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Kornum, Niels; Johnsson, Mats

2001

[Link to publication](#)

*Citation for published version (APA):*

Kornum, N., & Johnsson, M. (2001). *Designing Distribution Systems for Consumer Related E-Commerce*.

*Total number of authors:*

2

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# DESIGNING DISTRIBUTIONSYSTEMS FOR CONSUMER RELATED E-COMMERCE

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*Working document – not to be referenced*

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## ABSTRACT

Consumer goods can be delivered in a number of different ways. One important and very interesting method is the use of e-commerce to deliver the groceries to the consumer. Distribution of consumer goods, especially groceries, poses a number of challenges to the use of e-commerce. Challenges that must be solved in order to find a justified solution.

This paper will present and discuss a new research project called E-bizz Öresund, sponsored by the governments in Denmark and Sweden. It is a collaboration between ten companies, Copenhagen Business School, Lund University, Teknologisk Institute and SIK.

This project is focusing on four major research topics that will be further discussed in the paper: Different distribution systems for e-commerce and how to control them in a efficient way, Warehouse layouts and how to perform a cost effective and productive order picking process, Systems that secure the temperature in the distribution chain and intelligent packages that will secure the temperature and that alarm when not met, and finally What are the most important customers requirements on a e-commerce solution and how design e-solutions that meet these requirements.

*Key Words: E-commerce/E-fulfillment/Use of Internet , Distribution Logistics; Packaging logistics*

## 1. INTRODUCTION

The Internet makes it easier for the consumer to buy goods at suitable periods of the day. At the same time e-commerce firms can obtain costs reductions for operating the physical shop. The road seems fairly open for convenient direct deliveries of consumer goods.

The recent experiences shows that consumers who already have used an e-commerce delivery system, emphasizes precise delivery service, systems for returning and handling of products and consumer “friendly” packaging that meet demands according to aspects like durability and environmental footprint. The consumers also wants to buy products that demands special handling and stocking conditions i.e. chilled or frozen products. This demands special designs for packaging and distributionsystem. The different residential areas of consumers also influence their demands for delivery service and packaging options. For example people living in apartments have fewer possibilities of storing transport boxes between deliveries.

We also know that delivery service is important for customer satisfaction and recurrent buying. So it is crucial that systems for returning products and packaging are optimal. Together these needs are very demanding to the systems of a firm. So the e-commerce systems designed must be sustainable in the long run but at the same time implemented fast. This seemingly “Catch 22” situation calls for cooperation between firms, technological institutes and science, and also cross-country and cross-disciplinary cooperation.

## **2. A RESEARCH STRATEGY SUITED FOR DESIGNING E-COMMERCE DISTRIBUTIONSYSTEMS**

Within logistics and transport research it is often emphasized that the different flows and links within the distributionsystems are interdependent. Changes in design in one part of the distributionsystem will normally have impact on the other even remoter parts of the distributionsystem. The number of warehouses will influence the distance to households and as a consequence also the lead-time. If the lead-time is altered this can possible affect the need for packaging i.e. if the warehouse for chilled products is located close to the final customer, then the need for separate specialized packaging solutions is reduced.

For consumer related e-commerce distributionsystems business and science now have the opportunity to rethink the entire distributionsystem from the producers to the refrigerator / kitchen of the individual households. Optimally every initiative to innovate parts of the system must be evaluated on the potential impact other parts of the system. Luckily the total systems concept is widely recognized within logistics and transport research and this systems concept can handle the tradeoff between different elements in the system. Figure 1 is based on classic logistics concepts: 1) total distribution costs 2) trade off between the total distribution costs and varying service levels, but also between the different cost elements constituting the "total distribution costs"<sup>1</sup>

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<sup>1</sup> The cost elements is not shown in this model, but discussions on trade off between cost elements is classic within logistics i.e. as trade off between number of warehouses and costs of lost sales (Abrahamsson 1992) or the relation between the number warehouses and safety stock (Maister 1976) .

