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Transport and Environmental Impacts of Current Home Delivery Services and the Benefits of Alternative Measures

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ABSTRACT

FACULTY OF ENGINEERING, SCIENCE & MATHEMATICS
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TRANSPORT AND ENVIRONMENTAL IMPACTS OF CURRENT HOME DELIVERY SERVICES AND THE BENEFITS OF ALTERNATIVE MEASURES

By Liying Song

Home shopping and delivery services offer customers the opportunity to purchase goods and receive deliveries to their home rather than having to travel to high-street stores. Given the promising future of home shopping and delivery market, many efforts have been devoted to solving the problems currently encountered by service providers and customers which include unsecured deliveries, first-time delivery failures, demands for faster delivery, and product returns. Of major concern in this research are the implications of home delivery failures when there is nobody in to receive the package at the delivery address. Collection/delivery point (CDP) systems are one of the emerging solutions to mitigate failed home deliveries, in which CDPs are used as alternative addresses to receive the packages.

Particularly focused on the small package home shopping market, this research has identified and modelled the existing home delivery and CDP methods. The carrier and customers travelling distance incurred in each delivery method was compared. It was then possible to quantify whether the CDP method is an economic solution to improve home delivery operations and the environment.

A six-step research method was then developed to achieve those research objectives. Firstly, the existing and emerging home delivery methods were identified from the literature. The second stage consisted of conducting two home delivery surveys in Winchester and West Sussex, respectively. The surveys were used to identify the home shopping and delivery characteristics of customers. In the third research step, the

theoretical benefits of CDP methods on householders and carrier in Winchester were analysed using people's experiences of home delivery services. After that, the modelling work was repeated in West Sussex in the fourth stage, to see whether there were significant differences in modelling results of CDP benefits against the Winchester study. The analysis in both Winchester and West Sussex study was implemented through optimising carrier's theoretical delivery rounds. Instead, the CDP system could be appraised by replicating the exact carrier rounds, which shaped the fifth research stage. The carriers' historical delivery schedule was collected from a major carrier company in the same area as the fourth stage (West Sussex). The delivery operations were then simulated. In the final research step, a discussion of the feasibility of the CDP system was provided.

The main conclusion from this study is that the major benefits of using CDPs were achieved by householders. There were few kilometers benefits to carrier but the processing costs associated with delivery failures were reduced significantly by CDPs. Furthermore, the CDP methods were able to reduce emissions generated in current home delivery operations. Additionally, it was found that the CDP method would function effectively in terms of reducing overall vehicle kilometres incurred in the current situation (carrier and householder combined) when the first-time delivery failure rate was over 20% and the proportion of people travelling to depot was over 30%.

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TERMINOLOGY

Home Delivery

All goods delivered to a customer's home or another location selected by the customer at the point of order rather than customer having to buy the goods in person and transport themselves.

Home Shopping

The supply of consumer goods directly by a company to a customer in response to an order. The order could be generated in a number of ways, e.g. through mail order/ catalogues, Internet etc, but the customer home is the final point of the logistics network.

Small Package

Many small, packaged items purchased such as books, CDs, clothing and footwear, jewellery, watches and gifts; The small packages typically lend themselves to delivery through existing parcels networks (in terms of their weight and size) (Retail Logistics Task Force @Your home, 2001).

The small packages adopted in this research are slightly larger than a letterbox.

Locker bank

The locker bank consists of an array of reception boxes, to which access is remotely controlled by a locker management company.

The reception box can be permanently attached to the outside wall or door of customer's home, or allocated to the customer dynamically. Carrier driver drops in the parcel into the reception box and then the locker management company notify the recipient of a delivery automatically by SMS message or email.

Collection/delivery Points (CDPs)

This concept uses attended facilities (e.g. local convenience stores, garages, post offices, schools and railway stations) or unattended facilities (e.g. secure locker banks at sites such as park and ride terminals, individual lockers) as local 'collection points'. The customer could designate one of these facilities as an alternative delivery address when ordering goods, to be used in the event of them not being at home when a courier arrived to deliver a package. The customer would be notified of the arrival of the package through a text message to his/her mobile phone, email or phone call.

One example of such a service provider is the Royal Mail and Parcelforce Worldwide, allowing consumers to choose delivery to the participating post office branches offering Local Collect service, as a first choice or an alternative should they not be home when delivery is first attempted.

Other examples include KIALA and PACKSTATION. Kiala allows customers to nominate the local shops (grocery stores, supermarkets, dry cleaners', newsagents, petrol stations, etc) in its scheme as the alternative delivery addresses to collect and return their parcels. PACKSTATION consist of an array of locker boxes, which are accessible 24/7 with a smart card and PIN code to the registered customers. Customers are notified of a waiting parcel by email or SMS. The scheme can be used for collection of parcels, dropping-off parcels and returns.

Home Delivery Method

The home delivery method offered is characterized by the delivery time-windows, whether people need to be home or not to receive, and type of products being delivered.

For the home delivery methods of 'small packages' modelled in this research, there are: existing delivery method, attended and unattended CDP delivery method.

In the existing delivery method, carrier makes up to two delivery attempts and failed delivery is diverted to the local carrier depot for customer's collection. In the attended CDP delivery method, the CDPs (e.g. convenience store, post office) are used as either the first-time delivery addresses or the addresses for the failed first-time deliveries. Customers can then collect their failed deliveries locally. In the unattended CDP delivery method, the packages are delivered to an unattended CDP, typically a locked reception box.

Delivery Failure Rate Proportion of customer's who experience a failed first-time delivery per round.

When the carrier makes a first-time delivery attempt and there is no-one at the delivery address (or an appropriate signatory cannot be obtained) to receive the goods.

Brick-and-Mortar Located or serving consumers in a physical facility as distinct from providing remote, especially online, services.

Multi-channel The term channel is defined as various marketing and communication media available to a retailing organization to interact with its customers. The multi-channel company offers customers more than one way to buy something - for example, from a Web site as well as in retail stores.

Brick-and-Click Offering online services for customers to buy something.

IMRG Interactive Media in Retail Group.

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CHAPTER ONE

INTRODUCTION

1.1. The growth in home delivery market

Electronic commerce through the Internet has dramatically changed people's lives in recent years. According to Verdict's e-Retail 2006 report, online retail spending in 2006 grew by 33.4% to £10.9 billion in the UK, excluding spending on services such as tickets, insurance and business expenditure (Verdict, 2007). This is almost 13 times faster compared to the overall retailing sector. Verdict predicted that online sales will almost triple to £28 billion by 2011, equivalent to 8.9% of all retail spending. By 2011 the typical spend of an online shopper will grow to £1,056 per annum, up from £606 in 2005. The 'clothing and footwear', 'DIY and gardening' and 'food and grocery' sectors are currently achieving the fastest growth.

E-commerce has also altered Christmas shopping habits. The research body Interactive Media in Retail Group (IMRG, 2006) has announced that £5 billion was spent online during Christmas 2005, £7 billion during the same period in 2006, and £13.8 billion in Christmas 2007. Tesco.com was one of the leading e-retailers over the Christmas period, with a record of 1.3 million orders delivered in the four weeks leading up to Christmas 2006, an increase of around 30% on 2005 requiring an additional 300 delivery vehicles.

The growth in e-commerce is partly due to easier and cheaper access to the Internet with 61 percent of the UK households in 2007 (National Statistics, 2007). Table 1 illustrates the purposes of personal Internet use, indicating that using email, searching for information, general browsing and Internet shopping are the most frequent activities. Each value represents a percentage of the total sample. For example, in response to a question 'What uses do you make of the Internet?" 86% of people said using email and 84% finding information about goods.

Table 1 Purpose of personal Internet use, 2005

Purpose	**Percentage**
Using e-mail	86 % ([1])
Finding information about goods or services	84 %
Searching for information about travel and accommodation	76 %
General browsing	73 %
Buying or ordering tickets/goods or services	55 %
Personal banking and financial services	42 %
Reading or downloading on-line news	39 %
Finding information relating to education	36 %
Playing or downloading music	30 %
Looking for a job/sending job application	27 %
Other	26 %

Source: National Statistics, UK, 2003.

From customer's point of view, Internet-based technologies reduce the customer's search costs in obtaining and processing information about the prices and product features. Such information can be collected from the Internet very quickly. For example, many sites help customers to identify the products offers and price comparisons, such as www.google.com. By reducing search costs through the Internet, it is possible for the customers to consider more product offerings and purchase the goods which better match their needs.

[1] Percentage does not add up to 100 percent as respondents could give more than one answer.

From the retailer's point of view, the Internet-based technologies allow them to increase the number of products offered, which would be constrained by the shelf space in high-street store. This results in a more effective communication between retailers and potential customers on product availability. E-commerce also puts increased price competitions among the retailers. E-retailers are theoretically supposed to offer lower prices than the high-street store due to the lower costs of retail operation. According to Brynjolfsson and Smith (2000), online prices for books and CDs were between 9-16% lower than in high-street stores, even after accounting for shipping and handling costs and local sales taxes. Thus e-retailer Amazon had a market share of round 80% in books in 2000. Consequently, e-commerce can help retailers improve their market power by providing more products, lower prices, convenient home delivery services.

Although online shopping increases dramatically, the traditional mail order/catalogue market still dominates home shopping transactions, with some 60% of the overall market in 2005 (Mintel, 2006). Overlapping with other forms of retailing (for example, catalogue/mail order, traditional brick-and-mortar, multi-channel sales, etc), e-commerce offers the opportunities for customers to purchase goods from home and receive deliveries to their home rather than having to travel to the high-street stores. This could especially benefit disabled or elderly people in suburban areas, and households which are largely empty during the working day.

The advent of e-commerce has brought new methods of retailing over the Internet which has again increased the demand for home delivery services. According to IMRG (2006b), approximately 860 million home deliveries were shipped to the UK's 26 million Internet shoppers in 2006, each Internet household receiving 33 parcels annually. Among the goods delivered, 59% of them were classed as 'small packages' (such as books, CDs, clothing, etc) and 39% large packages (such as furniture, white goods, other large electrical appliances, etc) (Retail Logistics Task Force @Your home, 2001). Small package home shopping is still dominant in the current home shopping market. According to Mintel (2006), about 30% of the books sold in the UK were purchased over the Internet, with music sales at about 30%, clothing and footwear 20%, computer software and entertainment tickets 20%.

The growth in the home shopping and home delivery markets could impact on the economy, through accelerating business processes, reducing costs, reaching new customers and developing new business markets. These activities will influence road traffic and affect the environment, resulting in a growing concern about the system-wide implications of home delivery. Unfortunately, a clear identification of the extent and direction of the implications has not yet been achieved, and the issue remains unclear. It is tempting to assume that the home delivery service could reduce road traffic and thus improve the environment. For example, home shopping could replace store shopping travel by consumers, which could theoretically decrease, assuming that there are no additional leisure trips using the time saved by home shopping and home delivery. Thus emissions from vehicles driven to the store could be reduced. However, replacing store shopping by home shopping shifts the travel required to deliver purchased goods from the customer to the retailer, with an uncertain impact. An argument is that home delivery journeys provided by a retailer may be more efficiently organized than customers' trips using their own cars, or they may not be, depending on the extent of the trade-offs between cost-efficiency and the timeliness of delivery. Another argument is that although there is a reduction of shopping trips on the road, some trips for other maintenance or leisure activities have been made with the saved time instead (Farag, *et al.*, 2003). Further research is needed to quantify the transport and environmental implications of home delivery service.

1.2. Problems associated with home delivery

The growth of home shopping market has challenged goods distribution processes, which play a key role in the home shopping transaction. The modern retailing industry is reliant on fast and efficient distribution systems and the success of a business can be totally dependent on the speed with which customer orders can be fulfilled. There are specific issues associated with the operating efficiency of these systems.

Customers usually demand fast delivery within narrow time windows making it difficult for the shipping company to use its vehicles effectively. The carrier has to dispatch a vehicle carrying a small number of packages in order to meet the delivery time requirements, resulting in an increased number of 'less-than-truck-load' vehicles. According to Department for Transport (2006), delivery vans were empty for 15% of total distance travelled. Forty percent of all delivery vehicle traffic in 2004 utilized only 25% of capacity, resulting in increased road congestion and greenhouse gas emissions.

The growth in the home shopping market has resulted in more demands for vehicles to deliver in residential areas. Looking forward to 2010, the Department for Transport (2005) estimated an increase of 15-22% in passenger car traffic; a 19-20% increase in light goods vehicle (LGV) traffic; and a 5-6% increase in heavy goods vehicle (HGV) traffic. The Department for Transport (2006) has indicated that 34% of the distance travelled by vans was related to the collection or delivery of goods. In many cases, delivery vehicles to serve the residential areas are mostly small vehicles.

The increased number of delivery vehicles has generated negative environmental impacts. According to the Department for Transport (2005), CO_2 emissions by road transport have increased 8% since 1990. Although the growth in light delivery vehicle and heavy-goods vehicle traffic has only accounted for 29.0% of the total growth in vehicle-kilometres since 1990, they have collectively accounted for over 97% of the increase in road-transport CO_2 emissions over the same period. In contrast, although the level of vehicle-kilometres driven by passenger cars since 1990 has risen 18.5%, their carbon emissions have only risen 2.1%.

Given these increases in delivery vehicle movements, of increasing concern are the numbers of failed home deliveries where no-one is at home to receive the package. Unsuccessful deliveries could obviously result in higher operating costs for the carrier and higher transport costs for the customers to retrieve the failed package. Packages delivered when the customer is not home have to be redelivered or the customer could drive to the carrier's depot to make the collection. Failed home deliveries increase carrier operating costs and cause inconvenience to the customers. IMRG (2006b) has estimated that £682 million of direct costs per annum will be borne by customers, retailers and carriers due to Internet shopping delivery failures. Estimates of delivery failure rates vary considerably with reports of 12% (IMRG, 2006b), and 60% (Department of Trade and Industry, 2000).

Home delivery of groceries is usually made on a pre-arranged day and within a specific time window. It is important for the customers to be in because of the deterioration of groceries. Delivery of small package and large items is less tightly scheduled with the customer and there is often no pre-arranged delivery time-window. For small packages required for a signature, it is necessary for people's presence at the time of the delivery.

Another issue associated with home delivery operations is unsecured delivery. Sometimes the home delivery service providers can provide 'doorstep' (unsecured) delivery in accordance with customer's instructions. McKinnon and Tallam (2003) identified various forms of potential crime by leaving the customer's goods unsecured at their home, including theft of product, denial of receipt and burglary. People witnessing the goods delivery could easily steal them. The customers could also utilize the insecurity of doorstep delivery by fraudulently claiming not to have received the goods. Furthermore, the presence of goods outside a house might increase the risk of burglary.

1.3. Home delivery methods

To satisfy the increasing demands for fast delivery, various home delivery methods have been set up for small packages, including both attended and unattended reception modes. Although the delivery operations are different, there is an overall classification of existing and emerging home delivery methods.

- **Traditional delivery method**

There are several variations to the traditional delivery method but generally a customer signature is required. Goods are ordered by the customer and delivered to their home using certain time windows defined by the retailer. If the delivery fails because no-one is at the address to receive the item, there are several options for the carrier and the customer: 1) the parcel is left with a neighbour; 2) the parcel is left outside the door; 3) the parcel is returned to the carrier's depot for customer collection later; 4) re-delivery attempts are made either on the same delivery day or on subsequent days.

- **Attended local collection/delivery point (CDP) concept**

The theory behind the CDP concept is that facilities such as convenience stores, petrol stations and post offices could be selected as a first-time delivery address by the customer at the point of order or as an alternative delivery address to be used in the event of a first time delivery failure at the home. The main advantage of this delivery option to the customer is that they can collect their failed deliveries locally rather than having to re-arrange a subsequent delivery attempt to the home or personally collect from a carrier's depot, which might be a considerable distance away, or having to arrange to be at home for another attempted redelivery. The CDP concept has distinct advantages for the carrier too, reducing wasted mileage associated with rescheduling deliveries to customers.

Several companies (e.g. Kiala, DHL, Royal Mail) are currently establishing CDP networks in the UK. For example, the 'Local Collect' service from Royal Mail allows consumers to have failed 'signature required' packages returned to a sorting office re-directed to a nearby post office for collection by customer (e.logistics, 2003). The CDP system is suitable for handling small packages that do not require temperature control.

- **Unattended local CDP concept**

In this system, the small packages are delivered to an unattended CDP, typically a locked reception box. The reception boxes are either 'individual' boxes (i.e. Hippobox, Dormousebox and BearBox) (e.logistics, 2002b) at the customer's premises or part of a 'communal' locker system (e.g. ByBox) (e.logistics, 2004b) at an industrial estates or business park.

1.4. Research objectives

The research focuses on the transport and environmental impacts of small package home delivery, with the specific objectives of:

1) Identifying the existing and emerging models for the home delivery of small packages;

2) Quantifying and comparing the transport costs of existing and CDP home delivery methods, in terms of carrier and customer travelling distance; and identifying the benefits to carriers and householders separately of having the failed first-time home deliveries automatically diverted to local CDPs;

3) Quantifying the environmental cost of existing and CDP home delivery methods;

4) Quantifying the impact of failed home deliveries on carrier journeys of making deliveries and customer trips of collecting their failed first-time deliveries;

5) Comparing people's home shopping and delivery characteristics over two demographical areas;

6) Identifying the practical issues when setting up a CDP system, for example, location problem and capacity issue.

1.5. Structure of the dissertation

Chapter Two presents a comprehensive literature review on various issues. Firstly, the home delivery market is introduced by retailing sectors and goods sectors, respectively. It is followed by theoretical analysis of the logistics of home delivery services in Section 2. The home delivery strategies are introduced for two types of goods, i.e. groceries and small packages. Particularly focusing on small package home deliveries, the operating characteristics of traditional, attended and unattended CDP home delivery methods are provided. In Section 3, a discussion of the transport and environmental implications of home delivery operations is provided. In Section 4, the techniques for modelling home delivery operations are reviewed.

In Chapter Three, the research methodology is presented. A six-step research process, data collection and the modelling tool adopted are introduced. The existing and emerging home delivery methods are identified from the literature in the first research step. The existing policies adopted by carriers to deal with the home delivery failures are also explored. The second stage consists of conducting a home delivery survey in West Sussex. Customer's home shopping behaviour findings from the survey are then compared against a second data set collected from another home delivery survey in Winchester as part of MIRACLES project, to see whether their experiences and therefore home delivery trends are shared. In the third research step, customer's home delivery behaviors are modelled in Winchester on the basis of their experiences of home delivery services. After that, the modelling work is repeated in a wider geographical area (West Sussex) in the fourth research stage, to see whether there are significant differences in modelling results of customer's home shopping experiences against the Winchester study. In the fifth stage, the carriers' historical delivery information is collected from a major carrier company. The exact delivery schedule is then simulated. In the final research step, a discussion of feasibility of the CDP systems is provided.

Chapter Four introduces the customer's home delivery characteristics, based on a home delivery survey designed for cross-section householders undertaken in West Sussex, UK. Detailed cross-population analyses are undertaken to identify the differences in home shopping behaviour among different population groupings. The results are compared between two demographical areas (Winchester and West Sussex).

Chapter Five provides the home delivery operation for the small packages in Winchester. Various home delivery methods are modelled and their delivering performances are analyzed with the aid of a routing and scheduling tool. The theoretical potential for CDP delivery service to reduce carrier and householder driving distance are estimated. Based on the emission factors and distance travelled, the environmental costs associated with those home delivery methods are quantified. The transport and environmental costs are compared to the existing delivery method. Moreover, the most favourable CDP locations are identified and the impacts of failed home deliveries are analysed.

To explore the home delivery characteristics and identify the benefits of a CDP delivery model in a wider area and build a more accurate picture of home delivery services experienced by householders, the modelling work adopted in Winchester study is repeated across West Sussex in Chapter Six. The theoretical transport and environmental benefits of CDP delivery operations on both carrier and householders are analysed.

In Chapter Seven, the real operating data from a carrier is replicated to analyze the transport and environmental implications of home delivery in West Sussex. The exact delivery information from one week in October 2006 is collected from a carrier company, including 43559 orders in West Sussex. Customers' street addresses were obtained from the survey undertaken in West Sussex. Based on the computational results, the most favorable CDP network across West Sussex is determined. The economic feasibility of the CDP system is also discussed.

In Chapter Eight, a summary on the research findings is provided. The contributions and limitations of the current research are indicated. The future research agenda is suggested.

CHAPTER TWO

HOME DELIVERY OPERATIONS:

A LITERATURE REVIEW

This chapter starts with a review of the literature covering the characteristics of home delivery services. Firstly, the home delivery market is introduced by retailing sectors and goods sectors, respectively. It is followed by theoretical analysis of the logistics of home delivery services in Section 2. The home delivery strategies are introduced for two types of goods, i.e. groceries and small packages. Particularly focusing on small package home deliveries, the operating characteristics of traditional, attended and unattended CDP home delivery methods are provided. In Section 3, a discussion of the transport and environmental implications of home delivery operations is provided. The techniques for modelling home delivery operations are reviewed in Section 4 and a summary provided in Section 5.

2.1. The home delivery market

Home delivery services have been taking place in the UK for centuries. By 1697, there were over 2,500 pedlars (a person who travelled to different places to sell small goods, usually by going from house to house) licensed to sell goods in locations all over the UK (Spufford, 1994). Recently the advent of e-commerce has brought the new methods of retailing over the Internet which has again increased the demand for home delivery services.

The Verdict report (2005b) calculated that £1 in every £7 spent in the UK retail sector in 2004 was on goods purchased from home. More than half the UK adult population (26.1 million people) had home deliveries in 2004. The UK home delivery market was valued at £34.7 billion in 2003 (Verdict, 2004) and £36.8 billion in 2004 (Verdict, 2005). The value has been increased to approximately £58 billion to year end 2006, over 65% up on 2003 (Verdict, 2006). This figure included all home shopping methods (catalogue, store sales, multi-channel, as well as Internet). In 2004 the home delivery market grew by 5.9%, much faster than the 4.2% achieved by the overall retail sector, as rapid growth in online shopping translated into demand for home delivered goods (Verdict, 2005b). Hence Verdict (2005b) concluded that online shopping is the fastest growing channel in home delivery market, driven by perceived advantages of buying online — low prices, access to a potentially vast product range, the simplicity of the ordering and payment process, and the ability to shop around the clock.

Online shopping brings new opportunities to customers and the benefits have been recognised widely. According to Jarvenpaa and Todd (1997), convenience and price are the most quoted benefits by customers. The business-to-consumer (B2C) segment has undergone notable growth over the past 10 years. According to Verdict's e-Retail 2007 report, by 2011 the typical spend of an online shopper will grow to £1,056 a year, up from £606 in 2005. The 'clothing and footwear', 'DIY and gardening' and 'food and grocery' sectors are achieving the fastest growth. The transactions through Internet shopping are even more significant over Christmas. The e-retail report from the research body Interactive Media in Retail Group (2008) has indicated that £3.3 billion was spent online during Christmas 2004, £5 billion during the same period in 2005, £7 billion in Christmas 2006 and £13.8 billion in Christmas 2007. Among those Internet retailers, Tesco.com was one of the leading players during the Christmas, with a record 1.3 million orders delivered in the four weeks to Christmas 2006, an increase of around 30 percent on 2005. The dramatic growth of B2C commerce is partly due to the fact that easier and cheaper access to the Internet with two thirds of the UK adult population in 2005 (Verdict, 2006). Although online shopping increases dramatically, the traditional mail order/catalogue market still dominates home shopping transactions, with some 60% of the overall market in 2005 (Mintel, 2006).

E-commerce is an opportunity based on the developments in the Internet. It offers customers the opportunity to order goods from home, and to receive deliveries direct to the home. In recent years, e-commerce has grown dramatically as one of home shopping and delivery channels. According to the latest figures from the Office for National Statistics, the value of e-commerce in the UK rose by 232 percent between

2003 and 2006, from £39.3 billion to £130.4 billion, representing nearly 4 percent of the overall sales (National Statistics, 2007).

The growth of e-commerce has influenced many aspects of business practices such as trade globalization, customized production and just-in-time distribution, resulting in a number of changes in the home delivery market. The most significant change is the increase in direct home delivery for smaller shipments. According to National Statistics (2003), the most common commodities purchased through e-shopping are small packages, such as books, tickets for events, grocery, computer software, music/video, and clothing/footwear. In a traditional store-based business, goods are typically distributed in a sequence from the manufacturer, to the wholesaler, to the retailer, and finally to the customer. Customers have to take care of the 'last-mile' transportation of goods, i.e. delivery from the retailer's shop to home. However, this is not the case with e-commerce as manufacturers and distributors can communicate directly with consumers and suppliers, and products delivered directly to the customer's home. However, customers are increasingly demanding for the prompter delivery. Smaller and more frequent leading to 'less-than-lorry-load' shipments become the consequences of home delivery.

Those changes driven by e-commerce bring business opportunities to the logistics service providers, particularly couriers handling parcel delivery. Many retailers have been developing strategic alliances with logistics suppliers. A good example is a successful collaboration between Federal Express (FedEx) and Amazon in the U.S. Amazon.com deals exclusively over the Internet and has become one of the biggest booksellers over the world, with 4.7 million items (Amazon, 2005). When an item is sold from Amazon, FedEx can therefore offer very quick and reliable home delivery service (generally less than 48 hours).

Overlapping with other forms of retailing (for example, catalogue/mail order, traditional brick-and-mortar, multi-channel sales, etc), e-commerce offers the opportunities for customers to purchase goods from home and receive deliveries to their home rather than having to travel to the high-street stores. In this section, e-commerce and its social and economical impacts are introduced firstly due to its rapid growth and promising future. It is followed by exploring the home delivery markets in terms of retailing sectors, i.e. traditional brick-and-mortar company, multi-channel company, catalogue/mail order company, and pure Internet player. In the final part, the home delivery market is analyzed by goods sectors, including groceries, books and CDs, clothing and footwear, electronic items, and household appliances and furniture.

2.1.1. Nature of e-commerce

The advent of the Internet has changed people's lives dramatically. Based on the developments of this technology, the way business is conducted has undergone rapid revolutions. Internet shopping has been becoming more popular than ever, providing people with convenience, time-savings and freedom. "The Economist" (1997) pointed out that:

"The Internet has already connected 50m-60m of the world's people through a seamless digital network. Where they live and what time zone they are in makes no difference."

There are many ways of defining e-commerce. Two of them are introduced in this research.

"*Electronic commerce is defined as undertaking normal commercial, government and personal activities through computers, telecommunications, and networks and includes a wide variety of activities involving the exchange of information, data or value-based exchanges between two or more parties* "(Chan and Swatman, 1999).

Another definition of e-commerce contains more details (European Commission, 1997):

"*Electronic commerce is about doing business electronically. It is based on the electronic processing and transmission of data, including text, sound, and video. It encompasses many diverse activities including electronic trading of goods and services, online delivery of digital content, electronic fund transfers, electronic share trading, electronic bills of lading, commercial auctions, collaborative design and engineering, online sourcing, public procurement, direct consumer marketing, and after-sales service. It involves both products (consumer goods, specialised medical equipment) and services (information services, financial and legal services); traditional activities (healthcare, education) and new activities (virtual malls).*"

From those two definitions, it can be seen that e-commerce integrates three kinds of sales styles including business-to-business (B2B), business-to-customer (B2C) and consumer-to-consumer (C2C). At present, the biggest volume of e-commerce is B2B. According to the European Information Technology Observatory (2006) (http://www.eito.org/), B2B accounted for 87 percent of the overall e-commerce across Europe in 2006. The B2C segment is the second-largest form of e-commerce (12%). A third type of e-commerce, C2C, gives the Internet power to the customers to make personal transactions, and has gained spectacular growth since the launch of e-bay. It has fairly limited market share compared to B2B and B2C (1%). This research aims to quantify the transport and environmental implications of e-commerce, narrowing the focus to the B2C segment. Although B2C is significantly less important than B2B in terms of number and value of transactions (Mansell and Nikolychuk, 2002), it has gained much more public attention than B2B transactions.

E-commerce is transforming economic processes and markets. Clearly, the electronic market (including the exchange of information, products, services and payments using the Internet, networks and digital technologies) and virtual business networks (an information exchange that is intended to build or sustain a working relationship in virtually the same way that normal business networking does) will entail both economic and environmental consequences. These effects could be either beneficial or damaging to the environment.

Fichter (2003) summarized the impacts from several elements of e-commerce on the economy and the environment (Figure 1). Generally the economic impacts were generated from four key elements of e-commerce, i.e. production, retail, distribution and consumption. The environmental impacts referred to the energy consumption, traffic emission, land use associated with satisfying e-transactions.

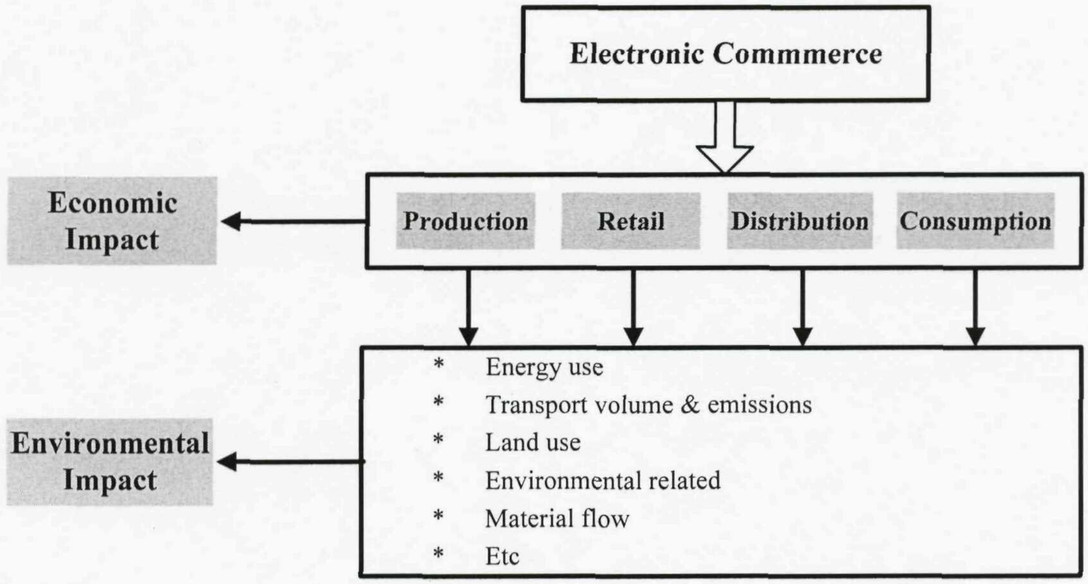


Figure 1 Economic and environmental impacts of e-commerce (Source: Fichter, 2003)

Fichter (2003) explained the wider economic and environmental impacts of e-commerce as below.

Production and Inventory

Production and inventory scheduling is made more efficient through customers placing orders directly with the manufacturer. The customers' requirements are transferred directly into the production and inventory system. Then the manufacturer provides the products according to customers' requirements. Such a circle could result in lower safety stocks, making it possible to gain competitive advantages in price, product innovation and service. That is to say, Internet technology permits the businesses to manage their operations more efficiently by reducing the inventory costs and minimizing surplus production, resulting in decreased costs in storage, production and wastage.

Retailing Activities

With the development of e-commerce, retailing activity has become more global. Customers can source items globally from around the world, leading to increasingly complex supply chains. One change in the electronic retailing industry is that the logistics activities have to be managed over greater distance than ever before. Another change is that the close cooperation among businesses is required in order to succeed in competition. Currently, most of e-retailers offer the delivery service to the customer's home. An argument is that home delivery journeys may be more efficiently organized than customers' trips using their own cars, or they may not be, depending on the extent to the trade-offs between cost-efficiency and the timeliness of delivery. Another argument is that although there is a reduction of shopping trips on the road, some trips for other maintenance or leisure activities have been made with the saved time instead (Farag *et al.*, 2003). These could include, for example, additional leisure trips to sports centres, cinemas or restaurants, or visits to friends and relatives.

Time-based Transportation and Delivery

Because the process of production is inseparable from the consumption of goods purchased, goods distribution processes play a key role in the Internet transaction. Modern e-retailing relies on fast and efficient distribution systems. The success of a business can be totally reliant on the speed with which customer orders can be fulfilled.

Realizing the importance of time-based delivery, many retailers have been actively involved in either reconstructing the traditional distribution channel to improve the efficiency, or utilizing specialized shipping companies to manage the logistics process. The advent of e-commerce has indicated a shift from the traditional delivery operations based on moving large bulk shipments to individual item shipments directly to the customer. To offer shorter lead times and smaller order quantities, many e-retailers have decided to outsource their distribution to a third party logistics service provider, which has the advantage of transporting the goods from retailers to customers through just-in-time (JIT) delivery.

However, there is a counter argument that customer demand for fast delivery or for delivery within narrow time windows makes it more difficult for the shipping company to achieve economics in loading and routing trucks (Niles, 1994; Lin and Mahmassani, 2002; Siikavirta *et al.*, 2003) where a carrier has to dispatch a vehicle accommodating a small number of packages in order to meet the tight time requirements. This can be inefficient and potentially expensive. Such a problem is even more serious for the seasonal online shopping boom. During 2007 Christmas, the value of goods bought online in Britain was £13.8 billion, almost double the value in 2006 (IMRG, 2008). The shopping peak is expected to result in less emergency stock held by retailers, more single vehicle and 'less-than-lorry-load' trips made to the customer. For example, Tesco.com had revenues from online shopping channel reached £190 million with a record of 2 million orders delivered in Christmas 2007. An extra 300 vehicles were employed to deliver all those orders (Silicon.com, 2008).

Consumption

Internet shopping allows people to free themselves from the temporal and spatial constraints of high-street shopping. It also saves customers' time because product information from all available e-retailers can be assembled very quickly (Mokhtarian, 2004). The potential customers are not constrained by the stock at a high-street shop as all the inventories provided by e-retailers are available to the customers. E-retailers are theoretically supposed to offer lower prices than the high-street store due to the lower costs of the retail operation. The most attractive advantage of e-commerce might be the home delivery service, which avoids customer shopping trips and transporting the goods in person. To satisfy the customer's needs for timed home deliveries, a variety of delivery options are offered, for example, standard delivery, evening delivery, Saturday delivery, and unattended reception method.

2.1.2. Home delivery markets by retailing sectors

Currently many different types of retailing companies are involved in arranging and providing home shopping and home delivery service. With the advent of e-commerce, the retailing industry has undergone dramatic changes. The following section will look at different types of companies in the Internet age and their interaction with the retailing market. Here four basic categories are identified: traditional brick-and-mortar retailer, pure brick-and-click retailer, catalogue/mail order retailer, and multi-channel retailer (William, 2002).

2.1.2.1. Traditional brick-and-mortar company

The traditional brick-and-mortar companies initially were not positive to the e-commerce. Reynolds (2000) indicated that the traditional retailers were rigid and slow in decision-making. Many of them didn't want to change their organisational habits to satisfy the needs of e-commerce. The Internet channel was considered quite risky and profit potential was uncertain (Ghosh 1998):

"Consumer companies are particularly vulnerable to rapid change. Ten of the 25 retailers that were the world's largest in 1960 have disappeared. Eight of the 25 retailers at the top in 1997 either didn't exist in 1960 or had nominal sales. Change can overwhelm even the most capable of management teams. The reality of consumer marketing is "innovate or die" ".

Towards the advent of Internet in the mid-1990s, most of the traditional brick-and-mortar businesses had in general been slow to accommodate the Internet technology in their developing online shopping channel. However, a small number of companies realized the opportunities brought by Internet and started to make the initial attempts. Soon the traditional companies realized the overwhelming strength of Internet to transform the way how the business was conducted. A number of academic studies have focused on the business adoption of the Internet (O'Keefe, *et al* (1998), Hoffman and Novak (1998), Cockburn and Wilson (1996), Ellis-Chadwick *et al* (2002) and Jones and Biasiotto (1999).

To identify whether any changes had occurred over time in the UK traditional retailing sectors, Ellis-Chadwick (2002) reviewed the website activities on an annual basis over a 4-year period from 1997 to 2000. The survey was conducted in around 2 months (from October to early December) before Christmas since the retailers generally planned well in advance of the selling seasons and websites would possibly be most developed at this period. The survey targeted the top retailers in the UK in various sectors (grocery, electrical, clothing, etc) with a turnover greater than 5 million pounds. The examples of those retailers included, for instance, Tesco and Blackwells. The survey results suggested that the majority of retailers (72%) had taken the preliminary step of registering a URL; however, only 18% of these used the website for online sales. It was also found that the extent of Internet adoption varied in terms of goods sector. Books and music, and toys and clothes were achieving the quickest adoption by the traditional retailers over the Internet retailing. The survey also found that larger retailers were more likely to develop the Internet business, and the retailers with more outlets tended to be more positive to adopt online sales.

Similarly, Jones and Biasiotto (1999b) analysed the websites of 160 store-based retailers worldwide (US, Canada, Europe, etc) with 9 goods sectors (food, wine, health and beauty, clothes, electrical, automotive, department store, other retailer, restaurant).

The survey results found that over 75% of the retailers had URL registration in 1996, with 21% providing the online shopping function. The retailers with Internet selling tended to focus on several sectors, computer hardware and software, clothing, books and CDs, flowers, chocolates and toys. The use of Internet by the retailing sector was still in the experimental stage when the research was implemented. The majority of the respondents (61.5%) principally used the Internet as a tool for disseminating the company information electronically. Only 5% thought the Internet would increase their sales over the short run. Management Horizons (1997b) concluded that "The Internet represents a highly dynamic shopping medium and it is creating a new set of rules and expectations between the on-line shopper and the cyber-merchant."

2.1.2.2. Multi-channel company

The term channel is defined as various marketing and communication media available to a retailing organization to interact with its customers (Goersch, 2002). The advent of the Internet has driven more and more traditional retailers and catalogers to become multi-channel companies.

There are different degrees of adoption of the Internet in undertaking company businesses. Some companies may still utilize traditional outlets or catalogue only operations for the sales of products, while providing post-sales service over the Internet, or online sales parallel to the original operation (multi-channel company). At the same time, others may have fully integrated the Internet technology into their brick and mortar business (pure brick and click business). The multi-channel retailer offers products through one or more channels to the customer.

By adopting a multi-channel strategy, retailers could achieve significant benefits. They have already set up stable and profitable business relations with their customers. Internet shopping can help them to attract new customers or provide extra service to the existing customers. Porter (2001) indicated a wide range of potential benefits by adopting a multi-channel strategy. Firstly, a customized information platform for all the company activities could lead to a unique and integrated system which would reinforce the business strategy. It was difficult for the competitors to imitate this system. Secondly, the multi-channel strategy could complement the existing business, for instance, by providing the online customer with personalized advice, after-sales service, etc.

White and Daniel (2004) suggested that associating the Internet channel with traditional retailing could be an effective method to create customer awareness to the retailer and its product offerings, by utilizing website and stores mutually. The strategy could also increase customer trust concerning payment, privacy, security and ethical use of information.

