Increasing the cost efficiency of e-fulfilment using shared reception boxes

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Keywords

Home shopping, Delivery, Costs, Efficiency

Abstract

Recent research into last mile e-grocery logistics has revealed that goods reception mode is one of the key issues for the operational efficiency of home deliveries. Hitherto, the research has considered home delivery concepts using attended reception and concepts enabling unattended reception based on customer-specific reception boxes and delivery boxes. Customer-specific reception boxes are installed in the consumer's home yard or garage, while delivery boxes are insulated boxes that are returned to the retailer. Focuses on a third possible concept for unattended deliveries, namely shared reception boxes. Due to shared usage, the utilisation level of the facility is higher than in the case of customer-specific unattended reception concepts. Analyses the operational cost levels of home delivery concepts using both attended and unattended reception, using real point-of-sales data and vehicle routing tools. The results show that transportation costs using the shared reception box concept are 55-66 per cent lower in comparison with the current standard concept with attended reception and two-hour delivery time windows. On the basis of our analysis, the cost reduction alone justifies the two-to-five-year payback period of the investment required, even if there is only a fairly small number of deliveries per day. Surprisingly, the payback period is longer when customer density increases.

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Introduction

One of the major problems of consumer direct e-business is home delivery transportation, which is generally referred to as last mile logistics (UK Foresight Report @ Your Home, 2001; Browne *et al.*, 2001; Carneal, 2001; Dagher *et al.*, 1998; Jones, 2001; Laseter *et al.*, 2000; McKinnon and Forster, 2000; Reda, 1998; Van der Laan, 2000). To illustrate the importance of last mile logistics let us use Webvan, a pure play e-grocer, as an example. Webvan launched its e-grocery business in June 1999. To reach market dominance, Webvan offered home delivery with attended reception and delivery time windows of 30 minutes, free of charge, for orders above $50. However, Webvan was unable to create sufficient demand to reach economically viable home delivery operations. Low customer density, attended reception, and short delivery time windows together resulted in extremely high delivery costs. In November 2000 Webvan started to charge $4.95 for deliveries less than $75 (Austria-Farmer, 2000). In December 2000 Webvan tried to decrease the home delivery costs by cutting down its service level to 60-minute delivery time windows (Webvan, 2001a). Then again in May 2001 Webvan raised the delivery fees for orders under $75 from $4.95 to $9.95 and imposed a new fee of $4.95 for orders between $75 and $100, leaving free delivery only for orders over $100 (Sandoval, 2001a). Later, in June 2001, it offered a home delivery scheduling system whereby the customer earned bonus points by selecting the same delivery timetable as had already been selected in the neighbourhood (Webvan, 2001b). Even rationalising and pricing its home delivery service was not enough to prevent Webvan from running out of money as a result of an unexpected drop-off in incoming orders when delivery fees were introduced (Austria-Farmer and Sandoval, 2001; Reinhardt, 2001). Finally, in July 2001 Webvan ceased the operations (Sandoval, 2001b).

Next to the picking and packing operations, home delivery is the major cost driver in online grocery shopping. Vehicle routing problems connected to time windows have been investigated by a number of operations researchers (for example Solomon, 1987; Desrochers *et al.*, 1992; Bramel and Simchi-Levi, 1996). However, this research has mostly been concerned with the development of routing algorithms. In the context of last mile physical distribution routing tools have been used, for example, in research on city logistics, focusing on co-operation between various freight forwarders delivering goods to shops in the inner city (Taniguchi and Van der Heijden, 2000; Kohler, 1997). Analysis of food home delivery operations, considering the environmental effects of home delivery service, showed that reductions in mileage of some 70-80 per cent are possible (Cairns, 1997, 1998, 1999). More recently, research into last mile e-grocery logistics has shown that unattended reception leads to significant savings in operational costs by allowing optimised routing, higher capacity utilisation, and more even capacity load in picking operations. The analysis using empirical point-of-sales data has demonstrated operational cost savings of 40-60 per cent in home delivery transportation when home delivery with one-hour delivery time windows is replaced by delivery to customer-specific reception boxes (Punakivi *et al.*, 2001; Kämäräinen *et al.*, 2001; Punakivi and Saranen, 2001; Yrjölä, 2001). Additionally, using unattended reception the customer not at home problem could be eliminated. The cost savings potential is considerable, according to the UK Foresight Report @ Your Home (2001) as many as 60 per cent of small package deliveries may fail due to the absence of the customer from the home. Furthermore, for the customer unattended reception means a better level of service and greater convenience. The problems involved in the unattended reception concepts are, however, high investments in the facility, low utilisation rate, and slow growth of demand.