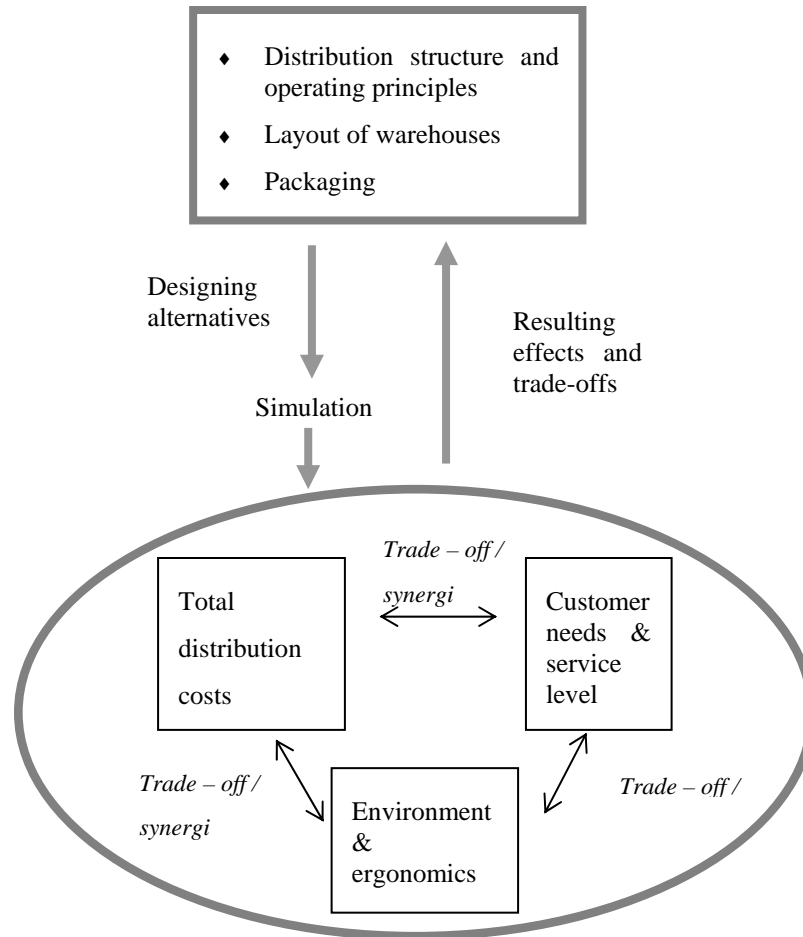


Figure 1. Designing distributionsystems

The research profile in figure 1 is different from the classic view. This is because: 1) simulation is suggested as an important tool to handle and analyze interdependencies between single units of the total system, 2) impact on external environment (pollution), ergonomics and working conditions are considered to be important elements. E-commerce distributionsystems is only build in small scale yet. So business and researchers still have the possibility to consider many feasible alternatives and therefore also are obliged to search for alternatives that have the smallest impact on external environment and the best design for optimal ergonomics.

Figure 1 then illustrate how the basic concepts of the design process interplay and thereby underpin the importance of taking into account the interdependence of decisions taken by a single unit and the need to view the process as a whole. However there is a need to be more specific concerning the design of different parts of the distributionsystems for e-commerce and to base the further research process on scientific knowledge generated

within subdisciplines i.e. warehousing. On this background 4 subthemes has been identified:

1. **Distribution structure and operating principles** is focusing on themes like the number and location of warehouses, the level of inventory, push or pull operating principles, optimal order penetration point, etc. See section 3
2. **Warehousing / picking & packing**. Designing picking & packing systems for consumer related e-commerce is very different from BTB systems. The unit size is smaller, often a broader assortment should be handled and manual handling routines are often needed for specific products i.e. the careful handling of vegetables. See section 4
3. **Intelligent packaging and chilled transports systems**. Perishables need chilled transport environments either the vehicle is equipped with chilling facilities or a transport box<sup>2</sup> is developed to be able to meet demands for keeping the product at the correct temperature for a specific period. Combining a transport box with intelligent capabilities will give possibilities for monitoring chock exposure, temperature deviations, contamination, etc. See section 5
4. **Consumer needs, behavior and attitude**. As the distributionsystem should be designed to meet the needs of the consumer obviously the attitudes, current behavior and current and future needs of these consumers are very crucial in order to design an optimal distributionsystem. So this research is important input to the other three themes. See section 6

E bizz Øresund and this paper will have a primary focus on distributionsystems for grocery e-commerce, but many aspects are also valid for other types of consumer goods.

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<sup>2</sup> Dependend on the actual use and size other words are used : transport container or parcel. Still the word: "box" gives better mindset of this new unit in e-commerce distribution.

### 3. DISTRIBUTION STRUCTURE AND OPERATING PRINCIPLES

Designing distributionsystems that are able to handle the delivery of groceries from the retailer DC to the household must be based on 1) new experiences from e-commerce systems, but will also take into consideration the 2) knowledge of existing distribution from DCs to the grocery shops. Below we will discuss the latter subject (2) first and then continue to discuss the specific issues related to the distribution of groceries in e-commerce systems (1). As a part of these two subjects research focusing on environmental effects from the distribution of groceries will be included.