Unlike a single-channel retailer, a multi-channel retailer was able to choose the most appropriate channel in its overall portfolio to sell the products to customers (Berman and Thelen, 2004). Each channel was unique in terms of strengths and weaknesses. For instance, traditional store-based business enabled customers to see the product, feel it, try it out and then pick it up and take it home. Catalogue retailer offered high visual image of products. The online shopping method provided an interactive format, a personalized customer interface, virtually unlimited space, and the ability for the customer to view stock information and order status. Hence one channel could be used to complement another.

Apart from the above advantage provided by each channel, the multi-channel has great implications on customer shopping behavior. The customer tends to take each retailing channel in a multi-channel retailer as a complementary experience. According to the report by consultant J. C. Williams Group (2001), based on 48,000 interviews of customers in all retailing channels, 78 percent of Internet shoppers also purchased goods through the retailer's high-street stores while 23 percent of catalogue shoppers also had the experiences of shopping through the retailer's website.

2.1.2.3. Catalogue/Mail order company

As a traditional shopping method, catalogue/mail order companies provide customers with a wide range of goods through issuing comprehensive catalogues and letting customers place orders by post or telephone. During the 1980s, the catalogue/mail order sector achieved the fastest growth to dominate the retail market. Gehrt and Yan (2004) analyzed the wide range of differences among high-street stores, catalogues, and Internet retail, in terms of availability of product information, ability to compare products, and amount of shopping time required. The format of traditional high-street store was limited by operational hours; however, it was able to provide the fastest delivery time. The catalogue format was the most efficient one in terms of spending time to find a specific product. The Internet format was the most time-consuming method for both shopping and delivery.

Apart from the efficiency in finding a specific product, catalogue/mail order channel also allows customers to use credit systems to pay installments without paying at once. Furthermore, the advanced technologies in specialized mailing lists and computerized data procession could improve the market efficiency (Kim, 1996).

Catalogue/mail order companies are among the early adopters to e-commerce (Jones and Biasiotto, 1999). They already have a suitable logistical infrastructure in place to set up the Internet channel very quickly. There is no need to substantially change their basic organizations and operating processes. Based on the survey of 1099 companies, mail order/catalogue sectors were most likely to register a URL and develop a transactional site (25 percent) (Hart *et al*, 2000).

2.1.2.4. Pure brick-and-click company

Pure brick-and-click companies typically sell the products only via the Internet. Since the Internet technology prospered in late 1990s, many pure Internet companies have emerged. The most successful one is, for example, Amazon.com, who has been the leading enterprise in the online booking retailing sector (The Times, 2007). However, people's estimation on the dot.com boom tended to be overenthusiastic and the Internet prosperities didn't last over a long time.

According to Reynolds (2000), pure brick-and-click retailers were able to provide the customers with greater shopping advantages with a wide range of products worldwide, unlimited opening hours, more flexibility in stock ability and speed of delivery. The fully Internet-enabled operations can also benefit the retailers through reducing storage costs, and attracting new international customers (Doherty *et al*, 1999).

The pure Internet retailers also face some problems and weaknesses. First of all, the fully Internet-enabled system is extremely expensive to set up. Only large organizations are able to afford to do it. Apart from the implementation expenses, the retailers have to invest on marketing their products since they didn't have any business recognition and customer base in place. It is not surprising that the customer is reluctant to shop from a new business, even more reluctant from a virtual Internet shop. If they were not satisfied with the experience, they would probably not come back again (Nicholls and Watson 2005). Furthermore, home delivery operations provided by pure Internet retailers tend to be more important than their counterparties. According to Xing and Grant (2006), the last-mile operation is critical for pure Internet retailer since there is no direct interface with customer. Hence it is very important for the Internet retailer to offer speed and reliable delivery to customers.

2.1.3. Home delivery market by goods sectors

Among the goods delivered, three categories were identified as groceries, small packages and large items by Browne (2001). The definitions for each category were adapted here:

Grocery: all items purchased from supermarkets that are delivered to a customer's home or another address chosen by the customer, including food and other household items.

Small package: many items purchased such as books, CDs, clothing and footwear, jewellery, watches and gifts, which can not fix into a mailbox or requires customer's signature.

Large item: many items purchased such as furniture, white goods, other large electrical appliances and garden buildings and structures.

The research suggested that the home delivery market for grocery, small packages and large packages accounted for 2%, 59% and 39% of overall home delivery market, respectively. Browne (2001) generally summarized the current home delivery market and introduced the supply chain partners involved in arranging and carrying out the home deliveries, i.e., retailers, manufacturers, distribution and logistics companies, fulfillment companies, collection and delivery point companies, unattended delivery system providers.

Verdict (2004) generated a commercial report regarding the home delivery market in the UK. In terms of frequency of home deliveries in 2003, the top four categories of goods were: 'books, music and videos', 'health and beauty', 'clothing and footwear' and 'DIY products'.

The following section discusses the home delivery market by those goods sectors.

2.1.3.1. Groceries

The overall grocery home shopping sales for 1999 were £197 million in the UK (Insightresearch.co.uk), which was only 0.5 percent of the grocery market. However, Verdict (2004) indicated that 'food and grocery' sector was achieving the fastest growth. It predicted that e-grocery market would expand rapidly over the next 5 years (to 2010), by more than 20 percent year on year.

According to Verdict Home Delivery and Fulfillment Report (2004), 26.1 million UK customers used home delivery service in 2003. More remarkable, nearly a quarter of them (23 percent) had groceries delivered to their homes once a week, up from 6 percent in 2001. The online grocery sales were £1,386 million, accounting for 1.4% of overall retail spending in 2004.

There are good reasons to expect the sustainable developments of grocery home shopping and delivery market, providing customers, retailers and society with many advantages. For the customers, these include the convenience and the ability to search for products, to arrange home delivery at a convenient time. Retailers are able to develop their share in the market by providing home shopping and delivery services. Retailer can also generate positive social implications by servicing the 'time-intensive' people, parents with young children, the disabled and elderly people (Murphy, 2003).

The grocery home shopping market currently is provided by most of the existing store-based supermarket chains — Tesco, Sainsbury's, Iceland, ASDA and Waitrose, with Tesco being the most successful player. Tesco had 66 percent of the UK's online shopping market in 2006. Other big players in the market, the Wal-Mart-owned ASDA chain, took 16 percent, with Sainsbury's following close behind with 14 percent (ZDNet, 2006). The supermarket chain is now the largest online grocer and takes around 250,000 orders per day which are collectively worth £2.5 million.

2.1.3.2. Books, music, CDs and videos

A survey of 2,000 UK shoppers suggested the most popular goods for home delivery were books, music and videos, with 20 percent of those respondents having ordered such items (Verdict 2005b). It estimated that online sales accounted for 10.3 percent of overall retail spending in this sector, equivalent to £872 million in 2004.

Some companies selling those products are pure brick-and-click company (such as Amazon.com), some are traditional catalogue/mail order companies (such as Britannia), while others are traditional store retailers (such as Waterstones). Online sales have achieved success in this sector. Amazon.com is the world famous Internet book seller, with a market share of around 56 percent in books, CDs and videos in 2000 (Mintel, 2000), followed by Bertelsmann, WH Smith, Waterstone and Blackwell with sales of 9 percent, 5 percent, 2 percent and 1 percent, respectively.

Books, Music CDs and Videos are standard products to ship, making it possible to utilize the existing postal services for home deliveries.

2.1.3.3. Clothing, footwear, and gifts

The online apparel market turns out to be particularly appealing to some consumers, and has been developed rapidly. Verdict research (2005b) estimated that the overall retail spending in this sector was £37,980 million in 2004, with home shopping market accounting for 16 percent. Online sales in clothing, footwear and gifts were £701 million, equivalent to 1.8 percent of overall retail spending in this sector.

The market is expected to further expand since more and more people have been becoming comfortable buying clothes online. A survey undertaken by the Economist (2004) indicated that the Internet would never become the largest sales channel for clothing but it would be one of the best-performing. The UK apparel industry is dominated by traditional high-street department stores (for example, Marks & Spencer, John Lewis, Debenhams), long-established catalogue/mail order companies (for example, GUS, Grattans, Littlewoods) and also some new online retailers (for example, La Redoute, figleaves.co.uk, asos.com).

These retailers either use their own delivery operations especially for those long-established catalogue/mail order companies, or outsource the delivery operations to the carrier company.

2.1.3.4. Electronic items

Verdict (2005b) suggested that the second most popular goods for home delivery were electrical goods, with 19 percent of respondents among 2,000 UK shoppers having ordered such items. It estimated that the overall retail spending in this sector was £22,369 million in 2004, with home shopping market accounting for 7 percent. In terms of online sales, UK customers spent over £2 billion online on electrical goods in 2003 (e.logistics, 2004).

Retailers in this sector are composed of pure Internet retailers (such as Dabs.com, dell.com) as well as long-established retailers (such as Dixons Group and Comet).

Some of the store-based companies operate their home delivery services using their own delivery vehicles with some retailing using the party logistics companies.

2.1.3.5. Household appliances and furniture

Household appliances and furniture are typically heavy and expensive, for example, refrigerators and washing machines. The overall retail spending in this sector was £10,025 million in 1999 (Verdict, 2000), with home shopping sales of £654 million. Retailers are composed of long-established stores (such as Argos), manufacturer direct selling firms, catalogue/mail order companies, as well as pure Internet retailers (such as Furniture123.co.uk).

Some companies make deliveries from stores while others deliver directly from manufactures. Most of the companies in this sector utilize their own delivery fleets; a few outsource the home delivery operations to the carrier company.

2.2. The logistics of home delivery

In this section, the logistics and supply chain management of home delivery services is introduced. First of all, the relationship among three stakeholders in the home delivery market is explored, i.e., customer, retailer and carrier. Secondly, traditional supply chain operations are explained, and their changes due to advent of e-commerce. It is followed by the introductions on logistics of grocery and small package home delivery operations, respectively. Particularly focusing on small package home deliveries, the traditional home delivery methods and emerging CDP delivery methods are presented in the final part.

2.2.1. Customer, retailer and carrier relationships

There are three important stakeholders involved in the home shopping and home delivery market, i.e. customer, retailer and carrier company. Obviously it is necessary to understand the responsibilities for each character in order to make the home delivery operations work well.

Retailers and carriers are responsible for goods successfully reaching the customer. To initiate and manage the successful delivery process, the retailer needs to collect some necessary information. This includes the basic delivery address, the dimensions of the package, the delivery preference of the customer (e.g. next day, standard), and the shipping address of the customer. Incomplete information will result in the home delivery failure and increase the operating costs to the retailer. The research body IMRG (2006b) estimated that, due to incorrect delivery information, 2% of home deliveries were undeliverable in 2005, i.e. 8.76 million of the 400 million total. If the home shopping industry successfully tackled the delivery inefficiencies and failures, IMRG suggested that £1.76 billion per annum of benefit would be available.

To satisfy the customers' requirements for speedy deliveries, many retailers have outsourced their home delivery operations to the logistics service providers (e.logistics, 2002d). According to Van Laarhoven *et al* (2000), cost reduction and service improvement were the two major reasons for outsourcing the home delivery operations. Logistics service providers could reduce retailer's operating costs by utilizing multiple resources from more than one company. They also were experts in logistics management, with specialist expertise and experience. Consequently, the retailer which outsourced its logistics function could focus on the core business and provide better service to customers (McKinnon, 1999). There are several types of logistic service providers according to their services provided to the retailer. Sink *et al* (1996) classified the typical functions that logistics service providers performed (Table 2).

Table 2 Activities associated with logistics service providers in the USA

Logistics function	**Activities**
Transportation	Shipping Forwarding (De)consolidation Contract delivery Freight bill payment/audit Household goods relocation Load tendering Brokering
Warehousing	Storage Receiving Assembly Return goods Marketing/labeling Kitting
Inventory management	Forecasting Location analysis Network consulting Slotting/layout design
Order processing	Order entry/fulfillment
Information systems	EDI/VANs Routing/scheduling Artificial intelligence Expert systems
Packaging	Design Recycling

Source: Sink *et al.* 1996

According to Waller (2001), transportation and warehousing were the most popular functions to be outsourced. This research focused on the logistics service providers specializing in transportation. The advent of e-commerce has seen that the traditional delivery operations based on moving large bulk shipments were replaced by smaller, more frequent shipments directly to the customer anywhere in the world (Table 3).

Table 3 Characteristics of e-commerce delivery

Attributes	**Traditional delivery**	**E-commerce delivery**
Distribution chain	Producer – Wholesaler – Retailer	Online retailer - customer
Shipment size	Large	Small
Shipment type	Homogeneous	Heterogeneous
Number of loads (density)	High	Low
Number of delivery stops	One or more stops	Many stops
Delivery failure	Few	Many
Delivery frequency	Low	High
Delivery time sensitivity	Low	High
Number of vehicles required	Low	High
Vehicle size	Large	Small
Delivery cost per each load	Small	High

Source: Park and Regan (2003).

Obviously the carrier has the greatest responsibility and exposure in the home delivery operations. In reality, the carrier companies may face some practical difficulties through poor data, either because the customer doesn't provide the necessary correct information, or the retailer doesn't pass it to the carrier as requested.

To solve the inefficiency of home delivery operations, Joyce (2005) suggested that the responsibilities and communications of each stakeholder needed to be improved: "*By ensuring that the necessities of up line and down line stakeholders are defined, monitored and effectively operated at the interfaces between them, inefficiencies are not transferred, and individual cost effectiveness is improved*" (Figure 2).

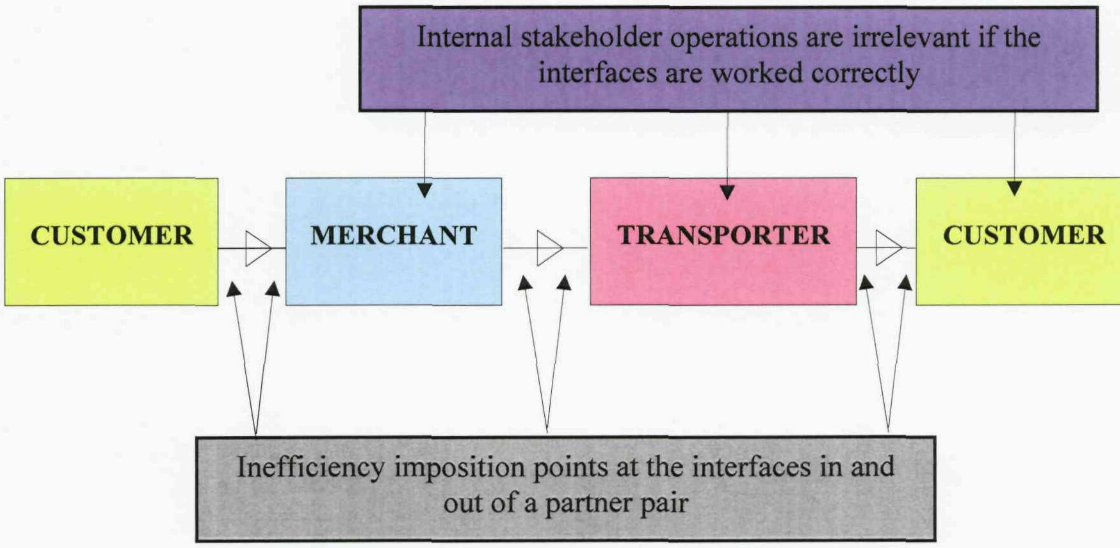


Figure 2 How to solve the inefficiency of interfaces between retailers, carriers and customers (Source: Joyce, 2005)

2.2.2. Traditional supply chain operations

According to Christopher (1992), the definition of logistics is:

'*the process of strategically managing the procurement, movement and storage of materials, parts and finished inventory and the related information flows through the organization and its marketing channels in such a way that current and future profitability are maximized through the cost efficient fulfillment of orders*'.

In the early 1950s the management of logistics was still quite an unexplored area. Companies had concentrated on transportation and inventory activities with the main focus on transportation (Ballou, 1999 and Bowersox *et al.*, 1968). During the 1950s, the potential for integrated logistics was discovered (Lewis *et al.*, 1956). Integrated logistics was defined as the system-wide management of entire logistics chain as a single entity, instead of separate management of individual logistical functions, including facility location, transportation, inventory, communication, and material movement (Bowersox, 1974). The main finding was that the lowest total cost might not be achieved by pursing the lowest achievable cost in each individual logistics function. To reduce the total costs, it was now seen possible to spend more on one function, such as selecting air transportation, in order to reduce the costs of other functions, such as production and inventory.

The challenges currently facing logistics managers are to integrate the performance of the different logistical functional activities in the whole supply chain. The supply chain can consist of raw material suppliers, production factories, warehouses, distribution centers, transportation services, and the consumers (Seppälä and Holmström, 1995). The interacting functional elements of various supply chains form a logistics network, as shown in Figure 3.

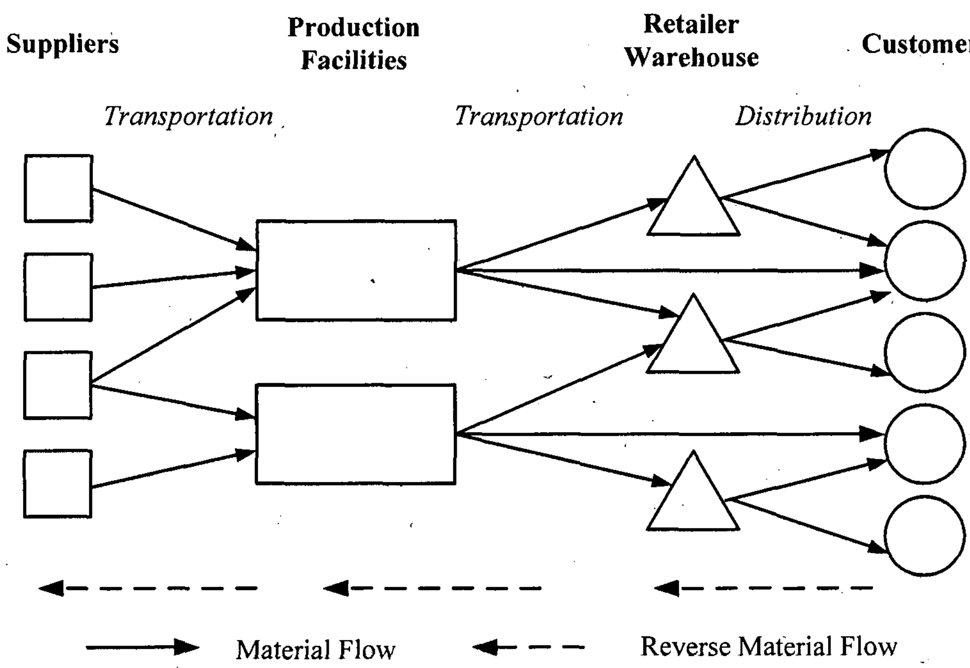


Figure 3 Logistics network (Source: Seppälä and Holmström, 1995)

A single company is not able to control the entire supply chain from raw material source to final consumption. For practical purposes, it usually has a narrower scope, controlling the immediate physical supply and physical distribution (Ballou, 1999). This is why managing the whole supply chain is generally treated as a broader concept than managing logistics. Supply chain management focuses more on the management of sourcing, manufacturing, and delivery systems (Novack *et al.*, 1992), while logistics has focused on the operational principles of these systems. The supply chain management is defined as: '*The supply chain is the network for organizations that are involved, through upstream and downstream linkages, in the different processes and activities that produce value in the form of products and services in the hands of the ultimate consumers*' (Christopher, 1992).

The supply chain partners perform a variety of logistical functions, including warehousing, transportation, sales, marketing, order taking, customer service, and merchandising. There are many ways of bringing the products from the manufacturer to the customers in the traditional supply chain. Two basic categories are adopted in this research, 'push' and 'pull' systems. In a 'push' system, goods are moved from the manufacturing plants to distribution points on the basis of sales forecasting or planning. The second approach is the 'pull' system which requires that the product be moved from the plants based on actual demand (Ballou, 1992).

Figure 4 illustrates one type of simplified structure of the traditional supply chain. Here, the supply chain is viewed as providing the products from the manufacture's factories to the retailers. The consumers pick and take the goods home themselves using their cars. After production and storage at the factory, the goods are delivered to the national distribution centre. Here they are stored, consolidated and reloaded, and then sent on to the next destination, i.e. the local distribution centre. The goods are handled in the same way as at the national distribution centre, and are thereafter sent on to the retailers, where they are sold to the consumers (Lumsden, 1998). In traditional supply chain, the customers buy the products in a shop.

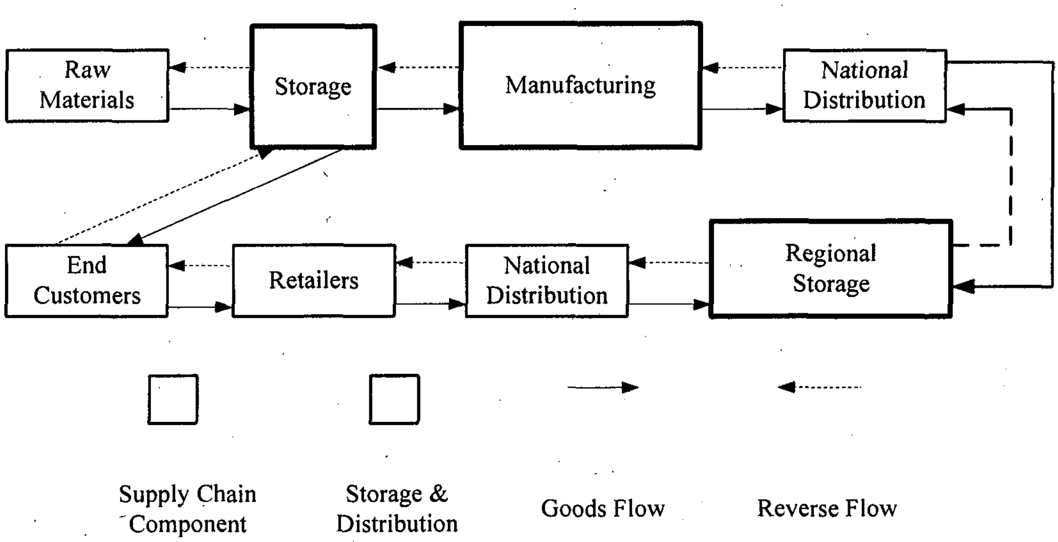


Figure 4 Home delivery in traditional supply chain (Source: Lumsden, 1998)

With the advent of e-commerce, there are dramatic changes within the supply chain because the customer order point will be moved upstream in the chain, in some cases even up to the manufacturer. The supply chain could then be simplified to consist of only direct distribution from the manufacturer to the customer. One of the primary changes in the supply chain is the reduced number of participants in the chain, compared to the traditional supply chain. What used to be processed from the manufacturer through wholesaler and retailer to the customer has been changed significantly, by deleting one or more of the costly operations in the traditional supply chain (Abbey *et al.*, 2001).

There are several participants in the traditional supply chain could be deleted. One of the options is to remove the retailer and then distribute the goods directly from manufacturer to the customer, which named direct home delivery. In this distribution centre, the goods are consolidated into smaller consignments and then transported to the consumers (Figure 5). Another possible alternative is to remove the local warehouse from the supply chain and adopt the postal service to transport the goods from the national warehouse to the customer, called mail-order shopping. The last alternative is to distribute goods from the national distribution centre to the customers.

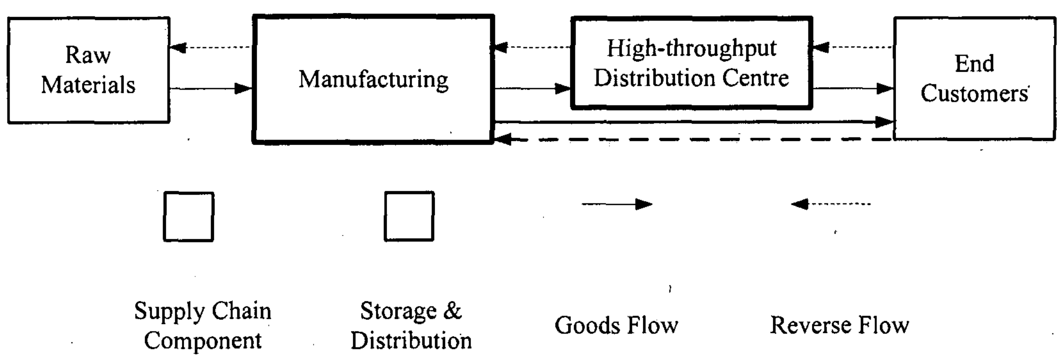


Figure 5 Home delivery in new supply chain (Source: Lumsden, 1998)

2.2.3. Grocery home deliveries

2.2.3.1. Grocery home delivery market size

Groceries are defined as all items purchased from supermarkets that are delivered to a customer's home or another address chosen by the customer, including food and other household items (Browne, 2001). Customers are able to order groceries from home and get them delivered to their home. The overall grocery home shopping sales for 1999 were £197 million in the UK (Insightresearch.co.uk), which was only 0.5 percent of the grocery market. However, Verdict (2004) indicated that 'food and grocery' sector was achieving the fastest growth. It predicted that e-grocery market would expand rapidly over the next 5 years (to 2010), by more than 20 percent year on year. IMRG estimated that nearly 20 percent of the UK populations purchased their groceries from the Internet in 2006 (IMRG, 2007).

E-grocery services are currently provided by most of the UK's leading supermarket chains (Tesco, Sainsbury's, Iceland, ASDA and Waitrose), with Tesco being the most successful player (Figure 6). Tesco.com has over 850,000 regular online grocery customers and 250,000 orders a week (Tesco, 2006), covering 90 percent of the UK population by 1999 (Economist, 2000; The Times, 2000). Tesco recently announced that its online sales for 2006 reached £1.2 billion, accounting for two thirds of overall online grocery sales in the UK. Tesco is now the UK's fourth largest Internet retailer, and shares 31.5 percent of the UK's overall retail market.

Figure 6 Home delivery vehicle from Tesco.com

Another successful player in the e-grocery market is Ocado (Figure 7). Based in the north-west of London, Ocado started as a joint venture with the John Lewis Partnership (owner of the Waitrose grocery chain). By 2005, it had a turnover of £144 million, representing 70 percent growth on 2004.

Figure 7 Home delivery vehicles from Ocado

The Iceland store chain is able to reach 95 percent of the UK population through its home delivery system, with sales of £20 million in 2005. Iceland has 1000 delivery vehicles all around the UK.

The detailed home delivery operations for groceries are explained in the following section.

2.2.3.2. Grocery home delivery strategies

There are a variety of operating strategies adopted by the existing grocers offering home delivery services, based on either the dedicated fulfilment centre or the existing stores. Some grocery retailers utilize the existing high-street stores, where the home delivery orders are picked up by staff and dispatched to customers. Some are opting for dedicated fulfilment, where the goods are picked up and despatched directly to the customers. Others adopt a hybrid model of combined dedicated fulfilment centre and high-street stores. Traditional grocers have generally used the first strategy, in which the home delivery operations are based on existing store infrastructure. The second strategy, based on dedicated distribution centres, has been adopted mainly by the pure e-grocers (Kämäräinen *et al.*, 2001).

Both of those strategies have their strengths and weaknesses. A dedicated fulfilment centre is typically designed to achieve efficient picking operations while high-street stores are designed primarily for displaying and selling products to customers (Peters, 2000; Yrjölä, 2001). Some of the picking operations may even be automated in the dedicated fulfilment centre (Kämäräinen *et al.*, 2001b). However, investments on a dedicated fulfilment centre are higher than when operating from an existing store. For example, Webvan's automated distribution centres cost between $25 million and $35 million each (Kämäräinen and Punakivi, 2002).

When picking operations are based on the existing store infrastructure, the required investment is significantly smaller compared to setting up a dedicated fulfilment centre. Furthermore, customer acquisition is easier because of the fact that traditional retailers usually have a well-known brand on the market.

A comparison on the handling costs per order in each strategy was provided by Merrill Lynch, a financial management and advisory company (Merrill Lynch, 2001. cited in Financial Times). It was estimated that it can cost up to £24 to fulfil each home shopping order by in-store picking and £15 for dedicated fulfilment centre (Table 4). Fulfilment centre is able to handle a significant amount of orders per week (8000/week) and thus achieve a better record of sales (560,000/week). However, more customer service staff (1293) and delivery stuff (38,400) are needed to maintain the activities in that setting.

Table 4 Characteristics of two home delivery strategies for groceries (in-store and dedicated fulfilment centre)

	In-store picked orders	Fulfillment centre picked orders
Number of orders per week	420	8,000
Average order value (£)	85	70
Weekly sales (£)	35,700	560,000
Customer service staff	343	1293
Delivery staff	2,016	38,400
Costs per order (£)	24	15

It has been found that the type of delivery system used can lead to significant variations in efficiency. To illustrate this, a few case examples with different home delivery strategies are introduced here. The first case is Webvan based on the dedicated fulfilment centres, one of the most attractive stars in the Internet boom, and also one of the most shocking failures (Research and Markets, 2001). Webvan founders raised about $1 billion to set up the dedicated fulfilment centre for groceries in Oakland in 1999. Initially serving Silicon Valley in California, Webvan promised to deliver to customers within 30 minutes time slots. Furthermore, it offered free delivery for orders more than $50 and $4.95 delivery charge imposed on smaller orders. To reach market dominance, Webvan aimed to automate the grocery home delivery operations based on its dedicated warehouse in edge-of-town locations (Perman, 2000; Cassidy, 2002). It had planned to enter 16 cities across the U.S. with one single large fulfilment centre hub (Mendelson, 2001).

However, Webvan was unable to guarantee sufficient delivery density and reach economically viable home delivery operations. Low customer density and short delivery time windows together resulted in extremely high delivery costs. In May 2001, Webvan started to raise its delivery charges from $4.95 to $9.95 for orders under $75, and impose a delivery charge of $4.95 for orders between $75 and $100. Free delivery was available only for orders over $100 (Sandoval, 2001). However, all those measurements were not enough to prevent Webvan from running out of money and finally it decided to cease its home delivery operations in 2001 (Sandoval, 2001b).

Another two examples of grocers utilizing a dedicated warehouse concept are Toronto-based 'GroceryGateway' and Vancouver-based 'Quick.com' in Canada. Quick.com used a dedicated warehouse in 2001, which was 1/10th size of Webvan as smaller scale was considered more financial sustainable, but it ceased handling in 2002 as a consequence of small market demand. In the UK, Sainsbury's and ASDA initially started the home delivery operations with dedicated warehouses, but switched to store-based fulfilment centre soon after it was clear that order volume was insufficient to offset the expense (e.logistics, 2002). As of March 2006, Sainsbury's offers home delivery with 1-hour delivery time window. A standard delivery charge of £5 is applied to orders less than £70 and free delivery for the larger orders. ASDA provides customers with 2-hour delivery time windows and charges £4.25 as delivery fee for orders less than £100.

Other examples of 'warehouse-based' grocers include Ocado supermarket chain in the UK (the second largest, behind Tesco), Royal Ahold in the Netherlands, Carrefour in France, Woolworths in Australia, and Foodtown of New Zealand (e.logistics, 2000c).

Apart from the warehouse-based home delivery strategy, some e-retailers adopt store-based method, in which the home delivery operations are based on existing store infrastructure. Tesco.com was started in 1996 and is currently the world's biggest e-grocer with annual sales of £43.1 billion in 2006 (Tesco, 2007). Tesco offers home delivery with 2-hour delivery time windows and next day delivery. The delivery fee charged is between £4.85 and £6.85 for orders less than £100, depending on how fast the customers anticipate the goods to be delivered. Tesco.com implements its picking operations in nearly 700 stores across the UK, covering 90 percent of the UK population in 2006. It employs teams of people to pick up the goods according to customer's order transmitted from the Tesco.com website, and teams of drivers to deliver the orders at agreed times. When the customer order is received by Tesco.com website, it is routed to the nearest physical Tesco store where employees started picking and delivering (Sandoval, 2001b). With its current in-store picking and delivery strategy, Tesco has been able to develop its online business with great successes. It delivered more than two million orders in the UK before Christmas 2007 (Silicon, 2008). As shown in an earlier report, Tesco.com interpreted this as 'confirmation that Britain has now accepted online supermarket shopping as a normal part of day-to-day life' (Tesco press release, December 2002).

However, there are several issues to be considered in Tesco's home delivery operations. The in-store picking strategy is very labour-intensive. The delivery charges (between £4.85 and £6.85) may not be able to cover the costs of employing stuff of picking and driving. Reinhard (2001) has estimated that the costs of picking and home delivery operations accounted for 14 percent of sales. Moreover, when there are crowded customers in store at weekends, the efficiency of picking and delivering is impeded.

The third model of combined dedicated fulfilment centre and high-street store seems to be a natural evolution from the previous two. In the in-store pick concept, lower investment is required but is less efficient in terms of picking and delivering than having a dedicated fulfilment centre. Therefore, some grocers have adopted and developed a hybrid model by maintaining both in-store picking and a dedicated warehouse, for example, Sainsbury's.

Sainsbury's initially adopted a store-based home delivery strategy, in which orders were picked in-store and delivered to customer's home. In May 1999, Sainsbury's decided to set up the largest grocery picking centre in the UK to handle customer orders transmitted from Sainsbury's website because a store-based strategy was believed to be incapable of dealing with significant volume of orders without impeding the customer's shopping activities in-store. Since then, Sainsbury's has built two dedicated warehouses in London and Manchester, which are able to handle nearly 15,000 products. Currently, Sainsbury's adopts a hybrid home delivery strategy based on two dedicated fulfilment centres and 33 high-street stores. A major problem with the hybrid home delivery strategy is the difficulty of integrating the picking and home delivery operations to handle both online and regular orders since dedicated warehouse and high-street stores are jointly used in hybrid delivery strategy (Beamon, 2001). Other grocers utilizing the combined dedicated fulfilment centre and in-store picking are Peapod, Albertsons and Safeway in the U.S.

A summary of home delivery strategies adopted by some leading grocers is provided in Table 5.

Table 5 A summary of home delivery strategies adopted by leading grocers

Grocers	Home delivery strategy	Delivery charge	Delivery time slots	Year opened	Year closed
ASDA	In-store	£3.75-£4.25, free order>99 (valid in March 2008)	Next day delivery; Standard delivery; 2-hour slot	1965	—
Sainsbury's	Combined dedicated fulfilment centre and in-store	£5, minimum order £25 (valid in March 2008)	Next day delivery; Standard delivery; Weekend delivery; 2- hour slot	1973	—
Waitrose	In-store	£5, minimum order £50 (valid in March 2008)	Standard delivery; Weekend delivery; 2- hour slot	1955	—
Tesco	In-store	£4.85-£6.85, free order>100 (valid in January 2008)	Standard delivery; Weekend delivery; 2-hour slot	1956	—
Webvan	Dedicated fulfilment centre	\$9.95 for orders < \$75, \$4.95 for orders between \$75 and \$100 Free for order >\$100 (valid in January 2000)	30 min time slots	1999	2001
Albertsons	Combined dedicated fulfilment centre and in-store	\$9.95 any order (valid in March 2004)	90 min time slots, Sameday delivery; Next day delivery	1999	—
Peapod	Combined dedicated fulfilment centre and in-store	\$2.95 to \$9.95, minimum order £25 (valid in October 2005)	Next day delivery; Standard delivery	1989	—
Iceland	In-store	No but order must >£40 (valid in October 2004)	Next day delivery; Standard delivery; 2- hour slot		—
Ocado	Dedicated fulfilment centre	£5, order must>=£25, free for order >=£75 (valid in December 2006)	Standard delivery; Weekend delivery; 1- hour slot		—

2.2.4. Small package home deliveries

2.2.4.1. Small package home delivery market size

Small packages are defined as small, packaged items delivered to customer' homes (or another delivery point chosen by the customer) for example, books, CDs, clothing and footwear, jewellery, watches and gifts (Browne, 2001). According to UK Department of Trade and Industry (2000), home shopping market for small packages was the biggest sector, accounting for nearly 60 percent of the overall home shopping market. With the promising future of Internet based e-commerce, there was a good reason to predict that Internet would generate an extra £3.2 billion in overall retailing by 2010. The sectors that would benefit most will be small packages. For example, clothing and footwear sales were expected to reach £2.27 billion, a 160 percent rise (Paypal, 2007). The research organisation Mintel (2006) estimated that about 30 percent of the books sold in the UK are purchased over the Internet, with music sales at about the same percentage, clothing and footwear at 20 percent, the same as computer software and entertainment tickets in 2005.

Various estimates about the number of home deliveries received by each household a year range from 18 (Transport for London, 2006), 28 (Transport for London, 2004) to 33 (IMRG, 2006b). According to the results from Royal Mail CDP practice trial in Nottingham from February 2003 to October 2003, there were 28 home deliveries per household per year. The trial was launched in two postcode areas of Nottingham (NG5 and NG9), and covered all the parcels that wouldn't fit through the letter box or require customer's signature (Department for Transport, 2004). 18 home deliveries per year per household were suggested by Transport for London (2006), based on 304 responses from a home delivery survey undertaken in London.

In terms of weight and size, small packages typically lend themselves to delivery through three general types of channel, i.e., postal delivery, parcel delivery and mail order delivery (McKinnon and Tallam, 2003). Postal delivery is applied to the packages small enough to pass through a letter box. It is the most cost-effective delivery option since the existing postal network has been developed intensively. For example, Royal Mail has the biggest postal network over the UK. The parcel delivery strategy is applicable to retailers whose home delivery volumes are too small to set up a dedicated delivery network. Most of the existing carriers operate a hub-satellite system, comprising both local depots and a large centralised sorting centre to enable centralized consolidation. Retailers have their home delivery orders collected by the carrier vehicles and routed via the local depot. If the order volumes are significant enough, they can arrange a bulk shipment directly to the dedicated warehouse. After that, the carrier distributes parcels via the parcel network to customer's homes. The large mail order companies normally have long established distribution networks and own a network of a national distribution centre or central warehouse and local depots. The customer orders are picked from the central warehouse. The detailed operating strategies adopted by the retailers and carriers are provided in the following Section 2.2.5.

For most small packages delivered to customers' homes, there is no pre-arranged day or time of delivery between retailer/carrier and the customer. A report from IMRG (2006b) suggested that 79% of retailers/carriers did not allow the customer to pick a time of day and time for delivery. 75% of the retailers/carriers did not allow the customer to specify a Saturday delivery. Consequently, the home delivery of small package is less tightly scheduled with the customer, resulting in problems of failed delivery attempts due to nobody being in to receive the packages. However, little research has indicated the impacts of the home delivery failures, which becomes one of the biggest motivations of current research. The delivery charge for small packages was between £3 and £6, with the average of £4.26 (IMRG, 2006b).

Clearly, failed home deliveries increase the operating costs of the retailer and carrier and cause inconvenience to customers. It is estimated that a carrier might incur costs of £38.50 for each delivery failure, made up of £4 for customer service costs, £5 for handling stock/ replacements/ damages, £1.50 for one additional re-delivery attempt, £28 of other potential costs (e.g. answering customer enquiries; escalating complaints, handling claims, recalculating invoices, re-issuing invoices; customer attrition/loss; customer recruitment costs to replace those lost due to delivery problems) (IMRG, 2006b). IMRG also estimated 64.8 million first-time home deliveries failed in 2006, leading to an annual cost of £682 million, which was composed of direct costs of £300 million to the retailers due to the 1^{st} time failures and undeliverable, £123 million to the carrier to make redelivery attempts, £259 million to customers of wasted time to wait for the deliveries and redeliveries, or collect the parcels from local carrier depot by themselves. Consequently, one of the significant difficulties in the home delivery operations for small packages lies in the delivery failures. To solve this problem, several home delivery models have been developed, including attended and unattended CDP concepts. A detailed description of the existing home delivery models for small packages is provided in the following sections 2.2.5, 2.2.6 and 2.2.7.