Hitherto, research into last mile e-grocery logistics has considered home delivery concepts using attended reception and concepts enabling unattended reception based on customer-specific reception boxes and delivery boxes. Customer-specific reception boxes are installed in the consumer's home yard or garage, while delivery boxes are insulated boxes with a docking mechanism that are returned to the retailer. The focus in this article is on a third possible concept for unattended deliveries, namely the shared reception box concept. Shared reception box units, also known as collection and delivery points (CDP), may be placed beside petroleum stations, tobacconists, in bus or underground stations, or wherever the retailer believes it to be convenient for consumers (UK Foresight Report @ Your Home, 2001). Due to shared usage, the utilisation level of the facility ought to be significantly higher than with customer-specific unattended reception concepts. In this article the cost levels of various home delivery concepts are analysed using vehicle routing tools and real point-of-sales data. The questions that will be studied in the analysis are:

- What are the operational home delivery costs using the shared reception box concept, in comparison to alternative reception modes?
- What is the payback period of a shared reception box investment with various utilisation rates and demand levels?

We start the first section with a brief review of the current situation of e-grocery home delivery practices. In the second section of the article we cover the methodology, cases, and data used in the analysis. The third section reveals the results of the analysis in this article, including operational cost levels and the calculation of the payback period for the investments. In the final section we discuss the results shown and the validity of the shared reception box concept. Additionally, we reach final conclusions and raise further research questions that can direct future research.

A review of the current situation in e-grocery home delivery operations

During the greatest period of e-commerce hype in the years 1999 to 2000, the pure play e-grocers in particular were investing heavily in dedicated distribution centres to enable efficient picking and packing operations. Due to lower-than-expected growth and high investments, this structure proved highly unprofitable. Currently, the major e-grocers are relying on traditional stores when considering their picking operations. For example, Tesco.com uses 250 of its 690 stores for e-grocery picking operations, covering 91 per cent of the population of the UK (Reinhardt, 2001). This decentralisation of picking operations also makes home delivery a very local operation.

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At the moment the standard service concept offered, for example, by Tesco.com and Peapod.com (owned by Royal Ahold), is attended reception with two-hour delivery time windows. Tesco.com, currently the world's biggest e-grocer, has annual online grocery sales of £300 million, leading to more than 3.7 million deliveries per year in the UK market. The cost of home delivery operations for Tesco.com is some 7 per cent of sales (Reinhardt, 2001). To develop operational efficiency and customer service, Tesco has plans for unattended reception, and Peapod is already offering unattended deliveries (Tesco, 2001; Peapod, 2001; Bentham, 2001). Service offers with a delivery box concept have also been started in the UK, for example by the Food Ferry and Sainsbury's (Homeport, 2001). Consignia, the former Post Office organisation, is also launching trials of five different solutions to the question of unattended deliveries in the UK (Rowlands, 2001a). Additionally, major white goods manufacturers like Siemens in The Netherlands and Electrolux in the UK have projects in which facilities for unattended reception are being tested (BearBox, 2001; Siemens, 2001).

