The latest possible arrival time is then used as the starting point of the pick-up time window. In the simulation model, the pick-up time ends as the delivery time ends.

The data used in the simulations are a sample of traditional grocery shopping POS data from one of the largest grocery retailing companies in Finland. The exact receipt information of the shopping, a representative week from October 1999, was collected from five grocery shops of the supermarket chain in question. These data include, for example, quantities, volume (litres), dates, shopping time and prices of shopping baskets bought by anonymous regular customers, thus keeping customer identity confidential.

The data selected for simulations was limited in a number of ways. The order size taken into account was limited to "orders" priced over €25 (FIM 150). This selection was made to have reasonable size of the e-grocery shopping basket for home delivery simulations. The second limitation was the customer's residence, which had to be inside the boundaries of the test region selected. The test area (135km^2) selected for the simulations covered partly the Helsinki metropolitan area in Finland. The number of inhabitants in the test area is approximately 202,000 and the number of households is about 89,000 (Statistics Finland, 1996). Finally, in the simulations the demand modified from traditional grocery shopping data contained the exact POS information from 1,639 orders. The orders were placed during one week by 1,450 anonymous household customers, located in the selected test area. In the simulations the orders were delivered from a single distribution centre to the customer addresses. The distribution centre was located in a suburban area next to an existing store. For the simulations four home delivery solutions 1-4 were identified (Table I). Solutions 1-3 are presented and analysed earlier in Punakivi and Saranen (2001) focusing on the cost difference between unattended and attended reception. Here we extend the analysis by investigating a new alternative solution for unattended reception, i.e. delivery box (solutions 4a and 4b). Furthermore, in this article the payback times for investments for the alternative solutions enabling unattended receipt are analysed based on the differences in operating efficiency between attended and unattended reception.

Conceptually, delivery box solution 4a is equivalent to the reception box solution. In delivery box solution 4a the pick-up of the delivery box is during the next delivery time. This requires investment in delivery boxes stored with each customer. Delivery box solution 4b enables better utilisation rates of a single delivery box but requires a separate drop-off and pick-up trip for each order. In the simulations the daily drop-offs and pick-ups can be scheduled on the same route according to the vehicle capacity.

As noted earlier the routing is limited by the delivery time windows, vehicle characteristics and the volume of orders in the simulation model. The

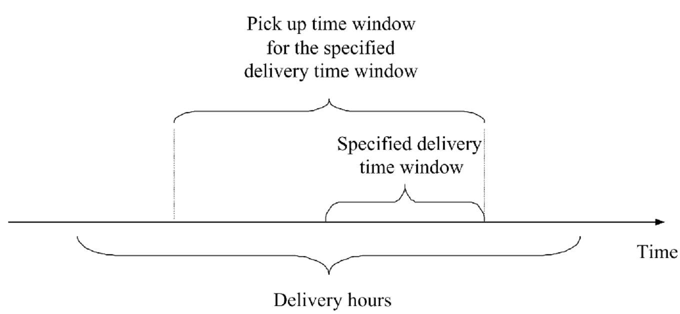

Figure 1.
Order file time windows

Table I. Table description of the modeled solutions

Solution	Order	Delivery	Reception	Delivery time window	Example
1	by 10.00	Same day	Attended	Three delivery time windows: 17.00-19.00, 18.00-20.00, 19.00-21.00	Matomera, Sweden (www.matomera.se) Ruok@net, Finland (www.ruoka.net)
2	by 24.00	Next day	Attended	One-hour delivery time windows between 12.00 and 21.00	WebVan, USA (www.webvan.com) Tesco (2h), UK (www.tesco.com) Ykköshalli, Finland (www.yalli.fi) Eurospar, Finland (www.eurospar.fi)
3	by 24.00	Next day	Unattended reception box	Delivery between 8.00 and 18.00	Streamlime, USA (www.streamline.com) S-kanava, Finland (www.s-kanava.fi/s-box)
4a	by 24.00	Next day	Unattended delivery box	Delivery time window 8.00-18.00, pick-up of delivery box on next delivery	Food Ferry, UK (www.foodferry.co.uk)
4b	by 24.00	Next day	Unattended delivery box	Delivery time window 8.00-18.00, pick-up of boxes on the next day 8.00-18.00 (14h-34h from delivery)	Food Ferry, UK (www.foodferry.co.uk)

characteristic has been defined within an ongoing e-grocery pilot (S-kanava[5]), where the customers are provided with refrigerated reception boxes. The limiting values of the vehicle fleet are the following:

- maximum 60 orders/boxes per van;
- maximum 3,000 litres per van;
- working time maximum 11 hours per van;
- working time maximum five hours per route;
- costs of van and driver: FIM 135 (€22.5) per hour;
- loading time per route: 20 minutes; and
- drop-off time per customer: two minutes.

In delivery box solution 4a the drop-off and pick-up of the delivery boxes is modelled with the two minutes drop-off parameter. However, for solution 4b where the delivery boxes are picked up during the next day without delivering a new order we used an additional parameter for pick-up: pick-up time for returned boxes: two minutes.

Cost levels of the home delivery solutions

The costs of the home delivery transportation in e-commerce are closely linked to the number of vans needed during the same time window. The more the customer can control or select the home delivery time window the higher the costs. The reason for this is simply that with one-hour time windows the delivery vehicle needs to drive back and forth in the service area to meet the promised delivery time windows. This results in longer working hours and a growing number of vans needed, leading to a significant growth in the total costs of the home delivery solution (Yrjölä, 2000; Punakivi and Saranen, 2001).

Figure 2 displays the results of the simulations showing the operational cost levels of the typical home delivery solutions used today. Using the "standard solution" with one-hour delivery time windows results in the highest costs. To

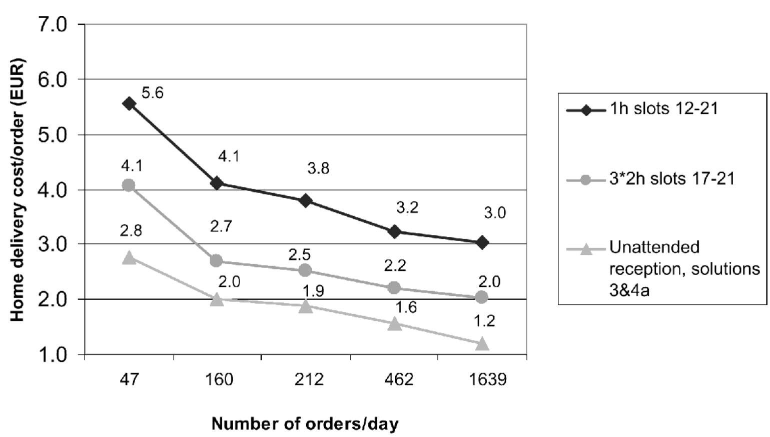

Figure 2.
The transportation cost levels of the home delivery solutions (€22.5/hour)

increase efficiency, service time window limitations to three two-hour delivery slots enables greater route and schedule optimisation, leading to a significant cost reduction. From a service provider's point of view this operating concept is cost efficient, but considerable cost reductions can still be experienced using delivery box or reception box solutions, enabling unattended reception. Even up to 60 percent cost reduction is achievable, when a solution offering unattended reception and the "standard solution" requiring attended reception are compared.

Comparing the solutions that enable unattended reception, we have modelled the transportation cost base of delivery box solution 4a as equal to the reception box solution. This is based on the assumption that the drop-off and pick-up of secured movable delivery boxes is equal to the delivery and collection of the delivery totes (Himelstein, 1999) to and from a customer-specific reception box. The efficiency is based on the fact that the customer stores the delivery box until the next order and attaches it back to the locking device. The pick-up of the first delivery box is then done during the next delivery time when delivering the second order. In solution 4b we assumed that the average order contains two delivery boxes. According to the simulation, delivery box solution 4b, requiring a separate drop-off and pick-up stop for each order, is as inefficient as the solutions based on attended reception. Although the density of stops increases and the average price per stop decreases, the doubled number of stops eliminates the cost benefit. The comparison of operating concepts 4a and 4b is shown in Figure 3.