To illustrate how the home delivery operations for small packages work in practice, two case examples for book delivery and clothing delivery are introduced. The first example is Amazon, which is one of the first Internet companies to set up, and has become synonymous with the dot.com revolution, with its sales of books, and subsequently, sales of other leisure products like CDs and videos. All items destined for the UK addresses are dispatched by Royal Mail, Parcelforce or DHL Express. It normally takes 1 to 7 days to arrive customers, depending on the delivery service chosen (super saver delivery, standard delivery, first class delivery, guaranteed express delivery). The delivery charge ranges from £1.16 to £4.19.

Another example is clothing retailer GUS, which is one of the leading UK catalogue and mail order companies (Figure 8). Home shopping sales by GUS in 2004 were £104 million. GUS outsourced its delivery service to White Arrow, with a fleet of around 4900 cars and 2500 vans and trucks. GUS offers three delivery options, i.e. standard delivery, next day delivery and Saturday delivery. As of August 2005, the delivery charge ranges from £4.95 to £7.90.

Figure 8 GUS home shopping and home delivery

2.2.4.2. Small package home delivery strategies

The UK Competition Commission (2004) has estimated shares by value in the UK express home delivery market (Table 6). Parcelforce, DHL and TNT are the top three carriers offering express delivery services.

Table 6 Market shares by value in express home delivery services in 2002.

Company	**Market share (%)**
Parcelforce Worldwide	21
DHL	15
TNT UK	14
Parceline	7
Business Post (include Fedex)	7
LYNX Express	5
Initial CityLink	5
ANC	4
Amtrak Express Parcels	3
UPS	3
Interlink Express Parcels	3
Targer Worldwide Express	3
Nightfreight	3
Reality	2
Tuffnells Parcels Express	2
Others	3

Source: UK Competition Commission 2004.

Table 7 shows a comparison of the main characteristic of the home delivery services offered by the carriers listed in Table 6.

Table 7 The operating characteristics of home delivery services offered by some carriers listed in Table 6

Company	Delivery options	Weight limit	Product types	Re-delivery policy
ANC	Standard (2-3 days) Same day Next day (before 9:00, 10:00, 12:00) Saturday Evening delivery	Up to 30kg		Driver leaves a card through the customer's letterbox and invites the customer to arrange a re-delivery (either to the original address or an alternative address); Customer can also collect the packages from ANC Express depot.
DHL	Standard Start day (next day before 9:00) Midday (next day before 12:00) Pre-10 am (next day before 10:00)	Up to 20kg		Driver notifies the customer and makes second delivery attempt; If all the delivery attempts are failed, customer arranges a convenient time with carrier to pick up the shipment from DHL depot.
LYNX	Next day (before 9:00, 10:30, 12:00) Standard (2-3 days) In-night delivery	Up to 25kg	Mainly computers and mobile phone	Goods can be collected from a third party, for return delivery to another address; LYNX 'Pick-up and Drop-off' delivery solutions allow customers to collect their goods from collection points.
Parcelforce	Next day (before 9:00, 10:00, 12:00) Standard (2-3 days) Overnight delivery Saturday Parcelforce 24 (next day) Parcelforce 48 (2 days)	Up to 30kg		Driver leaves a card through the customer's letterbox and invites the customer to arrange a re-delivery to the original address; Customer can also arrange a re-delivery to a 'Local Collect' post office where their goods can be collected; Customer can also collect from Parcelforce depot.

Table 7 continued

Company	Delivery options	Weight limit	Product types	Re-delivery policy
Parcelnet	Standard (5-6 days) Next day Nominated day Time banded delivery	Up to 17kg	Mainly AMO* / DMO**	Driver makes up to 3 deliveries until the packages are delivered; If all the delivery attempts are failed, the customer collects from the Parcelnet depot.
Royal Mail	First class Second class Same day Next day Special delivery 9:00 am Standard	Up to 20kg		Driver leaves a card and invites the customer to arrange a re-delivery to the original address; Customer can arrange a re-delivery to a 'Local Collect' post office where their goods can be collected; Customer can also collect from Royal Mail sorting office.
TNT	Same day Next day (before 9:00, 10:30, 12:00) Saturday Standard	Up to 20kg		Carrier automatically makes another attempt on the following working day.
Initial CityLink	Next day (before 7:30, 9:00, 10:30, 12:00, 17:30) Nominated day Saturday Timed delivery Standard	Up to 30kg	Mainly high value products	Carrier automatically makes another attempt on the following working day. If all the delivery attempts are failed, customer can collect from CityLink depot.

Source: Competition Commission, 2004. *Agent Mail Order**Direct Mail Order

The home delivery strategies of those distribution channels are described below, in terms of delivery options and delivery charge.

Delivery options

The delivery options provided by carrier companies are generally:

- Standard delivery option
  Normally taking between 1 to 7 days to be delivered to the customer.

- Same day and timed delivery option
  Some carrier companies provide same day and timed delivery option, for example, ANC Express Group, Royal Mail and DHL.

- Next day and timed delivery option
  This usually applied if a customer selects next day delivery, where a delivery time window may be needed. There are two types of next day delivery options. One option is the next day delivery without the delivery time constraint. Another option is that the goods are delivered on next day within a range of delivery time windows, including before 9:00, 10:00, or 12:00, AM, PM, 1-hour time slot, and 2-hour time slot, etc. Examples include the next day delivery service from DHL and TNT.

- Nominated-day delivery option
  The goods are delivered at the day nominated by the customer. Several carrier companies provide this delivery option, including DHL and Royal Mail.

- Saturday delivery option
  Some carrier companies provide a Saturday delivery option, for example, ANC Express Group and Parcelforce.

- Evening delivery option
  The goods are delivered to customers during the evening (for example, 6pm to 8 pm), when people tend to be home. Currently evening delivery option is offered by ANC, LYNX, and Amtrak in the UK. Amtrak, for instance, offers

the evening delivery option throughout the UK, delivering the goods to customers' home between 5.30 p.m. and 8.30 p.m.

Although most carriers provide a wide range of delivery options from standard delivery to express delivery (next day, same day or nominated day), standard delivery is the most common option accounting for at least 50% of all deliveries (Xing, 2007). In a study of fourteen retailers from several industry sectors (apparel, household products, DIY, office supplies and department stores), Xing (2007) found that several delivery options were offered to reduce the proportion of failed first-time deliveries. Next day delivery options were becoming more popular and were the second most common option, accounting for 7% of all deliveries. Also, there were increased demands for weekend and evening deliveries but had not been adopted by many carriers.

A report from IMRG (2006c) has summarized the existing operating strategies for small packages. For most small packages delivered to customer's home, there is no prior delivery arrangement i.e. specific day and time of delivery, with the customer. 84 percent of the e-retailers did not allow the customer to pick a time of day and time for delivery. AM/PM delivery option is the most common option, accounting for 11% of all deliveries. 75 percent of the e-retailers did not allow the customer to specify Saturday delivery. Consequently the home delivery of small package is less tightly scheduled with the customer, causing the problems of failed delivery attempts due to nobody being in to receive the packages.

Delivery charges

The costs vary according to the delivery options selected by the customers and the size of the package.

According to IMRG (2006c), the average delivery charge to the customer is £4.26 per parcel based on a survey of 100 retailer websites. Those retailers were from several industry sectors, including clothing, electrical, wine, DIY, gifts, sports and entertainment. 56 percent of the retailers have opted to set their delivery prices between £3 and £6, depending on how fast the goods would arrive at the customer. IMRG estimated that customers need to pay £3.5 for standard delivery option, £4.5 for next day delivery option, £9.5 for Saturday delivery option and £12 for the evening delivery option. The average delivery cost to the retailer was £7.84 per parcel, based on the IMRG Merchant Survey conducted in June 2005.

A detailed description of the existing home delivery models for small packages is provided in the following sections 2.2.5, 2.2.6 and 2.2.7, including traditional delivery method, attended and unattended CDP delivery method.

2.2.5. Traditional home delivery methods

2.2.5.1. Operating characteristics

There are several variations to the traditional delivery method for small packages but generally a customer signature is required. Goods are ordered by the customer and delivered to a location of their choosing (some retailers insist on delivering to the customers' billing addresses) using relatively narrow time windows defined by the retailer. If the delivery fails because no-one is at the address to receive the item, there are several options for the carrier and the customer: 1) the parcel is left with a neighbour; 2) the parcel is left outside the door; 3) re-delivery attempts are made either on the same day or on subsequent days. Some carriers make an automatic free re-delivery attempt on the following day, regardless of whether the customer has contacted the carrier following the first failed attempt. If the second attempt to deliver also fails, (whether pre-organized by the customer or not), subsequent delivery attempts will be made at an additional charge to the customer; and 4) the parcel is returned to the carrier's depot where the customer may collect from, but not all carriers allow this.

For packages which can not fit through the letterbox, or require a signature, it is important for someone to be at home to receive the delivery. This requires greater planning in order to ensure that a satisfactory proportion of deliveries are successful. Deliveries attempted when the customer is not at home result in the need of re-schedule and call again.

2.2.5.2. Problems encountered in home delivery operations

There are several issues that can cause home delivery services to operate in an unsatisfactory manner. Those issues will result in significant costs and inconvenience to the customers and home delivery service providers. This section identifies several issues encountered in current home delivery operations.

- **Unsecured deliveries**

With the approval of the customers, the home delivery service providers can provide 'doorstep' delivery in accordance with customer's instructions. McKinnon and Tallam (2003) identified a various forms of potential crime by leaving the customer's goods unsecured at their home, including theft of product, denial of receipt and burglary. The people who see the goods outside the property can easily steal them. The driver himself can also steal the goods, claiming that they were left at the customer's house and stolen by someone else. Without the customer's signature, they can fraudulently claim not to have received the goods. Leaving the package outside a house usually increase the risk of burglary by indicating that the house is empty.

- **1st time delivery failures**

Given these increases in delivery vehicle movements, of increasing concern are the numbers of failed home deliveries where no-one is at home to receive the package. Unsuccessful deliveries could obviously result in higher operating costs for the retailers and higher transport costs for the customers to retrieve the missed packages. Packages delivered when the customer is not home have to be redelivered or customer has to drive to carrier's depot for collection.

Estimates of delivery failure rates have varied widely. According to IMRG Merchant Survey (2006b), 12 percent of e-retail home deliveries will be 1st time delivery failures. 60 percent was suggested by Department of Trade and Industry (2000), where a delivery time has not been agreed in advance.

According to Park and Regan (2003), several social and economic factors may lead to homes being empty in daytime. These may include increases in people spending more of their free time away from their home, flexible working patterns, long commuting time, increases in working women, and the growth in single-person households in the UK, which have resulted in up to half of UK homes being empty between 9 a.m. and 4 p.m. during weekdays (DTI, 2001). This will result in a high proportion of missed home deliveries; even the delivery day and time are agreed with the customer in case of grocery delivery. It is important for the customers to be in because of the deterioration of groceries. Delivery of small package is less tightly scheduled with the customer. Hence the proportion of missed home deliveries is particularly high in the case of small packages because most of the retailers do not make a pre-arrangement with customer before the delivery. For the small packages required for customer's signature, it is necessary for customer's presence at the time of the delivery.

- **Demands for faster delivery**

Increasing demand for faster delivery is identified as another issue for retailers and delivery companies. Customers anticipate that products purchased from home have to be shipped as soon as possible after the order is placed. Hence there are increased demands for fast delivery or for delivery within a narrow time window.

To satisfy people's needs, various initiatives have been taken by retailers and delivery companies to offer the delivery convenient to customers. The examples include same-day delivery, next-day delivery, weekend delivery and evening delivery options. However, there is little evidence that the majority of customers were prepared to pay extra for it (Park and Regan, 2003). Data on the UPS domestic package delivery operations (cited by Park and Regan, 2003) suggested that the largest proportion of UPS operations was still standard delivery (66 percent in revenue and 83 percent in number of shipments), compared to overnight delivery and speed delivery options.

As delivery time shortens, it makes it difficult for the shipping company to achieve economics in loading trucks (Niles, 1994; Lin and Mahmassani, 2002; Siikavirta *et al.*, 2003), consequently increasing the operating cost and delivery vehicle trip generation. The carrier has to dispatch a vehicle carrying a small number of packages in order to meet the delivery time requirements, resulting in an increased number of 'less than truck loads' vehicles. This certainly will impede road traffic and generate negative impacts on the environment. According to the Department for Transport (2006), delivery vans were empty for 15 percent of total distance travelled, considering the low utilization of vehicle capacity and the empty driving for the vehicle back to the depot. Consequently an EU project (PLUME) suggested a series of instruments to mitigate the negative impacts of home delivery industry: time windows and weight restrictions for deliveries; congestion charging; environmentally friendly vehicles, etc (PLanning and Urban Mobility in Europe, 2002).

The traffic problems caused by home delivery vehicles are even more serious in the seasonable shopping rush, for example, Christmas. According to The Times (2007), Internet shopping has become a Christmas tradition for many people, offering the customers with the choices, convenience and great value. In the earlier report (2006), IMRG has seen the dramatic growth in the Christmas online shopping sales: £3.3 billion spent online during Christmas 2004, £5 billion during the same period in 2005, £7 billion in Christmas 2006. Tesco.com was one of the leading retailers during the Christmas, with a record 1.3 million orders delivered in the four weeks to Christmas 2006, an increase of around 30 percent on 2005. It needed an additional 300 delivery vehicles and picking staff. Amazon was the most visited online retailer and received 750,000 orders for books, DVDs and toys and 600,000 parcels delivered on its busiest day, December 4, compared with a previous record of 480,000.

- **Returns policies**

In the UK, many retailers with home delivery services agree to take back and refund the costs of unwanted goods. However, the costs of returning the goods are often born by customers (Browne *et al*, 2001).

A survey undertaken by Snow Valley on behalf of IMRG (2005) reported that 96 percent of retailers had a link on their websites which led to returns information. The most popular returns option, used by 46 percent of retailers, was to allow the customer to return unwanted goods by post. Nearly half of retailers expected the customer to pay the postage on returning any unwanted goods.

There are a lot of variations in returns policies adopted by retailers. The returns policies of several major high street retailers are identified below (Table 8).

Table 8 Returns policy adopted by several major high street retailers

Retailer	Returns policy
Marks & Spencer Plc	The returns policy allows customer to choose : • Take the item to any UK M&S store (apart from Outlets and Simply Food stores). • Return by Royal Mail using the Return Postage Paid label provided.
John Lewis	Returns can be made within 28 days of original purchase through either of these options: • Returns via courier collection • Returns via a John Lewis shop
Argos	Returns can be made within 30 days of original purchase through either of these options: • If the product was delivered, the customer needs to contact the customer service and arrange a collection • Brings it back with proof of purchase
Dorothy Perkin	Returns can be made within 14 days of receipt through either of these options: • Returns to store; • Returns via courier collection
B&Q	Returns can be made within 90 days of receipt through either of these options: • Return the product to the local B&Q store • Contacts the customer service to arrange a collection
Tesco	Returns can be made within 28 days of original purchase through either of these options: • Contact customer services to arrange a collection • Returns via a Tesco store

Returns obviously result in significant costs to home delivery service providers for collection and replacement of returns and administrative costs of dealing with returned products. According to Browne *et al* (2001), small packages encountered far higher return rates than large items such as furniture. Online sales of non-food goods encounter an average of 30 percent of return rate, compared to 6-10 percent for high-street sales (Nairn, 2003). However, there are certain goods which customers can not return, for example, flowers, newspapers, magazines. The market for managing returns has grown by 25 percent with the development of online sales (Park and Regan, 2003).

Consequently, it is becoming more important to develop efficient and reliable home delivery services.

2.2.5.3. Re-delivery policies

A problem of home delivery practices lies in the delivery failures. Various measures have been taken up by home delivery service providers to deal with the failed deliveries. To explain this, the strategies of redelivery policies adopted by some carriers are introduced below.

Second delivery attempt

If the carrier can't deliver on the first attempt, driver will notify the consignee by leaving a 'We're holding an item of mail for you' card at the delivery address. The card gives the customer the address, contact number and opening hours of the local delivery office. Then the carrier arranges to deliver on another day for free. Some carriers even make a third attempt.

For example, an ANC driver normally posts a card through the customer's letterbox, advising the consignee that they have attempted delivery and inviting the customer to arrange one of the following options:

- Redelivery to the original address at a mutually convenient time during normal working hours (Monday to Saturday);
- Redelivery to an alternative address on receipt of authorization from the customer. Requests to reattempt delivery may attract additional carriage charges;
- Redelivery to the original address without a signature i.e. leave the goods in a safe location, following prior authorization from customer.

There are variations in operations for making re-deliveries. Some carriers automatically make a re-delivery attempt on the following working day without contacting the consignee first, for example, TNT. Others try to contact the customer before making the re-delivery, for example, Royal Mail, Parcelforce and DHL.

Customer collection from local carrier's depot

The customer can arrange a convenient time with the carrier to pick up the shipments from the local carrier depot. For example, ANC, LYNX and DHL allow customers to make collections on a weekday. However, the option of customer collection is not necessarily provided by every carrier company. For example, TNT tries to make further redelivery attempts instead of encouraging customers to collect from TNT depots.

Customer trips to collect the failed packages from the local carrier's depot clearly affect the road traffic associated with home delivery operations. However, there is little evidence on the take-up level of collection option from the carrier's depot. Consequently, this research aims to identify the proportion of customers choosing this option, and thereafter estimate the road traffic associated with those collection trips.

Customer collection from a local collection point

In certain circumstances, the customer can arrange the re-delivery to a nominated CDP for later collection. For example, Royal Mail 'Local Collect' service now allows customers to have failed first-time packages diverted to a local Post Office™ (note that there's a 50p charge for re-direction to a local Post Office). Local Collect is available totally free of charge (excluding license fee), the customers just pay normal postage and packing costs.

There is a range of CDP examples which have been set up and still in development, including Packstation, Kiala, Bybox, etc. Under each CDP scheme, the detailed operating characteristics will be explained in following two sections.

Leave the goods with a neighbour

In the event that the customer is not at the delivery address when the carrier delivers, the goods are left with a neighbour and a calling card is left informing the customer where the parcel is. Customers are often required to specify the neighbour address as the alternative address at the time of order. Some carriers require the neighbour's signature when the goods are delivered, such as Royal Mail, ANC and City Link. Others don't need the neighbour's signature at the time of delivery, including DHL and TNT.

Although it is convenient for customers to nominate their neighbour to receive the goods on their behalf, there are security issues to be considered. The main risk associated with this delivery option is that the neighbour claims not having received the goods. Many companies require neighbours to sign for the goods they take in. According to McKinnon and Tallam (2003), because the nominated neighbours are not the purchasers of the delivered goods, they have no direct contract with the retailer and thus their signatures have little legal weight.

Leave the goods outside the customer's home

Under this delivery option (also called 'doorstepping'), the goods are left on the doorstep or at some concealed location around the house. Customers normally need to specify the locations to put the goods at the time of order. With the approval of the customers and their instructions, the goods are then left in a pre-arranged location or location at the carrier's discretion. The decision is often made based on drivers' experience of whether the goods can be safely left outside.

As discussed above, in the event of home delivery failures, the carrier can either make a re-delivery or return the goods to the depot for customer's later collection. Apart from those two options, the goods can be diverted to a CDP and then customer collects them at a convenient time. Furthermore, the carrier also has the options of leaving the goods with a neighbour or outside the customer's home. However, the take-up level of each option has not been estimated before, which is important to quantify the road traffic associated with carrier's re-delivery journeys and customer's trips to make collection either from local carrier depot or a CDP. Consequently, one of the research objectives is to find out the proportions of each reaction towards the home delivery failures, and then quantify the impacts of failed home deliveries on carrier's extra distance to make re-deliveries and customer's additional distance to collect the goods from local carrier's depot or a CDP.

2.2.6. Attended CDP delivery methods

For those packages which are not small enough to fit in through a letterbox or mailbox or require a signature, one of the major issues in home delivery operations is that somebody has to be home to receive the delivery. Browne *et al* (2001) proposed the factors affecting whether customers had to be present during delivery (Figure 9).

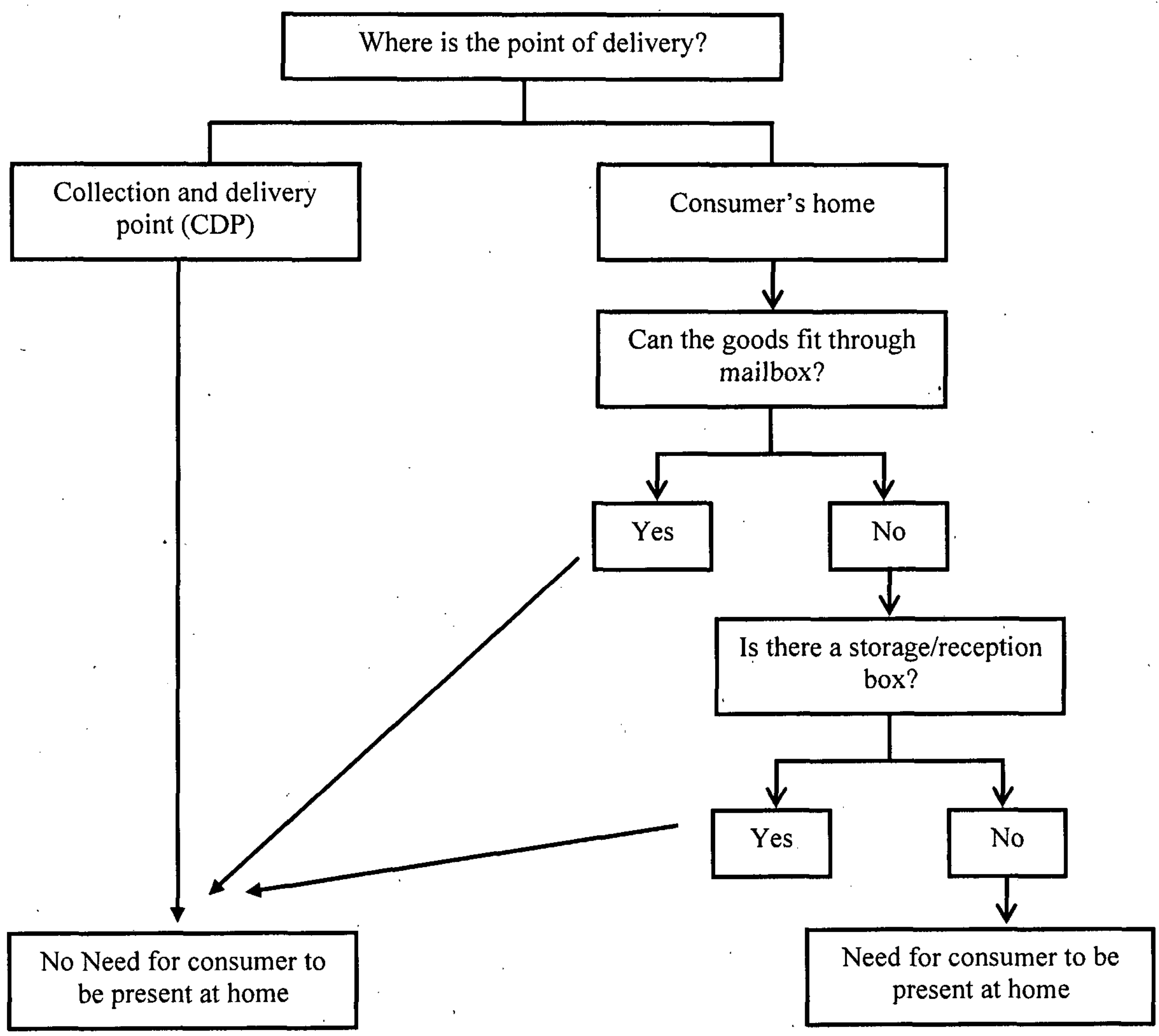


Figure 9 Factors affecting whether customers have to be present during delivery (Source: Browne *et al*, 2001)

Figure 9 presents two types of delivery reception methods, i.e., attended and unattended. In the former category are deliveries to customer's homes or alternative addresses where someone is available to receive the products. In the later category are deliveries to storage/reception boxes, thus there is no need for someone to be present at home.

A more detailed summary of unattended delivery solutions have been proposed by McKinnon and Tallam (2003) (Figure 10). Secured delivery options included home access system, reception box, collection point and drop-off/delivery service. Home access system allowed delivery company to access the customer's premises. The goods could be left in the reception box. It could either be individual or communal. Collection points could be used either as the initial or secondary location, where goods were left for customers to retrieve at a convenient time. It could be attended where someone had to be present during delivery, or unattended. Small shops, post offices, petrol stations and supermarkets were identified as the most suitable existing outlets to be collection points.

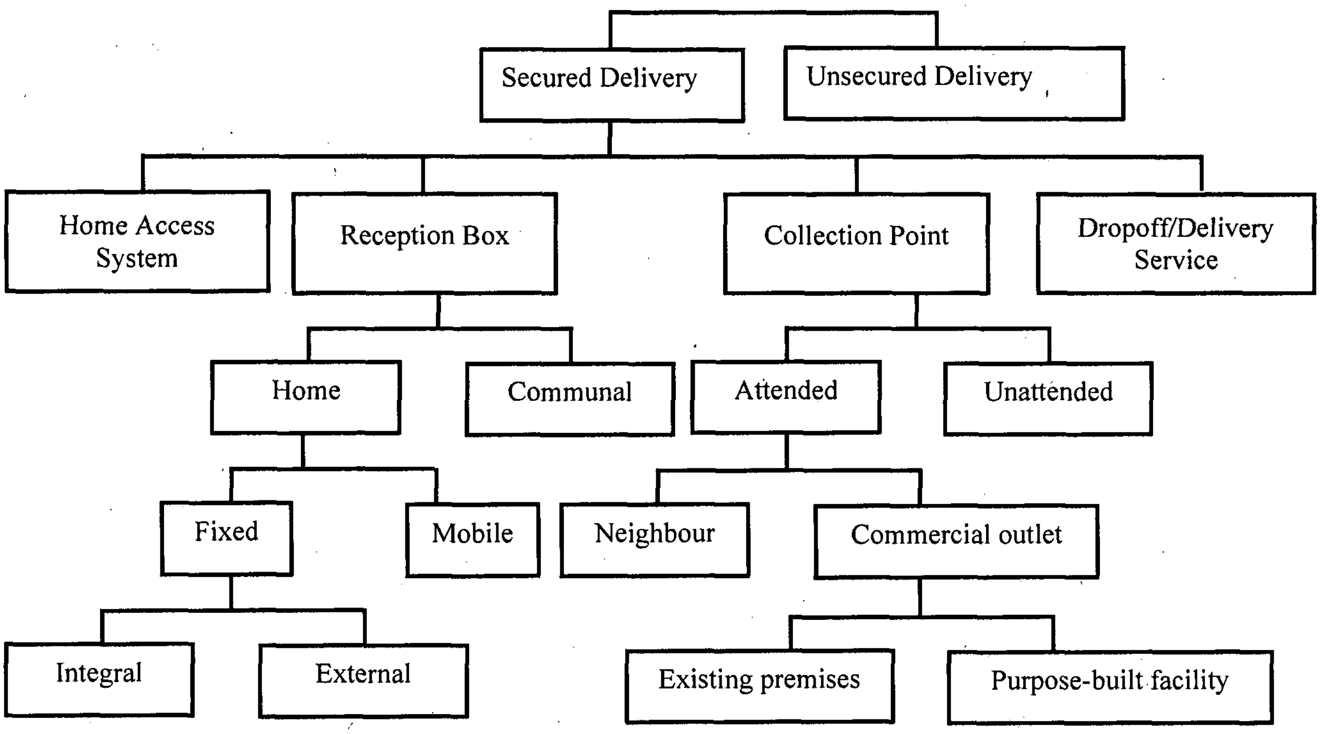


Figure 10 Classification of unattended delivery methods (Source: McKinnon and Tallam, 2003)

In this section, the attended CDP examples and applications are introduced, followed by descriptions of the unattended CDP examples in next section.

The theory behind the CDP concept is that facilities such as convenience stores, petrol stations and post offices can be selected as alternative delivery locations by customers to receive failed first-time packages or act as an alternate 'home' delivery address. The customer is then left a notification card detailing the address of the CDP, or could, in principle be sent an email or a text message to inform the collection instructions, after which, the customer is free to collect the item.

There are variances in the existing CDP mechanisms.

- Customers' goods will first be delivered to the CDPs. On arrival the barcode on the package would be scanned by the delivery driver and customers would be informed for the package delivery. The customer then travels to the CDP with proof of their identity and issued with his goods.

- The deliveries will continue to be made to customers' homes. The CDPs act as the alternative addresses to the failed home deliveries. For example, under the Royal Mail CDP scheme, the customers can contact a Royal Mail local sorting office and ask for the package to be re-delivered to the nearest local post office for 50p.

The operating characteristics of a CDP scheme are explained as follows:

- The CDP is located locally, typically within 1.5 miles from the customer's house;
- The local CDP is open for long hours every day;
- Service charges are reasonable, normally on top of the retailer's standard home delivery charge.

The CDP system is suitable for handling small packaged items. It is unlikely to be used for handling grocery and large items; since the grocery requires large refrigeration space and large item needs significant storage space. To illustrate how the CDP concept works in practice, some CDP examples are provided below.

Several attended CDP networks have been established in the UK and Europe, using post offices, petrol stations and small shops (e.logistics, 2002e). Some of them have achieved success.

- **Collectpoint in the UK**

Collectpoint was founded in December 1999 and set up a national network of 3,200 delivery points where carriers could leave B2B or B2C consignments for customers to pick up. The CDPs were in convenience stores (e.g. One Stop, Londis, and Spar) and petrol stations (e.g. Q8, Jet), which would receive deliveries on behalf of customers during their hours of operations (typically 07:00 – 23:00) (e.logistics, 2002e). Customers selected a Collectpoint as the delivery address when buying from a participating supplier, then collected the goods from the Collectpoint when they were ready. Collectpoint had successfully set up partnerships with various retailers, including Gadgetshop.com, Worthaglance.com, Martin Dawes (consumer electronics), Accessories 4 U (mobile phones), Talkingbooks.org and Botham's (bakery products).

Collectpoint was used to handle small packages, up to 75cm by 75cm by 100cm. The service charge to customers was £3.5 in 2000. However, Collectpoint plc has ceased B2C business and recently was taken over by RedPack Network Inc in 2007.

- **Kiala in Netherlands/Belgium/France/Luxembourg/UK**

Kiala allows customers to nominate the local shops (proximity grocery stores, supermarkets, dry cleaners', newsagents, petrol stations, etc) as the alternative delivery addresses to collect and return their parcels. It reported a revenue of €25 million euros in 2006, compared to €20.5 million in 2005 and has attracted some high-profile investors including La Poste and TNT. The Kiala network with 4,450 "Kiala Points" can handle 65,000 parcels in one day in peak time. Customers are automatically advised by telephone or e-mail when their goods have arrived at the delivery point.

Kiala was founded in March 2000 in Brussels. After launching its service in Belgium and Luxemburg in July 2001, Kiala also spread its network to France and the Netherlands in October 2002. Kiala started its service in the UK on 3 July 2006 and it by far has developed 130 delivery points in densely populated areas in the UK. Kiala's commercial partners include, amongst more than retailers, GUS, La Redoute, the 3 Suisses, Hewlett-Packard, Next and Yves Rocher.

The Kiala point works as follows. The customer orders with one of the Kiala partners and select a Kiala point for delivery. The site operator has some basic equipment on hand, including a barcode scanner with communication capability, and swipes a barcode on the parcel on its arrival. The data is transmitted back to Kiala which contacts the customer by phone, email or text message alerting the recipient to its arrival. The customer then comes to collect the parcel with a valid proof of ID.

The requirements for the premise to be a Kiala point are a storage space of 2m wide x 2m high, a power connection, a telephone line, a modem and 24-hour accessibility. Kiala charges around £2 per customer to use its service.

- **Pickpoint in Germany**

Pickpoint in Germany has set up a national network of 2,000 locations in 2005. Nearly all the points were located in petrol or gas stations. Pickpoint acted as sending interface (4.75 to 10 Euro per parcel) as well as an alternative delivering address to pick up consignments (1.50 Euro per parcel). When the consignment was delivered to the PickPoint, the customer received an SMS or e-mail as confirmation. The commodity could be stored up to 10 days (http://www.pickpoint.de).

- **Dropzone1 in the UK**

Dropzone1 allowed customers to divert their goods to Jet petrol stations and Londis and Spar convenience stores while they were away from home (e.logistics, 2000b). In 2002, Dropzone1 was acquired by Pickupworks. The Pickupworks system consisted of a secure cabinet or array of cabinets, mounted in a store or other suitable building. The goods were then delivered directly to that site by the e-retailer's usual carrier. The site operator had some basic equipment on hand, including a barcode scanner with communication capability, and swiped a barcode on the parcel on its arrival. The data was transmitted back to the service operator, which sent an email (or SMS message) alerting the customer to its arrival. On collection, the customer verified his or her identity with the credit or debit card that was originally used to make the purchase.

In addition to these and Jet, Dropzone1 has now signed up BP, Texaco, Granada Road Services, United Norwest Co-op and Premier (e.logistics, 2000c).

2.2.7. Unattended CDPs delivery methods

Small packages are delivered to a locked reception box, which is allocated to an appointed customer with every new delivery. The customer then receives the code to access the box through mobile phone by SMS message, e-mail, etc. Thus the carrier could arrange its delivery schedule more efficiently. Consequently, using reception box to receive deliveries would allow carriers to optimise vehicle route and hence achieve better delivery efficiency. The reception boxes are either 'individual' boxes (i.e. Hippobox, Dormousebox and BearBox) (e.logistics, 2004b) or parts of a 'communal' locker system (e.g. ByBox) (e.logistics, 2004). The details of a various reception boxes are explained below.

ByBox. Bybox have deployed over 38,000 networked lockers across 20 countries. A locker is allocated dynamically for each new delivery as it arrives. The delivery driver enters a code at a simple LCD-based central console, and one of the lockers automatically pops open to receive the delivery (Figure 11). If it isn't big enough for the goods, the driver rejects it, and then a bigger locker opens up, and so on. The computer in turn is connected to a remote ByBox server, which monitors transactions and can send an email or SMS message to the recipient once the delivery has been completed (www.bybox.com). The customer then collects the goods (Figure 12). The working procedure is explained in Table 9.

Table 9 Working procedures of ByBox locker-banks

Order	Customers register with ByBox and are issued with a unique delivery code. When the consumers make order and request deliveries to a locker-bank, they are asked to quote their ByBox delivery code and the address of the locker-bank.
Pick & Pack	Order details are transferred to the ByBox central servers and processed by the warehouse staff.
Deliver	The carrier collects the orders from the warehouse and makes deliveries to the locker-bank. The lockers are allocated dynamically for customers' use. The customers will receive an email and SMS containing a unique collection code to retrieve their delivery.
Collect	The customer scans their delivery code and the correct door opens. If multiple doors have been used in case of a large order, each door will open in turn.

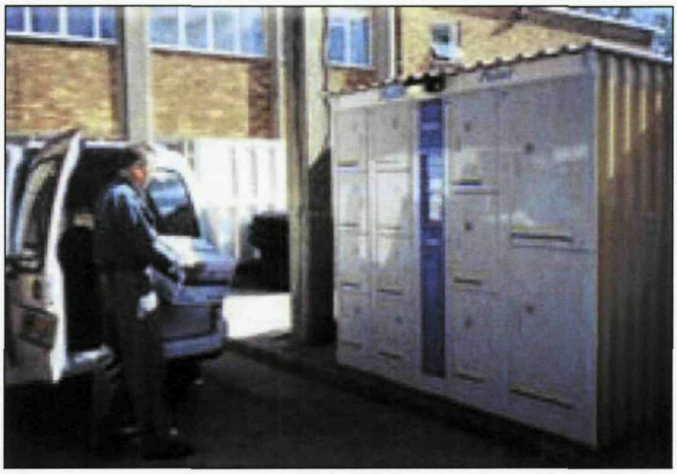


Figure 11 Carrier sends the package to the ByBox locker-bank

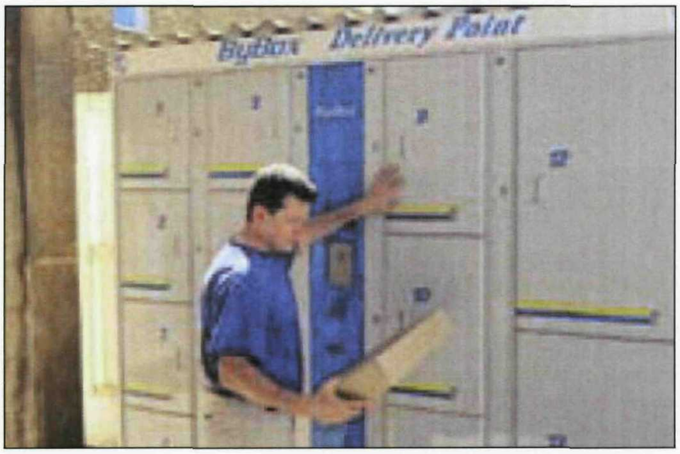
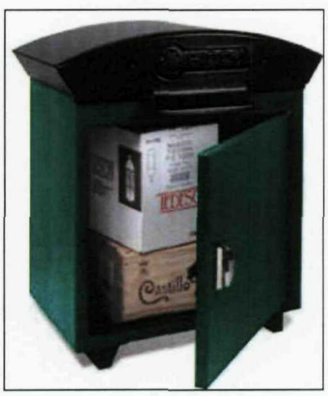


Figure 12 Customer collects the package from the ByBox locker-bank

Hippobox and Dormousebox. There are two versions of home box solutions. The Hippobox is big enough to take two cases of wine, at 82 cm high * 73 cm wide * 43 cm deep; and the Dormousebox can accommodate packages slightly larger than a man's shoebox, at 48 cm high * 34 cm wide * 24 cm deep (Figure 13). The boxes are attached to the outside wall or door of customer's home. Each box incorporates a handle with a lock. The box is normally left unlocked until a delivery is made; the driver takes out a permission card if necessary (saying a package may be left), drops in the parcel, and then turns the handle to lock the box (www.hippo-box.co.uk). The working procedure is explained in Table 10.

Table 10 Working procedures of Hippobox and Dormousebox

Order	Customers make order and request deliveries to a Hippobox or Dormousebox.
Deliver	On the day of delivery, customers leave the Hippobox or Dormousebox door closed, but unlocked. The carrier makes the delivery into the box and pushes the lock.
Collect	The customers unlock the Hippobox or Dormousebox with their unique personal keys.