However, there are still many unsolved problems concerning customer-specific unattended reception concepts. Facilities require high investment and, at the same time, the utilisation rate is very low. One of the solutions that has been suggested and is also supported by policy makers is the usage of shared reception boxes also known as CDP (Browne *et al.*, 2001; Rowlands, 2001b). The assumption is that using shared reception boxes, the utilisation rate of the facilities would be higher than in the case of customer-specific concepts. One of the earliest shared reception box pilot projects was introduced in 2000 by the GIB Group in greater Brussels, Belgium (GIB, 2001). GIB had 18 trucks specially designed to act as pickup points for grocery shopping baskets ordered online. Every day the 18 trucks were loaded with up to 45 orders each and driven to selected pickup points to intercept the consumer on the way home from work. The trucks stayed at the pickup point from 4pm until 9pm, or for five hours (Ring and Tigert, 2001). Unfortunately, the business concept did not work, presumably as a result of the high level of investment in the inefficient usage of trucks.

Recently, shared reception box units for receiving grocery products have been introduced, for example by Hollming Oy in Finland and Boxcar Systems Inc. in the USA (Hollming, 2001; Boxcar, 2001). The shared reception box units have various amounts of separate lockers, each of which contains freezer, chilled, and room temperature compartments. The separate lockers also have electronic locks with a changing opening code to enable shared usage of the lockers. Pilot experiments with these shared reception boxes are planned to start in the near future. Additionally, Consignia in the UK already has a pilot project in which a shared reception box concept from Bybox is used for parcel deliveries (Rowlands, 2001a).

The problem of the high investment involved in unattended reception facilities could be solved by sharing the responsibility. Companies willing to encourage their employees to use e-grocery services, thus saving working hours, could be interested in participating. Another part of the investment could be carried by savings in transportation costs. However, as a result of lack of research, the potential savings are not currently known. In this paper we analyse the operational home delivery cost levels for the current standard concept with two-hour delivery time windows and the three concepts enabling unattended reception. The potential savings and payback period for the investment in the facilities are then shown.

Research data and method

The data used in the analysis are a sample of point-of-sales data from one of the largest grocery retailing companies in Finland. The exact receipt information from one week in October 1999 was collected from five of the company's supermarkets. These data include, for example:

- quantities;
- volume (litres);
- dates;
- shopping time; and
- the prices of shopping baskets.

Customers' street addresses were obtained from their loyalty cards. The customers were, however, kept anonymous in order to keep their identities confidential. The data selected for simulations was limited in a number of ways. The order size taken into account was limited to purchasing baskets that exceeded €25. Smaller purchases were considered not to be feasible for home delivery service. The second limitation was the customer's residence, which had to be inside the boundaries of the selected test area (135km^2), which covered part of the suburban area of Helsinki 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). This area was considered reasonable for deliveries from one location. Given these limitations, the research data contained 1,639 shopping baskets of 1,450 anonymous household customers. Using these shopping baskets as a pool of orders, various amounts of daily orders were selected for analysis. The number of daily orders in the analysis ranged from 20 to 720.

In the analysis we used a vehicle routing tool, RoutePro, from CAPS Logistics Inc. RoutePro algorithms utilise digital maps of the selected area, enabling different characteristics for different road types, exacting the simulation outcomes such as working hours and the number of vehicles needed. The scenarios for analysis were constructed in two steps. First, orders were generated, then they were routed using the routing software. The vehicle routing in this analysis was limited by the volume of orders, vehicle characteristics, and by the delivery time windows included in each order file. The limiting values of the vehicle fleet in the simulations were as follows:

- maximum 40 orders per van (two totes per order);
- working time max 11 hours per van;
- working time max five hours per route;
- costs of van and driver: EUR 26 per hour;
- loading time per route: 20 minutes;
- drop-off time per customer: two minutes; and
- pick-up time per customer: two minutes (in concept 3B).

These values have been defined and proven within an ongoing e-grocery pilot in Finland. In this pilot project, 40 household customers located in the test area are currently provided with customer-specific refrigerated reception boxes (SOK, 2001). The average order size in this concept is only about €50, due to the frequent (twice a week) home delivery service. The average physical size of the orders in the pilot project is two 50-litre totes.

In the analysis, the delivery time windows, specified by "drop-off start" and "drop-off end", depend on the type of reception. If, for example, the shared reception box concept is used, the delivery time window equals the delivery hours defined in the service description. In the case of attended reception, the delivery hours of each order are divided into time windows defined by the service concept (for example two hours) and the actual time of purchase is derived from the point-of-sales data. The pick-up time window describes when the orders can be loaded into the vehicle at the distribution centre. In the order file it is determined by using "pick-up start" and "pick up-end". Figure 1 presents an example of the relationship between the time windows in the order file.