Analysis of the results indicates that the cost level of delivery box solution 4b, where the delivery box is picked up the next day from the customer, is nearly the same as in the standard solution with one-hour delivery time windows. However, the real operative cost level of the delivery box solution depends on when the service provider picks up the delivery boxes. This is why the cost level is probably somewhere in between the cost levels shown for solutions 4a and 4b. These results indicate that the most interesting focus for

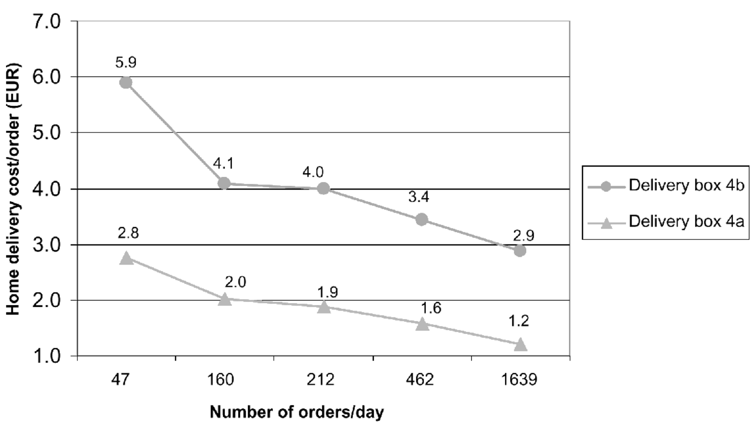

Figure 3.
The transportation cost in delivery box solutions 4a and 4b (€22.5/hour)

further study is comparing the investments needed for unattended reception based on the reception box solution and delivery box solution 4a.

Comparing the solutions for unattended reception: reception box or delivery box

For customers it is convenient to have groceries delivered straight to a reception box or secured movable delivery box near the home door. In this case customers are independent of delivery time windows. For the home delivery service providers the unattended reception means elimination of tight time windows and capacity problems resulting from uneven demand during the daily working hours. Both reception box and delivery box solutions shorten the delivery time used at the door and eliminate (Jones, 2000) the redelivery cost when the customers are not attending to their given delivery time window.

Although both the reception box and delivery box solutions enable the benefit of unattended reception, there are several differences. The customer-specific reception box requires location at the customer's garage or home yard and is equipped with refrigerator-freezer, providing total independence of the delivery time windows (e.g. S-kanava[5], Brivo[6] and IDS[7]) (*The Times*, 2000; Croft, 2000). The secured delivery boxes, however, are insulated and should ensure frozen/chilled food remain frozen/chilled for 12 hours, which serves the purpose in most cases (e.g. Homeport[3]). An open question is whether the delivery boxes function in the northern winter. Do the groceries freeze if a delivery box is left outside in -15°C (5°F)?

The issue of finding the space required for customer-specific reception boxes in, for example, apartment buildings can be avoided using the delivery box solution. Normally there is scarce space around the buildings, especially in the centre of the cities. Reception boxes could be installed in the cellars, but delivery boxes, such as Homeport's[3], could even be left on the sidewalk, securely attached to locking devices bolted in the building wall.

The price of a reception box (for example, from Markantalo[8] is comparable to a normal refrigerator-freezer, i.e. €400-900 (*The Times*, 2000; Markantalo, 2001). For the secured delivery boxes the price is, according to Homeport[3], approximately €170 (£60+£9+£30) for the delivery box, the cable and the locking device. Thus, insulated delivery boxes are lighter, simpler and cheaper than refrigerated reception boxes. The investment needed to enable unattended reception using the delivery box solution can be expected to be significantly lower than using customer-specific reception boxes, where the electronics, the refrigerator and the freezer increase the costs. The interesting issue is, considering the costs and benefits of unattended reception, to assess how high investments the cost savings in transportation justify from an e-grocer's or distribution service provider's point of view. To be operationally cost efficient, the investments in the solution for unattended receipt needs to be recovered by the savings achieved when moving from either of the solutions using attended reception and customer specified delivery time windows.