Hippobox

Dormousebox

Figure 13 Hippobox and Dormousebox

BearBox. This is an intelligent box linked to a dedicated communications network (Figure 14). Boxes would allow access only to people armed with a one-off digital code, and would notify the recipient of a delivery automatically by SMS message or email. Recording of delivery events would also provide a full audit trail. Currently bearbox lockers are installed on over 200 petrol stations (www.bearbox.co.uk).

Figure 14 Bearbox

Compared to the traditional delivery methods, alternative delivery locations for the first-time delivery are growing and can be found in different forms of unattended CDPs across the UK and Europe. Those innovative solutions can improve the quality of customer's lives by freeing them from the delivery time and location constraints, and to improve the home delivery efficiency by reducing the unsuccessful delivery attempts. It is worth mentioning that this concept has been successful in the B2B market. For example, both BearBox and ByBox companies now have a solid B2B customer base, working with major business clients in delivery operations (e.logistics, 2004b).

- **PACKSTATION in Germany (DHL)**

The free locker box service was provided by DHL since 2002 to customers in Germany. Currently it serves 500,000 customers with 700 stations. The locker box is accessible 7/24 with a smart card and PIN code to the registered customers. Customers are notified of a waiting parcel by email or SMS. The scheme can be used for collection of parcels, dropping-off parcels and returns. The system is located at the popular sites with heavy utilization, for instance, railway stations, as well as premises of large employers such as SAP and Siemens (Figure 15 and Figure 16).

Figure 15 PACKSTATION in Germany (DHL)

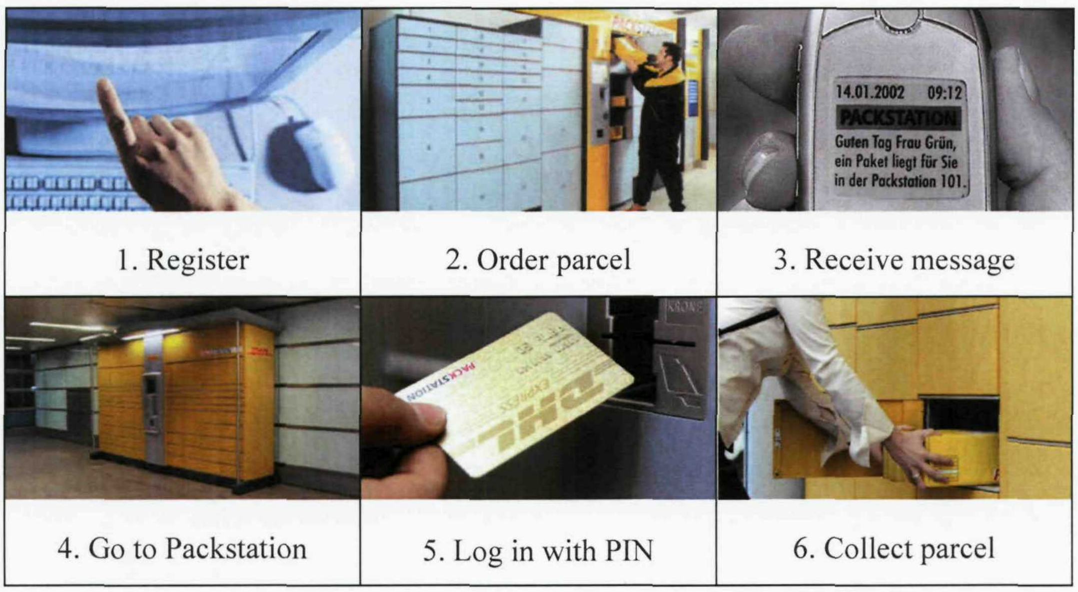


Figure 16 A figure showing how the PACKSTATION works

The PACKSTATION service initially has been available in Dortmund and Mainz (Germany) since 2001, was expanded to the major cities nationwide in 2003. Packages with a minimum size of 15 x 11 x 1 cm and a maximum size of 60 x 35 x 35 cm are suitable for the PACKSTATION, for instance, books, CDs. The parcels can be hold for the customers for up to 9 days.

All the requirements for a premise to install a PACKSTATION are an area of 4 x 2 x 2.5 m, or 3 x 2.5 x 2.5 m (width/depth/height), a power connection, a telephone line and 24-hour accessibility.

DHL PACKSTATION has set up close partnerships with retailers like QVC, and Amazon.de.

- **Locker Bank in UK (Royal Mail and Parcelforce Worldwide)**

The scheme was initiated in early 2003 with Royal Mail, Parcelforce Worldwide and the network of Post Office® branches. The customer could choose where the parcels would be delivered to, for both initial and failed delivery, including automated locker bank, local Post Office branch or Royal Mail delivery office. The scheme was conducted in several areas (Beverley, Newbury, Nottingham and Bristol), ceasing on 22nd November 2004.

The locker bank system consists of several individual lockers arranged in columns around, and controlled by, a central console. The control console has an ATM-style interface for secure coded access, a barcode scanner and a receipt printer. A central software hub linked to the Royal Mail database constantly monitors each locker bank and facilitates deliveries and customer collections at any time of day (Figure 17).

The requirements for the premise to install a locker bank system are an area approximately 4m x 2m x 2m (wide x deep x high), 24-hour access, electricity connection and convenient location with easy access. In the trial, the potential locations for locker banks include the supermarkets, railway stations, car parks, park and ride sites, petrol stations, local amenity stores, Post Office® branches, Royal Mail delivery offices, large business premises such as offices, and industrial estates, where people visit regularly anyway. Most of the post office branches didn't encounter capacity issues in terms of storage space. The capacity problem due to the obvious seasonal factors could be handled by the management experience of the premises.

The scheme was used to handle small products including books, DVDs, CDs, computer software, tickets and clothing, which would not fit through a letterbox or items that required a signature. It was found from the trial that on average, users collected around three items from a locker bank each month. This is approximately twice as many items per month as those users who collect their items from the Post Office.

Figure 17 Locker bank scheme in the UK

As well as giving residents a more comprehensive delivery service, the trial scheme also brought environmental benefits (Royal Mail Group plc, 2004). 44 percent of users in the trial indicated that they walked to the locker bank, local Post Office branch or Royal Mail delivery office. It resulted in distance savings of between 4,000 and 8,000 miles per month, equivalent to approximately 50,000 - 100,000 miles per annum within the trial area. This resulted in an annual saving of 5,000 to 10,000 kg of carbon and equivalent savings of other polluting emissions. Scaling these figures up by population across the UK equates to an annual saving of between 30 and 60 million miles and between 3 and 6 million kg of carbon a year.

2.3. Impacts of home delivery operations

In this section, the traffic and environmental impacts of home delivery operations are analyzed. Practical problems encountered in existing home delivery operations are identified, including security issue, 1st time delivery failures, demands for faster delivery, and returns of unwanted goods.

2.3.1. Traffic impacts

Home shopping and delivery services (as a product of non-traditional commerce methods such as e-commerce, catalogue/mail order shopping) could change the way business is conducted as well as peoples' everyday activities, in a number of ways (increased numbers of less-than-truck load vehicles, smaller delivery vehicles, potentially less private vehicle trips for shopping, potentially more leisure vehicle trips).

Smith *et al*, (2001) undertook a study of e-commerce impacts on urban freight for the Australian National Transport Secretariat. The study sought to investigate three principal questions on e-business implications: how will the transport task change; what will be affected; and how can the transport system respond? Using a strategic planning method, the results suggested that e-commerce would have implications for urban freight including higher levels of demand for goods and services, increased requirements for logistics distribution, changes in location preferences and improved transport network performance based on the opinions of transport experts. Special interests were concentrated on transport effects of electronic home shopping because of the potential for high levels of householder trip substitution. The local trips for shopping by householders were substituted by carrier trips identified in two categories: local deliveries for local shopping trips and the citywide deliveries where goods from a central store substituted for local shopping trips. However, using the time savings made by the home delivery services, the extra trips could possibly be generated by e-commerce in two ways: induced demand, indicating that online shopping provided new opportunities to buy goods which would not have been bought otherwise from e-retailers; and opportunities identified, where window shopping and comparison shopping online could lead to passenger trips outside the local area to purchase goods.

Hesse (2002) considered the significance of e-commerce to freight transport, logistics and physical distribution, in both the B2B (business-to-business) and B2C (business-to-customer) markets. The potential implications of e-commerce were identified in the broader context of structural change, instead of specific assessments. The author argued that some conventional estimates of the e-commerce benefits were probably too optimistic while its negative effects were underestimated. The conventional retailing method suggested that e-commerce would make transport operations more efficient by eliminating redundant layers of the supply chain. However, e-commerce would also generate negative impacts by increasing the demand for local distribution systems and generate short-term order behavior by customers.

A growing body of research is focusing on the transport impacts of home deliveries. On one hand, it is argued that home delivery services benefit transport since they release people from carrying the goods, theoretically reducing the traffic. On the other hand, home delivery services might increase road traffic (Retail Logistics Task Force, 2000).

Cairns *et al.* (2004) examined the transport impacts of grocery home delivery operations. The potential reduction in motorised travel that might arise if 1 percent of supermarket shoppers in the Oxfordshire town of Witney (a population of 7000) used a home delivery scheme on any given afternoon was assessed. The research assumed that delivery vehicles could each carry eight householder loads of shopping and a set of vehicle routes to serve 39 randomly chosen households were devised using TransCAD. The results suggested that a home delivery service would reduce the amount of motorised travel emanating from these households by 77 percent over the traditional store-based shopping model, a saving of 104km per day.

In earlier research, Cairns (1996) analyzed the current experience of providing home delivery services for groceries and addressed some of the key issues often raised, including the attractiveness, speed, prices, reliability and accuracy of a home delivery service. The study involved 58 companies in 9 countries. It encompassed a range of different types of scheme, based on both simple and complex dimensions of providing services. A simple type of home delivery services might be initiated by individual retailers, or computer companies, or by specialist firms. Joint ventures might be involved in a more complex dimension of the home delivery operations. A variety of ways in which they were introduced and made economic were presented. The first type of scheme was that the shoppers never left home by ordering via established communications technology. The second type was that the shoppers ordered via a local shop/community point. The community centers act as pick up and CDPs for their street. The last type of home delivery scheme was that shoppers visited the shops, but left the goods bought for later delivery. The popularity of those schemes was then discussed, which was highly related to the range of products delivered.

Particularly focused on the grocery home shopping, Cairns (2005) later explored the impacts of home delivery operations on road traffic. She examined a wide range of international evidence, including the results of 9 modelling assessments. The evidence was used to examine the trade-offs between increased delivery movements and reduced private car travel. To look at the effects of directly substituting personal car trips for goods transport by delivery vehicles, modelling simulations were undertaken in different scenarios, including the proportion of the population taking up home delivery, time-windows for home deliveries, and delivery destinations. The results suggested that with realistic levels, a direct substitution of car trips by LGV trips could reduce vehicle-km by 70 percent or more. In reality, the traffic impacts tend to be more complex and more complicated shopper behavioral responses would occur. The research suggested that the benefits of home delivery services could be maximized by use of appropriate cost structures, new types of delivery location, less polluting vehicles, greater cooperation or outsourcing by retailers, and measures to encourage greater consumption of local produce.

Similar results were found in Browne *et al.* (2001), Kämäräinen and Punakivi (2002) and Punakivi *et al.* (2001). Browne (2001) contributed to the home delivery studies by identifying: 1) distribution implications of e-commerce, 2) changes in distribution activities in urban areas, and 3) impacts of e-commerce on the supply chain. Firstly, the growth of e-commerce could have impacts on the physical distribution networks in terms of vehicle fleet capacity and activities. At a high level of e-commerce growth, there would be extra demands for smaller delivery vehicles in residential areas. Secondly, the number of home deliveries in urban areas was determined by several factors, including population density, order/delivery frequency, number of companies offering home deliveries and market penetration of home shopping. The research provided an indication of possible changes in vehicle traffic in urban areas that could result from home delivery operations. Based on the assumptions that population density of 3,000 people per square km, 2.4 persons per household, 20% of households receiving one grocery home delivery each week and 100% of households receiving one non-grocery home delivery each week, it was then estimated that the additional home delivery vehicle trips and distance covered each year were almost 630 vans performing 7.6 million vehicle kilometers each year in the city of 1 million population and approximately 120 vehicles performing 1.1 million vehicle kilometers in the 200,000 population city. Thirdly, the impacts of e-commerce on the supply chain and logistics were explored by identifying the existing and emerging home delivery systems and the need for the customer to be present at the time of delivery. Collection and delivery points (CDPs) as one of the emerging home delivery systems, stored the goods until it was convenient for the customer to collect, or acted as delivery addresses of a local delivery round. A list of possible CDP locations was suggested, for instance, local store and railway station. It was one the few research papers which has introduced the CDP concept. However, it was a general qualitative study and quantitative analysis was involved in efficiencies of CDP system, changes in road traffic associated with carrier and customer trips, the feasibility of using various optional CDP locations.

Kämäräinen and Punakivi (2002) identified existing operational models for grocery home delivery service, i.e. the attended reception method with 2-hour delivery time windows and unattended method using reception boxes. The effects of different receiving alternatives, home delivery solutions, supplier and customer relationships, and demand variation in the distribution centre were studied. An e-grocery pilot was implemented in the Helsinki metropolitan area. In the pilot, the products were picked in an existing supermarket and reception boxes were used by around 50 household customers in June 2000. Based on the benchmarks from existing e-grocers, and the results from the e-grocery pilot operation, the best logistical practices for the e-grocery supply chain were presented, as the unattended reception method is able to save 61 percent of costs from attended 2-hour delivery method.

Punakivi *et al.* (2001) introduced two main approaches of unattended reception of the home delivered groceries: reception box and delivery box. The reception box was a refrigerated, customer-specific reception box installed at the customer's garage or home yard. The delivery box was an insulated secured box equipped with a docking mechanism. Using the shopping data collected from 89,000 households across four cities in Finland, the study quantifed the reduction in motorised travel that could result from the imposition of collection points for receiving home deliveries. Based on the data about all grocery shopping bought by 89,000 households at 5 supermarket stores in the cities of Helsinki, Espoo, Vantaa and Kauniainen during a representative week in October 1999, the transport impacts of 6 case studies involving various delivery time options were examined. In all cases it was assumed that all household purchases over 25 Euros would become home deliveries. Case 5 represented the traditional shopping model where the householder travelled to the supermarket and took the goods home themselves. The average distance travelled by a household in this case was 6.9km whereas in Case 6, where the goods ordered from home were delivered into locker boxes at the household addresses, the average number of kilometers travelled per order fell to 0.6km with 55 orders on the average delivery round. In the case of delivery options of next-day and 10-hour time slot deliveries (Cases 3 and 4), the results suggested that vehicle kilometers incurred in the traditional shopping method (Case 5) would be reduced by 87 percent and 93 percent respectively. It was found that the operating costs of attended delivery were found to be 2.5 times higher than those for delivery into an unattended locker box, based on simulation results.

As shown in the previous research of the traffic impacts on householders of using home delivery services, much of the interest in this area has been restricted to B2C e-commerce and within that it has tended to focus on the extent to which customer shopping trips were directly substituted by delivery vehicle trips. The potential for reductions in householder vehicle kilometres resulting from home deliveries has been estimated in the range of 75 percent - 90 percent by different authors for various grocery home delivery schemes (Cairns (1998), Palmer (2001), Punakivi and Saranen (2001), Farahmand and Young (cited in Cairns (2005)). This type of results was mostly produced by modelling.

A variety of existing and emerging home delivery methods have been identified in the literature, including the attended and unattended CDP delivery methods. In theory, the CDP methods were assumed to enable better delivery efficiency. However, little quantitative evidence has proved this assumption. Further research needs to deal with the feasibility of CDP delivery methods, in terms of transport costs, CDP locations, etc.

2.3.2. Environmental impacts

According to 2005 Traffic Statistics Great Britain (Department of Transport), CO_2 emissions by road transport have increased 8 percent since 1990. Although the growth in LGV and HGV traffic has only accounted for 29 percent of the total growth in vehicle-kilometers since 1990, they have accounted for over 98 percent of the increase in road-transport CO_2 emissions over the same period. In contrast, although the level of vehicle-kilometers driven by passenger cars since 1990 has risen 19 percent, their carbon emissions have only risen 2.1 percent.

Siikavirta *et al* (2003) studied the greenhouse gas emissions in the food production and consumption system in Finland based on the data about all grocery shopping bought by

89,000 households at 5 supermarket stores during a representative week in October 1999. The study revealed many opportunities for e-commerce to reduce emissions. First, e-commerce required the production system to follow the fluctuation of demand more accurately, thus reducing overproduction. With the saved energy consumption of storing the products, of avoiding the waste of production, e-commerce provided the potential to reduce the GHG emissions by 87%. Second, e-commerce customers frequently demanded faster deliveries (Jedd, 2000), causing the retailers to provide shorter lead times to succeed in competition. To do so, many e-retailers outsourced logistics operations to specialist courier companies, which could assemble a wide range of products from different e-retailers and establish better vehicle fill rates. This would make e-commerce distribution more efficient and reduce the GHG emissions. Some possibly negative effects were also identified in the research. For example, the shortening of applicable delivery lead times would result in many companies having to switch from sea and land transportation to airfreight, which would negatively impact on the environmental effects of e-commerce in theory.

To quantify the reductions in greenhouse emissions through implementation of various e-grocery home delivery strategies, a variety of delivery methods defined by the time windows were modelled using vehicle and routing software. The home delivery models in the research were: 1) delivery in three two-hour slots, 2) delivery in one-hour time slots, 3) delivery to reception boxes, 4) delivery once a week per customer, and 5) traditional shopping method where customer did the shopping themselves using their own cars. According to the computational results, the average distance driven per order in case 2, was only 46% of the distance driven in the traditional shopping method (case 5), where customers used their own cars. Through limiting the delivery time windows to three 2 hr delivery slots (case 1), better delivery efficiency was achieved with a significant reduction (76%) in the distance driven in the current situation. Even better situation was attainable by using the reception boxes (cases 3 and 4), resulting in 87% and 93% reductions in the distance driven in the traditional shopping method (case 5). Based on the distance reductions and emission factors, it was then possible to estimate that the greenhouse emissions generated from grocery shopping were reduced by 18-87 percent compared to the situation in which households didn't choose a home delivery service. The results revealed that in countries where road transport's share of greenhouse gas emissions was more significant, the potential for emission reduction based on e-commerce services was higher.

2.4. Techniques for modelling home delivery operations

The application of modelling approaches involving optimization, heuristics and simulation in logistics has gained more attention and interest than before. The models applied within logistics could be separated into two groups (Ulla Seppälä and Jan Holmström, 1995). In the first group the logistics network has been broken down into distinct parts and the models focus on problems in distinct parts of the system. Route optimization programs are the most frequently used tools for different sectors of the logistics system. The number of route optimization programs is endless. Almost all the logistics software companies have their route optimization programs, for example, RouteLogix, Pro Opt and TransCAD. Another group of problem-focused models consists of logistics management programs which include one or several features of the following: cost accounting, sales management, inventory planning and supply management. There are a lot of these programs, e.g. Mikro-Sped, Movex, Hansa, Optimi 2000, DRP-8, Warehouse Management, Dispatch-1, Lagos and Power Freight (Stenger, 1986).

However, the use of modelling techniques frequently requires large amounts of quantitative data (Shapiro, 2001). The reliability of the results was highly dependent on the reliability of the input data. Using approximate data was often more effective than abandoning the effort to make an analysis (Shapiro, 2001).

In this section, efforts devoted to applying modelling techniques to distribution and home delivery operations are briefly reviewed.

2.4.1. Modelling in distribution systems

Goods distribution provides the link between production, storage and consumption. The major requirements of distribution system are reductions on cost and transit time, on-time delivery, and lower variability of transit time.

Many modelling efforts have been implemented by operational researchers, engineers and distribution analysts to improve goods distribution. The work has been concentrated in four main areas (Sussams, 1994):

- Warehousing: Design of handling and storage systems including computer controlled cranes, electronic guided vehicles and other sophisticated devices; deployment of stocks within a warehouse; methods of scheduling and controlling the operations of goods receiving, putting away, replenishing, picking, checking, packing and dispatch;
- Inventory management: Sales forecasting, stock control, purchasing and supply; integration of production planning and finished goods stock control;
- Transport: Design of vehicles; methods of routing and scheduling;
- Network optimization: Strategic studies to determine the least cost configuration of factories, depots and sub-depots required to supply a given set of demand points.

Typical examples include Maister (1975) who utilized Square Root Law to approximate the amount of inventory needed in the distribution system, Or and Pierskalla (1979) who adopted a spreadsheet method to minimize the Euclidean distance from the distribution center to its customers, and Hammant *et al.* (1999) who used a gravity optimization to determine optimal network design. Regardless of inventory management and warehouse design issues, the goods in a home-delivery operation have to be delivered to the customer and it is the 'last mile problem', which forms the focus of this research. Many efforts have been devoted to solving this problem, however, the main approach is the vehicle routing and scheduling problem, considering some factors, such as vehicle capacity, driver working conditions and capital employed in transport, etc (Lalwani *et al.*, 2006).

2.4.2. Modelling home delivery operations

Home shopping is the provision of consumer goods directly by a company to a customer in response to an order which could be generated in a number of ways (catalogs, Internet shopping etc.). The key distinguishing factor is that the final point of the logistics network is the customer's home (Brady and Harrison, 1990). Achieving success in the home-shopping market depends on cost-efficient delivery and consolidating many small shipments into one vehicle enables this. According to Lee and Whang (2001), the cost of home delivery is justified only if there is a high concentration of orders from customers located in close proximity if the value of the order is large enough. In selecting the most effective operating strategy, service providers have to consider the following elements (Van der Laan (2000), Laseter *et al.* (2000), Reinhardt (2001) and Browne (2001)):

- size of the service area;
- order frequency;
- customer density;
- vehicle routing according to promised delivery time windows;
- the stop time at customers' locations;
- the loading and unloading time;
- vehicle fill rate.

2.4.3. Vehicle routing and scheduling problem

Reaching cost-efficient home delivery operations is challenging due to delivery locations, missed deliveries, traffic congestion, parking restrictions and strict delivery time windows. In home delivery operations, a Vehicle Routing Problem (VRP) typically arises in situations where carriers have to travel to a number of locations to deliver packages. Generally, the objective of solving a routing and scheduling problem is to minimize total operating costs and maximize the vehicle work load. At the same time, the problem aims to fulfill the service promised to the customer. Several principles have been applied successfully in solving the routing problems (Ballou, 1999):

- Load trucks with stops that are in the closest proximity to each other;
- Stops on different days should be arranged to produce tight clusters or service areas;
- Build routes beginning with the farthest stop from the depot;
- The sequence of stops on a truck route should form a teardrop pattern, so that no paths of the route cross;
- The most efficient routes are built using the largest vehicles available;
- Pickups should be mixed into the delivery routes rather than assigned to the end of routes;

- A stop that is greatly removed from a route cluster is a good candidate for an alternative means of delivery;
- Narrow stop time window restrictions should be avoided.

Although some of the principles are not applicable for home delivery operations (for example, home delivery operations are always restricted to a narrow time window required by the customer), other principles are very useful in this research.

Considerable work has addressed various vehicle routing problems related to multi-drop deliveries and collections with time window constraints (e.g. Cordeau *et al.*, 2002). This has tended to concentrate on the problems associated with optimally dispatching goods from central warehouses to multiple customers under guaranteed delivery time windows (Ioannou *et al.*, 2001; Repoussis *et al.*, 2006) and the scheduling of supplier collections and customer deliveries from regional distribution centres involving heterogeneous products and vehicles (Currie and Salhi, 2003; Eglese *et al.*, 2005).

The travelling salesman problem (TSP) is recognized as one of the most widely studied routing problems. TSP is a problem in which a number of cities have to be visited by a salesman who must return to the same starting point; each city must be visited exactly once and the aim is to minimize the total distance travelled (Lawler *et al,* 1985 and Onal *et al*, 1996). The vehicle routing problem is an extension of the travelling salesman problem.

Solomon (1987) described the vehicle routing problem as to design a set of minimum-cost vehicle routes for a fleet of vehicles from a central depot to a set of customers with known demand. The routes have to be designed so that each customer is served exactly once by one vehicle, considering the fact that the total demand of all points on the route does not exceed the vehicle capacity. Routing and scheduling problems are typically NP-hard problems (nondeterministic polynomial-time hard), where no polynomial-bounded algorithm has yet been found; meaning that solving these problems optimally suffers from an exponential growth in computational burden with problem size. In other words, NP-hard problems (nondeterministic polynomial-time hard) are difficult because there is no algorithm that will solve them optimally. Consequently, the possible solutions are to find out the best possible results.

In nature, the problem of home delivery operations is a vehicle routing problem. However, a customer may select delivery time windows defined by the e-retailer. Consequently, the problem of home delivery operation has the characteristics of VRP (Vehicle Routing Problem) with Time Windows, increasing the complexity of the problem solution. This problem has recently attracted intensive research interest, for example, Solomon and Desrosiers (1988). The objective is to minimize the travelling distance and journey time, as well as satisfying the constraint due to delivery time windows. To solve the VRP with Time Windows, optimization algorithms need to be presented. For example, mathematical programming-based heuristics, exact optimization algorithms and artificial intelligence techniques have been developed (Fisher, 1995).

A range of research projects have modelled the grocery home shopping and home delivery service. Cairns (1996) utilized Geographical Information System software package TransCAD to undertake modelling work in Witney, to estimate the shortest paths that customer cars would take between a supermarket and home, and delivery vehicles might make to deliver among a group of customer addresses. Palmer (2001) undertook the modelling work for grocery home delivery operations on behalf of the UK government's Retail and Logistics Task Force. The research adopted CAST-dpm software (Computer-Aided Strategy and Tactics – Distribution Planning Model) to calculate the shortest route for customers to shop and carriers to deliver. The Claritas database was used, which included data about the grocery spend of the most affluent 40 percent of households and details of where they shopped. Claritas database is commercially available, providing comprehensive source of updated marketing research data about American and European consumers and businesses. It was assumed that the households' weekly grocery purchases were undertaken by one car trip to the store for their typical uses. For those householders selecting home delivery service, their weekly shopping trip was replaced by one delivery trip. Four scenarios with varying proportions of grocery home delivery take-up were modelled in the research, corresponding to 0.5 percent, 2 percent, 5 percent and 10 percent of grocery home shopping take-up. Two main simulations were implemented based on different delivery models. 1) delivery from existing stores; 2) delivery from a mixture of stores and dedicated fulfillment centers.

A set of modelling exercises was undertaken by a research group in Finland (Kämäräinen *et al.*, 2001, Punakivi and Saranen, 2001; Punakivi *et al.*, 2001; and Siikavirta *et al.*, 2003), focusing on the traffic impacts of time window constraints on grocery home delivery efficiency. Kämäräinen *et al.* (2001) applied the modelling work in a one-vehicle environment; Punakivi and Saranen (2001) then used a vehicle routing tool in a multi-vehicle environment. Vehicle routing and scheduling software, RoutePro was utilized to simulate the shortest route for carrier to make deliveries and customer to shop. A test area of 135 km^2 containing 89,000 households in metropolitan Helsinki (Finland) was selected for modelling work. The input data contained all shopping bought from one of 5 major supermarkets in the test area during a representative week in October 1999. The shopping orders worth more than €25 were selected for modelling as home delivery orders.

Using Paragon vehicle routing and scheduling software, Nockold (2001) modelled the grocery home delivery operations with different time window constraints. In the modelling work, Nockold compared the effects of offering all customers a 3-hour time slot, with the situation where deliveries could be made at any time during the day. Various scenarios were modelled, considering the home delivery service take-up level by customer and capacity of the delivery vehicles. The results indicated that replacing 3-hour time slots with delivery at any time during the day reduced customer travelling distance by 27–36%.

Persson and Bratt (2001) identified the effects of grocery home delivery operations in Hammarby Sjöstad, Stockholm (Sweden) with 2200 population. The modelling work was undertaken by using a computerized calculation model, *Miljöbelastningsprofilen* (Environmental Impact Profiles). Four different scenarios with different shares of home shopping market (0, 10%, 25% and 50%) were calculated for 2,200 and 8,000 households. Each scenario was explored with six cases, depending on the source of deliveries (from existing retailers or e-business warehouses), and the final point of goods reception (to local centers, to temperature-controlled reception boxes, or directly to the customers). The results suggested that customer grocery shopping trips could be reduced by 6-24 percent, compared to the situation where no home delivery service was taken up by people.

2.5. Summary

This Chapter has reviewed the literature covering several issues in home delivery studies. In the first section, the home delivery market was described by retailing sectors and goods sectors, respectively. The home delivery strategies were introduced for two types of goods, i.e. groceries and small packages. Particularly focusing on small package home deliveries, the operating characteristics of traditional, attended and unattended CDP home delivery methods were provided in the second section. A discussion of the transport and environmental implications of home delivery operations was provided in the third section. Lastly, the techniques for modelling home delivery operations were reviewed. As discussed above, there are certain gaps in the existing literature.

- **Previous research has been focusing on grocery home delivery, which was constrained by tight delivery time-windows.**

  However, small package home delivery market was still dominant in the overall market, accounting for 60% of whole home delivery market. Small package home deliveries lend themselves to the postal network/parcel company/mail company. Few retailers allow customers to choose the delivery time for small packages. Standard delivery is the most common option. Hence for the small package home delivery, delivery failures are even more serious.

- **Most of successful CDP schemes have targeted at B2B market, instead of B2C.**

  Most of the CDP schemes have established firm relationship with retailers in B2B market, particularly for field service. For example, ByBox is successful in developing parts returns and delivery business in the UK. However, this doesn't necessarily mean that the B2C market is abandoned. Little research has identified whether CDP concept is cost-efficient for B2C customers. Most of the work about the CDP scheme has been qualitative rather than quantitative. Additionally, the B2B CDPs are normally located at business parks or carrier's depot, which are less appealing to the customers.

- **With the rapid developments of home shopping and delivery market, delivery failures have become one of major concerns in the field.**

  The estimates of delivery failure rates range from 12% to 60%. Most of the previous work has been focusing on directly substituting the supermarket shopping trips with home delivery trips organized by the carrier. IMRG estimated the cost of each delivery failure to the carrier would be £38.5. Little work has investigated the impacts of home delivery failures on householders and carrier in the current home delivery system, where people have to travel to carrier's depot to collect the failed packages and carrier has to make multiple delivery attempts.

- **Various delivery failure rates have been estimated by previous research, but these are mostly based on surveys in individual locations.**

  Most of the research in the field has collected home delivery information through surveys in limited areas. Cross-population analysis within an individual study would be ideal, but has not been undertaken to date.

- **Practical issues of CDP systems have seldom been covered before.**

  These can include locations, capacity issues, technical requirements and service charges.

These gaps in the existing literature have formed the basis for the research described in the next chapters.

CHAPTER THREE

METHODOLOGY

3.1. Introduction

There is little evidence to quantify how effective the CDP method could be in mitigating the negative impacts of failed first-time home deliveries. The transport and environmental benefits that could be realised through reduced carrier and customer activity and a more localised response to package handling in the event of failures should be addressed. This thesis focuses on comparing the various home delivery methods involving CDPs to quantify these potential benefits.

3.2. Research questions

Five research questions are proposed in this research.

RQ 1. What are the problems in current home delivery operations and how do they impact on home delivery service?

The research needs to present practical and meaningful results. By identifying the problems in the industry and quantifying the implications of those problems on the home delivery service, it is then possible to suggest solutions to improve the home delivery service. The research thus has important managerial implications. As stated in Section 1.4 (Chapter 1), the first objective of this research is to identify the existing and emerging models for the home delivery, which could be derived from the existing literature. The literature review revealed a range of difficulties and constraints in the current home delivery operations, including unsecured deliveries, first-time delivery failures, demands for faster delivery, returns of unwanted goods, transport and environmental implications, etc. Of major concerns is the failed home delivery, which shapes this research.

In the literature review, various failed home delivery rates have been suggested. However, few researches have quantified the impacts of the failed home deliveries on carrier and customers. Consequently, this research sets to determine the proportion of failed home deliveries suggested by customers and carrier, respectively, since they have different perceptions on home delivery service.

RQ 2. What are the cost-efficiencies of the existing and the CDP home delivery methods?

The second and third objectives of this research are to quantify and compare the transport and environmental costs of various home delivery methods (Section 1.4, Chapter 1). Particularly focusing on small package home deliveries, the delivery methods modelled in this research are the existing delivery method and the CDP delivery method. Each delivery method will be modelled and the relative cost-efficiencies compared. The costs of a delivery method are interpreted in terms of distance travelled by carrier and householders.

RQ 3. What are the existing policies adopted by carriers/retailers to deal with home delivery failures, and the corresponding take-up levels?

It has been identified from the literature review that in the event the customer is not at the delivery address when the carrier delivers, the carrier can either make up to two re-delivery attempts or return the goods to the depot for the customer's later collection. Instead, the goods can be diverted to a local CDP and then customer collects them at a convenient time. In some cases, the carrier also has the option of leaving the goods with a neighbour or unsecured outside the customer's home in accordance with customer's instructions. However, the take-up level of each option has not been estimated before, which is important to quantify the road traffic associated with carrier's re-delivery journeys and customer's trips to make collection either from local carrier depot or a CDP.

The fourth objective of this research is to quantify the impacts of failed home deliveries on carrier and customers (Section 1.4, Chapter 1). Consequently, this research sets out to determine the take-up level for each option towards a failed home delivery, and then quantify the impacts of delivery failures on travelling distances incurred by the carrier in delivering goods and the distance travelled by customers in collecting failed deliveries, either from the local carrier depot or from CDPs.

RQ 4. Are there any differences in customer's home delivery perceptions among different demographic areas?

The fifth objective of this research is to compare people's home shopping and delivery characteristics over two demographical areas (Section 1.4, Chapter 1). It is important to find out customer's demographic information, which will contribute to further understanding of the needs of home delivery services from various types of customers. Although there have been some studies in this topic, few of them have indicated the differences of results in different demographic areas.

Consequently, this thesis sets out to determine customer's attitudes towards the existing and emerging home delivery operations in one area, and then compares the results with the residents from another demographical area. The insight into such differences can be best obtained by surveying customers who have used home shopping and delivery services.

RQ 5. If the CDP delivery method is more cost-efficient and environment friendly than the traditional delivery method and if there are sufficient demands for such service, what are the optimal locations for CDPs?

The last objective of this research is to deal with the practical issues when setting up a CDP system (Section 1.4, Chapter 1). The literature review revealed that the existing CDPs are normally located at post offices, convenience stores and petrol stations. It is noted that some of the CDP locations have received much discussions. According to the results from the Royal Mail CDP trial (Department for Transport, 2004) in Nottingham from February 2003 to October 2003, around 80% of 2000 respondents would consider using the Local Collect post offices as CDPs. Another research by Verdict (2001) indicated that post offices and workplaces were the most popular CDP locations of customer's choices.

It is necessary to consider the CDP locations at other popular sites with heavy utilization. DTZ Research (2000) has identified several types of CDPs which appeared to offer the greatest potential in terms of accessibility, geographical coverage, opening hours and likely existing capacity. The examples include superstores, petrol stations, post offices, convenience stores, business parks, and major employee sites. Some of them have been used as CDP locations in practice, for example, post offices by Royal Mail 'Local Collect', convenience stores by Collectpoint and petrol stations by Kiala. Further research is needed to identify other potential CDP locations. Consequently this research sets to identify whether there are CDP options which are more popular and attractive to customers. Besides the location of a CDP system, other issues will be discussed as well, including the capacity, technical requirements, service charges, etc.

3.3. Research design

The research design serves the purpose of facilitating answering the five research questions. A six-step method was developed in this research. To answer part of RQ2 and RQ1, the existing and emerging home delivery methods were identified from the literature in the first research step. The existing policies adopted by carriers to deal with the home delivery failures were also explored. The second stage consisted of conducting two home delivery surveys in two areas (Winchester and West Sussex, respectively), to respond to RQ4 and part of RQ2. Customer's home shopping behaviour findings from Winchester were compared against a second data set from West Sussex to see whether their experiences and therefore home delivery trends were shared. In the third research step, to answer RQ1, RQ3 and RQ5, theoretical benefits on householders and carrier of using the CDPs in Winchester were analysed on the basis of householder's experiences of home delivery services identified through RQ4. After that, the theoretical analysis was repeated in a wider geographical area (West Sussex) in the fourth research stage, to see whether there were significant differences in modelling results about the transport and environmental benefits incurred from reduced carrier and customer activity of using the CDP concept against the Winchester study. The analysis in the Winchester study and West Sussex study was implemented by optimising carrier's theoretical delivery rounds among a group of sample householders. Instead, the CDP benefits could be appraised by replicating the actual carrier rounds, which shaped the fifth research stage. The carriers' historical delivery schedule was collected from a major carrier company in the same area as the fourth stage (West Sussex). The home delivery operations were then simulated. In the final research step, a discussion of feasibility of CDP system was provided.

A flowchart is provided to illustrate the research process (Figure 18).

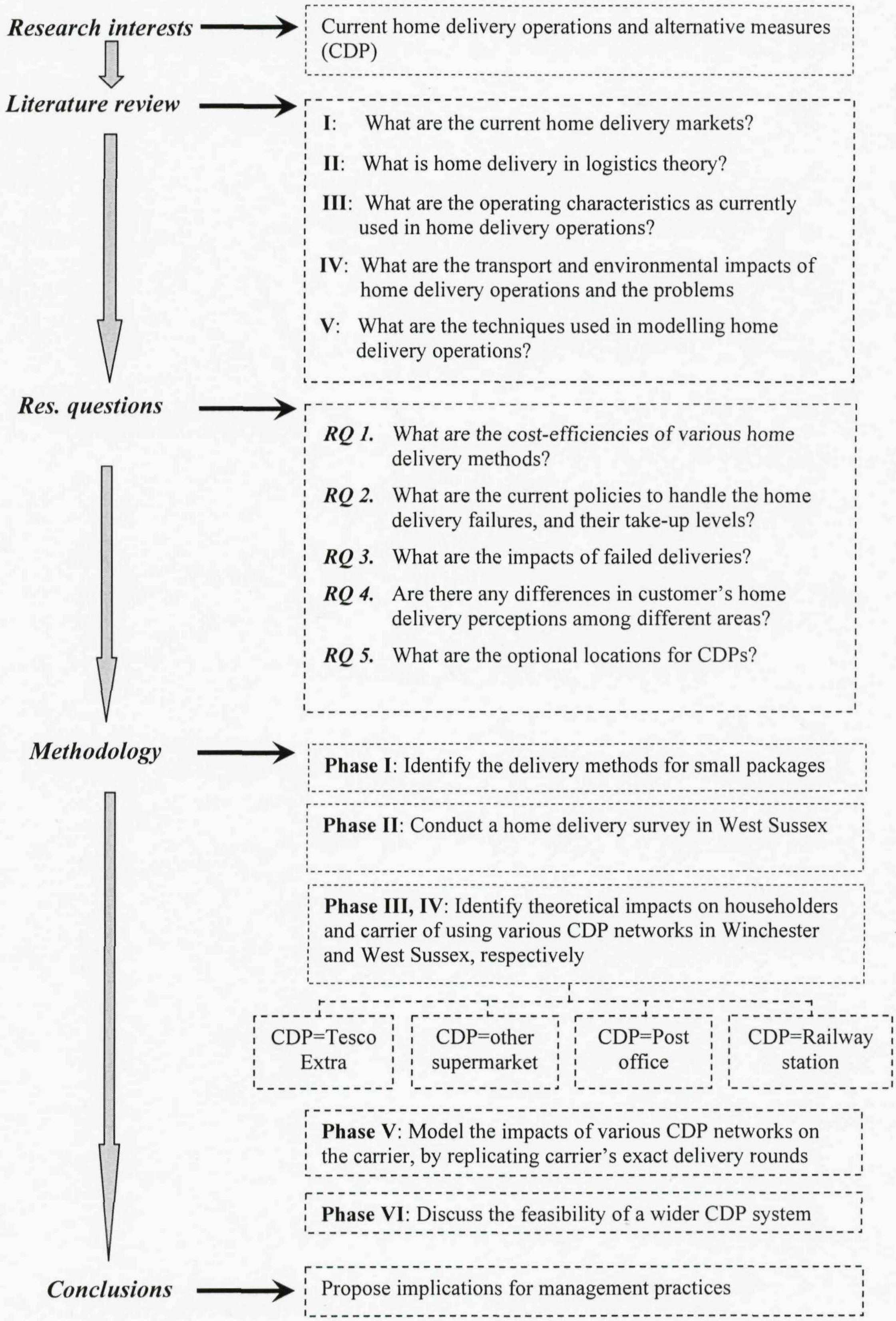


Figure 18 A flowchart to show the research process

3.4. Research Phase I

There are two types of home delivery methods identified by the literature review: the traditional home delivery method and the CDP delivery method. In the traditional delivery method, the customer needs to be present to receive the goods. There are variances in measurements adopted by carriers to deal with the home delivery failures. Some carriers make an automatic free re-delivery attempt on the same day or on subsequent days. If the second attempt to deliver also fails, subsequent delivery attempts will be made at an additional charge to the customer. Others return the parcel to the depot where the customer collects it, but not all carriers allow this. Instead, the carrier can leave the parcel with a neighbour or outside the door in accordance with customer's instruction.