In the analysis five home delivery concepts were modelled (see Table I). The first of the concepts describes the current "standard" in home delivery, attended reception with two-hour time windows. The following concepts, 2, 3A, and 3B, describe customer-specific unattended reception concepts. Concept 4 is the shared reception box concept. In the shared delivery box concept various (five, ten, 20, and 30) unit locations were selected, whereas in the other cases the deliveries were made to the customer's street addresses. The shared reception boxes were placed in central locations in the test area, such as busy bus or underground stations, petrol stations, or near current shopping centres. In the analysis, the distribution centre was located in a suburban area, next to an existing store. The home delivery concepts analysed are described in detail in Table I.

Figure 1 Order file time windows

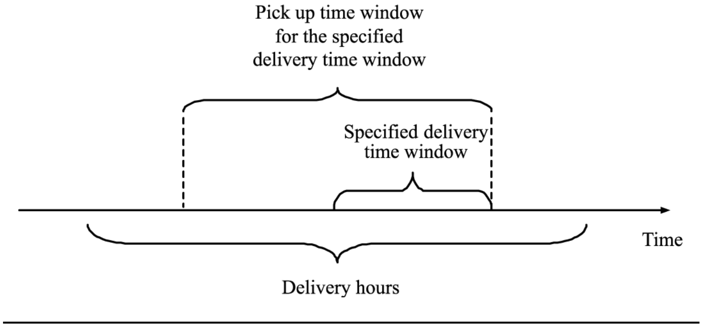

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Table I Description of the modeled home delivery concepts

Case	Home delivery concept and description	Example
1	*Attended reception with two-hour delivery time windows*	Peapod.com, USA
	Delivery hours 8am-10pm	Tesco.com, UK
	Customer locations based on POS data	
	Number of orders per day varies from 20-720	
2	*Reception box concept*	SOK, Finland
	Delivery time window 8am-4pm	Streamline, USA
	Customer locations based on POS data	
	Number of orders per day varies from 20-720	
3A	*Delivery box concept, with pick-up of the box on next delivery*	Homeport, UK
	Delivery time window 8am-4pm, pick-up on next delivery	
	Customer locations based on POS data	
	Number of orders per day varies from 20-720	
3B	*Delivery box concept, with pick-up of the box on next day*	Homeport, UK
	Delivery time window 8am-4pm, pick-up on next day	Sainsbury, UK
	Customer locations based on POS data	Food Ferry, UK
	Number of orders per day varies from 20-720	
4	*Share reception box concept*	Hollming, Finland
	Time window 8am-4pm, "by the end of working hours"	Boxcar Systems, USA
	Five, ten, 20, 30 selected locations of the shared reception box units	ByBox Holdings, USA
	Capacity of the shared reception box units varies: eight, 16, 24 and 32 customer-specific lockers per unit	
	Utilisation rate of a shared reception box units in the analysis: 50 per cent and 75 per cent	
	Number of orders (20-720) per day according to the combination of above elements	

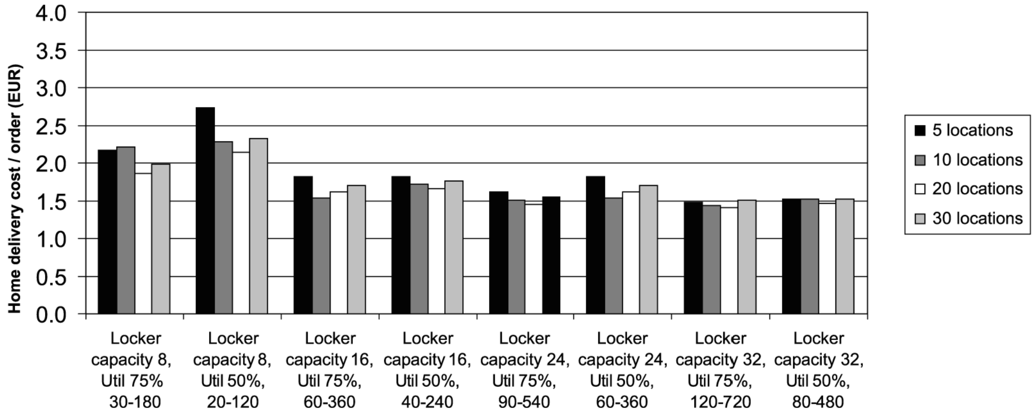
Operational cost levels of the home delivery concepts