Much attention in logistics research have been given to the efficiency and cost reducing effects of reducing the number of warehouses i.e. from a large number of warehouses to few in Europe (Abrahamsson 1992, Christopher 1992, Cooper 1994 and Schary and Skjøtt-Larsen 1995). However the reported cost reducing effects is primary stemming from the fact, that the studied firms are selling high value products giving access to large reductions in inventory. To low value products centralization of distribution structure is less attractive (Cooper 1994) and to groceries the combination of low value and high rate of turnover indicates, that the rationale for centralization should not primarily be found in inventory reductions, but instead be linked to the very complex task of picking and packing groceries and economies of scale obtained by large warehouses (The Coca Cola Retailing Research Group - Europe and GEA 1994, Kornum 1996 and 1997). This mechanism is estimated to generate further centralization of grocery distribution structure (Kornum 1996).

The effects from centralization measured in vehicle km. are very sparsely studied. Velden (1994) identify a number of factors influencing the increase in ton km. and Cooper (1994) proposes a “hypothetical example” that shows a 40 % increase in vehicle km. as a consequence of a reduction of the number of warehouses from four to one. For the distribution of groceries Kornum (1996, 1997) and Nedergaard (1998) have identified a number of factors specific for the generation of vehicle km. / tons km. in the grocery sector and later studies point to the localization, needs and demands of customers as crucial subjects (Lumsden & Hultkrantz 2000). Other studies focus on the transportsystem i.e. vehicle utilization, routing and scheduling and technical optimization of vehicles and equipment (Matthiesen and Skjøtt-Larsen 1986, Krarup 1986 and McKinnon 1996, 1999).

Food and grocery related studies outside the logistics tradition three types of studies should be mentioned: 1) Statistical studies of the total environmental footprint of the grocery sector (Jørgensen 1995, 1997). 2) Studies on the environmental footprint of single food products (life – cycles analysis) (Böge 1993, Forbrugerstyrelsen 1996 and Liedtke et. al. 1996). 3) In Sweden studies have been mapping the total energy consumption of every tier in the supply chain and distributionsystems for foods (Naturvårdsverket 1997).

There is an obvious need to include both warehousing and transportsystems in total grocery supply chain studies (Kornum 1997, Lumsden & Hultkrantz 2000). Sustainable



solution should be developed in close cooperation between the important actors of the grocery sector. As a platform for this development quantitative studies of different alternatives for distribution structure and operating principles is needed. Such studies will normally cover large, complex systems, where changes in one part of the system will impact other parts of the system. Some parts of the system will function as bottlenecks and impede an efficient flow (Houlihan 1985, Christopher 1992, Ackere, Larsen and Morecroft 1993, Schary and Skjøtt-Larsen 1995 and Normann 1995).

However in order to handle quantitative analysis of such complex systems modeling and simulation is needed. A model should reflect the total system and the different parts of the system under the precondition of realistic time-space, cost and customer service parameters. Simulation should be the tool to handle and identify interdependencies between different parts of the total system (Forrester 1961, Mohamed and Towill 1994, Wikner 1994 and Holmström 1997). As part of these quantitative analysis and scenarios also environmental aspect should be in focus (Kornum 1996, 1997 and Berglund, 1999).

So the need for this type of quantitative analysis has grown in significance and the development of e-commerce systems is not reducing this need. On the contrary. A PC - based model and evaluation method have been developed to facilitate the analysis of current dynamic and complex systems (Johnsson, et al, 2000) (Bousonville, Wiggen, 1999) and a pilot study of a PC –based model is ongoing at the University of Lund (Jönson et. al., 2000). A model of the total distributionsystem can generate a need for supplementary methods and/or techniques for evaluating of the single activities within the system (Björnemo et al, 2000).

The environmental effect of establishing consumer related e-commerce systems is from a first hand view negative. To distribute groceries directly to the household instead of to the groceries would logically give longer transportdistances and therefore larger emissions. However around 50 % of the energy consumption for the distribution of groceries in Denmark consists of shopping trips in private cars (Jørgensen 1995, 1997). If some of these trips are substituted by trips by bike or as pedestrian the overall environmental balance might be positive. The first pilotstudies in Denmark and Sweden evaluate the potential as respectively neglectable (PLS Consult A/S & DMU 1996) and positive (Orremo, Wallin, 1999, Jönson, Johnsson, 2000) but further studies based on more complex and time-space realistic preconditions is in demand (Cairns 1999).