In the CDP delivery method, facilities such as convenience stores and post offices act as alternative delivery locations for either the first-time delivery or the failed home deliveries. The customer is left a notification card detailing the address of the CDP and then retrieves the goods at a convenient time.

3.5. Research Phase II

The objective of this research phase is to quantify home delivery characteristics on two population samples, i.e. Winchester and West Sussex. To acquire household's perceptions on home delivery services and prepare the input data for the modelling work, a surveying method is adopted because it is believed the best way to reach a wide cross-section of householders (Sachan, 2005). The postal questionnaire survey was one of the most frequently used methods in logistics research (54.3%), with computer simulations and interviews the next two mostly used methods (Mentzer and Kahn, 1995).

In this research, two home delivery questionnaires are designed in order to investigate the householders' home shopping activities (for example, frequency of home shopping transactions, types of goods purchased from home, etc), experiences of home delivery services and failed home deliveries, responses to deal with the failed home deliveries, and opinions on the CDP methods.

3.5.1. Winchester Survey

The questionnaires were firstly distributed in Winchester, as part of MIRACLES (Multi Initiatives for Rationalised Accessibility and Clean, Liveable EnvironmentS) project (from January 2002 to January 2006). The main aims of the project were to reduce environmental impacts caused by local traffic, to increase accessibility within the city and to achieve an overall improvement in quality of life for residents. To achieve these objectives, a wide range of integrated, innovative and sustainable urban transport measures were developed, including reduction of high-polluting vehicles, sustainable parking policies; and improving freight efficiency etc. Measures about improving freight efficiency were implemented through reducing the impacts of deliveries on both traffic congestion and local air quality.

To develop an understanding of the problems encountered in home delivery operations, a home delivery questionnaire was designed. The questionnaire was posted to 1600 residents in Winchester and total of 790 completed questionnaires were returned in September 2004.

In details, Winchester survey aimed to find out whether the respondents regularly experienced failed home deliveries, whether they often travelled to a depot to collect their failed deliveries, and whether they would use a CDP as an alternative delivery address where deliveries could be re-directed in the event of a first-time delivery failure at the home. There are several main reasons why Winchester was selected.

Firstly, when the research started in 2005, the local CDP service was provided by Collectpoint plc in Winchester (Collectpoint, 2005) who owned about 1600 CDPs in the country, utilizing 7-day 'seven-till-eleven' type convenience stores. Unfortunately the company has now ceased 'business-to-consumer' operations and recently was taken over by Redpack Network, Inc. Secondly, Winchester is relatively small ensuring that all home delivery addresses lie within a compact area and home delivery operations can be modelled in a reasonable scale. More importantly, it makes the extension of future modelling work in a bigger area feasible (see Chapter Five and Chapter Six). Lastly, it was easier to obtain detailed household names and addresses for the survey from Winchester City Council than from any other city council.

3.5.2. West Sussex Survey

In order to compare the customer's home shopping behaviour against a second data set to see whether their experiences and therefore home delivery trends are shared, a second 'home delivery' questionnaire was designed as part of West Sussex County Council's continuing work to develop sustainable travel solutions for people living and working in the county.

The overall objective of this survey was to identify the problems householders currently experienced with home delivery services, especially failed home deliveries, and explore the potential for the new home delivery methods to improve the efficiency of urban freight delivery. If significant differences are found regarding customer's home shopping and delivery behaviourfrom the two data sets, the reasons for the differences needed to be explored and general statements on those questions needed to be presented.

There were three main reasons why West Sussex was selected. First, Winchester survey collected data on people's home delivery experiences from a relatively small city, which might narrow the scope of the research and thus generate the biased computational results. To overcome those difficulties and generalize the findings on people's experiences of home delivery service, the survey should be undertaken in a wider geographical area. Second, Dixon and Marston (2002) reported that Southeast England and London had higher Internet access (45% of households) than Northeast England (26%). Southeast England is one of leading areas in terms of online shopping (Fernie and McKinnon, 2003). It was reasonable to assume that populations in this area were supposed to have more home deliveries generated from various home shopping methods, including online shopping. According to Verdict Research (2003) which carried out interviews to 1938 adults to discover their home delivery behaviours, 67% of respondents with Internet access purchased at least one home delivered product in the past 12 months, compared with 45% of respondents without internet access. It then concluded that there was an important difference in the number of home deliveries based on whether or not people had internet access. Third, when the research started, it was easier to obtain the detailed household names and addresses from database of panel members who had agreed with West Sussex County Council to take participate in various surveys over a period of time. The database of those panel members was administered by a consultancy, BMG Research, who worked in partnership with the Council on all residents' Panel Surveys.

The questionnaire was posted in June 2006 to 1000 panel members and a total of 379 completed questionnaires were returned, giving a 38% response rate.

3.6. Research Phase III and IV: quantify the impacts on householders of using CDP home delivery operations in Winchester and West Sussex, respectively

From the modelling point of view, the most important data acquired from the two home delivery surveys are householders' detailed home delivery information, experience of failed home deliveries and their potential adoption of emerging local CDP services. Using the data gathered from the two surveys, particularly the respondents' home postcodes, the traditional delivery method and the local CDP method were modelled with the help of a vehicle routing and scheduling package (DPS RouteLogix). Using the software, carrier's theoretical delivery route among a group of the respondents' delivery addresses was optimised. Carrier's travelling distance to make all delivery attempts was calculated based on the theoretically optimized routes. Householders' travelling distance to collect their failed packages either from the local carrier's depot or local CDPs was quantified. The transport and environmental costs of existing and emerging CDP methods were then compared.

To validate the behavioural findings from the Winchester study against a second data set and see whether the modelling results of their home delivery experiences were shared, the modelling work was repeated in West Sussex.

In the modelling work in both Winchester study and West Sussex study, the research takes the following CDP locations into consideration.

- **Option 1: Tesco Extras**

Grocery shopping trips are normally made more frequently and shorter than the non-food shopping trips. DfT survey of personal travel (2007) suggested that approximately half of all shopping trips were for food shopping (105 trips per person per year, equivalent to twice a week). Food shopping trips tended to be shorter than non-food shopping with an average trip length of 3.1 miles compared with 5.4 miles respectively. The car was the main mode of travel for nearly two thirds (63%) of all shopping trips, with 42% made as a car driver and 21% as a car passenger. 15% were made on foot and most of the remainder (8%) was made by bus. Hence people may be able to collect their packages from a supermarket at the same time doing shopping.

Another study indicated that 92% of food expenditures occurred in supermarkets (IGD Shopper Insight, 2006, cited by Competition Commission, 2007). 56% of the shoppers using a supermarket visited once a week while 31% visited more than once a week. Among those supermarkets, Tesco reported a larger proportion of customer shopping more frequently compared with Sainsbury, ASDA, and Morrison (IGD Shopper trends in products and store choice, 2007, cited by Competition Commission, 2007).

According to the Guardian (2006), Tesco's share of grocery market was 31% in 2006, much higher than ASDA (17%), Sainsbury's (16%), Morrison and Safeway chain (14%) and Waitrose (4%).

Furthermore, Tesco has a long time of opening hours, normally from 8:00 am to 8:00 pm, some even open for 24 hours. Currently there are 1,380 Tesco stores in the UK (www.tesco.co.uk), including 147 Extras (approx. 60,000 sq ft), 433 superstores (approx. 20,000 – 50,000 sq ft), 162 Metros (approx. 7,000 – 15,000 sq ft), 735 Expresses (up to 3,000 sq ft). Tesco has become the world-largest e-grocer, covering 96% of UK populations with home delivery services.

Clearly there is great potential for Tesco to be used as a CDP considering its heavy utilization, store space, number of stores in the country and opening hours. Overlapping with Tesco superstores, Metros and Expresses, Tesco Extras provides significant sales areas with a limited quantity of stores, which accounts for 31% of UK space.

As the biggest Tesco stores, Extras therefore should be in areas serving the greatest concentrations of households. Also they should have sufficient space, in theory, to house a CDP. Consequently, Tesco Extras are proposed as a CDP option to be modelled in this thesis.

- **Option 2: Supermarkets from ASDA, Morrison, Sainsbury and Waitrose chain combined**

Considering the characteristics of food shopping trips discussed above, there is also great potential for other major supermarkets to be used as CDPs. Together with Tesco, ASDA, Sainsbury's, Morrison and Safeway chain and Waitrose have been identified as the top grocers in the UK (Guardian, 2006).

From Neighborhood Statistics (Office of the Deputy Prime Minister (ODPM, 2005), the average road distance to a supermarket or a convenience store is 1.59km in the UK (excluding smaller shops, bakeries, confectioneries, greengrocers and butchers), indicating that supermarkets are highly accessible by the public.

As the potential CDP outlets, the supermarkets modelled in this research should have theoretical space to house a CDP (the capacity issue of a CDP will be discussed in Chapter Seven). Considering the types of stores in terms of size, the biggest stores from those supermarket chains are modelled in this research, including Sainsbury's Central (approx. 7,000 - 20,000 sq ft), ASDA Wal-Mart Supercentre (average 42,000 sq ft), ASDA Supermarket (approx. 4,000 - 10,000 sq ft), Waitrose Supermarket (average 20,500 sq ft) and Morrison Supermarket (average 26,899 sq ft).

Furthermore, a supermarket has a relatively long period of opening hours, normally from 8:30 am to 8:00 pm. During any working day, ASDA opens from 8:00 am to 10:00 pm (some are even opening for 24 hrs), Morrison opens from 8:00 am to 8:00 pm, Sainsbury opens from 8:00 am to 8:00 pm, and Waitrose from 8:30 am to 8:00 pm.

Considering the characteristics of food shopping trips, opening hours, accessibility by public, supermarkets from ASDA, Morrison, Sainsbury's and Waitrose chain combined are proposed as a CDP option to be modelled in this thesis.

- **Option 3: Post offices offering 'Local Collect'**

Post offices have been used as CDPs by Royal Mail 'Local Collect' service, which allows customers to arrange re-deliveries of failed first-time deliveries to the participating post office branches and then they collect their packages at a convenient time. According to Neighborhood Statistics (Office of the Deputy Prime Minister, 2005), the average road distance to a post office is 0.94km and ninety percent of households live within 15 minutes or less of walking distance to a post office (National Travel Survey, 2006).

Consequently, a post office network offering 'Local Collect' service is considered to be a CDP option in this thesis. It is noted here that collection out of working hours would impose problems as the post office network currently operates between 09:00 and 17:30.

- **Option 4: Railway stations**

Railway stations have been used as CDPs by the existing CDP systems, for instance, DHL PACKSTATION in Germany. According to National Travel Survey (2006), 6 percent of people use rail transport at least once a week and a further 11 per cent saying at least once a month. Neighborhood Statistics (Office of the Deputy Prime Minister, 2005) suggested that 44% of residents live within 26 minutes by foot of a railway station nationally. A railway station normally has extended opening hours.

Consequently, a railway station network is taken as a CDP option in this thesis.

3.7. Research Phase V: quantify the impacts on the carrier of using home delivery operations

In this research phase, the transport and associated environmental impacts of current traditional home delivery operations and various theoretical CDP methods are investigated based on historical delivery schedules for the West Sussex area provided by a major carrier.

Specifically, the transport benefits to the carrier of having failed first-time home deliveries automatically diverted to a local CDP nearest to the customer's home are investigated. This is compared to the existing system where the carrier may make multiple re-delivery attempts to the customer on the same delivery day or on subsequent days if the initial delivery fails. The theoretical CDP's using supermarkets, railway stations and post offices would potentially be able to receive packages in a secure area, manage their storage and through a web based communication system, liaise with the customer via email, text message to arrange collection (as in the Kiala model, Section 2.2.6).

The exact delivery information from one week in October 2006 was collected from a carrier company, including 43559 consignments for delivery across private homes in West Sussex. A consignment is defined as a delivery to the receiver's address and within one consignment, there could be more than one item. Customers' street addresses were obtained from the survey undertaken in West Sussex.

The database contained the detailed customer delivery information from 10th October to the 16th October 2006, which was taken to represent typical non-peak operations over one week. A consignment was defined as a delivery to the receiver's address and within one consignment, there could be more than one item. The 43,559 consignments made were served by 1243 delivery rounds. The delivery trips started from one of three local carrier depots serving West Sussex, located at Alton, Crawley and Southampton with the majority of the deliveries being made between 09:00 and 16:00. The receiver's signature was required at the point of delivery and in the event of first-time failures, (after potentially multiple attempts on the same round) the carrier would leave a notice at the receiver's address stating that the delivery had been attempted and the consignment had been taken back to the depot. The carrier would then try to make one more attempt on the following day. Additional costs could be incurred by the customer for any subsequent re-delivery attempts of for returning the consignment to the consignor.

The database showed that of the consignments destined for households in West Sussex, 14,938 originated from the Crawley depot, 13,865 from Southampton and 9769 from the Alton depot during the sample week. There was an average of 2.3 items per consignment with an average consignment weight of 2.23 kg. The average number of weekly consignments delivered to each postcode sector was 75 and the average count of households per postcode sector in West Sussex is 77 (National Statistics Postcode Directory, 2006). From this, it was estimated that the average household received 0.97 consignments over a week.

From the modelling point of view, the most important elements in this real data were delivery sequence including the failed and the successful delivery operations, departure depot, householders' addresses, delivery round number and time for both successful and failed delivery attempts. Through the unique consignment ID, the carrier databases provided the delivery address, delivery times for both successful and failed attempts and the consignments originating depot. The actual consignment delivery order making up the round is made available and simulated using DPS RouteLogix routing and scheduling software. The failed first-time deliveries are manually inserted at the point where the CDP is to be visited. The missed first-time deliveries are automatically diverted to the nearest CDP relative to the respective householders' locations after all the delivery attempts are made in its catchment area.

3.8. Research Phase VI: economical feasibility of a CDP system

The research needs to be practical and meaningful. Before promoting the CDP delivery method, it is necessary to discuss its feasibility, in terms of payback period of investment, location, service charge, capacity issues and technical requirements.

The results are useful for the decision maker to develop an efficient and feasible CDP system. Carrier could also benefit from such system to reduce the impact of failed first-time deliveries.

3.9. Modelling tool used

In this research, the home delivery operations are modelled using DPS RouteLogix, a commercially available vehicle routing tool from DPS International. The heuristic adopted in this research for modelling home delivery operations is developed by DPS International, to calculate the quickest delivery route. The modelling work could thus be described as static and deterministic, i.e., the modelling is a representative of a particular time, and the components such as costs and date are known with certainty. At the same time, spreadsheet programs were adopted in data processing and analyzing the costs of the home delivery models.

DPS provides software solutions for the vehicle routing and scheduling problem. RouteLogix Professional is a route planning system designed to provide effective vehicle scheduling management. The software can calculate the quickest, shortest and cheapest route between a series of points giving detailed route plans, both in printed form and with on-screen maps. The software automatically calculates optimum routes based on order volume, distribution and operator preferences, giving the user more time to manage the fleet. The system allows the user to create a user-controlled optimisation.

Initially the research adopted Microsoft MapPoint as a base tool to model the carrier's and householder's route. However, it was soon found out that the route optimization by MapPoint was slightly less efficient than the DPS RouteLogix, in terms of reducing the route distance. Additionally, RouteLogix processes several characteristics, which better match the needs of this research than the other software:

- Manual insertion of orders and time windows into the existing route
  This research uses DPS RouteLogix to determine the optimal route for the carrier around a sample of the delivery (and re-delivery) addresses, taken from the survey respondents. Where the carrier has to also visit CDPs to drop off failed deliveries, these points are inserted manually at an optimal position on the round (Chapter Five). To the authors' knowledge, few routing and scheduling tools allow this. Hence DPS RouteLogix is suitable to this research. It should be noted that this research did not set out to address the routing and scheduling problem (i.e. designing new algorithms specifically tailored for home delivery), but rather to use an existing tool to better understand the impacts of new home delivery scenarios.
- Single and full multi-depot planning
  There are two carrier's depots involved in the West Sussex study (Chapter Six). RouteLogix is able to allocate the optimal depot for each delivery order with an objective to minimize the travelling distances to make all deliveries.
- Customise icons in map with standard Windows tools
- Convert order and call point data to txt/excel format
- Multiple-day vehicle routing
- Route editing on screen
- Vehicle capacities and order measured in user-specified units
- Multiple drops and customers per stop
- Unlimited product types including size and load/unload time
- Driver regulations
- Depot (names, time windows, throughput)

Consequently, considering the software's features relevant to this research and its capability of route optimization, DPS RouteLogix was then selected as the modelling tool. Every route available from its mapping database was used in the modelling.

The algorithm used to allocate the orders to routes is node based. Each order is taken in turn and tried in each possible position on each route. If it cannot be allocated to any existing route, a new route will be started (if possible). This order is now processed and the routine moves on to the next. As each order is attempted the progress bar/bars are incremented. During this process, the screen is updated frequently but not necessarily after every single calculation. Please see Figure 19 for an example of RouteLogix worksheet. The algorithm used in RouteLogix seems effective in solving the routing problem in home delivery operations. Other possible vehicle routing tools that could have been adopted in this research are, for example, Microsoft MapPoint Europe.

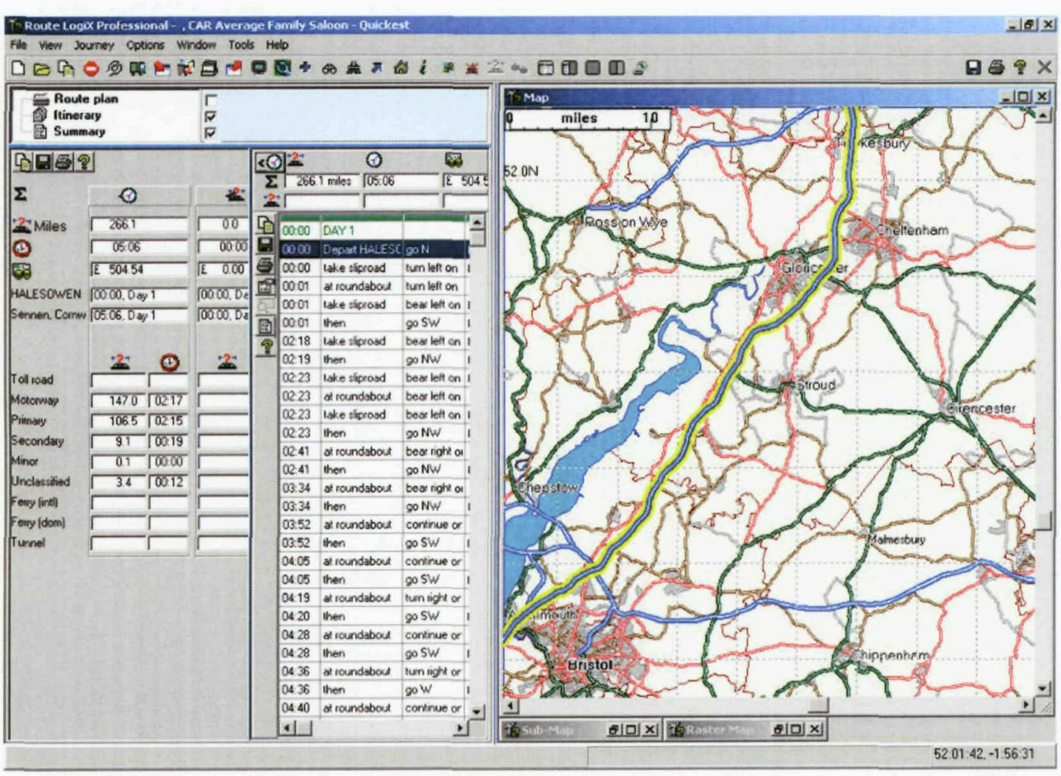


Figure 19 Illustration of RouteLogix Worksheet

MapPoint was used as a complementary tool, with an algorithm developed to calculate the quickest road distance from household origins to CDPs. It was also used to display the maps showing the locations of household origins and CDPs.

3.10. Validation

Determining the effectiveness of a computer simulation model in duplicating a desired real world phenomenon is an important issue. Model validation is usually defined to mean 'substantiation that a computerized model within its domain of applicability possesses a satisfactory range of accuracy consistent with the intended application of the model' (Schlesinger, 1980). The ultimate objective of model validation is to make the model useful in the sense that the model addresses the right problem, provides accurate information about the system being modelled, and leads to the model being used with confidence.

For a simulation model, validation is concerned with determining whether the conceptual model is able to accurately represent the system under study. If a simulation model is valid, then the decisions made with the model should be similar to those that would be made by physically experimenting with the system (if possible) (Law and Kelton, 1991). This requires adjusting model parameters until the results agree closely to the observed data. Consequently, validation of the simulation model can be established by comparing the results between the observed data from the actual system and the output data provided by the simulation experiments conducted with the computer model.

In this research, the validation process was implemented through testing two vehicle routing and scheduling software (i.e., DPS RouteLogix and Microsoft MapPoint) among a group of sample customers in the selected geographical area. The differences between the calculation results (in terms of the quickest distance to serve those customers) from RouteLogix and MapPoint were small, but the DPS RouteLogix was slightly better in optimising the routes in the selected area.

Other possible vehicle routing tools which are commercially available and could have been used in this research are, for example, Paragon Software and Optrak Distribution Software. However, it was noticed that reaching the objective of this research (i.e. through optimising the carrier's route among a group of customers in the existing delivery method and the CDP delivery method) did not require the use of more than one vehicle routing tool. The key focus of this research was to analyse the cost differences among the existing and the CDP delivery methods in the small package home delivery business. Even if the absolute numerical outcomes of the tests had been slightly different using another vehicle routing tool or another routing algorithm, the relative differences and relations of the analysed home delivery models would have been the same.

CHAPTER FOUR

HOME DELIVERY CHARACTERISTICS

4.1. Introduction

The objective of this chapter is to explain how the first and part of fourth research steps were implemented on the consumer (i.e. householder) side of the home delivery study. To acquire householder's perceptions of current home delivery services and prepare the input data for the modelling work, a surveying method was adopted because it was believed the best way to reach a wide cross-section of householders and identify their experiences on the home delivery services. According to Mentzer and Kahn (1995), the postal questionnaire survey was one of the most frequently used methods in logistics research (54.3%), with computer simulations and interviews the next two mostly used methods. Xing (2006) developed a quality evaluation system for home delivery services based on 423 survey responses from 3000 households in Edinburgh. The home delivery survey aimed to acquire consumers' expectations and perceptions of e-retailers' physical distribution service quality performances (e-PDSQ). Also a survey methodology was adopted by Cairns (1997), which utilized Geographical Information System software package TransCAD to identify the transport impacts of home delivery based on the data from the Oxfordshire County Council survey about shopping habits in Witney. The survey collected information of people's real shopping behaviour from one main central Waitrose supermarket in Witney.

In this research, the questionnaires were designed to investigate the householders' home shopping activities, experiences of home delivery services and failed home deliveries, responses to deal with the failed home deliveries, and opinions on the new home delivery scenarios (CDP methods).

Besides this 'home delivery' survey distributed to 1600 residents in Winchester, several surveys of over 450 shops and businesses were also carried out. Based on the whole sets of responses, MIRACLES developed an understanding of the problems encountered by both customers, retailers and carrier companies in home delivery services. MIRACLES set out to develop an alternative delivery system that would become self-sufficient at the end of the project. Hence a CDP trial was carried out with the support from MIRACLES and Collectpoint plc. MIRACLES widely publicised Collectpoint and offered a ten week free trial in 2004. However, the trial failed because of insufficient demand and technical difficulties. MIRACLES projects did not involve any computational work related to the survey results to quantify the transport benefits associated with the CDP scheme, which forms the current research.

However, the survey data from a fairly limited test area might narrow the scope of the research and thus generate the biased computational results. Additionally, one of the research objectives is to compare customer's home shopping take-up level and their attitudes amongst different demographic groups. Consequently, to overcome those difficulties and generalize the findings of people's experiences of home delivery service, the survey should be undertaken in a wider geographical area. As a result, the home delivery questionnaires were distributed to 1000 households in West Sussex.

In addition to these two surveys quantifying householder behaviour related to home delivery and CDP preferences, home delivery records from a major carrier were also obtained to assess the impacts of various new home delivery scenarios.

4.1.1. Winchester survey (September 2004)

A 'home delivery' questionnaire was designed as part of the work undertaken by the MIRACLES project (January, 2002 - January, 2006). A pool of 1600 residents agreed to be panel members, participating in travel diaries and other surveys throughout the MIRACLES programme. The 'home delivery' questionnaire aimed to gather information on the frequency of home shopping transactions undertaken by the household, the mediums used, the types of goods purchased, experiences with failed home deliveries and reactions to them, and their views on the CDP system as a viable option for them. Key objectives of the survey were to find out whether the respondents regularly experienced failed home deliveries, whether they often travelled to depots to collect their experienced failed deliveries, and whether they would use a CDP as an alternative delivery address where deliveries could be re-directed in the event of a first-time delivery failure at the home.

The questionnaire was posted in September 2004 to 1600 people either working or living in Winchester. A total of 790 completed questionnaires were returned, giving a 49% response rate.

The questionnaire was printed out in A4 format, double sided and folded. There were two sections in the questionnaire (Appendix A). The first section gathered the information about householders' home shopping habits. Respondents were firstly asked the methods used either through Internet, telephone, interactive TV or mail order, and the frequency of such home shopping activities. Then the respondents were asked to provide the types of goods ordered from home through the various mechanisms mentioned. Respondents were also asked to provide the names of retailers and carriers who had made deliveries to them in the past year along with an estimate of the total number. Among those home deliveries, some of them might have failed. The respondents were asked to estimate the number of such failed deliveries, and provide their typical responses to retrieve the failed packages (arrange a re-delivery, have the package diverted to local post office, travel to depot, etc). If they were going to travel to the carrier's depot to collect their failed deliveries, they were asked to provide the transport mode adopted (car, bus, walking, cycling, van, train, etc). This was used to explore the road traffic generated by trips collecting failed home deliveries. Then the respondents were asked to fill in the carriers who had make deliveries to them in the past 12 months. This was used to identify the carrier's depot which was most frequently used by Winchester residents.

The second section collected the respondents' personal opinions on a new home delivery method, the CDP service provided by Collectpoint plc (now disbanded).

The Collectpoint company were previously involved in Business to Business (B to B) delivery, but were interested in initiating a Business to Consumer (B to C) service when MIRACLES projects were implemented in Winchester. An opportunity thus arose within MIRACLES for such a trial to take place as Hampshire County Council was interested in promoting it to see whether this measure would reduce the numbers of private vehicle trips associated with failed home deliveries. The concept of the scheme was to use local convenience stores to act as delivery points for carriers, re-directing failed deliveries to householders. A questionnaire was then sent out in September 2004 to 1600 households in Winchester, asking about home shopping activity, experiences of failed deliveries and attitudes to the Collectpoint scheme.

The respondents were firstly asked to indicate the most convenient collection time and location of using CDP (near home, near work, or another place). They were also asked the transport mode to CDP (car, bus, walking, cycling, van, train, etc). The reasons for not using CDP service were also needed from the respondents. At the end of section, the respondents were asked to provide their home/workplace postcodes in order to help quantify the travel distances to various carriers depots and combinations of CDPs. The householders were asked for their home and work postcodes which could be used in conjunction with route mapping software.

Respondents were also asked if they were willing to participant in a more detailed Collectpoint trial and 312 people expressed an interest. After the respondents willing to take the Collectpoint trial were identified, it was planned to offer a free trial of the Collectpoint service to Winchester residents. However, the B to C part of the Collectpoint company was disbanded before the trial could begin and so any further trials within MIRACLES had to be abandoned.

4.1.2. West Sussex survey (June 2006)

A 'home delivery' questionnaire was designed as part of this PhD research to aid West Sussex County Council's continuing work to develop sustainable travel solutions for people living and working in the county. The overall objective of this survey was to identify the problems householders currently experienced with home delivery services, especially failed home deliveries, and explore the potential for the new home delivery methods to improve the efficiency of urban freight delivery.

The respondents were selected randomly from a group of panel members who had agreed with West Sussex County Council to participate in various surveys over a period of time. The database of those panel members was administered by a consultancy, BMG Research, which worked in partnership with the Council on all residents' Panel Surveys. BMG Research was then responsible for survey distribution and collection. The questionnaire was posted in June 2006 to 1000 panel members and a total of 379 completed questionnaires were returned, giving a 38% response rate.

The questionnaire was printed out in A5 format, double sided and folded (Appendix B). It was composed of 4 sections with a total of 21 questions. Section A asked for demographic information about the householder. The respondents were asked first the number of males and females by age group within the household. The questions that followed inquired about the number of cars available, the type of house, occupations of the household members and Internet accessibility. These questions were very important as they provided information in terms of who the home delivery users were and what their home shopping habits were. The demographic information would be compared to Winchester sample households to see whether there were significant differences in two groups of sample households.

Section B collected information about the householder's current high-street shopping habits, frequency of high-street shopping trips for groceries and the names and locations of the supermarkets they frequently used. This was used to determine people's habitual shopping behaviour and see whether large supermarket/supermarkets featured as part of that habitual behaviour. If it proved to be true, those supermarkets could be modelled as CDP locations. The supermarket postcodes helped quantify the travel distances from home to supermarkets in conjunction with route mapping software.

Section C focused specifically on goods that were ordered from and delivered to home. Firstly respondents were asked their home shopping methods: either through Internet, telephone, interactive TV or mail order, and frequency of such home shopping experiences. It was followed by a question on the types of goods purchased from home. The respondents were asked to estimate the number of home deliveries received in the past year, the number of failed deliveries due to no-one being in the household at the time of delivery, their typical responses about how to retrieve the failed packages (travel to carrier's depot, arrange a re-delivery to home or local post office, etc). This was used to explore the road traffic generated by trips collecting failed home deliveries.

Section D asked for people's opinion on an alternative delivery service which would allow them to nominate local convenience stores, garages, post offices and secure 24-

hour locker banks as alternative delivery addresses, to be used in the event of deliveries being made to home address when no-one was in. The respondents were asked to select the most convenient locations for a CDP (convenience store, post office, petrol station, etc). They were also asked to indicate the most convenient collection time and location of using CDP (near home, near work, or another place). The question followed was the transport mode used to get to the CDP (car, bus, walking, cycling, van, train, etc). The reasons for not using CDP service were also needed from the respondents. At the end of section, the respondents were asked to provide their home/workplace postcodes and their wiliness to use CDP service.

4.2. Initial Findings from home delivery surveys in Winchester (September 2004) and West Sussex (June 2006)

In this section, the common questions between those two surveys are analyzed in details and results compared to each other.

4.2.1. Respondents' demographic data

In the Winchester survey, the household demographic information was collected through other surveys within the MIRACLES programme that used the shared household database. Consequently, it was not included in the latter 'home delivery' questionnaire. In the questionnaire, three types of demographic questions were proposed: number of cars available for household use, type of house, and number and age of household members. Overall, the sample households were above the national average in terms of affluence. A large proportion of the respondents (81%) owned their own property compared to 70% nationally (National Statistics, 2005) while around 90% of households had at least one car (compared to 73% nationally).

From the samples in the West Sussex survey, 44% lived in detached houses, while 26% lived in semi-detached houses, perhaps indicating the affluent nature of the respondents. 89% of households had at least one car. Overall, the sample households were above the national average in terms of affluence.

Each demographic question in both home delivery surveys is described below.

4.2.1.1. Number of persons/household

Both questionnaires asked for the number of people living in each household and their ages. A frequency plot of the number of householders in Winchester and West Sussex is presented in Figure 20. It indicated that among the Winchester sample households, 44% were made up of two-person households. The average number of persons per household was 2.3. This was the same as the results from the General Household Survey 2005 (National Statistics, 2006). Forty eight percent of the West Sussex sample households were made up of two-person households. The average number of persons per household was 2.3.

To simplify the problem, the households were categorized as 'families' (those households which contained at least one individual between the ages of 0 and 16), 'elderly' (households containing at least one person over the age of 64 and no one under the age of 21) and 'professionals' (those households which didn't meet the 'elderly' or 'family' definitions) households. It was found that the sample households in Winchester were composed of 27% 'families', 50% 'professional' and 23% 'elderly'. The sample households in West Sussex were made up of 15% 'families', 46% 'professional' and 39% 'elderly' households.

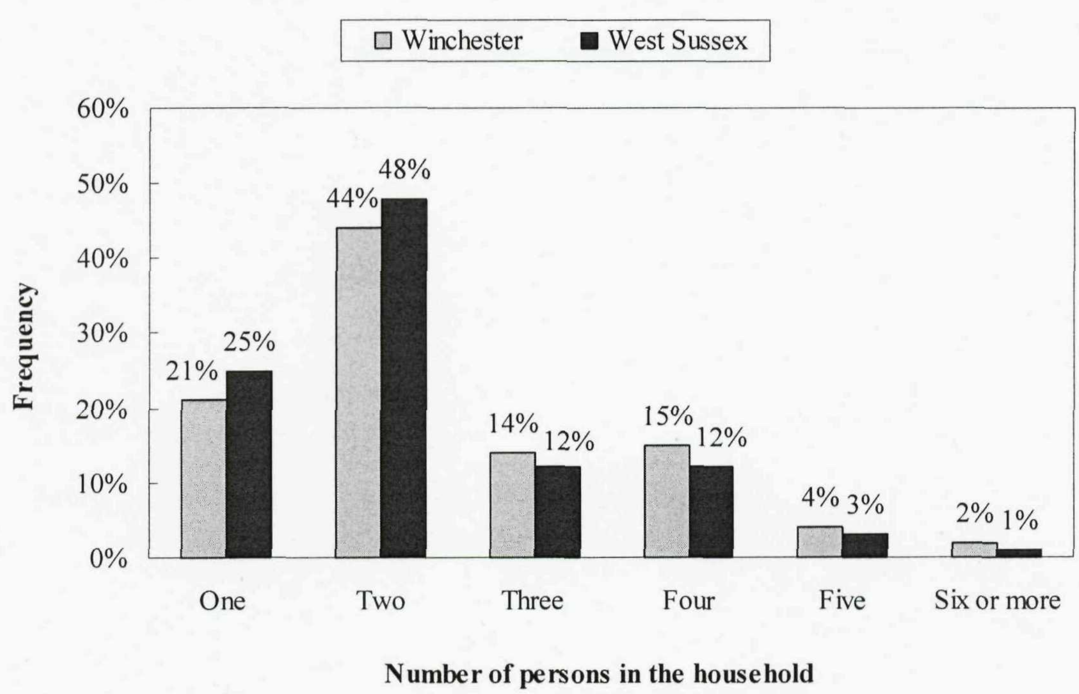


Figure 20 Number of persons per household amongst the Winchester and West Sussex panel members

To explore whether there were significant differences in household types among the Winchester and West Sussex sample households, a 3 by 2 homogeneity Chi-square test was undertaken. The Chi-square statistic is a nonparametric statistical technique used to determine if a distribution of observed frequencies differs from the theoretical expected frequencies. Chi-square statistics use frequencies of categorical or ordinal level data, rather than using means and variances. The results showed that there were significantly more elderly households responding to the survey among the West Sussex sample households than Winchester ($\chi^2 = 111.28$ and χ^2 (0.05), 2df = 6.28). Thus they might have different attitudes towards home delivery.

4.2.1.2. Car ownership

In terms of car ownership levels, around 90% of households in Winchester and 88% in West Sussex had at least one car available regularly available for their use (Table 11).

Table 11 Number of cars available for households in Winchester and West Sussex

No. of cars	None	One	Two	Three or more
Winchester	10%	48%	35%	7%
West Sussex	12%	50%	31%	7%

In terms of car ownership levels, both the Winchester and West Sussex sample households were above average in terms of car ownership. Nationally 73% of households have at least one car available for use in 2005 (National Statistics, 2005). The number of cars per household might influence their transport mode choices in relation to home shopping activities. This will be discussed later. To explore whether there were significant differences in car ownership among the Winchester and West Sussex sample households, a 4 by 2 homogeneity Chi-square test was undertaken and no significant differences were found ($\chi^2 = 1.84$ and χ^2 (0.05), 3df = 7.82).

4.2.1.3. House type

A frequency plot of home ownership or rental among Winchester sample (Figure 21) showed that over 80% of the sample households owned their own home, compared to 70% nationally (National Statistics, 2005). Neighborhood Statistics suggest that 79% of overall Winchester households own their home (National Statistics, 2005). Hence, the MIRACLES sample was representative of the general population in Winchester, but more affluent than the national level, in terms of home ownership.