In this section we first analyse the home delivery costs with the shared reception box concept. Then the costs of all the home delivery concepts described in Table I are compared side by side. Several factors affect home delivery transportation costs in the shared reception box concept. The first is the capacity of the shared reception box unit, that is, the number of separate lockers. In this analysis we used unit capacities of eight, 16, 24, and 32 lockers. The second is the number of separate shared reception box units. We used five, ten, 20, and 30 locations, which equals the number of units. The third dimension is the utilisation rate of the shared reception box units. The definition used was that 100 per cent utilisation means one delivery per locker per day. In the analysis 50 per cent and 75 per cent utilisation rates were used. For example, in the case of a 16-locker unit, a utilisation rate of 50 per cent was eight deliveries per day and a 75 per cent utilisation rate 12 deliveries per day. A figure of EUR 26 per hour was used to describe the cost of the outsourced transportation service.

According to our analysis, the home delivery cost per order ranges from EUR 2.7 to EUR 1.4 and the average is EUR 1.8 per order (Figure 2). The results show that in the case of the shared reception box concept a low operational cost level is already reached with a fairly small (40-60) number of deliveries per day and with low 50-75 per cent utilisation rates of 16-locker shared reception box units. This indicates that 16-locker boxes are already big enough to significantly increase cost efficiency in home delivery operations and that after that efficiency increases only slightly.

After analysing the shared reception box concept, the interesting question was how this concept performs in comparison with other currently-used home delivery concepts. To compare the efficiency of the different operating concepts, the cost per order and number of vehicles needed were chosen as parameters. Knowing that home delivery operations are currently carried out on the basis of picking operations in the local store, we selected a start-up situation where the daily number of orders starts from 20, growing to 720. When describing the shared reception box concept, the results of eight-locker boxes were used up to 180 orders

Figure 2 Home delivery costs per order in the shared reception box concept

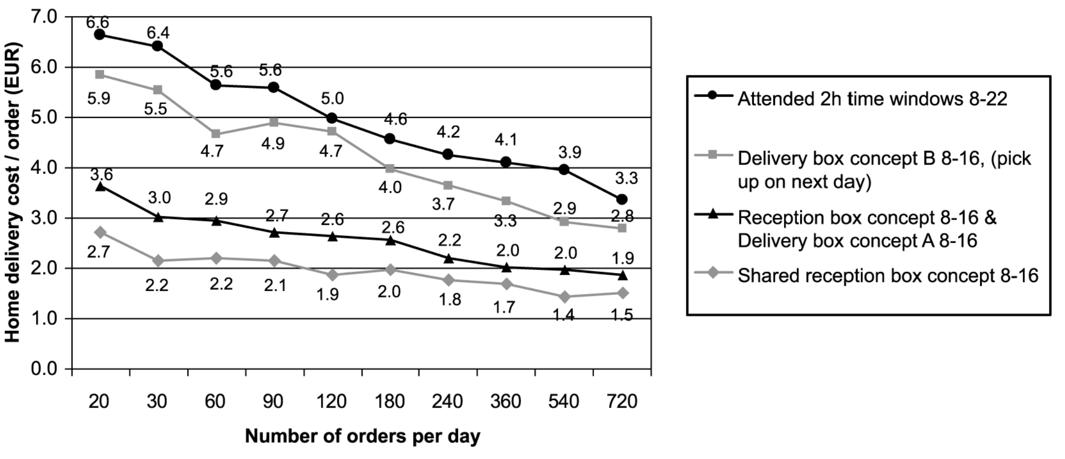


per day. For 240 and 360 orders per day, the results of 16-locker boxes were used. The results of 540 orders per day were obtained from the results of 24-locker boxes and 720 from the results of 32-locker boxes. The comparison of the cost levels in various home delivery concepts is shown in Figure 3.