The starting point of the analysis is the simulated difference in operating efficiency of the home delivery solutions in the selected test area of metropolitan Helsinki. The situation modelled is a start-up situation for the home delivery service. This means a situation with a low utilisation rate of the boxes, i.e. only one delivery per week to the reception box or delivery box. The comparison was made for the selected metropolitan area (135km^2) at five different customer density levels (47 to 1,639 orders per day), as shown in Figure 2.

Based on the results in the selected test area, Figure 4 illustrates how the e-grocer or home delivery service provider recovers the investment in unattended reception solutions when compared to the standard home delivery service with one-hour delivery time windows. An investment level of €200 per customer is recovered with the cost savings (not discounted) enabled by unattended reception in approximately two years. The payback time at an investment level of €1,000 per customer and the installation would be 7-12 years. This means that the operational cost savings in the home delivery service will not cover the €1000 investment if the life cycle of the equipment is less than seven years.

The payback time increases with the density of customers, that is the growing number of orders per day to the same area. This is due to the fact that along the increasing density the service solution with one-hour delivery time windows is more efficient and the savings created by the unattended reception solutions are smaller. Comparing the investments in unattended reception solutions with the cost level of home delivery service, with solution 1 in Table I (three separate two-hour delivery time windows), the payback time of a €200 investment is six years and on €1,000 even 30 years, making the investment unprofitable. However, the poor service level of solution 1, attending and awaiting the delivery for two hours, is not what the customers are willing to accept.

The question is, how do reception box and delivery box solutions measure up against the requirement of supporting a growing e-grocery business? When

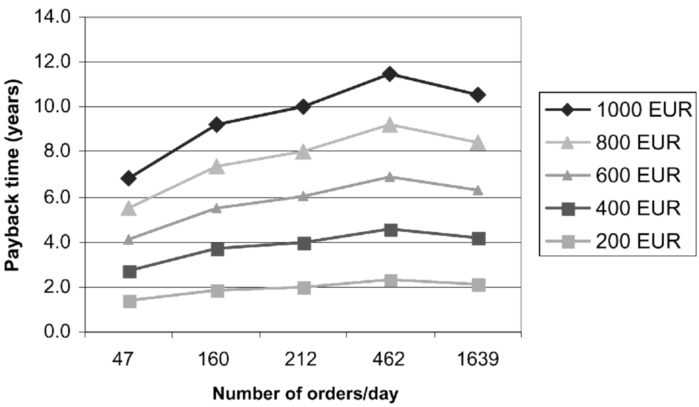

Figure 4. Payback time for the investment in unattended reception solutions when the starting point is the standard home delivery service with one-hour delivery time window

analysing the payback time for high cost solutions, corresponding to a customer specific and refrigerated reception box, it is obvious that part of the investment needs to be carried by the customer. The payback time from the efficiency improvement is simply too long from the e-grocery and logistics service provider perspective. To support a growing e-grocery operation, solutions for unattended reception are critical to reach operating efficiency but the cost savings do not justify high levels of investment.

Large up-front investments for unattended reception solutions lead to a danger of big losses if the service provider installs high priced equipment and the customer does not start using the service. Since June 2000 we have analysed an ongoing e-grocery pilot at S-kanava[5] where the customers are provided with refrigerated reception boxes. One of the biggest challenges in the pilot has turned out to be the start-up phase, to get the customer to start using the service.

Therefore, we studied in more detail the feasibility of a delivery box solution, potentially offering more flexibility and requiring lower investments from the e-grocery or home delivery service provider perspective. Figure 5 illustrates the payback time (not discounted) of the delivery boxes compared to both home delivery service solutions with attended reception from Table I.