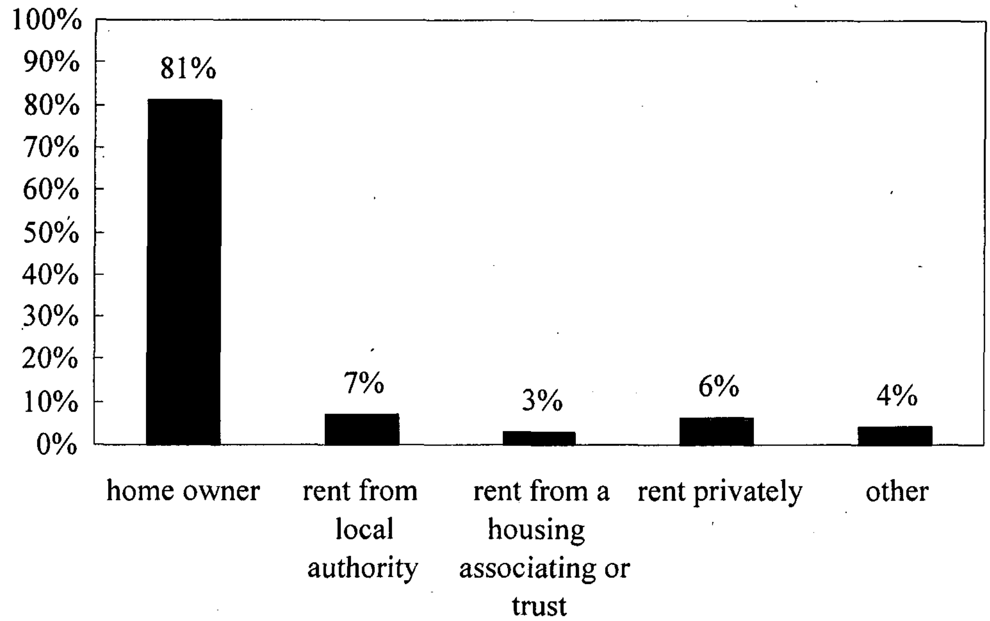


Figure 21 Housing status of Winchester panel members

From the West Sussex survey (Figure 22), it was found that 44% lived in detached houses, while 26% lived in semi-detached houses, perhaps indicating the affluent nature of the respondents. 19% lived in terraced houses while 10% lived in flats. It suggested that the sample households in West Sussex were above the national average in terms of housing , since 22% of national dwelling was detached house, with 33% of housing stock being semi-detached (UK Housing Statistics 2006). Therefore they might have different attitudes towards home delivery.

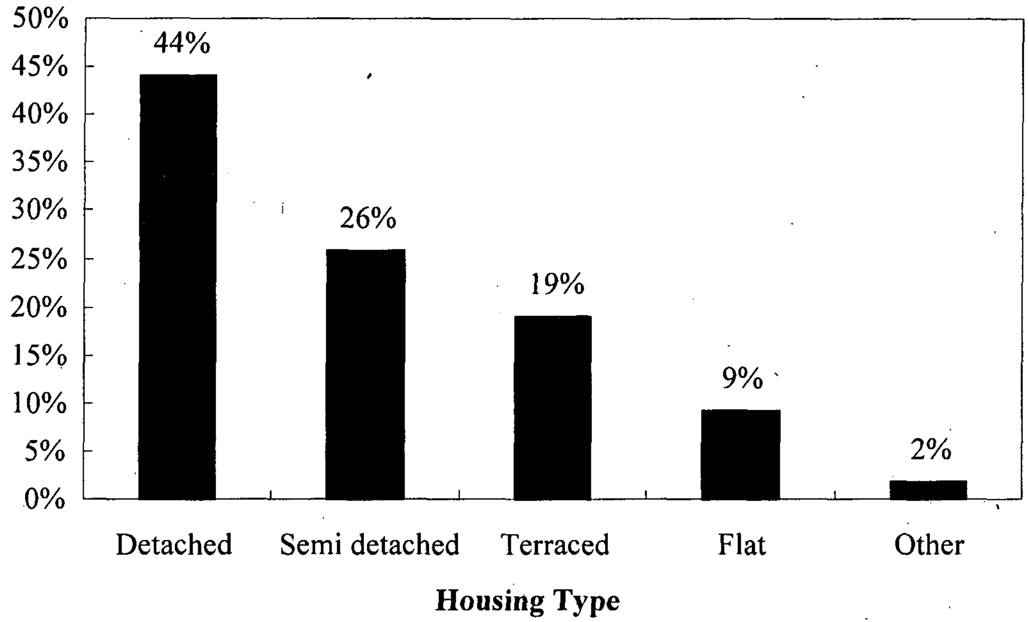


Figure 22 Housing status of West Sussex panel members

4.2.2. Home shopping methods

The home shopping methods suggested in both surveys were by Internet, either at home or at work, by phone, by mail order or by interactive television. The frequencies of using those home shopping methods were categorized as never, rarely (1-2 times a year), occasionally (3 to 11 times a year), frequently (1-2 times a month), and very frequently (once a week or more often). Frequency plots of home shopping methods of Winchester and West Sussex panel members are presented in Figure 23.

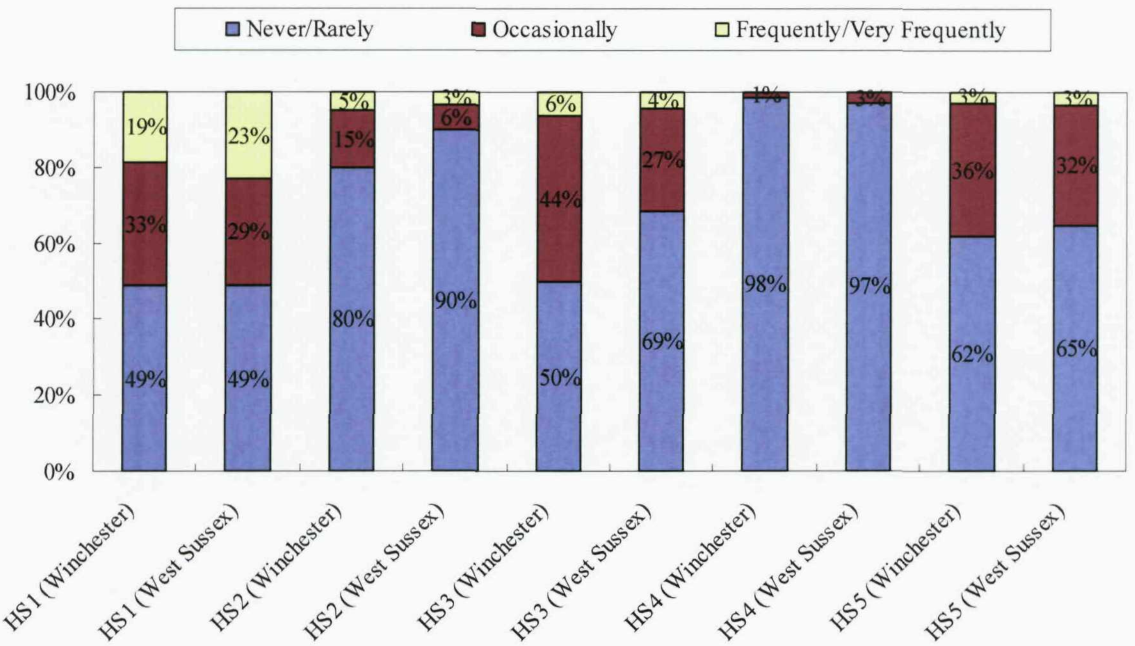


Figure 23 Home shopping methods adopted by the Winchester and West Sussex panel members ([2])

It was assumed that 0, 1.5, 7, 18 and 48 home shopping transactions resulted from those respondents selecting the never, rarely, occasionally, frequently and very frequently categories for using those home shopping methods. Descriptive statistics of survey data (Figure 23) indicated that in Winchester, the average household placed 9.6 orders through Internet shopping (N=702), 4.6 orders through telephone (N=743), 0.2 orders through interactive TV (N=630) and 3.7 orders through mail order (N=690). It can be seen that most home shopping was generated through the use of the Internet, followed by ordering by telephone then by mail order. Ordering by interactive TV was hardly ever used. In West Sussex, the average household placed 9.0 orders through Internet shopping (N=333), 3.2 orders through telephone (N=338), 0.3 orders through interactive TV (N=324) and 3.6 orders through mail order (N=337). The most frequently used method of home shopping was through Internet, followed by mail order and then telephone.

Both surveys suggested that most of home shopping transactions were generated either through Internet, mail order or telephone. These findings provided some indication of

[2] HS1 represents shopping method via the Internet from home; HS2 for shopping via the Internet from work; HS3 for telephoning an order to a retailer; HS4 for shopping via interactive television; HS5 for sending an order by post.

current trends of home shopping methods. There has been a very rapid growth in the Internet retailing, compared with other home shopping channels (catalogue shopping, TV shopping, telephone shopping, etc). Mintel (2003) cited the data from a nationally representative sample of 1476 adults (over 15 years old), where the proportion of respondents having bought goods from the Internet increased from less than 10% in 2000 to 25% in 2003. A more moderate increase in percentage share of home shopping market by Internet was recommended by Verdict (2004), from 1.3% in 2000 to 14% in 2003. Based on 304 responses from 10500, a home delivery survey undertaken by Peter Brett Associates for Transport for London (2006) indicated that the Internet was used most frequently (36%) when respondents were ordering goods. This was closely followed by the telephone (26%). Ordering by post, in a shop, or by agency or catalogue was used on average by 9% of respondents in each of these categories. Current trends also indicated that the mail order industry has been experiencing a rapid decline. Verdict (2004) presented the declining market share of home shopping mail order, from 37% in 1998 to 27% in 2003.

The frequency of home shopping transactions and the mediums used were collected from both surveys (Table 12).

Table 12 Frequency of home shopping transactions and media used from the West Sussex and Winchester surveys

Shop via the Internet from a computer at home						
Town	Never	Rarely	Occasionally	Frequently	Very frequently	Sum
West Sussex	124 (40%)	30 (10%)	89 (29%)	53 (17%)	16 (5%)	312
Winchester	242 (33%)	118 (16%)	241 (33%)	110 (15%)	28 (4%)	739
SUM	366	148	330	163	44	1051
Shop via the Internet from a computer at work						
West Sussex	261 (83%)	24 (8%)	20 (6%)	11 (3%)	0 (0%)	316
Winchester	450 (67%)	83 (12%)	102 (15%)	27 (4%)	5 (1%)	667
SUM	711	107	122	38	5	983
Shop through telephoning an order to a retailer						
West Sussex	132 (39%)	100 (30%)	92 (27%)	13 (4%)	1 (0%)	338
Winchester	127 (17%)	248 (33%)	327 (44%)	43 (6%)	5 (1%)	750
SUM	259	348	419	56	6	1088
Shop through interactive television						
West Sussex	306 (94%)	8 (3%)	10 (3%)	0	0	324
Winchester	639 (97%)	13 (2%)	9 (1%)	0	1 (0%)	662
SUM	945	21	19	0	1	986
Shop by sending an order form by post						
West Sussex	89 (26%)	129 (38%)	108 (32%)	9 (3%)	2 (1%)	337
Winchester	142 (19%)	307 (42%)	260 (36%)	19 (3%)	1 (0%)	729
SUM	231	436	368	28	3	1066

It was assumed that people did home shopping 0, 1.5, 7, 18 and 48 times a year by those respondents selecting never, rarely, occasionally, frequently and very frequently categories respectively. Thus it was calculated that average household in Winchester would receive 17 home shopping orders per year. It confirms the findings from West Sussex survey (16 orders per household a year). Most home shopping was generated through using the Internet at home, followed by ordering by phone then by mail order.

To explore whether there were significant differences in home shopping frequencies between two areas, a 5 by 2 homogeneity Chi-square test was conducted for each category of shopping media used across the Winchester and West Sussex samples. The results showed there were no significant differences in the Internet shopping frequencies between the two samples ($\chi 2$ =2.41 and $\chi 2$ (0.05)4df = 9.49), at the 95% significance level. The similar results were found for the shopping frequencies through interactive TV ($\chi 2$ =3.92 and $\chi 2$ (0.05)4df = 9.49) and sending an order form by post ($\chi 2$ =1.44 and $\chi 2$ (0.05)4df = 9.49). However, the results showed that there were significantly more households in Winchester involved in home shopping through telephoning an order to a retailer ($\chi 2$ =17.52 and $\chi 2$ (0.05)4df = 9.49) or through the Internet from a computer at work ($\chi 2$ =32.83 and $\chi 2$ (0.05)4df = 9.49). People's preferences on home shopping methods might be affected by the households' demographic information, which will be discussed in Section 4.4.

4.2.3. Types of goods purchased through home shopping

The respondents were asked to state the types of goods purchased through various home shopping methods mentioned (Figure 24). The most frequently purchased goods from home by the Winchester sample were small items, e.g. food and groceries, music CDs, books, flowers, clothes, electronic equipment, tickets for events and travel/accommodation.

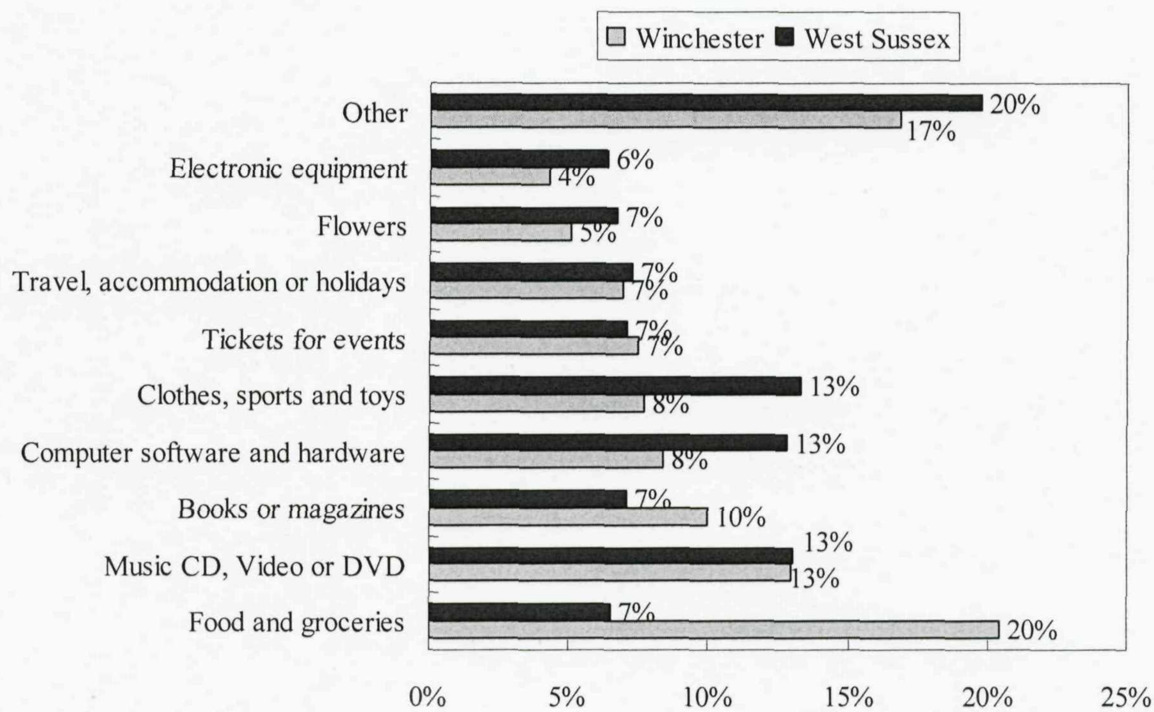


Figure 24 Types of goods purchased through home shopping from Winchester and West Sussex surveys

From the West Sussex survey, it was found that travel and accommodation, clothes, sports and toys, tickets for events and books/magazines were the most common items purchased from the home by various home shopping mediums.

Some of the findings confirm previous literature. Verdict (2004) produced a market report regarding the home shopping market. It was found that books and videos, health and beauty, clothing and DIY products had the highest home shopping frequency. Based on a survey of 2000 consumers, their motivations for using home delivery and their expectations of home delivery services were explored. The annual number of home shopping transactions for each product category was estimated as 6.4 (books and videos), 6.4 (health and beauty), 4.7 (clothing and DIY). Xing (2005) found that books and CDs were the most frequently purchased products from home shopping, followed by computer products, electronic products and photographic products. With 235 responses from 1000 overall, the annual number of products purchased through the Internet was estimated as 5.6 (books and CDs), 2.5 (computer products), 1.9 (electronic products) and 1.1 (photographic products). Based on 304 responses from 10500, a home delivery survey undertaken by Peter Brett Associates for Transport for London (2006) suggested that food, books and clothing were the most frequently ordered items from home (15%), with DVDs/CDs (11%) and holiday tickets (10%) also being popular purchases.

4.2.4. Number of home deliveries received

The respondents were asked to estimate how many annual deliveries were made as a result of goods ordered from their home by members of their household. Home delivery applied to packages that couldn't fit through the letter box or required a customer signature. There are several issues here which could affect the accuracy of the responses, notably whether the household member completing the questionnaire accurately recalls all the home delivery transactions undertaken by the other members of the household over a lengthy period of time. It was not considered realistic to ask the respondents to provide a figure, hence frequency categories were provided, e.g. 1 to 2 deliveries a year, 3 to 11 deliveries a year (Figure 25 and 26).

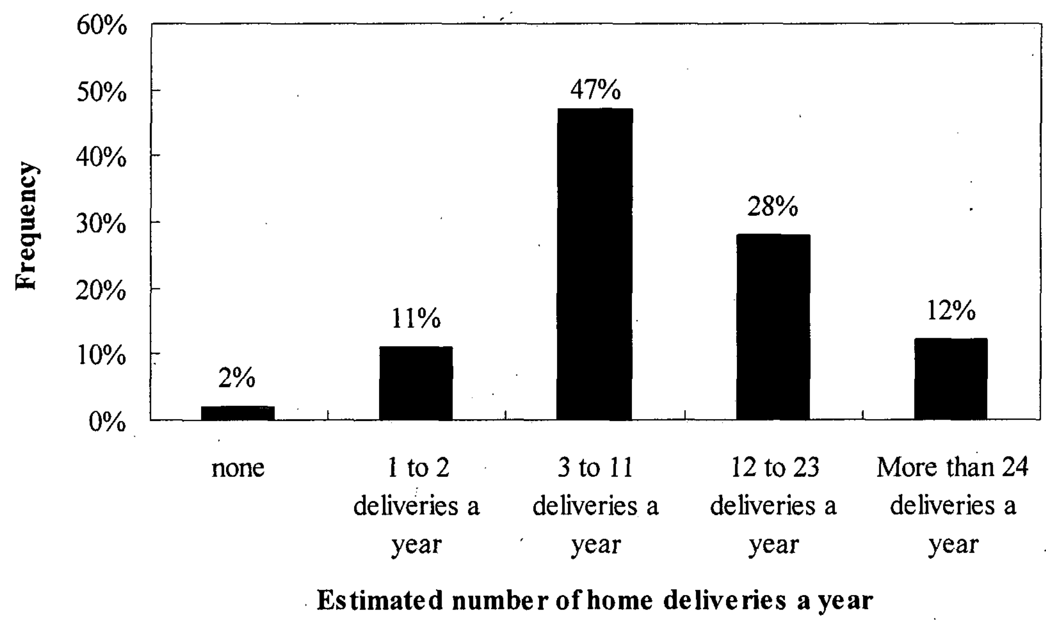


Figure 25 Estimated numbers of annual deliveries of goods ordered by the Winchester household members from home

The Winchester results (Figure 25) suggested that 28% of the householders typically received between 12-23 home deliveries over a year while 47% of them received somewhere between 3 and 11 home deliveries a year. From those responses it was possible to estimate the average number of annual home deliveries received by a household. It was assumed that 0, 1.5, 7, 18 and 48 deliveries were received by those respondents selecting the none, 1-2, 3-11, 12-24 and >24 deliveries per year categories respectively. The results indicated that the average household received 14 home deliveries annually.

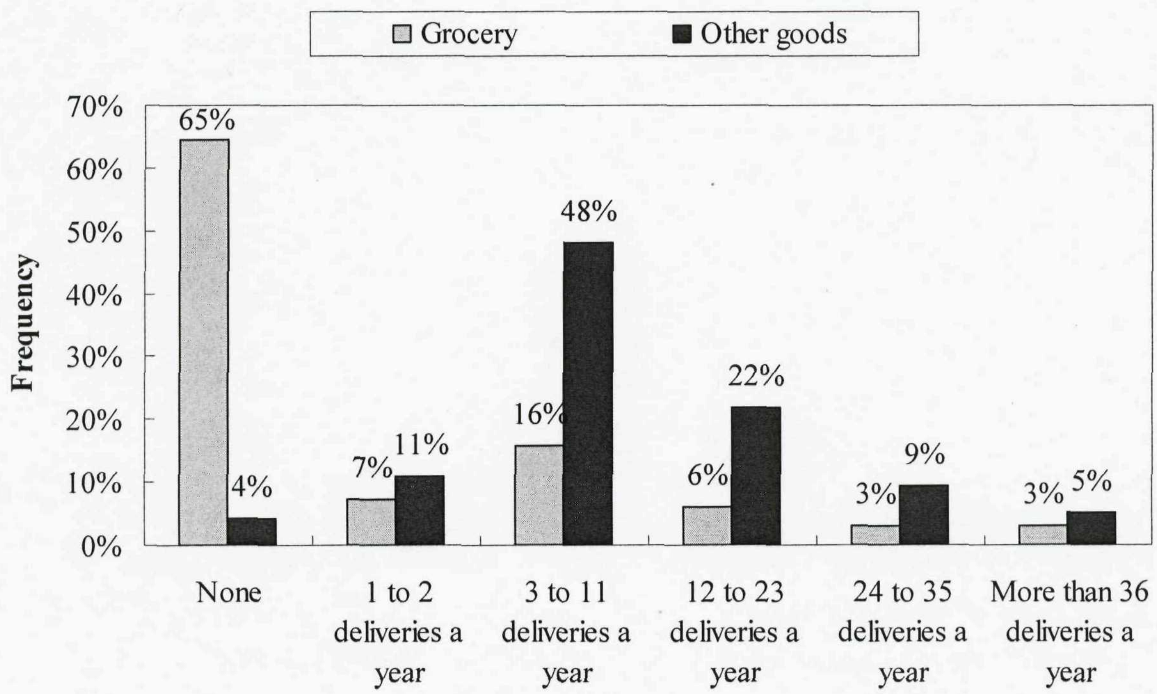


Figure 26 Estimated numbers of annual deliveries of goods ordered by the West Sussex household members from home

The West Sussex results (Figure 26) suggest that 16% and 48% of the households typically received somewhere between 3 and 11 home deliveries for groceries and other types of goods, respectively per year. From these responses it was possible to estimate the average number of annual home deliveries received by a household. The same methodology was repeated here as in the Winchester study. The results indicated that the average household would receive between 5 and 15 deliveries per year for grocery and other type of goods, respectively (excluding postal deliveries).

A considerable amount of annual home deliveries took place, with 14 and 20 being delivered to the average household in Winchester and West Sussex on average. This is less than the estimate of 22 deliveries per year suggested by Foley *et al.*, (2003) but nearer to the DTI (2001) figure of 16 deliveries per year. The number of home deliveries received per year in both surveys is shown in Table 13.

Table 13 Number of home deliveries received per year in the Winchester and West Sussex surveys

Number of home deliveries	Winchester	West Sussex
None	16 (2%)	197 (34%)
1 to 2 deliveries a year	82 (11%)	54 (9%)
3 to 11 deliveries a year	354 (47%)	190 (32%)
12 to 23 deliveries a year	211 (28%)	83 (14%)
More than 24 deliveries a year	92 (12%)	62 (11%)

4.2.5. Number of failed home deliveries

There are a number of social and economic factors leading to homes being empty for longer periods than they used to be. These include flexible working patterns, increases in female employment levels, people spending more of their free time away from their home and the growth in single-person households in the UK. This could result in the proportion of failed home deliveries being high even though the delivery day and time were agreed with the customer prior to delivery.

The respondents were asked to estimate how many home deliveries arrived when no-one was in to receive them. In the questionnaire, several frequency categories were provided, e.g. none, few (around 1 in 8 deliveries), some (around 1 in 4 deliveries), many (around 3 in 8 deliveries) and most (more than half of the deliveries) (Figure 27).

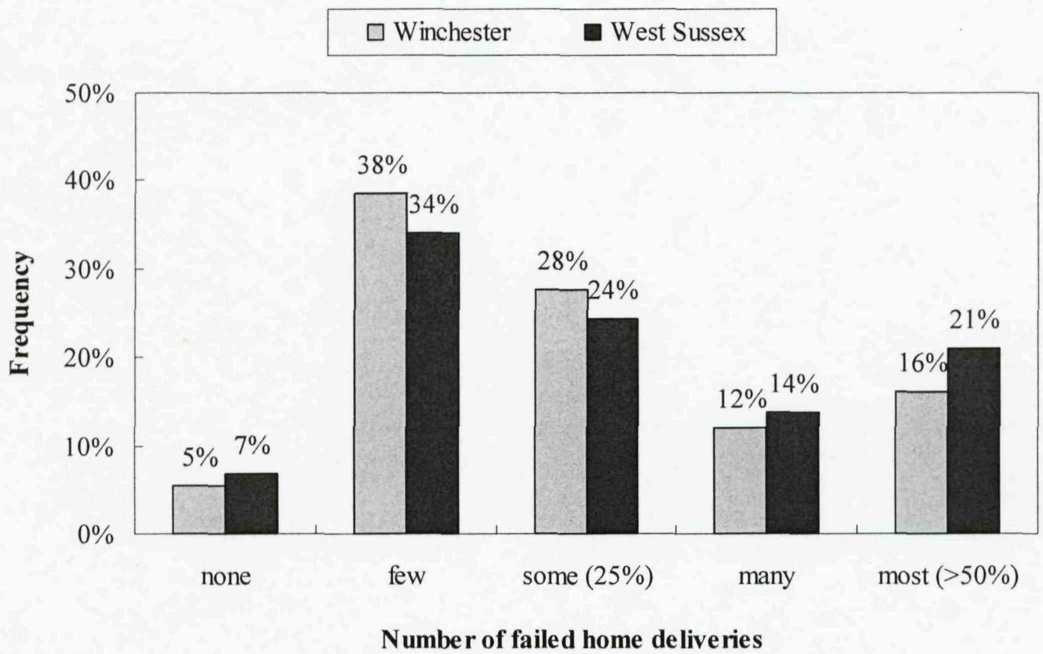


Figure 27 Respondent's estimates of the proportion of failed first-time home deliveries from the Winchester and West Sussex sample households

The Winchester results suggested that 12% of the respondents experienced a 25% or greater first-time delivery failure rate. At the same time, 16% claimed that they more than half of their deliveries failed the first-time because the house was empty during the working day. It was assumed that 0, 12.5%, 25%, 37.5% and 50% of deliveries failed related to the no-one, few, some, many and most of deliveries per year categories respectively. The results indicated that the average proportion of failed first-time deliveries was 24%.

The West Sussex results suggested that 60% of respondents experienced a 25% or greater first-time delivery failure rate, with 21% claiming that more than half of their home deliveries failed because the house was empty during the working day. Using the same methodology as in Winchester study, it was estimated that the average household had 26% of failed first-time home deliveries.

From previous research, the estimates of delivery failure rates have varied widely, from 12% (IMRG, 2006b) to 60% (Department of Trade and Industry, 2000). Research carried about for Transport for London (2006) suggested that 92% of respondents claimed that they have experienced failed home deliveries. Approximately 100 respondents stated that between 1 and 3 of their home deliveries failed on the first attempt in the last six months, with 40 respondents claiming to have failed deliveries of around 4 to 6. It was estimated that average household would have 7 failed home deliveries a year. The number of failed home deliveries in the past year in both surveys is presented in Table 14.

Table 14 Estimated number of failed home deliveries in the Winchester and West Sussex surveys

No. of failed deliveries	Winchester	West Sussex
none	41 (5%)	22 (7%)
few	289 (38%)	109 (34%)
some (25%)	208 (28%)	78 (24%)
many	91 (12%)	44 (14%)
most (>50%)	122 (16%)	67 (21%)
	751	**320**

To explore whether there were significant differences in people's experiences of home delivery failures among the Winchester and West Sussex sample households, a 5 by 2 homogeneity Chi-square test was undertaken and showed that there were no significant differences between the respondents from the two areas in the estimated number of failed home deliveries ($\chi 2$ =6.15 and $\chi 2$ (0.05) 4df = 9.49). It was then assumed that the experiences of those two population samples of home delivery failures were similar.

4.2.6. Typical responses to failed home deliveries

The respondents were asked what their typical responses were to failed home deliveries and the frequency of such responses. The following options were provided in the questionnaire:

- The householder contacts the carrier and arranges an alternative delivery time/day to the home address.
- The householder contacts the carrier and arranges an alternative delivery time/day to a work/alternative address.

- The householder contacts the carrier and has the package delivered to a local post office.
- A member of the household travels to the carrier's depot to collect the package.

People's responses to a failed home delivery in both surveys were summarized in Table 15.

Table 15 Responses to a failed home delivery from the West Sussex and Winchester surveys

Arrange a redelivery to home address						
Town	Never	Rarely	Occasionally	Frequently	Very frequently	Sum
West Sussex	35 (14%)	111 (44%)	101 (38%)	7 (3%)	2 (1%)	256
Winchester	164 (24%)	317 (47%)	186 (27%)	13 (2%)	1 (0)	681
SUM	199	428	287	20	3	937
Arranged alternative delivery to work or other address						
West Sussex	128 (63%)	40 (20%)	28 (14%)	5 (3%)	1 (1%)	202
Winchester	427 (69%))	125 (20%)	60 (10%)	6 (1%)	0 (0)	618
SUM	555	165	88	11	1	820
Arranged delivery to a local post office						
West Sussex	143 (75%)	34 (17%)	13 (7%)	2 (1%)	0 (0)	192
Winchester	516 (85%)	64 (11%)	24 (4%)	2 (0)	0 (0)	606
SUM	659	98	37	4	0	798
Travelled to carrier's depot to collect						
West Sussex	82 (38%)	77 (36%)	44 (21%)	9 (4%)	2 (1%)	214
Winchester	216 (31%)	243 (35%)	191 (28%)	38 (6%)	1 (0)	689
SUM	298	320	235	47	3	903

The Winchester results (Table 15) showed that the most common options used were either to arrange for an alternative delivery to the home (which had been taken by 27% of households between 3 and 11 times over the past year) or to travel to the carrier's depot to collect the goods (which 28% of households had undertaken between 3 and 11 times over the past year). Few households had arranged re-delivery to another address or used Royal Mail's 'Local Collect' service, had goods re-directed to a local post office.

Similar results were found from the West Sussex survey (Table 15). The most common options used were either to arrange for an alternative delivery to the household (which 38% of households had undertaken between 3 and 11 times over the past year) or to travel to the carrier's depot to collect the goods (which had been undertaken by 21% of households between 3 and 11 times over the past year). The least common options were either to arrange redelivery with their carrier to another address or to use the Royal Mail's 'Local Collect' service to re-directed items to a local post office.

To explore whether there were significant differences in people's reactions to the delivery failures among the Winchester and West Sussex sample households, a 5 by 2 homogeneity Chi-square test was conducted for each category of response to a failed home delivery. It was found that there were no significant differences between the respondents from the two areas in the frequencies of travelling to carrier's depot to collect the failed package ($\chi 2$ =7.35 and $\chi 2$ (0.05)4df = 9.49). However, the results showed that the West Sussex sample had arranged significantly more re-delivery attempts to home ($\chi 2$ =21.80 and $\chi 2$ (0.05)4df = 9.49) or to a local post office ($\chi 2$ =12.04 and $\chi 2$ (0.05)4df = 9.49) than the Winchester sample. The differences in two survey results might be due to the demographic characteristics of sample households, which will be discussed in Section 4.4.

Since the road traffic to and from the carrier's depot will affect the estimate of reductions on customers' trips by using the CDP method, it is then necessary to derive the proportion of customers choosing to drive to the carrier's depot to collect their goods. Again, it was assumed that people responded to failed home deliveries through the methods indicated (Table 15) by 0, 1.5, 7, 18 and 48 times a year by those respondents selecting never, rarely, occasionally, frequently and very frequently categories respectively. This suggested that 44 percent of Winchester respondents would travel to carrier's depot while 50 percent arranging a re-delivery to home or workplace and 6 percent arranging a re-delivery to post office. With the same methodology repeated West Sussex study, it was found that 31 percent of West Sussex respondents would choose to travel to the carrier's depot, with 62 percent arranging a re-delivery either to home or to workplace, and 7 percent arranging a re-delivery to post office.

When asked about the frequency of trips to collect packages from a carrier's depot, the responses indicated that such trips were made frequently (once a month or more: 5% of responses), occasionally (3-11 times a year: 25% of responses), rarely (1-2 times a year: 35% of responses) or never (35%).

People were also asked how they would travel to the local carrier's depot and most of the respondents (87%) stated that they would travel by car, 6% would walk, 5% would use the bus and 2% would cycle.

4.2.7. Householder's attitude towards the CDP concept

The respondents were generally positive towards using a local CDP solution if one was located near to their home or place of work, with 83% in Winchester and 79% in West Sussex saying that they would consider using it.

According to the results from the Royal Mail CDP trial (Department for Transport, 2004) in Nottingham from February 2003 to October 2003, around 80% of 2000 respondents would consider using the CDP service. Seventy eight percent of customers felt it was more convenient than collecting from the nearest Royal Mail sorting office. The trial was launched in two postcode areas of Nottingham (NG5 and NG9), and covered all the parcels that wouldn't fit through the letter box or require customer's signature. The aim was to provide the home delivery options to those who were not at home to receive deliveries during the day and evaluate the environmental impacts of such options (CDP using local post offices or Locker-bank, collection from Royal Mail sorting offices).

The most frequently mentioned concerns, particularly from those people who said they would not use the scheme were: security of the package at the CDP, difficulty in collecting large or heavy parcels, additional costs to the customer.

4.2.7.1. Locations of CDP

Given five potential options for a CDP location (convenience store, petrol station, post office, 24-hour locker bank, other), the respondents were asked to rank the most convenient location (Figure 28). The results showed that 46% would nominate their local post office as the most convenient CDP location with a second choice of a local convenience store (30%).

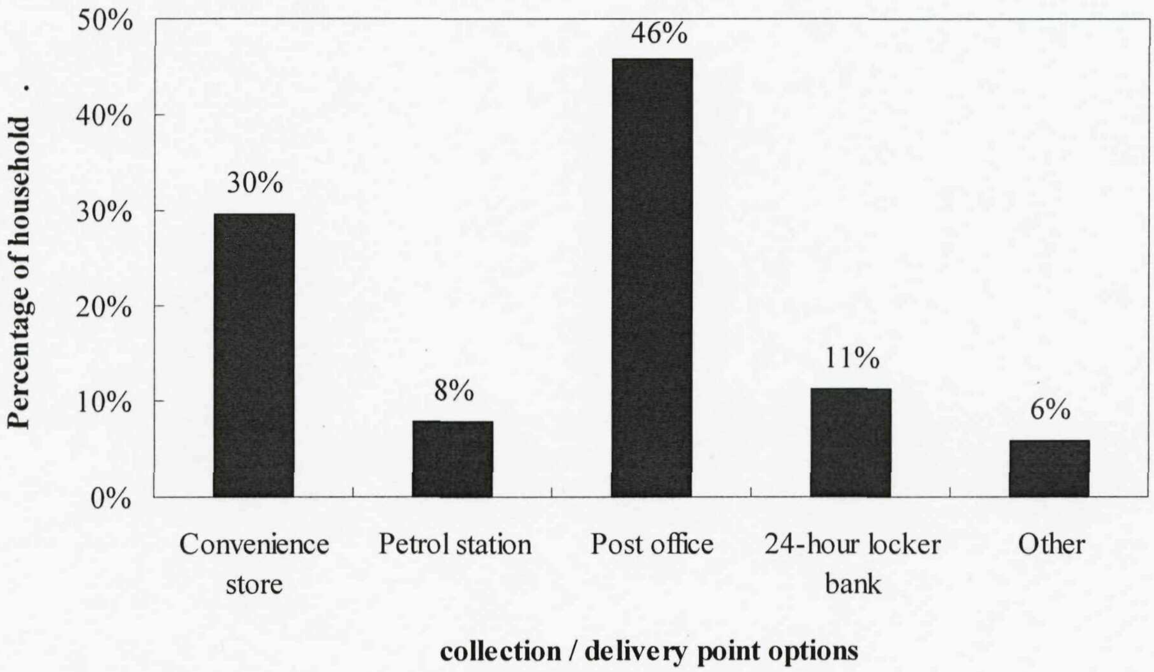


Figure 28 Respondent's preferred CDP locations

This was backed up by the results from Royal Mail trial (Department for Transport, 2004) where 58% of 2000 respondents specified their local post office branch as their preferred redelivery location, followed by the option of Royal Mail sorting office (25%), locker-bank (12%), and a neighbour (6%). Other options included supermarkets, railway stations, car parks, petrol stations, local convenience stores, hospital, and council office. Among those respondents willing to use the post office branch as the CDP, 44% had changed from using a car, motorcycle or bus to get to the Royal Mail sorting office to travelling on foot or by bicycle to their local post office. The overall results from the trial suggested that 55% of respondents walked to the CDP with 75% driving to the Royal Mail sorting office.

The respondents were also asked what mode of transport they were more likely to use to collect packages from their local CDP (Figure 29). The fact that 48% of the Winchester sample households would consider walking to collect their packages with 43% choosing to travel by car, 5% by cycle and 4% by bus was of particular interest. The West Sussex survey suggested that 40% of respondents would consider walking to collect their packages with 48% choosing to travel by car, 6% cycling and 4% using the bus. The results indicated that walking could be a serious option for small package collection from a local CDP in both areas.

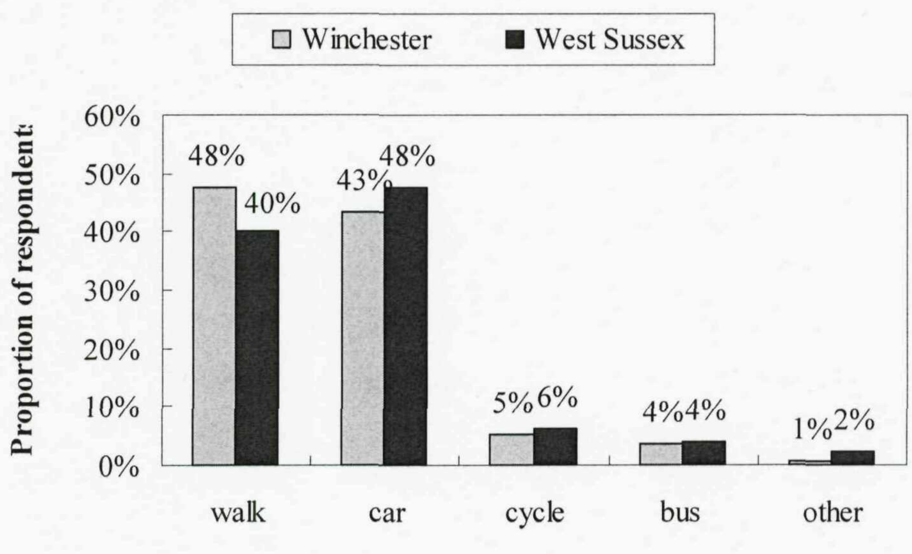


Figure 29 Respondents' transport mode choices to collect failed deliveries from their local CDP

To explore whether there were significant differences in people's mode choices of travelling to the CDP among the Winchester and West Sussex sample households, a 5 by 2 homogeneity Chi-square test was undertaken and showed that there were no significant differences between the two areas in the proportions of householders travelling to their local CDP by car, foot, bus, bicycle and other transport modes ($\chi2$ =5.74 and $\chi2$ (0.05)4df = 9.49). Hence it was assumed that the transport mode choices to CDPs of those two population samples were similar.