According to the results, the more the customer can control or select the home delivery time windows, the higher the costs. With two-hour time windows the delivery vehicle needs to drive back and forth to meet the delivery time windows promised to the customers. This results in longer working hours and the need for a large number of vans, leading to high total costs for home delivery operations. We also noticed that using the reception box concept (case 2) or delivery box concept A (case 3A) savings in costs as great as 44-53 per cent can be reached when compared to the current standard concept with attended reception and two-hour delivery time windows. The cost saving is based on operational efficiency that is 1.9 times higher, i.e. the ratio of number of deliveries per hour. Furthermore, the operational efficiency of the shared reception box concept (case 4) is even higher. Based on operational efficiency that is 2.8 times higher, the cost savings using this concept are as much as 55-66 per cent. However, the delivery box concept (case 3B), where the pick-up of the boxes is done separately on the day after delivery, results in double the amount of stops. This weakens the operational efficiency of this reception concept to the level of attended reception. In reality the extra number of stops also represents a threat of two-times-higher costs than in other customer-specific concepts, if the drop-off time increases. The current findings are in line with the results in Punakivi *et al.* (2001), although there are slight differences in vehicle characteristics and delivery time windows.

Next we analyse the number of vehicles needed in the various home delivery concepts described in Table I. Analysing the

Figure 3 The operational cost levels of home delivery concepts (EUR 26/hr)



operational efficiency of the shared reception box concept, we noticed that the deliveries per hour rate is already at a very high level, with a low number of deliveries per day. The variation ranges from ten to as many as 18 deliveries per hour. Various factors make this high efficiency possible: a wide delivery time window, a high utilisation rate of vehicle capacity, and the small number of locations of shared reception box units. Furthermore, this can be reached even without high delivery location density. The result is that in the shared reception box concept it is possible to deliver the orders (20-720) with a very small number of vehicles, ranging from one to five. In comparison, when using the standard concept with attended reception and two-hour delivery time windows, the number of deliveries per hour ranges from four to eight and the number of vehicles needed to deliver 20-720 orders per day ranges from one to 11 (Figure 4).

Payback period required for the investment

To be operationally feasible, the investment in shared reception box units needs to be recovered by the savings in home delivery costs achieved when changing from the concept with attended reception and two-hour delivery time windows. As a starting point for this payback period analysis, we used the cost difference in operating efficiency of the home delivery concepts shown above.

In the payback period analysis, the published price of a shared reception box unit with 24 separate lockers represented the investment required per unit. Based on an interview with Hollming Oy (Hollming, 2001) and published material from Boxcar Systems Inc. (Boxcar, 2001), the price of a unit of that kind is around EUR 42,000. In the cost analysis for 24-locker units the number of deliveries per day ranges from 60 to 540 and the utilisation rate is 50 per cent and 75 per cent. Additionally, the number of shared reception box units, defining the level of investment, increases step by step from five to ten, 20, and 30 in the analysis.

Figure 5 illustrates how the e-grocer or home delivery service provider recovers their investment in shared reception box units when compared to the standard home delivery service with two-hour delivery time windows. With a 75 per cent utilisation rate the payback time would be two to three years and with a utilisation level of 50 per cent between three and five years (not discounted). This means that the operational cost savings in the home delivery operations will not cover the €42,000 investment if the life cycle of the equipment is less than five years or the utilisation rate is lower than 50 per cent. This result encourages investing in shared reception box units rather than, for example, in specially designed vehicles, as in the GIB example (Ring and Tigert, 2001) described earlier.