## **4. WAREHOUSING / PICKING & PACKING**

As mentioned in section 2 e-commerce BTC systems is fairly different from BTB systems. New solutions must be developed to a number of functions in e-commerce: picking & packing function as a part of total warehouse layout, synchronization with transport operations, customer demands, new packaging solutions and ergonomics. It is also important to develop means to integrate these functions. The handling of goods in recent e-commerce systems has too low levels of productivity. Studies indicate in order to be profitable that the productivity should be more than 200 orders pr. hour (Guyrei, 1999) instead of recent level of 10 orders pr. hour. If the level of automation is to be increased this will demand the development of modular packaging systems combined with tracing facilities and with transport box systems supporting automation.

To choose appropriate handling equipment a number of factors have to be mapped and to be known i.e. goods volume, weight / volume of transport box, frequency, demand for stowage, delivery service, etc. These factors is input for the dimensioning of warehousing systems for BTC e-commerce and models must reflect flexibility concerning i.e. a broader assortment, higher delivery frequency and even expansions of the warehouse facility.

A traditional warehouse consists of several different components that must be identified i.e. staff, buildings, layout, material handling- and informationsystems. To traditional and e-commerce warehousing it is crucial to develop different types of cross – docking solutions that are able to handle a transfer directly to the shipment area without storing the goods. Therefore the right type of packaging and the right number of items pr. transport box must be identified. Other crucial issues are to decide to number of items pr. order, the mix of orders and the impact on layout and productivity.

The flow of goods inbound is another important area. Can this be handled without disturbing the other activities? What type of bufferstock should be accepted as buffer in periods where output from picking & packing functions is not matching input to the warehouse? How can suppliers match their deliveries to the output flow from the warehouse? Even different customer demands should be taken into account i.e. demands for shorter lead-time, larger or smaller consignments, specialized assortments, etc.

A warehouse for groceries often consists of several warehousing systems that are coordinated, departments i.e. for chilled products, fresh fruits, frozen products, beverage, etc. The flow through the different departments should be dimensioned and designed in order to support the overall best efficiency of flows and reduction of costs.

To support efficient solutions to e-commerce warehouses right from the start existing methods for analyzing warehouses should be refined and adjusted to specific needs. As an example the complex structure of the warehouse can be analyzed with WRA (Warehouse Performance Analysis) developed by Frazelle (1996).

Furthermore an increase in e-commerce consumer sales demands packaging to match efficient handling routines with fewer instances of handling the goods. Based on a cost analysis picking & packing at warehouse with efficient handling routines and a turnover of 164 Mio. SKR generate a 1.9 % higher margin than a similar shop with e-commerce solutions (Andersson et al 1997). This indicates the need for efficient e-commerce solutions.

Not only cross-docking and other functions for new e-commerce solutions must be developed and more deliveries synchronized (Simschi-Levi et al., 2000). Also informationsystems should be updated and able to handle information concerning all deliveries to the area served.

## **5. INTELLIGENT PACKAGING AND CHILLED TRANSPORT SYSTEMS**

This section discusses both intelligent and chilled transport packaging systems. The latter subject will be discussed first and in more detail than the former. In the last part of section 5 will contain a discussion of the potential of establishing recycling systems for product packaging is included.

Many of the e-commerce systems for the distribution of groceries use a high frequency system with an order cycle of four hours or less (Cairns, 1996, 1998 and Kornum 1999). This narrow time window for delivery automatically leads to short local transport time (about an hour). With such a short local delivery time it is relative easy to keep perishables chilled during transport. A simple box or sack with insulating material will stabilize temperature deviations.

However if the task is to develop systems that are able to handle a broader time window for delivery i.e. 10 – 20 hours then the need for a controlled and stable temperature is clear. This can be provided either in the distribution van / warehouse / terminal with chilled temperature zones or via a transport box keeping the temperature at certain levels. The first type is known from traditional distribution of groceries as separate flows for chilled, frozen and bread (Kornum 1996). The Danish firm Aarstiderne A/S [[www.aarstiderne.com](http://www.aarstiderne.com)] is selling biologically grown vegetables, fish and meat. They use chilled transport for both local and transit transport and a non-recyclable box chilled by ice-cubes (in a plastic bag) that keep the temperature. The service of this system is offered only to larger towns and densely populated areas and is dedicated to the customers of the firm.

However if the service area also must cower smaller towns and rural areas or entire nations it is necessary to use existing parcels distribution systems. By this it is possible to harvest economies of scale from distributing the groceries in the same system as ordinary parcels. Durables and fast moving consumer goods sold in BTC e-commerce systems is already distributed via national and international parcel systems, but groceries is not included because of the need for chilled environments.