4.2.7.2. Preferred collection days/times from CDPs

The respondents were asked the most convenient CDP location among three options (CDP near home, CDP near work, CDP at an alternative location), and their preferred collection days/times (Figure 30).

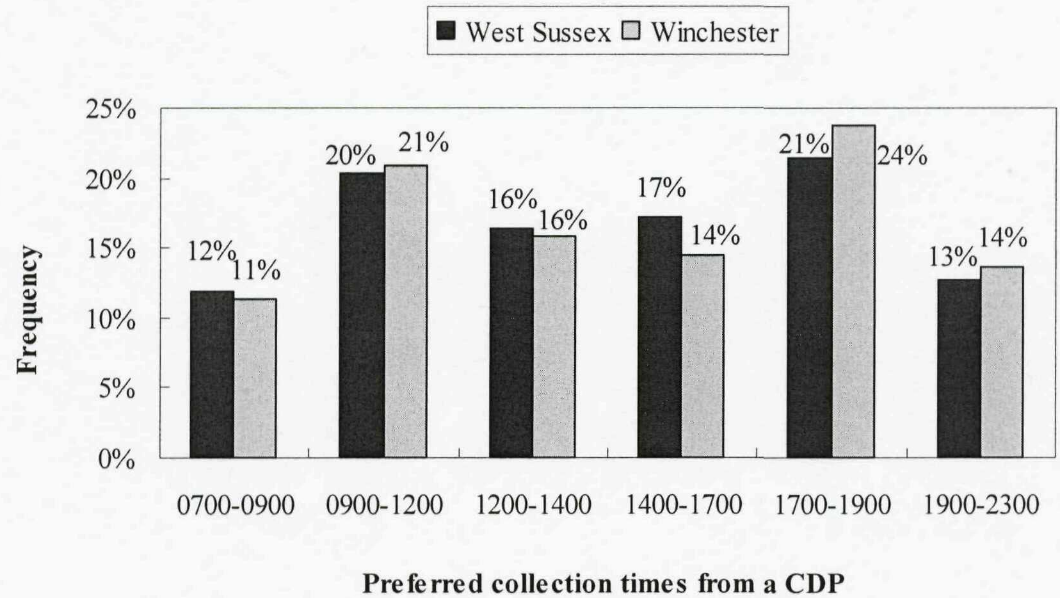


Figure 30 Respondents preferred collection time from a CDP based on the Winchester and West Sussex surveys

The Winchester sample suggested that 76% of householders would collect the failed deliveries from a CDP located near their home on a workday. In terms of preferred collection times, only 11% of the respondents would choose to collect a package between 07:00 and 09:00 implying that few collections would be made as part of the home-to-work commute. Respondents seemed more receptive to the concept of collecting packages from their local CDP after working hours (between 17:00 and 19:00) with 24% indicating that this would be the most convenient time. It was followed by the option of collection between 09:00 and 12:00 (21%), and 19:00-23:00 (14%). It was noted that collection out of working hours would impose problems as the post office network currently operates between 09:00 and 17:30. Convenience store attended CDP concepts (attempted by Kiala, http://www.kiala.com) or unattended locker bank concepts (e.g. http://www.bybox.com) appear to be the most flexible options.

Similar results were found from the West Sussex survey, with 74% of householders claiming to collect their failed home deliveries from a CDP near to their home on a workday. As shown in Figure 30, the top 3 options for collection time were between 17:00 and 19:00 (22%), 09:00 12:00 (20%) and 14:00-17:00 (17%).

4.2.7.3. Reasons for not using CDP services

21% of respondents stated that they would not consider using a CDP as an alternative delivery address in the event of not being at home when a carrier arrived to deliver a package. The most frequently mentioned concerns about such a system were:

- Security of the package at the CDP.

Although some of the CDP systems have been established and made some progress (for example, Kiala and PackStation), customers' experiences of most of them are still very limited. With the rapid developments of home delivery market, security issues of the CDP have gained much public attention (McKinnon, 2003). Two measures were suggested to improve the security issue. One was that government agencies should be working with trade bodies and industry groups to provide guidance to companies involved in home delivery operations on security standards. Another suggestion was to promote new technology to increase the delivery security, for example: automated storage and controlled access to the CDP using customer smart tagging, full CCTV coverage, electronic scanning of the products (McKinnon and Tallam, 2003).

However, tightening the security standards would inevitably reduce the convenience of using CDP service. As the market is customer-driven instead of security-driven, there would be trade-offs between security and convenience.

- Difficulty in collecting large or heavy parcels.

This point was often raised by elderly people. Home shopping potentially improves the access to products and services for the elderly, disabled and people in geographically remote areas. Consequently, the CDP service, as one component of home shopping and home delivery channel, could be tailored to meet the needs of those individuals. For example, local authorities could consider tailoring the CDP service to be part of the range of options that they can offer to the people with problems accessing CDPs as the social service. One of the first examples of a grocery home shopping service was provided by Tesco for elderly people in Gateshead in the North East of England since 1981, with the collaboration of Gateshead Council (McKinnon, 2003).

Despite this, elderly people may remain relatively disconnected from new technologies. For instance, Xing (2006) carried out a home delivery survey among 1000 residents in Edinburgh in May 2005, with 235 responses. Of all the respondents who had shopped online before, the 40-54 and 25-39 age groups accounted for 72% altogether. The 55-65 age group and young people aged between 16 and 24 represented 11% each, followed by the older people over 65 (6%). Consequently, it is reasonable to estimate that elderly people would be a small population segment of CDP users.

It is also worth mentioning that currently a CDP system is only suitable for handling small packages. It is not suitable to store large items and groceries due to the space limits of the average CDP and special requirements of groceries (Cairns, 2004). Hence, the problems of collecting large and heavy items from CDP would not be raised frequently.

- The CDP concept might involve additional cost to the customer.

In a home delivery survey undertaken in the borough of London by Peter Brett Associates on behalf for Transport for London in 2005, people were asked about how much they might be willing to pay for CDP services. Fifty five percent of 10,500 respondents thought that such services should be offered for free, 29% of them were prepared to pay £1 or £2 for most options.

In the Royal Mail CDP practice trial undertaken in Nottingham from February 2003 to October 2003, delivery to any post office with 'Local Collect' service was offered to customers at a cost of 25p.

Since customers are not expected to pay more, some existing CDP service is currently provided at a fairly low price. For example, the DHL PACKSTATION service is free for registered customers and Kiala charges around £2 per customer to use its service. Hence, the prices for current CDP service to the customers should be acceptable.

4.3. General shopping habits

Because this research set out to identify the possible public sites to be used as CDPs, householders' current grocery shopping habits were needed to determine their habitual shopping behaviour and see whether large supermarket/supermarkets featured as part of that habitual behaviour. If the householders visited them fairly regularly, there was then a scope for potentially using those points as CDPs. Consequently, one more section about people's current shopping characteristics was included in the West Sussex survey, which will be discussed in details here.

4.3.1. Frequency of high-street shopping trips

The objective was to see how frequently the respondents went grocery shopping from supermarkets and thus identify whether visiting the CDPs could be combined as part of their grocery shopping trips. The respondents were asked to provide details of their habitual shopping behaviour in terms of the types of goods purchased and the frequency of trips made (Figure 31). A large proportion of households went grocery shopping once or twice a week (70%). Trips to purchase other types of goods (non-food related products, including entertainment, clothes, gifts, etc) were made once or twice a month by 30% of the sample.

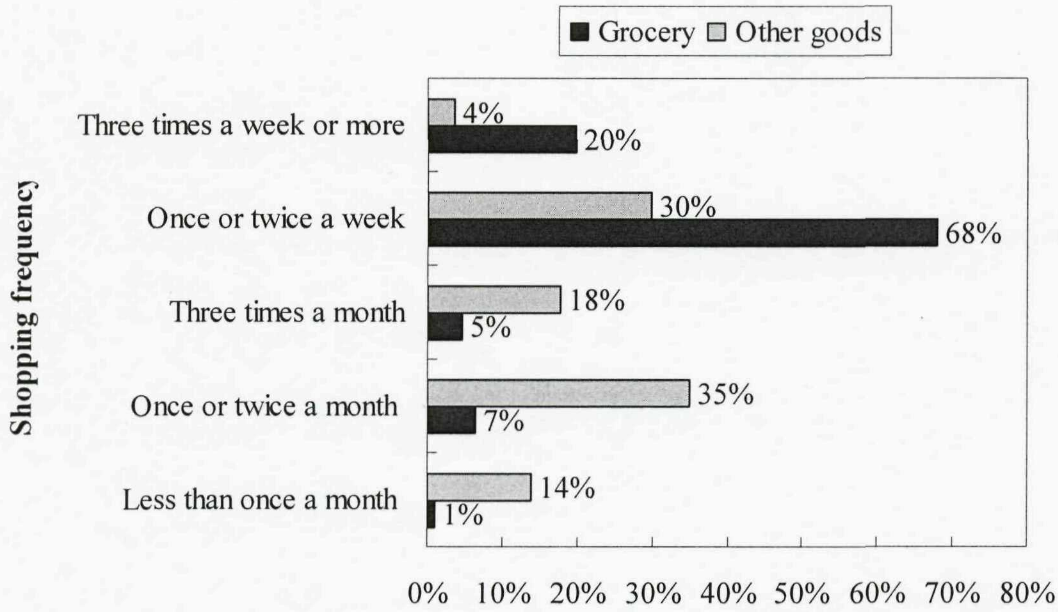


Figure 31 High-street shopping frequency stated by respondents by category

It was assumed that people carried out their high-street shopping 1, 1.5, 3, 6 and 12 times a month by those respondents selecting 'less than once a month', 'once or twice a month', 'three times a month', 'once or twice a week' and 'three times a week or more' categories respectively. Based on the responses for each category of shopping frequency, it was then possible to estimate that average person made 7 trips a month for grocery shopping and 4 trips a month to purchase non-food related goods. Clearly grocery shopping trips tend to be relatively frequent.

The findings were compatible with those from National Travel survey (2005), an annual survey of approximately 9400 households designed to be representative of the UK population. It was found that the average number of trips per person per month was 11 times for grocery and 8 times for non-food products. Mintel (2003) indicated that over 50% of households carried out a major food shop once a week.

The respondents were also asked to what extent were their grocery shopping trips combined with other activities. The results suggested that 67% of such trips were made as dedicated journeys, starting and finishing at home, with 12% being combined with travelling to/from work. It was in line with the findings from the National Travel Survey (2005) with 40% of food shopping trips being dedicated.

As we can see, grocery shopping travel was made frequently and usually on a dedicated basis, having a great impact on overall road traffic. The National Travel Survey (2005) indicated that grocery shopping trips accounted for approximately 40% of personal shopping travels and 5% of total personal travels being made as a car or van driver. This was equivalent to over 16 billion km of car travel every year. Consequently, there was a great potential for the supermarkets to be CDPs as part of habitual grocery shopping trips, which had to be made anyway. It would be attractive to the supermarkets as it would increase 'footfall' in their stores. People go to collect a package and at the same time, buy some goods.

4.3.2. Transport mode choice for grocery shopping trips

In terms of mode choice, the car was dominant with 78% of grocery trips and 76% of trips for non-food related products being undertaken by road. The secondary transport mode for shopping trips was by foot (Figure 32).

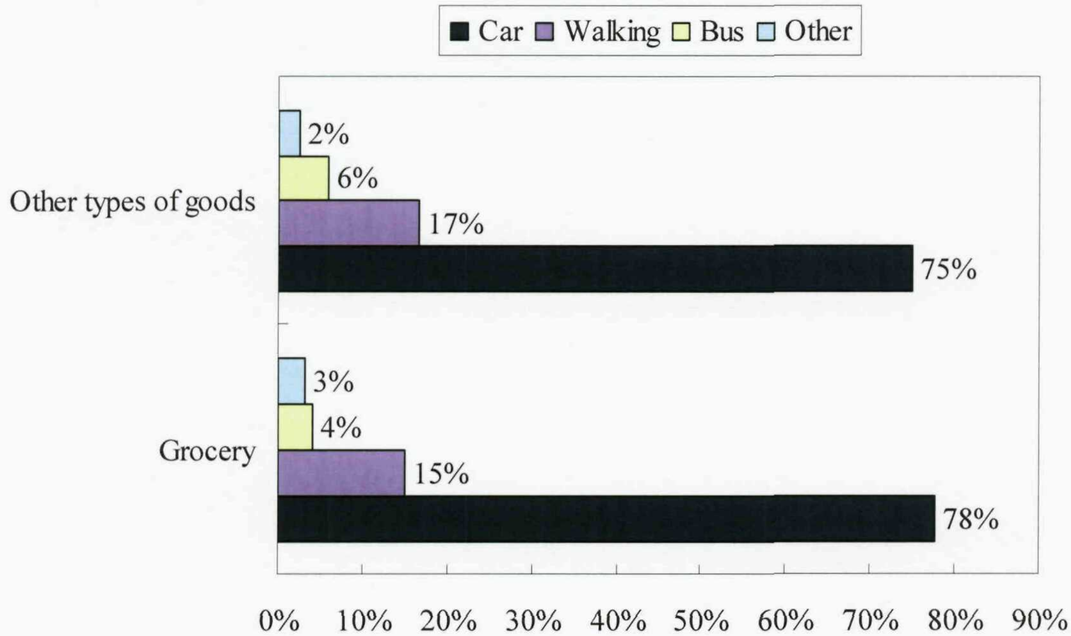


Figure 32 Transport mode used for shopping trips

This was in line with the National Travel Survey (2005) with 49.5% and 46.3% of shopping trips made by road to purchase grocery and non-food products respectively. Even 30% of non-car owning households used a car for their main food shopping, with 20% getting a lift and 10% taking a taxi (Sainsbury's research, cited in Cairns (2005)).

In the survey, the respondents identified the name of their most frequently used supermarket and using Microsoft MapPoint, the quickest route distances were determined between the household and this location. These distances were used in the modelling work to determine the most optimal locations to site CDPs across West Sussex. Sainsbury's, ASDA, Waitrose and Morrison were among the top supermarkets visited by respondents in West Sussex.

According to Mintel (2003), the grocery shopping sector was typically dominated by a few major retail chains, which were becoming increasingly significant. Sixty eight percent of consumers reported that they undertook their 'main grocery shopping' at Tesco, Sainsbury, ASDA or Morrison.

4.4. Research questions emanating from the surveys

In previous sections, the results from two surveys were presented and compared. Significant differences were found regarding some questions in the survey. The reasons for those differences needed to be explored and general statements on those questions needed to be presented. Consequently, in order to provide a fundamental understanding of the survey data and test the relations between those questions and the demographic questions, several hypothetical questions were brought forward here to be addressed.

A flowchart identifies all the nine research hypothetical questions and the objectives of the research (Figure 33).

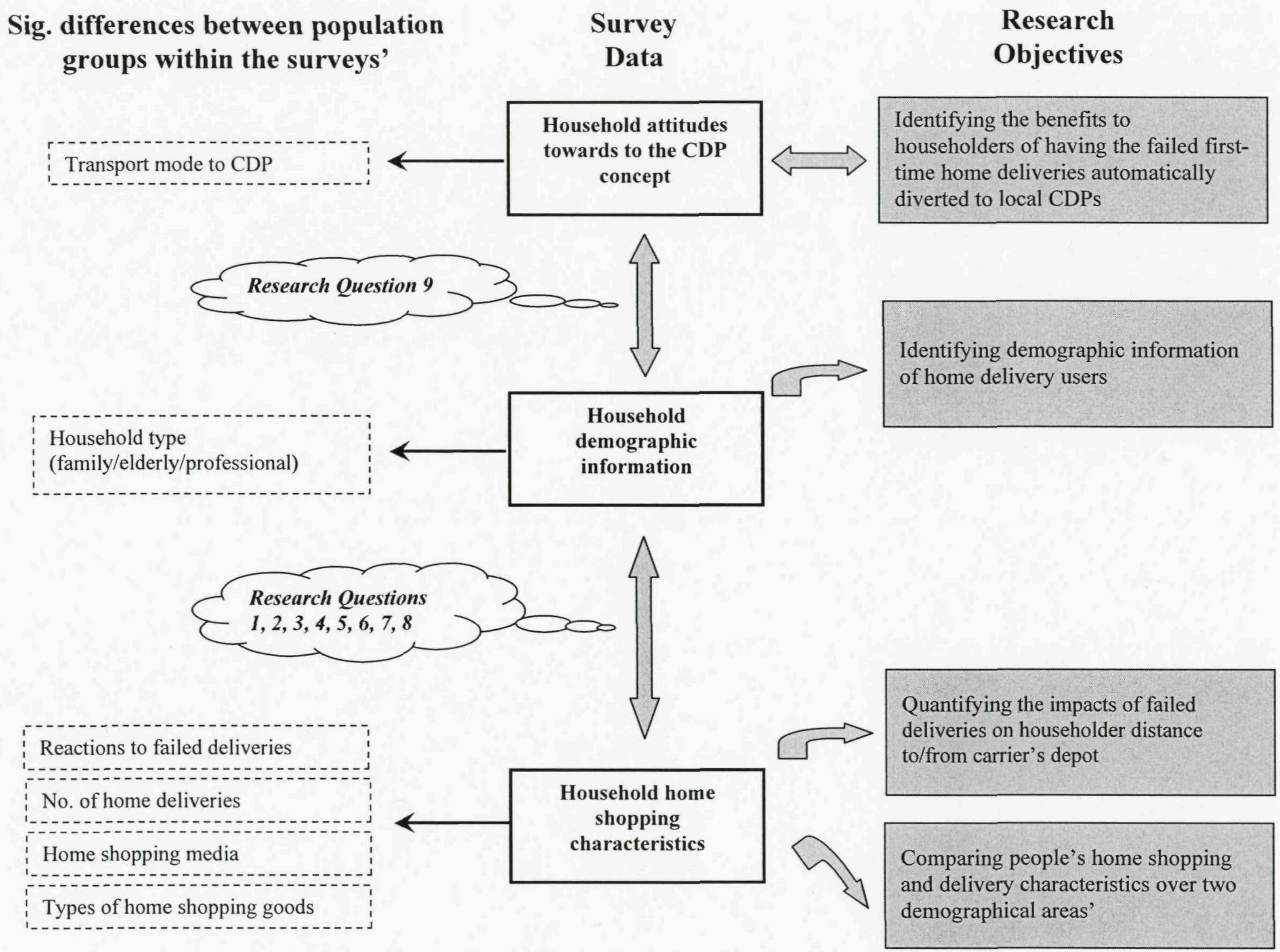


Figure 33 A flowchart showing the nine research hypotheses to be addressed

Research Question.1 Does the size of the household have any impacts on the methods used for home shopping?

Before carrying out the data analysis, it was assumed that larger households would have had more exposure to home shopping and therefore would use more methods. Overall, the analysis would help to find out whether large households tended to do more shopping from home, which inevitably would increase the number of deliveries received. Of major concern was to identify the characteristics of households willing to adopt the Internet as shopping media. This is important because the social profile of people who use different home shopping channels is different, and therefore current scale of home shopping markets could be differentiated and estimated. Few studies have tackled this problem.

From the Winchester responses, home shopping frequency using various methods by households with 1, 2, 3, 4, 5 or more residents were calculated, and then analysis of covariance and multivariate one-way analysis of variance techniques were utilized to examine the results and make inferences.

Before undertaking a MANOVA analysis (Table 17), cross-tabulation was conducted between the household size and home shopping methods selected. It was assumed that 0, 1.5, 7, 18 and 48 home shopping transactions were made by those respondents selecting the never, rarely, occasionally, frequently and very frequently for using home shopping methods indicated in the questionnaire (Table 16). Multivariate analysis of variance (MANOVA) is used to identify whether changes in the independent variables have a significant effect on the dependent variables. If the overall multivariate test is significant, it can be concluded that the respective effect is significant. Multiple comparisons are then implemented to find out the group differences, for example. Scheffe multiple range test.

Table 16 Cross-tabulation conducted on the annual number of home shopping transactions using various shopping methods and the households with 1, 2, 3, 4, 5 or more residents in Winchester

No. of person per household (sample size)	Internet from home	Internet from work	Telephoning	Interactive TV	Mail order
1 (150)	570.5 (total no. of home shopping transactions a year) (28%)	207.5 (10%)	667.5 (33%)	21 (1%)	571.5 (28%)
2 (311)	1977 (37%)	783 (15%)	1530 (29%)	21.5 (0%)	1052 (20%)
3 (97)	1080.5 (42%)	300 (12%)	657 (26%)	59.5 (2%)	459 (18%)
4 (107)	1124 (50%)	166.5 (7%)	550.5 (25%)	18.5 (1%)	369.5 (17%)
>5 (49)	336.5 (52%)	48 (7%)	146 (23%)	1.5 (0%)	109.5 (17%)

Table 17 MANOVA output from analysis conducted on home shopping methods and the households with 1, 2, 3, 4, 5 or more residents in Winchester

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	23197.184(a)	24	966.549	26.091	.000
Intercept	24980.064	1	24980.064	674.319	.000
household size	1812.229	4	453.057	12.230	.000
home shopping methods	11631.960	4	2907.990	78.499	.000
household size *home shopping methods	3026.630	16	189.164	5.106	.000
Error	122840.783	3316	37.045		
Total	194074.750	3341			
Corrected Total	146037.967	3340			

MANOVA analysis indicated that household size had a significant effect on the numbers of home shopping methods used (F (0.05) =26.091, p=0.000, MSe=966.549), with larger households experiencing more home shopping methods. A subsequent Scheffe multiple range tests identified that households with three residents or more had significantly more home shopping experiences through various home shopping methods compared to those with one and two residents at the 95% confidence level.

There were no significant differences in the number of home shopping experiences among the households with three (mean=4.6, N=554), four (mean=5.1, N=437), and five residents (mean=4.7, N=103). The average 1-person and 2-person households had 2.8 (N=738) and 3.6 (N=1509) home shopping experiences a year. The results suggested that the larger households tended to do home shopping more frequently than the smaller ones.

Repeat Scheffé multiple comparisons for home shopping methods indicated that people did significantly more shopping through Internet from home (mean=7.14, N=697) than telephoning (mean=5.0, N=705), mail order (mean=3.7, N=685), Internet from work (mean=2.4, N=629) and interactive TV (mean=0.2. N=625) at the 95% confidence level.

Similar results were found from West Sussex sample households (Table 18). MANOVA analysis on the annual number of home shopping transactions suggested that the households with three, four, five or more residents had home shopping transactions more than those with smaller number of residents (F (0.05) =16.604, p=0.000, MSe=589.955). A subsequent Scheffe multiple range tests indicated that there were no significant differences in the annual number of home shopping transactions among the households with three (mean=4.1, N=212), four (mean=4.8, N=208), and five residents (mean=5.1, N=54). The average 1-person and 2-person households had 2.1 (N=366) and 2.9 (N=818) home shopping experiences a year. Repeat Scheffé multiple comparisons for home shopping methods indicated that people did significantly more shopping through Internet from home (mean=7.7, N=334) than mail order (mean=3.5, N=339), telephoning (mean=3.1, N=338), Internet from work (mean=1.1, N=320) and interactive TV (mean=0.2. N=327) at the 95% confidence level.

Table 18 Cross-tabulation conducted on the annual number of home shopping transactions using various shopping methods and the households with 1, 2, 3, 4, 5 or more residents in West Sussex

No. of person per household (sample size)	Internet from home	Internet from work	Telephoning	Interactive TV	Mail order
1 (92)	231.5 (30%)	67 (9%)	180.5 (23%)	14 (2%)	285 (37%)
2 (176)	1074 (46%)	159.5 (7%)	507.5 (22%)	32.5 (1%)	561.5 (24%)
3 (46)	435 (50%)	85.5 (10%)	171 (20%)	14.5 (2%)	161.5 (19%)
4 (43)	652 (65%)	20 (2%)	172 (17%)	21 (2%)	143.5 (14%)
>5 (12)	200 (58%)	42 (12%)	45 (13%)	0 (0%)	56 (16%)

In summary, the households with more than three residents tended to have online shopping experiences more than smaller ones. It was reasonable to assume that households with three, four, five or more residents had more dependents and they did not have too much time shopping. Internet shopping does not require parents to leave their home so they could take care of their children in the same time.

The overall findings also provided some indication of current trends of home shopping markets. Internet retailing has been growing very rapidly, compared with other home shopping channels (catalogue shopping, TV shopping, telephone shopping, etc). Based on 304 responses from 10500, a home delivery survey undertaken by Peter Brett Associates for Transport for London (2006) indicated that the Internet was used most frequently (36%) when respondents were ordering goods. This was closely followed by the telephone (26%). Ordering by post, in a shop, or by agency or catalogue was used on average by 9% of respondents in each of these categories. Current trends also indicated that the mail order industry has been experiencing rapid decline. Verdict (2004) presented the declining market share of home shopping mail order, from 37% in 1998 to 27% in 2003.

Key Finding

Household size does influence the types of home shopping methods with large households having significantly more home shopping experiences over the Internet than the small ones.

Research Question.2 Does the household type have any impacts on the methods used for home shopping?

Before carrying out the data analysis, it was assumed that professional and family households are amongst the keenest to use Internet shopping. However, it was assumed that the elderly household with retired people aged over 65 might get behind on the Internet revolution and still rely on traditional shopping methods such as mail order or on the high-street. Hence the analysis would help to identify the age groups of online shoppers.

A cross-tabulation was undertaken on the number of home shopping transactions per year for the household type (elderly, family, and professional) and various shopping methods. It was assumed that 0, 1.5, 7, 18 and 48 home shopping transactions were made by those respondents selecting the never, rarely, occasionally, frequently and very frequently for using home shopping methods indicated in the questionnaire (Table 19).

Table 19 Cross-tabulation conducted on annual number of home shopping transactions for the household type (family, elderly and professional) and shopping medium used (Internet, telephoning, TV or mail order) in Winchester

Number of home shopping transactions a year	Family	Professional	Elderly	SUM
Shop via the Internet from a computer at home	1781.5 (48%)	2995 (41%)	312 (17%)	5088.5
Shop via the Internet from a computer at work	370 (10%)	1108.5 (15%)	26.5 (1%)	1505.0
Shop through telephoning an order to a retailer	974 (26%)	1855 (25%)	722 (40%)	3551.0
Shop through interactive television	23 (1%)	37 (1%)	62 (3%)	122.0
Shop by sending an order form by post	553 (15%)	1338.5 (18%)	670 (37%)	2561.5
SUM	3701.5 (100%)	7334 (100%)	1792.5 (100%)	12828.0

A 5 by 3 Chi-square test showed that there were significant differences among the family, elderly and professional households in the frequencies of using various home shopping methods at the 95% significance level (χ^2 =1123.26 and χ^2 (0.05) 8df = 15.51), with family and professional households having the majority of their home shopping transactions made over the Internet at home. Elderly households chose to make home shopping through telephoning an order to a retailer or sending an order form through the post (40% and 37% respectively).

Overall, family and professional households tended to have more home shopping experiences. Given that Winchester sample households (790) were composed of 27% 'families', 50% 'professional' and 23% 'elderly', it was calculated that on average, there were 17, 19 and 10 home shopping transactions made by each family, professional and elderly household over a year.

Similar home shopping behaviour was found from family and professional households in West Sussex (Table 20). Family and professional households did home shopping significantly more frequently than the elderly ones. Each family and professional household had 22 and 17 home shopping experiences over a year, while elderly household had 9. To explore whether there were significant differences in home shopping frequencies among the three types of households, a 5 by 3 Chi-square test was undertook and showed that there were significant differences among the family, elderly and professional households in the frequencies of using various home shopping methods at the 95% significance level ($\chi 2$ =565.76 and $\chi 2$ (0.05) 8df = 15.51). Family and professional households had 69% and 60% of their home shopping transactions over the Internet, respectively. However, there were some differences in the shopping methods between the elderly households in Winchester and West Sussex. West Sussex elderly households preferred to do the majority of home shopping either sending an order form by post (41%) or by Internet (34%).

Table 20 Cross-tabulation conducted on annual number of home shopping transactions for the household type (family, elderly and professional) and shopping medium used (Internet, telephoning, TV or mail order) in West Sussex

Number of home shopping transactions a year	Family	Professional	Elderly	SUM
Shop via the Internet from a computer at home	802 (63%)	1350 (49%)	440.5 (34%)	2592.5
Shop via the Internet from a computer at work	77.5 (6%)	293.5 (11%)	3 (0%)	374
Shop through telephoning an order to a retailer	209 (16%)	539 (20%)	328 (25%)	1076
Shop through interactive television	17 (1%)	60.5 (2%)	4.5 (0%)	82
Shop by sending an order form by post	167.5 (13%)	504 (18%)	536 (41%)	1207.5
SUM	1273 (100%)	2747 (100%)	1312 (100%)	5332

In summary, the cash-rich and time-poor people (family and professional households) were among the keenest to explore Internet shopping. As for the elderly households, sending an order form by post or telephoning an order to a retailer was the most popular methods for home shopping. However, in some areas, not all the old people aged over 65 were left behind the Internet revolution.

Some of the findings confirm the literature that stereotypical Internet users used to be young, for example, Xing (2006). Based on 423 survey responses from 3000 households in Edinburgh, it was found that of all the respondents who had shopped online before, the 40-54 and 25-39 age groups accounted for 72% altogether. The 55-65 age group and young people aged between 16 and 24 represented 11% each, followed by elder people over 65.

Key Finding

Household type does influence the types of home shopping methods with families and professionals having significantly more home shopping transactions made over the Internet than the elderly. For the elderly households, sending an order form by post or telephoning an order to a retailer was the most popular method for home shopping.

Research Question.3 Do the types of goods purchased through home shopping mediums vary according to the household type?

As defined previously, the sample households were categorized as 'families' (those households which contained at least one individual between the ages of 0 and 16), 'elderly' (households containing at least one person over the age of 64 and no one under the age of 21) and 'professionals' (those households which didn't meet the 'elderly' or 'family' definitions).

Before undertaking the data analysis, it was assumed that those three categories of households would buy different types of goods through home shopping. For example, 'elderly' households might still rely on traditional high-street shopping for certain products and thus made fewer purchases through home shopping than the 'family' households. It is more likely that the elderly are not familiar with computers and might have never experienced home shopping methods. Such analysis on the relationship between the respondents' demographic data and types of home shopping products would help to analyze and identify the current home shopping and delivery market by sectors of products.

Cross-tabulation was conducted between the household type and the annual number of home shopping transactions for types of goods in Winchester (Table 21).

Table 21 Cross-tabulation conducted on total number of home shopping transactions a year for various types of goods by household type (family, professional and elderly)

Number of home shopping transactions a year	Family	Professional	Elderly
Travel	675.5	1425	396
Tickets	717.5	1455	449
Books	951	1514	456.5
Sports	457	290.5	57.5
Flowers	317	631	281.5
Insurance	296	938.5	183.5
Music	557	1001.5	125
Videos	472.5	873.5	67.5
Clothes	845	1017.5	609
Software	329	312.5	55.5
Hardware	233.5	400	72.5
Electronic equipment	223	430.5	65.5
Food	1180	1129.5	360
Household goods	469	804	357
DIY	222.5	341.5	92.5

A MANOVA test showed that household type had significant effects on the types of goods acquired through home shopping ($F(0.05) = 17.226$, $p = 0.000$. $MSe=376.325$). Family and professional households tended to purchase a broader range of home shopping products, which almost covered every category, while elderly households tended to limit their purchases to a few categories such as clothes and books. It is reasonable to assume that family and professional households have higher incomes than elderly ones but don't have much time for shopping.

To further explore the differences in types of products purchased by 'elderly' and 'family' households, a T-test was applied for average number of home shopping transactions for each type of goods and results presented in Table 22. The T-test proposes the null hypothesis that a difference in means is zero for a normal distribution. The null hypothesis of a zero difference in means between groups cannot be rejected if the magnitude of a t-test value does not exceed .96 at the 5% significance level and has significant two-tailed probabilities.

Table 22 T-test results for average number of home shopping transactions a year for various types of products purchased by 'family' and 'elderly' households in Winchester

Average number of home shopping transactions	Family	Elderly	T-test	Sig (2 tail)
Travel	3.85	2.99	2.035	.043
Tickets	4.09	3.41	1.484	.139
Books	5.31	3.30	3.297	.001
Sports	2.76	0.50	6.292	0.000
Flowers	1.81	2.28	-1.010	0.313
Insurance	1.77	1.52	0.944	.346
Music	3.17	1.06	5.147	.000
Videos	2.77	0.60	5.579	.000
Clothes	4.71	4.45	0.454	0.650
Software	1.93	0.32	4.854	.000
Hardware	1.41	0.34	4.274	.000
Electronic equipment	1.34	0.57	3.285	.001
Food	6.81	3.20	2.466	.014
Household goods	2.70	2.83	-0.213	.831
DIY	1.34	0.77	1.788	.075

The results in Table 22 suggested that for 9 types of home shopping goods ('books or magazines', 'sports goods and toys', 'music CDs', 'videos or DVDs', 'computer software', 'computer hardware', 'electronic equipment', 'food and groceries' and 'travel'), 'family' households would shop significantly more than 'elderly' households at the 95% confidence level. It was noted here that the number of residents in the 'family' and 'elderly' household might be different. The results in Table 22 were generated based on the classifications of households adopted in this research. Future analysis could be undertaken by varying the definitions of household classifications.

It is not surprising that elderly households purchased less 'sports' goods than family ones. It is also reasonable to assume that older people tend to be disconnected with new technologies. Thus they don't frequently purchase music CDs, videos or DVDs, computer software and hardware. Elderly people may still prefer to visit shops in order to physically view and touch the products such as food and books, or expensive and large products such as electronic equipment.

Key Finding

Household type does influence the types of goods purchased from home with families and professionals buying a significantly broader range of products than the elderly.

Research Question.4 Does the household type influence the number of home deliveries and delivery addresses (home, place of work, or another location)?

Before undertaking the data analysis, the hypothesis that was made was that professional and family households would have more home deliveries than elderly ones since the elderly are not familiar with computers and might have never experienced home shopping methods. As for the delivery address, elderly households might prefer nominating their home as they have more free time being home while professionals and families use the workplace. The analysis would help to identify the extent of penetration of home delivery services into the various social and economic classes. It would also help to identify the number of deliveries received by each type of household. The relationship between household type (elderly, family, and professional) and delivery addresses (home, place of work, and another alternative location) was presented by cross-tabulations (Table 23).

Table 23 Cross-tabulation conducted on annual number of home deliveries for the household types (family, elderly and professional) and delivery addresses (home, workplace or another location) in Winchester

Number of deliveries a year	Delivery to home	Delivery to place of work	Delivery to another location	SUM
Family	3775.5 (87%)	413 (10%)	146 (3%)	4334.5
Professional	5307 (83%)	856 (13%)	239 (4%)	6402
Elderly	2859.5 (95%)	76.5 (3%)	68 (2%)	3004
SUM	11942	1345.5	453	13740.5

To explore whether there were significant differences in delivery addresses selected by those three types of households, a 3 by 3 homogeneity Chi-square test was undertaken and indicated that there were significant differences among the family, elderly and professional households in the number of deliveries to various delivery addresses at the 95% significance level ($\chi2$ =294.16 and $\chi2$ (0.05) 4df =9.49), with the elderly households having the majority of their deliveries sent to their home. Few households amongst the 'professional' and 'family' categories chose to have deliveries made to work (13% and 10% respectively).

In the Winchester survey, it was assumed that 0, 1.5, 7, 18 and 48 deliveries were received by those respondents selecting the none, 1 to 2, 3 to 11, 12 to 24 and >24 deliveries per year categories respectively. The average number of deliveries per household was calculated to be 14 (Table 24). The households amongst the 'professional' and 'family' categories had more deliveries (16.6 and 14.7 respectively) a year than the elderly ones with 8.7 deliveries a year.

Table 24 Average number of deliveries received by each type of households (elderly, family and professional) in Winchester

	No. of deliveries a year	No. of households	Average no. of delivery per household
Family	3129.0	213	14.7
Professional	6539.5	395	16.6
Elderly	1420.5	182	7.8
SUM	11089.0	790	14.0

In the West Sussex survey, it was assumed that 0, 1.5, 7, 18 and 48 for categories of none, 1 to 2, 3 to 11, 12 to 24 and >24 deliveries per year, respectively. The average number of deliveries per household was calculated to be 20 (Table 25). The average elderly household received 6.7 deliveries a year, far less than the family and professional household (24.3 and 14.6 respectively).

Table 25 Average number of deliveries received by each type of households (elderly, family and professional) in West Sussex

	No. of grocery deliveries a year	No. of deliveries for other goods a year	No. of households	Average no. of delivery per household
Family	720.5	1274.5	57	29.4
Professional	764.0	2884.5	174	17.6
Elderly	466.0	1433.5	148	9.8
SUM	1950.5	5592.0	379	19.5

As we can see, professional and family households were assumed to be cash-rich but time-poor hence they had more exposure to home delivery services. Elderly households with retired person had far less home deliveries since they did very little home shopping as stated in Section 4.4.2. For example, the average family and professional household received 29 and 18 home shopping orders a year, almost double the 10 orders received by an elderly household.

Key Finding

Household type does influence the number of home deliveries made with families and professionals receiving significantly more home deliveries than the elderly. Majority of households have deliveries made to their homes.

Research Question.5 Do larger households in terms of number of residents generate more deliveries?

Before undertaking the analysis, the hypothesis was that a large household in terms of number of residents might have more deliveries than a small one. Large households tend to have more dependents and they did not have too much time for shopping. Hence it was assumed that they might use home shopping and delivery service which could allow them to stay home and take care of their children at the same time. The analysis would help to quantify the number of deliveries received by households with various numbers of residents.

A One-way Analysis of Variance test (ANOVA) showed that there were significant differences in the annual number of deliveries received by households with 1, 2, 3, 4, and 5 or more persons (F=10.804, MSe=1901.539 and p=0.000). Subsequent Scheffé multiple comparisons found that households with 4 persons or more received more deliveries (19.2 on average) than smaller ones with 3 persons or less (13.6 on average) over a year at the 95% confidence level. There were no significant differences in the annual number of home deliveries among the households with 4 persons (mean=19.1, N=100) and 5 persons or more (mean=19.8, N=23). The average 1-person, 2-person and 3-person households had 9.4 (N=152), 14.5 (N=318), 16.4 (N=116) deliveries a year.

Similar results were found from the West Sussex survey. Descriptive statistics showed that there was an average of 3.6 grocery deliveries and 11.2 deliveries for other types of goods (N=368) a year. A one-way ANOVA test on the number of home deliveries suggested that there were significant differences among the households with 1, 2, 3, 4, 5 or more person (F (0.05) =6.229, p=0.000, MSe=390.575). The households with 4 or more persons (25.2 on average) received significantly more home deliveries a year than smaller ones with 3 persons or less (11.2 on average) at 95% of confidence level. There were no significant differences in the number of home deliveries among the households with 4 persons (mean=25.2, N=43) and 5 persons or more (mean=26.1, N=11). The average 1-person, 2-person and 3-person households had 7.4(N=91), 12.2 (N=176), 15.0 (N=46) deliveries a year.