For comparison we made a payback period analysis for customer-specific reception boxes, using a price of EUR 1,000 per unit. According to this analysis, the payback period

Figure 4 The number of vans needed in the home delivery concepts

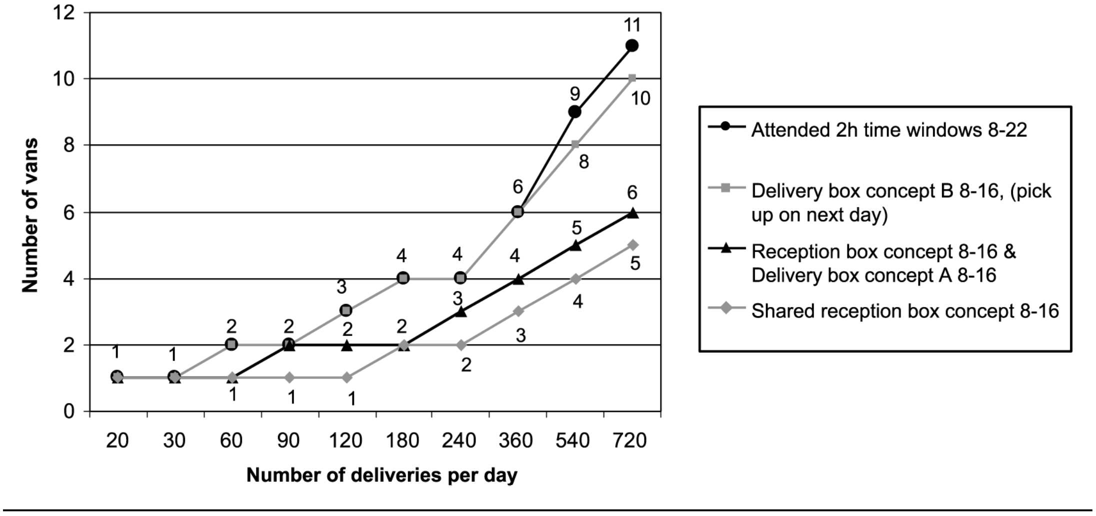


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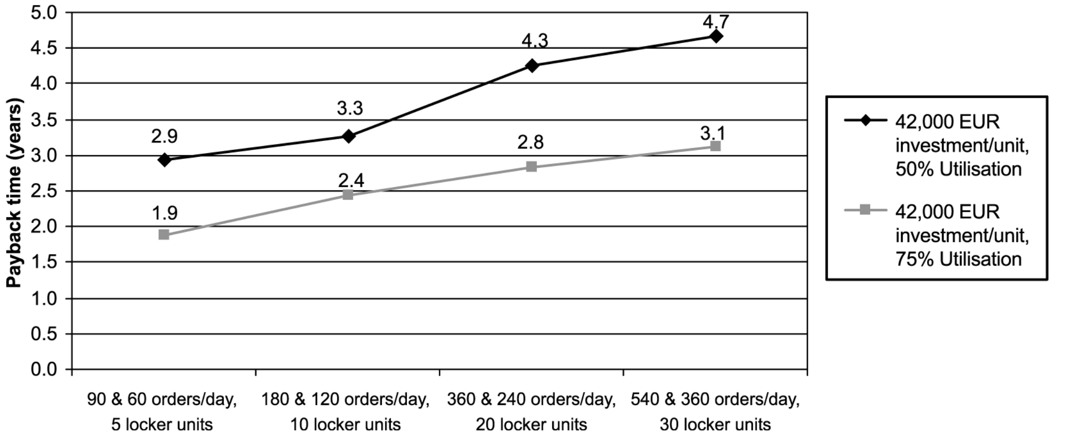
Figure 5 Payback period for a shared reception box unit with a capacity of 24 lockers



for reception boxes is between six and 13 years, when the number of daily deliveries ranges from 20 to 720. As in Figure 5, the payback period increases when there are more orders to be delivered per day. This is due to the reduced cost difference between the two-hour delivery time window concept and unattended reception. The reason for the reduced cost difference is based on the effects of economies of scale. With a higher number of orders, the density of the stops is also higher. With a higher density of stops the home delivery operations are more cost-effective.