If large parcel distribution systems will equip terminals and vehicles with chilling facilities this is likely to be an enormous initial investment that is not corresponding with the expected low volumes of chilled products in the first maybe many years after the introduction of chilled services. It is therefore a clear and straightforward idea instead to look for the possibilities of constructing a transport box that can be handled in the ordinary parcels system. Besides the above-mentioned economy of scale a box solution also reduce the need for large initial investments. There are some costs for designing the right box but the final production of the box can follow the expected increase in volume of chilled product distribution. So the potential gain from a well-designed transport box is significant.

Another interesting issue is whether the box shall be recyclable or not. In Denmark in 1993 the volume of sold groceries was around 5.3 mill tons (Jørgensen 1995). If all these groceries were sold directly in cardboard boxes of 0.7 kg (loading 20 kg) the yearly

consumption of cardboard in Denmark would be 184.000 tons. So the environmental potential for using a recyclable box seem large even with a penetration rate for e-commerce of 30%. But other parameters like energy consumption and emission related to the cleaning of recyclable boxes must be included in further investigations.

All together it is a very complex task to decide the optimal design. First of all, what types of needs and reservations do consumer have concerning specific designs? If the box is recyclable how do the distributor secure, that it is not used for other purposes and how is the return and cleaning process handled? How well and for how long time do the box keep specified temperatures? How is it possible to trace events that do not meet specified quality measures? These and a number of other critical questions have to be met in the design process.

Some of these questions point to the vision of making the transport box more intelligent. The use of bar-coding has had a significant impact on today's distributionsystems with possibilities of tracing the individual parcel through every step of the handling process. Due to the combined reduction of prices on microprocessors and sensors real-time registration on every single transport box of temperature, humidity, shock, vibrations, contamination, etc. is within economic reach. However the decision of using this technology must also take into consideration the questions asked just above.

Furthermore there is a close connection between the need for protection via a transport box and the protection secured by the product packaging. For example if the transport box is dedicated to chilled meat products and the meat products are prepared and sliced at the warehouse of the virtual retailer, then the need for product packaging is reduced.

Another of the potential benefits from selling groceries via the Internet is that the physical exposure in the shop to information or advertising is moved to a virtual exposure on a website (Kornum, Bjerre and Langberg 1999). There are good possibilities of offering information about new products or discounts. Advertisements on the website can contribute to brandbuilding just like other on-line media. But the Internet has additional features: 1) give the customer a more varied and "genuine" picture of the firm 2) work more individually with the customer and 3) via bilateral communication strengthen the involvement in the firm by the customer. (Andersen and Lindstrøm,1997). So the direct communication via the web (or by telephone) can replace some of the exposure via product packaging.

In this way new possibilities arise for establishing recycling systems for product packaging. There is a large potential for recycling product-packaging items and to obtain a significant reduction in the use of materials. However further research in this field is urgent. A part of this research will deal with the needs, behavior and attitudes of consumers both related in general to e-commerce of groceries and more specific to packaging and delivery issues.

## 6. CONSUMER NEEDS, BEHAVIOR AND ATTITUDE

As research concerning structural changes in distribution channels is beginning to take momentum (Sakar, Butler and Steinfield 1999, Kornum, Bjerre and Langberg 1999) just as typologies of the patterns of consumer behavior (Peterson, Balasubramanian & Bronnenberg 1997, Butler & Peppard 1998, Kornum, Bjerre and Langberg 1999). But only a few empiric pilot studies about the needs, behavior and attitudes of consumers have been finalized (Olsen, Knudsen & Jørgensen 1998, Kornum, Bjerre and Langberg 1999).

So there is an obvious need for detailed, cross-country investigations. *Firstly* studies must identify which factors in the living conditions and value set of the family / household that trigger distinct needs for specific services, including Internet based services. Based on this knowledge *secondly* the needs, behavior and attitudes of the households / families toward distribution and packaging relevant issues must be investigated i.e. delivery systems, point of delivery, packaging types, need for product information and acceptance of advertising.

## 7. FURTHER PERSPECTIVES

Research within everyone of the four research fields have challenging aspects, however the real challenge is to harvest the possible synergy of coordinating research from different disciplines: consumer behavior, design, ergonomics, transport, warehousing, packaging, etc. In a time where consumers demand convenience and where ethic and environmental considerations are important the design of distributionsystems with many new elements research must be a cross-disciplinary business.

Furthermore the cooperation between firms with e-commerce activities, technological institutes and research institutes will strengthen these potential synergies.

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