The situation modelled in Figure 5 is a start-up situation for the home delivery service using delivery box solution 4a. The start-up situation is described with a low utilisation rate of the delivery boxes, i.e. only one delivery per week. Using delivery box solution 4a leads to investments in delivery boxes, which stay at the customer location for a week. Additionally, the service provider must invest in an additional set to cover the deliveries for one extra day. Compared to the reception box solution, the total investment in the delivery box solution remains low, meaning a shorter payback time. More importantly, when starting the home delivery service based on the delivery box solution, the switching cost per customer for unattended home delivery is low. This is due to the low cost of installing a new locking device, compared to the high up-front investments and installation cost needed for the reception box solution. If the customer does not start using the service, only the locking

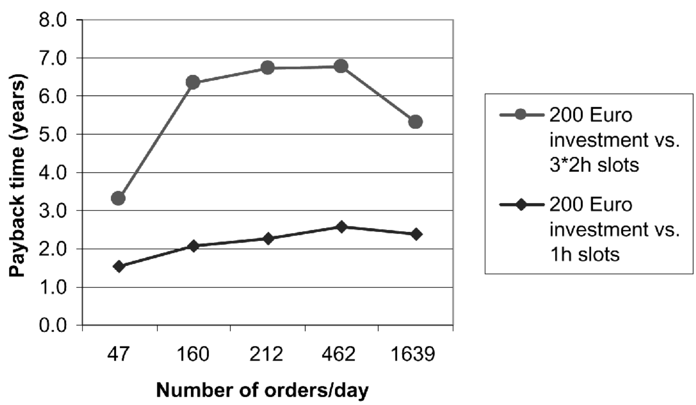

Figure 5.
Payback time for the investment in delivery box solution compared to the solution with attended reception

device has been there for nothing and the boxes can be used to serve other customers.

From the e-grocery or home delivery service provider perspective, the delivery box solution seems interesting, making faster acquisition of new customers and higher growth rate possible. However, from the customer perspective the reception box solution is preferable, offering total independence of the delivery time windows and logistics service providers. Additionally, a refrigerated reception box preserves the food supplies more reliably and issues such as hygiene of the box are up to the customer.

Conclusions

Based upon our simulation results, home delivery solutions enabling secure unattended reception are operationally the most cost efficient for last mile distribution. In the test area, metropolitan Helsinki, up to 60 percent cost reductions are achievable when compared to the standard solutions requiring attended reception. Furthermore, we identified and analysed two different home delivery solutions enabling secure unattended reception: customer-specific reception box solution and delivery box solution. The operational cost base of delivery box solution is on the same level as the reception box solution. This, however, requires that the delivery boxes are not picked up until the next delivery time. Investments needed for the delivery box solution are clearly lower when compared to the customer-specific reception box solution, where refrigerator and freezer units increase the manufacturing costs of the box. In addition, the delivery boxes can be flexibly used by different customers. This means that the utilisation rate of delivery boxes can be higher when compared to customer specific reception boxes.

Comparing investment levels and operational cost savings attained using the different solutions for unattended reception, investments in delivery boxes appear attractive with an approximate payback time of two years. There are strong reasons to believe that the delivery box solution is a competitive and scaleable solution from the e-grocer's or distribution service provider's perspective. However, even if the payback time for the reception box is longer it can be argued that it offers more value. From the customer's point of view probably the best value offers a two-way refrigerator as an integral part of the home. This is why the customer might choose to invest in the reception box to gain total independence of the delivery time windows and logistics service providers. E-tailers could in this case participate in the investment by providing service at a cheaper rate for the customers, helping to make their operation more efficient.

In order to provide guidelines for the development of a profitable and efficient home delivery service concept, further research is essential. Analysis and modelling is needed in, for example, more dense city areas than analysed in this study. Other topics not covered here are the effects of using a multiple distribution centre network and the appropriate service area for a single distribution centre. Furthermore, the practical feasibility of different service concepts and the consumer acceptance should be studied.

Web addresses

1. Webvan (HELP-Delivery), http://www000116.webvan.com/default.asp
2. Webvan, http://www000208.webvan.com/Wv/Marketing/zGlobal/prel/pr120400.asp
3. Homeport, http://www.homeporthome.com
4. CAPS, http://www.capslogistics.com/products/rprodisp/rpromain.htm
5. S-kanava, http://www.s-kanava.fi/s-box
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