However, the analysis of the shared reception box concept was made using fairly poor utilisation rates (50 per cent and 75 per cent) of the units. When a shared reception box is placed in a very busy railway or underground station, as many as two to three orders per day per locker, a 200-300 per cent utilisation rate, could be possible. Furthermore, in this analysis the drop-off time for both the attended two-hour time window concept and for the shared reception box concept was two minutes, to enable proper comparison. In reality, the drop-off time using a shared reception box concept could easily be one to two minutes per order and, in the worst cases, attended reception may take four to ten minutes. This would make unattended reception concepts even more efficient than shown in this comparison. Additionally, the characteristics of the local road network, the time needed to find a parking place, and, especially, the rush hours, would change the situation.

Discussion and conclusions

In this article we compared the current standard home delivery concept with attended reception and two-hour delivery time windows and concepts offering unattended reception. We focused our research especially on analysing home delivery operations using the shared reception box concept. According to the analysis, cost savings as high as 55-66 per cent can be reached with home delivery transportation when compared to the concept offering attended reception with two-hour time windows. The cost saving is based on an operational efficiency approximately three times higher and the fact that fewer vehicles are needed. While discussing the results we also analyse here, in a general way, the shared reception box concept from both the consumer's and retailer's points of view.

In the shared reception box concept the shopping basket is actually waiting to be collected, whereas in home delivery with attended reception the consumer is waiting for the goods to be delivered. However, in the shared reception box concept the goods are delivered only "half the way" and the customer has to pick up the goods within the pick-up time window defined by the service provider. This does not provide total independence of delivery time windows or carrying the goods, as is the case in the customer-specific reception box concepts (Kämäräinen *et al.*, 2001; Punakivi *et al.*, 2001). However, the consumer saves the time needed to make the trip to the store and pick up the groceries. Additionally, assuming that consumers are travelling anyway, to work, to

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leisure time hobbies, or to the petrol station, picking up the shopping basket would not increase the time used or the mileage undertaken.

This study shows that, using the shared reception box concept, a home delivery service could be offered to the customer at a fairly low price. However, demand for this type of "half the way" home delivery service is uncertain at the moment (Browne *et al.*, 2001; UK Foresight Report @ Your Home, 2001) and should be tested in the market. Additionally, according to UK Foresight Report @ Your Home (2001) some key questions to be resolved are the accepted distance from home to the collection point, the accepted price level for using the service, and how much additional traffic this concept may generate. Taking a longer perspective, the shared reception box concept can also be seen as a step towards increasing demand for online shopping services and changing consumer shopping habits generally. In the course of time this would presumably lead to increasing demand on customer-specific reception boxes, enabling the best possible service level and convenience for the customer.

For retailers, the concept of using shared reception box units opens up new business opportunities. Investing in shared reception box units and placing these in selected locations expands the retailer's area of coverage more cheaply than investing in new outlets. With the shared reception box concept the actual picking, packing, and shipping may be done outside rush hours and, at the same time, can increase the utilisation of current store resources. However, the investments required are seen as the problem for the retailer. Based on the results of this study, this problem is not that big after all. For example, Tesco.com currently has a delivery fee of £5 per home delivery with two-hour time windows. If half of this fee (£2.50) were charged per delivery to a shared reception box locker, the investment in the shared reception box units would be recovered in one to 1.7 years (not discounted), assuming a utilisation rate of 50-75 per cent. Furthermore, the retailer may not be the only possible investor in the shared reception box units. Employers would probably appreciate investment in shared reception box units and in this way offer their employees some extra compensation.

Finally, whereas customer-specific reception boxes are well suited to customers living in one-family houses or rows of houses in a suburban area, shared reception boxes are a solution for blocks of flats in the city centre and for rural areas. The retail chain may prefer an investment in shared reception box units and the cost of transportation to closing down traditional stores in the rural areas. The usage of online grocery and other online services, together with the shared reception box concept, may actually enlarge the range of products and services offered in rural areas.

In order to direct future research and development work, the feasibility of the unattended reception concepts and the level of customer acceptance should be tested in the market. Furthermore, the problem area of the right business concepts, including investment in unattended reception, should be analysed and developed. There are several possible investors, such as consumers, employers, new service operators, or retailers.

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