Key Finding

The results indicated household size tended to have a bearing on the use of home delivery systems. Large households with the presence of children were far more likely to have home delivery services. According to Browne *et al* (2001), 1938 adults were interviewed to discover their home delivery behaviour in 2000. 60% of respondents were from households of more than four people having received at least one home delivery over a year, compared to 51% of respondents from households of two or three people, and 39% of single person households.

Research Question.6 What is the relationship between the number of annual home deliveries and the number of failed home deliveries?

Before undertaking the research, the hypothesis was that the households receiving a large number of home deliveries were more likely to encounter the problems of delivery failures. The analysis would help to estimate how many first-time deliveries would fail among the total home deliveries made across the two samples.

In the home delivery survey, people were asked to indicate the number of home deliveries received in the past year among 5 options: never, rarely, occasionally, frequently, and very frequently. It was assumed that 0, 1.5, 7, 18 and 48 deliveries were received by those respondents selecting those five categories respectively. People were also asked to estimate how many home deliveries arrived when no-one was in to receive them. Several frequency categories were provided, e.g. none, few, some, many and most. It was assumed that 0, 12.5%, 25%, 37.5% and 50% of deliveries failed related to the no-one, few, some, many and most of deliveries per year categories respectively. Hence it was possibly to derive the number of failed home deliveries among those five categories of number of home deliveries received a year. A Pearson correlation was then conducted on the number of annual home deliveries and number of failed home deliveries from the Winchester and West Sussex sample households.

Figure 34 was plotted based on the average responses on number of failed first-time deliveries for each category of estimated number of home deliveries (0, 1.5, 7, 18 and 48).The results suggested that there was a positive correlation between the number of annual home deliveries and number of failed home deliveries (R=0.796) in Winchester. Similar results were found from West Sussex sample households, by using the same methodology repeated here (Figure 34). Based on the number of responses among 6 options (0, 1.5, 7, 18 and 48), the average delivery failure rate was calculated as 26.4%. Pearson correlation analysis was conducted to identify whether there was any correlation between respondents' home deliveries and failed deliveries. It was found that delivery failures had positive correlation with annual number of home deliveries with R values of 0.822 in West Sussex.

In general, the delivery failures would increase for those households receiving a large number of annual deliveries.

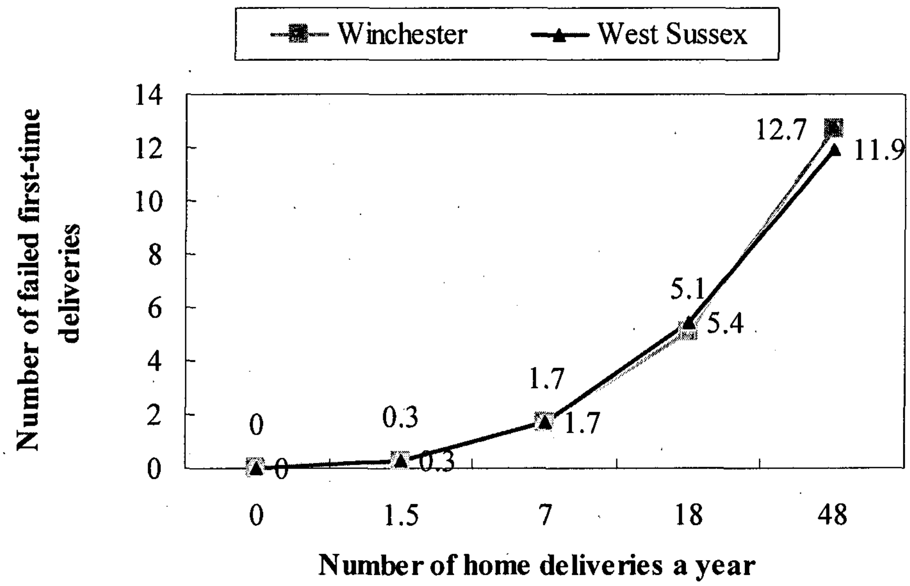


Figure 34 The plot shows the relationship between the annual number of home deliveries and the number of failed home deliveries, based on Winchester and West Sussex sample households

Based on the number of responses, the average delivery failure rate was 23.9%. The finding was lower than Xing (2006), who carried out a home delivery survey among 3000 residents in Edinburgh in 2005, obtaining 372 responses. According to the survey, 40% of the deliveries were not delivered due to the fact that 58% respondents said that normally no one was at home for the delivery. The finding was also consistent with that of a home delivery study by Browne *et al.* (2001) for Freight Transport Association which suggested that as high as 60% of home delivery of small items would fail if no delivery time was arranged.

Key Finding

The number of failed home deliveries has a positive relationship with the number of home deliveries received per year.

Research Question. 7 Does a family or elderly household experience less delivery failures than a professional one and do the characteristics of the failure differ?

Before undertaking the data analysis, it was assumed that families tended to experience less failures because in theory, there was more chance of catching someone in during the working day (e.g. parents looking after dependents). Such analysis would help to explore the problems of delivery failures imposed on three types of households and identify who were having the most exposures to the home delivery failures.

In both surveys, respondents were asked to estimate the percentages of home deliveries arriving when there was no-one in to receive it. It was assumed that 0, 12.5%, 25%, 37.5% and 50% deliveries failed by those respondents selecting none, few, some, many and most of delivery failures per year categories respectively. Based on the responses, it was then possible to calculate the average delivery failure rates for each household type (Table 26).

Table 26 Delivery failure rates among three types of households (family, elderly and professional) in Winchester and West Sussex

Estimated delivery failure rates	Winchester	West Sussex
Family	27.66%	30.70%
Professional	26.16%	26.81%
Elderly	15.84%	14.74%

The results suggested that all households encountered the problems of delivery failures, with retired person aged above 65 having the least exposure to the failed home deliveries (16% in Winchester and 15% in West Sussex). A 5 by 2 homogeneity Chi-square showed that families in West Sussex experienced significantly more home delivery failures than Winchester families (χ^2 =14.36 and χ^2 (0.05) 4df =9.49). The professional and family households were having the most exposure to delivery failures since the busy residents were supposed to work during the day. Research done for DTI suggested that half of UK homes are empty between 9am to 4pm (DTI, 2001). However, the standard delivery time is between 8am and 5pm.

In the questionnaire, respondents were asked the experiences of home delivery failures (the goods were left with a neighbour, left outside concealed, left outside visible, and returned to depot). A cross-tabulation was conducted on the experiences of failed home deliveries among three types of households in Winchester (Table 27).

Table 27 Cross-tabulation between the household type and experiences of failed home deliveries in Winchester

Frequency of experiences	Left with a neighbor	Left outside (concealed)	Left outside (visible)	Taken back to depot
Family	694.5 (23%)	691 (23%)	424 (14%)	1242.5 (41%)
Professional	1128.00 (23%)	1013.5 (20%)	733.5 (15%)	2114.5 (42%)
Elderly	336 (28%)	220.5 (18%)	159 (13%)	494.5 (41%)

The results in Table 27 suggested that the most frequent experiences of the home delivery failures encountered by all households were that the goods were taken back to the carrier's depot.

Key Finding

All households encountered delivery failures, with the elderly having the least exposure to the failed home deliveries, and families/professional experiencing the most ones.

Research Question.8 Is there any relationship between the households' reactions to the failed home deliveries and household type?

In both surveys, respondents were asked to indicate their typical responses to a home delivery that had failed, where the carrier returned the package to the depot and put a notification card through the door. They were asked to estimate the number of their typical reactions to failed deliveries (arrange a re-delivery to home, arrange a re-delivery to work, arrange a delivery to post office, and travel to depot).

The relationship between household type (elderly, family, and professional) and their reactions to failed home deliveries was determined (Table 28 and Table 29).

Table 28 Cross-tabulation between the household type and reactions to failed home deliveries in Winchester

Frequency of reactions	Redelivery to home	Redelivery to workplace	Redelivery to post office	Travel to depot
Family	553.5 (40%)	174.5 (12%)	36.5 (3%)	634 (45%)
Professional	279 (46%)	52.5 (9%)	47 (8%)	227.5 (37%)
Elderly	1227 (35%)	488.5 (14%)	216.5 (6%)	1572 (45%)
SUM	2059.5 (37%)	715.5 (13%)	300 (6%)	2433.5 (44%)

The results in Table 28 indicated that nearly half of professional households arranged redeliveries to their homes (46%). For the elderly and family households, the most common option was travelling to the carrier's depot to collect, because they don't need to work and thus could possibly find a convenient time to make the collections. For the overall sample of households in Winchester, it was found that travelling to the carrier's depot to collect the good was the most frequently used method used with the failed home deliveries. Forty four percent of households would generate such collection trips emanating from a failed delivery card.

Table 29 Cross-tabulation between the household type and reactions to failed home deliveries in West Sussex

Frequency of reactions	Redelivery to home	Redelivery to workplace	Redelivery to post office	Travel to depot
Family	295 (42%)	127.5 (18%)	40 (6%)	236 (34%)
Professional	296 (57%)	38.5 (7%)	58 (11%)	129.5 (25%)
Elderly	504.5 (41%)	228 (19%)	80 (6%)	394.5 (33%)
SUM	1095.5 (45%)	394 (16%)	178 (7%)	760 (31%)

Slightly different results were found from West Sussex survey. The majority of professional households arranged redeliveries to their homes (57%). This was also the most frequently used method by family (42%) and professional (41%) households, instead of travelling to the carrier's depot as shown in the Winchester study. For the overall sample households in West Sussex, it was found that 45% of households would arrange re-delivery attempts to home.

The proportion of households collecting from the carrier's depot would have a great impact on road traffic since 87% of such trips were made by car. This research suggested that a significant percentage of households would do so, with 44% of Winchester sample households travelling to the carrier's depot to retrieve their failed home deliveries, compared with 31% of West Sussex sample households.

Key Findings

The most common options to deal with failed home deliveries are either to travel to the carrier's depot or to arrange a re-delivery to home.

Research Question.9 Does the number of cars/household influence the method of transport used to travel to the CDP?

The number of cars in the household could impact on the choice of transport mode to the CDP to collect a failed delivery. The null hypothesis here was that the households with more cars available tended to travel to a local CDP by road. For the households with only one car, people might prefer to walk. Having two or more cars in the household might increase the possibilities for people to drive to CDPs since they were used to relying on cars for everyday activities.

Figure 35 shows the householders responses on their preferred transport mode to travel to the CDP (car, bus, cycling, or walking) for each category of car ownership per household (0, 1, 2, 3 or >3). It was found that households with two or more cars were most likely to drive to the CDP, with 56% of their trips being undertaken by road. It was followed by the households with one car, with 43% of trips made by road. Winchester is very affluent in terms of car ownership per household. Around 90% of households in Winchester had at least one car compared to 73% nationally (National Statistics, 2005). Consequently, the transport impact of CDPs in reducing the motorised travel was likely to be weakened by the increased road traffic to the CDPs in such an area which is particularly affluent.

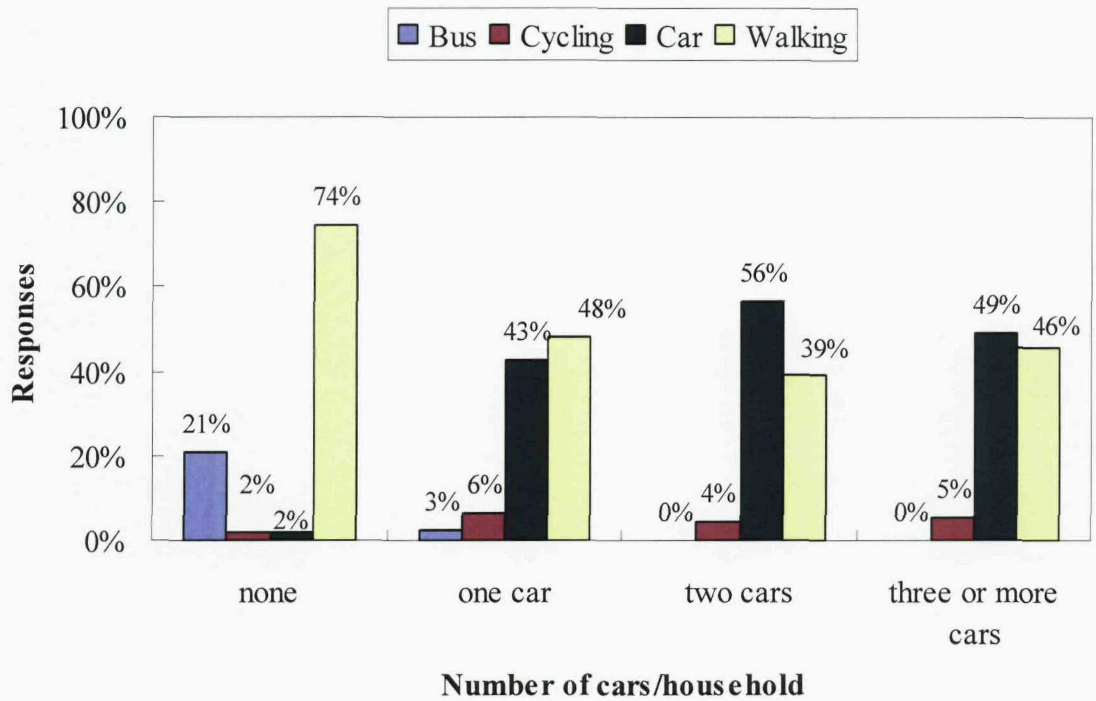


Figure 35 Responses on the transport mode to CDPs for each category of car ownership per household

Key Findings

Households with two or more cars were most likely to drive to the CDP. It is noted here that these are 'stated preference' responses, i.e. 'how do you think you would travel to pick up a package from a CDP?' because the householders had never experienced a CDP collection in the survey.

4.5. Summary

This chapter has summarized the data input for the modelling work in next three chapters. The initial results from Winchester and West Sussex survey were provided in Section 2. A combined analysis was also provided. In Section 3, the new added questions in West Sussex survey were presented and results analysed. In Section 4, nine research hypothetical questions were identified in order to provide a comprehensive understanding of the survey data.

The key findings from Winchester survey were:

- The 790 households were made up of 27% 'families' (those households which contained at least one individual between the ages of 0 and 16), 23% 'elderly' (households containing at least one person over the age of 64 and no one under the age of 21) and 50% 'professionals' (those households which didn't meet the 'elderly' or 'family' definitions) households.

- The average household received 14 home shopping deliveries annually with a first-time failed delivery rate of around 24%.

- Respondents perceived that trips to their nearest local CDP would be by foot (48%), car (43%), bicycle (5%) and bus (4%). The average distances (calculated using Microsoft MapPoint) from the respondents' homes to their nearest post office were 2km, implying that walking/cycling could be a serious option for small package collection.

- Trips to collect the failed packages from a local carrier depot were made between 3 and 11 times per year (28%) and between 1 and 2 times per year (35%). 87% of respondents stated that such a trip would be made by car.

The key findings from West Sussex survey were:

- The 379 households were made up of 15% 'families' (those households which contained at least one individual between the ages of 0 and 16), 39% 'elderly' (households containing at least one person over the age of 64 and no one under the age of 21) and 46% 'professionals' (those households which didn't meet the 'elderly' or 'family' definitions) households.

- The average household received 5 home deliveries of groceries and 15 of other goods per year.

- 60% of respondents claimed that they failed at least 1 in 4 of the home deliveries made to their house, with 21% claiming that they failed more than 50% of them because the house was empty during the working day.

- In response to failed home deliveries, the most common choice by householders was to either arrange re-delivery or to travel to the carrier's depot to collect the goods.

- 40% of the respondents said that they would walk to their local CDP to collect packages.

Significant differences were found regarding six questions in two surveys, including household type, number of home deliveries per household per year, home shopping methods used, types of goods purchased from home, people's responses towards the failed deliveries, and transport mode choice to CDPs. To find out the reasons, nine hypothetical questions were presented to investigate the relations among those questions and the demographic questions. A general statement on each of those six questions was then able to be derived.

The next chapter will begin to introduce the modelling work based on the survey data. The theoretical benefits of CDP delivery methods on the householders and carrier will be analyzed and compared to the current situation. A comprehensive study on the householder driving distance incurred in various scenarios is provided. The scenarios are described in terms of proportion of households collecting from the carrier's depot, number of failed home deliveries, and CDP locations (post office, Tesco Extra, railway station and other supermarket).

CHAPTER FIVE

QUANTIFYING THE THEORETICAL BENEFITS OF CDP NETWORKS IN WINCHESTER

5.1. Introduction

In this chapter, the transport and associated environmental benefits on householders of using various CDP networks for re-directing failed home deliveries are investigated based on the survey data collected from Winchester sample households. This is compared to the current system where the carrier may make multiple re-delivery attempts to the householder on the delivery day if the initial delivery fails or a second attempt on the following day if the first day attempts have been unsuccessful.

In this research, theoretical CDP delivery methods modelled here are (Section 3.6, Chapter Three): 1) CDPs at railway stations; 2) CDPs at Tesco Extras; 3) CDPs at supermarkets from ASDA, Morrison, Sainsbury's and Waitrose combined; and 4) CDPs at Local Collect post offices; the list of such post offices was obtained from the Royal Mail as confidential source.

Clearly the road traffic to and from the carrier's depot will affect the estimate of reductions on householders' trips by using the CDP method. It is then necessary to identify the proportion of householders driving to the carrier's depot. Consequently, to give an indication of a wide range of results that might occur in the existing delivery method, a range of proportions of householders travelling to the carrier's depot to collect their failed deliveries is modelled for the existing delivery methods in this research:

1) Existing delivery method with 10% of people (experiencing home delivery failures) collecting from the carrier's depot;
2) Existing delivery method with 30% of people (experiencing home delivery failures) collecting from the carrier's depot;
3) Existing delivery method with 50% of people (experiencing home delivery failures) collecting from the carrier's depot;
4) Existing delivery method with 100% of people (experiencing home delivery failures) collecting from the carrier's depot.

Clearly, there are four CDP delivery methods and four existing delivery methods to be modelled in this research. With the respondents' home addresses, the eight delivery methods were modelled with the help of DPS RouteLogix. Using the software, the carrier's delivery route around a group of delivery addresses was optimised. Hence the carrier's travelling distance to make all delivery attempts was calculated based on the optimised routes. Householders' routes to collect their failed home deliveries either from the carrier's depot or local CDPs were also optimised. Thus the householders' travelling distance was quantified based on the optimal routes. After the householder and carrier travelling distances were quantified, the environmental costs of existing and emerging CDP delivery methods were then calculated based on the emission factors. Also the changes in householder distances of collecting the failed home deliveries from a range of CDPs close to their home rather than from the carrier's depot were identified.

Furthermore, the impacts of failed first-time deliveries on carrier and householders were investigated, as one of the key overall research objectives. Previous research has suggested a wide range of first-time delivery failure rate, from 12% (IMRG, 2006b) to 60% (Department of Trade and Industry, 2000). Consequently, various scenarios of home delivery failure rates were modelled here, varying from 10% and 50%. Under each scenario, the carrier and householders travelling distances were quantified for those 8 home delivery methods. A process flow chart (Figure 36) describes the various stages in this Winchester study.

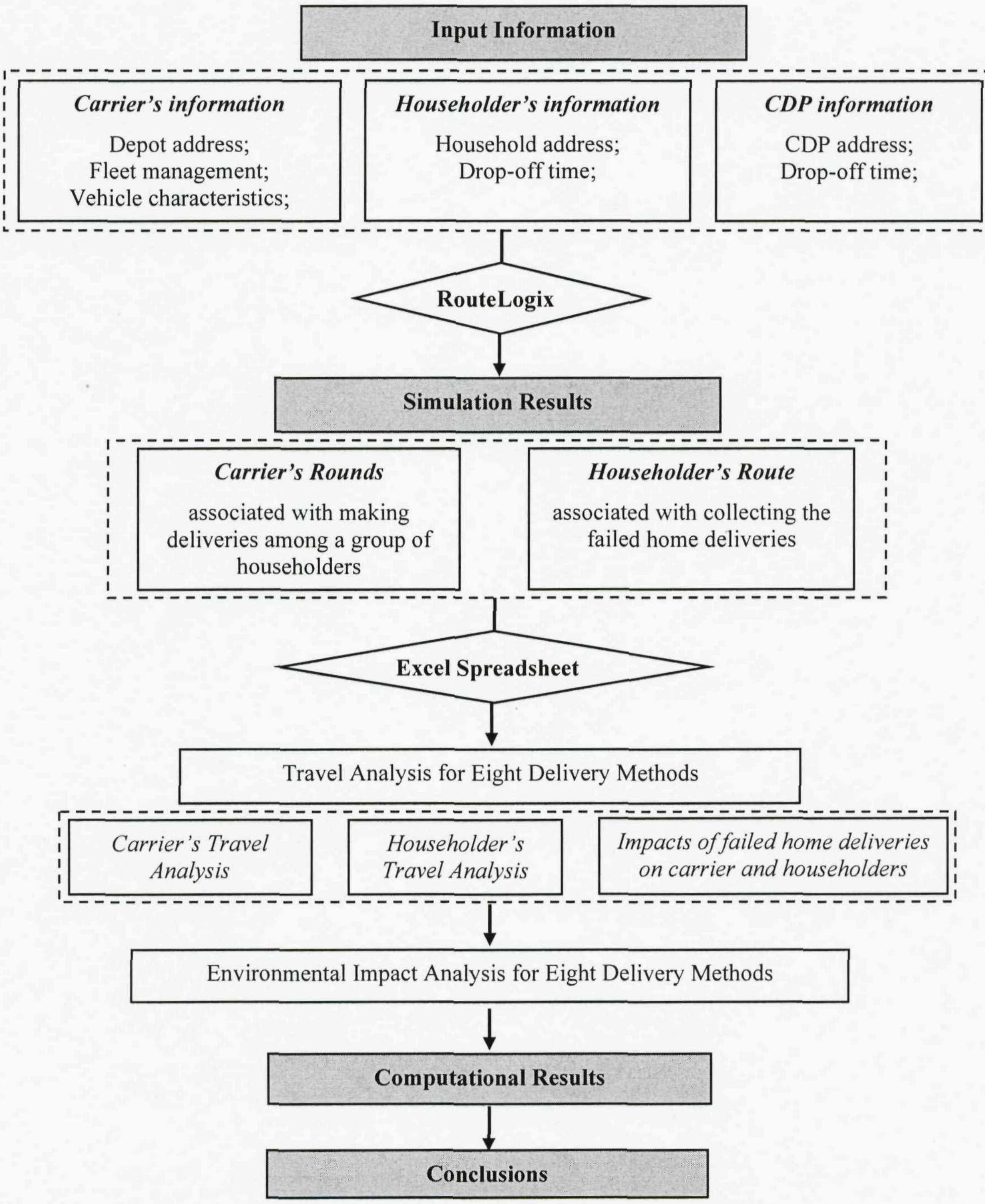
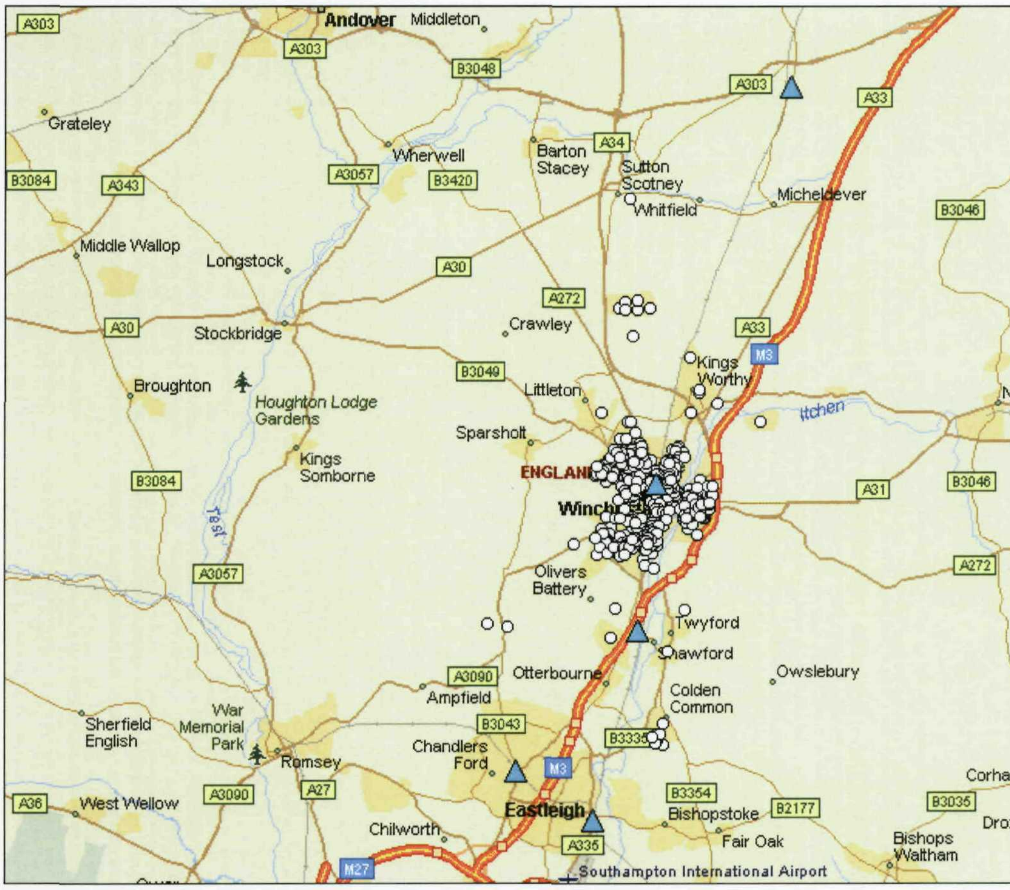


Figure 36 A process flow chart to illustrate the research stages in the Winchester study

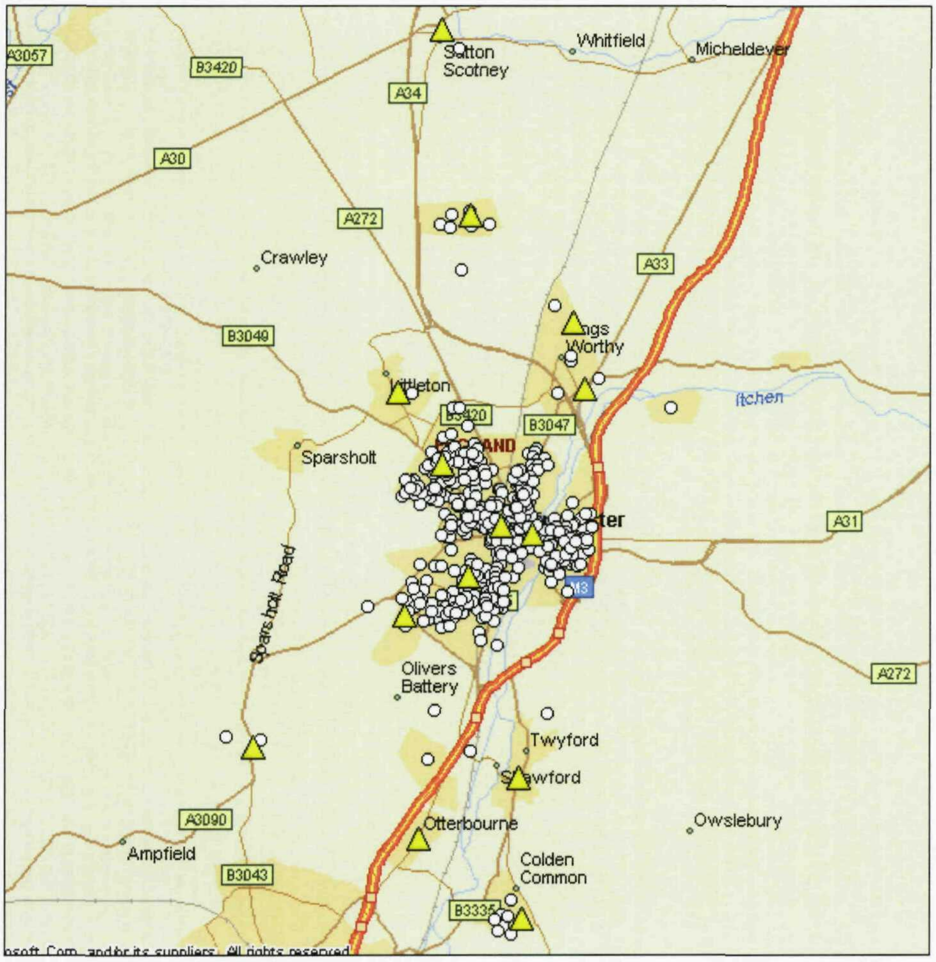
There were 790 respondents to the home delivery questionnaire in Winchester. After removing duplicate postcodes (some respondents lived within the same postcode) and removing postcodes outside Winchester (some of the questionnaire respondents worked in Winchester but lived elsewhere), there were 423 unique postcodes in the sample to be modelled. Figure 37, 38, 39 and 40 present maps showing the locations of the 423 sample Winchester householders, Tesco Extra, post offices with 'Local

Collect' service, railway stations and other supermarket chain from ASDA, Morrison, Sainsbury's and Waitrose combined in Winchester.



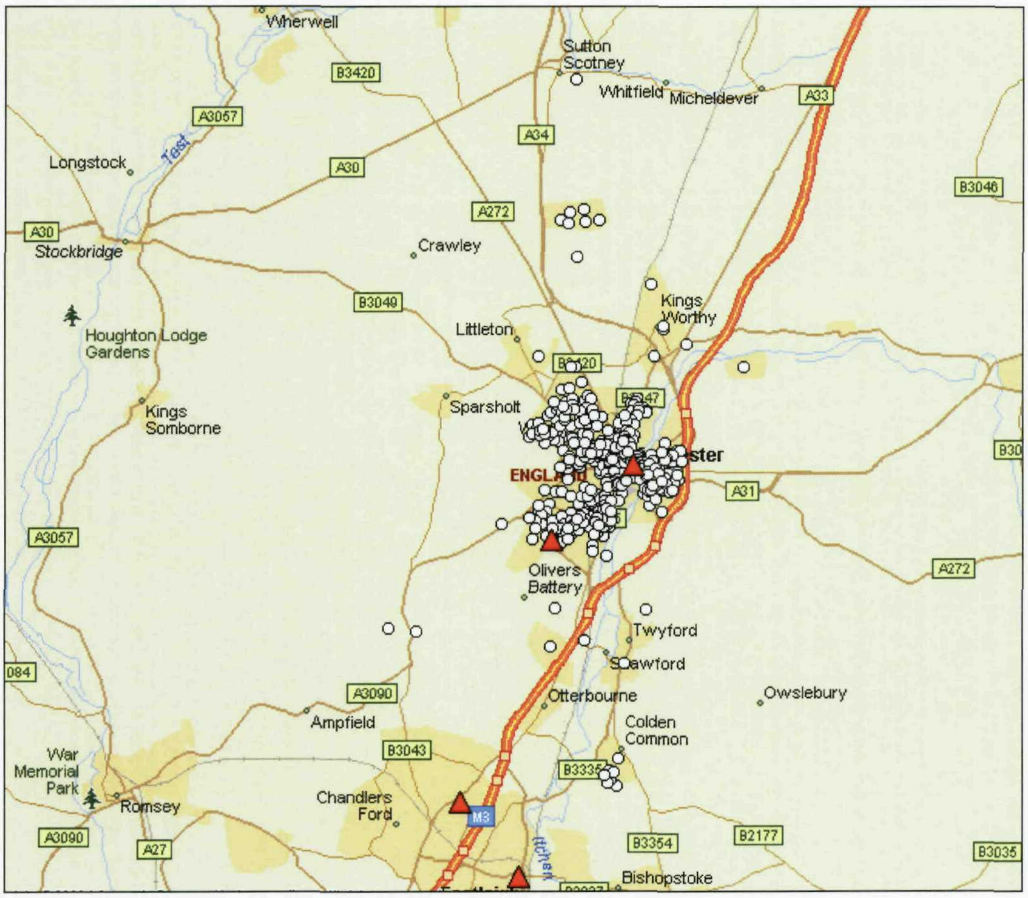
o Householder addresses ▲ Railway stations

Figure 37 A map showing the 423 sample householder origins in Winchester (white circles) and 5 railway stations (blue triangles) used as theoretical CDPs



○ Householder addresses △ Local Collect post offices

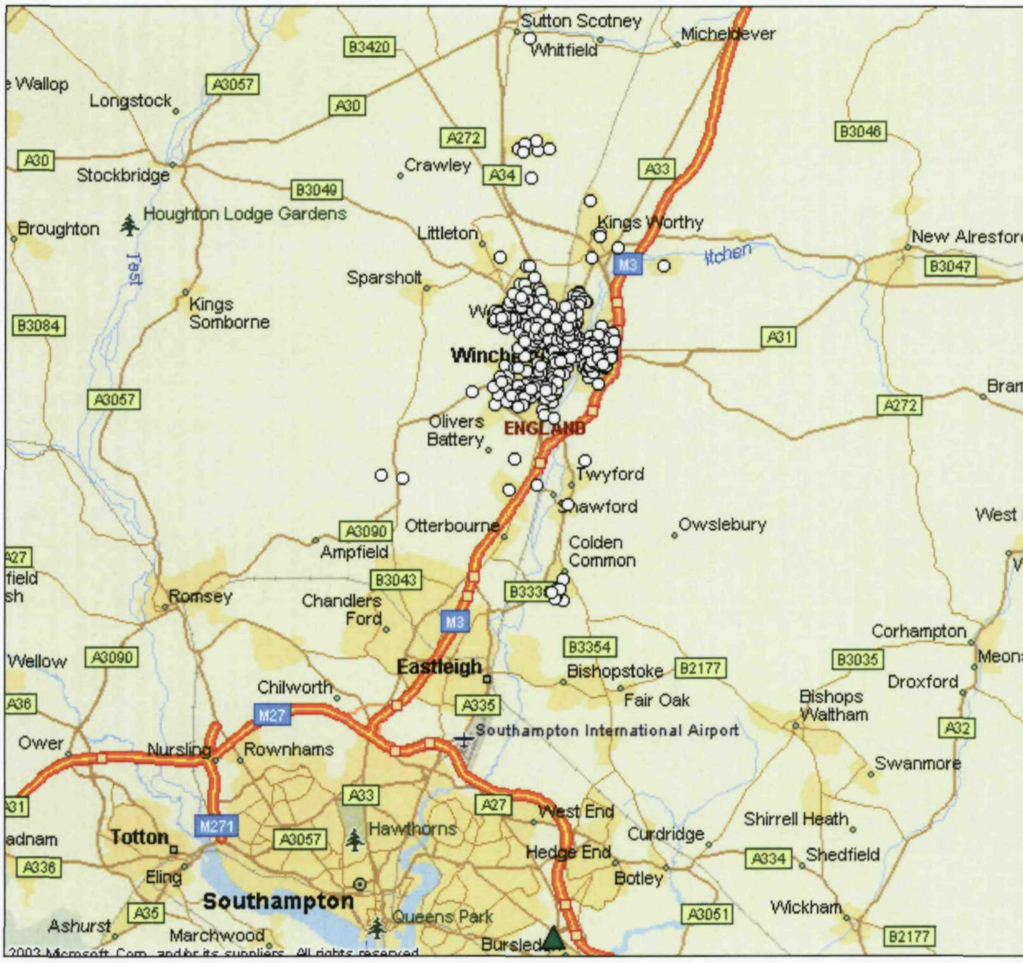
Figure 38 A map showing the 423 sample householder origins in Winchester (white circles) and 14 Local Collect post offices (yellow triangles)used as theoretical CDPs



○ Householder addresses

▲ Supermarket chain from ASDA, Morrison, Sainsbury's and Waitrose combined

Figure 39 A map showing the 423 sample householder origins in Winchester (white circles) and 4 supermarkets (red triangles) from ASDA, Morrison, Sainsbury's and Waitrose combined used as theoretical CDPs



○ Householder addresses ▲ Tesco Extra

Figure 40 A map showing the 423 sample householder origins in Winchester (white circles) and 1 Tesco Extra (green triangle) used as theoretical CDPs

The structure of this chapter is organized as follows. In Section 5.2, research objectives of this study are introduced and methodologies are explained in Section 5.3. In section 5.4, the carrier and householders travelling distances are simulated using RouteLogix. The environmental costs of CDP methods and existing delivery methods are then quantified based on the travelling distance and emission factors. The implications of failed home deliveries are also identified in this section. Conclusions are proposed in Section 5.5.

5.2. Objectives

The research objectives of this Winchester study were to:

- Quantify the transport costs on carrier of using the existing and the CDP home delivery methods by modelling the carrier delivery operations incurred in various home delivery methods around a sample of householders in Winchester;

- Quantify the transport costs on householders of using the existing and the CDP home delivery methods by modelling the householders' trips of collecting the failed first-time deliveries either from the carrier's depot or from local CDPs;

- Quantify the transport benefits to the householders of collecting the failed first-time home deliveries from a range of local CDPs close to their home;

- Identify the impacts of failed first-time home deliveries on the distance incurred by the carrier in delivering goods and the distance travelled by householders in collecting failed deliveries, either from the carrier's depot or from local CDPs;

- Identify the transport benefits of CDP method among various optional locations, including Tesco Extras, post offices offering 'Local Collect' service, railway stations and supermarket chain from ASDA, Morrison, Sainsbury's and Waitrose combined.

5.3. Methodology

5.3.1. The characteristics of the home delivery methods to be modelled

The characteristics for the home delivery methods to be modelled in this study were:

Existing delivery method

- The carrier makes up to two attempts to deliver to the home on successive days; to simply the problem, the third delivery attempt was not modelled in this research;

- Packages which are not delivered on either attempt are returned to the carrier's depot; people are left a card advising that the carrier has attempted delivery;

- Individuals collect failed deliveries from the carrier's depot. The proportion of people willing to generate such collection trips modelled in this study varies from 10% to 100%. The rest of people unwilling to travel to the depot will arrange re-deliveries to their homes.

CDP delivery method

- The carrier makes only one attempt to deliver to the home;

- Undelivered packages are taken to the individual's local CDP on the same day, automatically;

- Each failed home delivery results in individual trip collecting the failed packages from their local CDPs.

5.3.2. Routing and scheduling strategy for the carrier to make deliveries in the existing and CDP delivery methods

In the existing delivery method, the carrier route to make deliveries among a group of delivery addresses (including the re-deliveries) is optimised by DPS RouteLogix based on the quickest route between a series of points. The detailed route plans are presented both in printed form and with on-screen maps.

In the CDP method, the carrier has to decide a strategy that at what points the carrier will visit the CDPs on a round. An important assumption was that the carrier would visit each CDP not more than once on a round. If there was only one CDP to visit on a delivery round, it was reasonable to make all the deliveries first and then visit the CDP as the last task. If there was more than one CDP to visit, then a simple strategy was to visit the CDPs in an optimal sequence after all the delivery attempts were made in its catchments area. The carrier would have to drop the packages at the nearest CDP to the recipient's home. Figure 41 and 42 explain the methods to visit the CDPs adopted in this research.

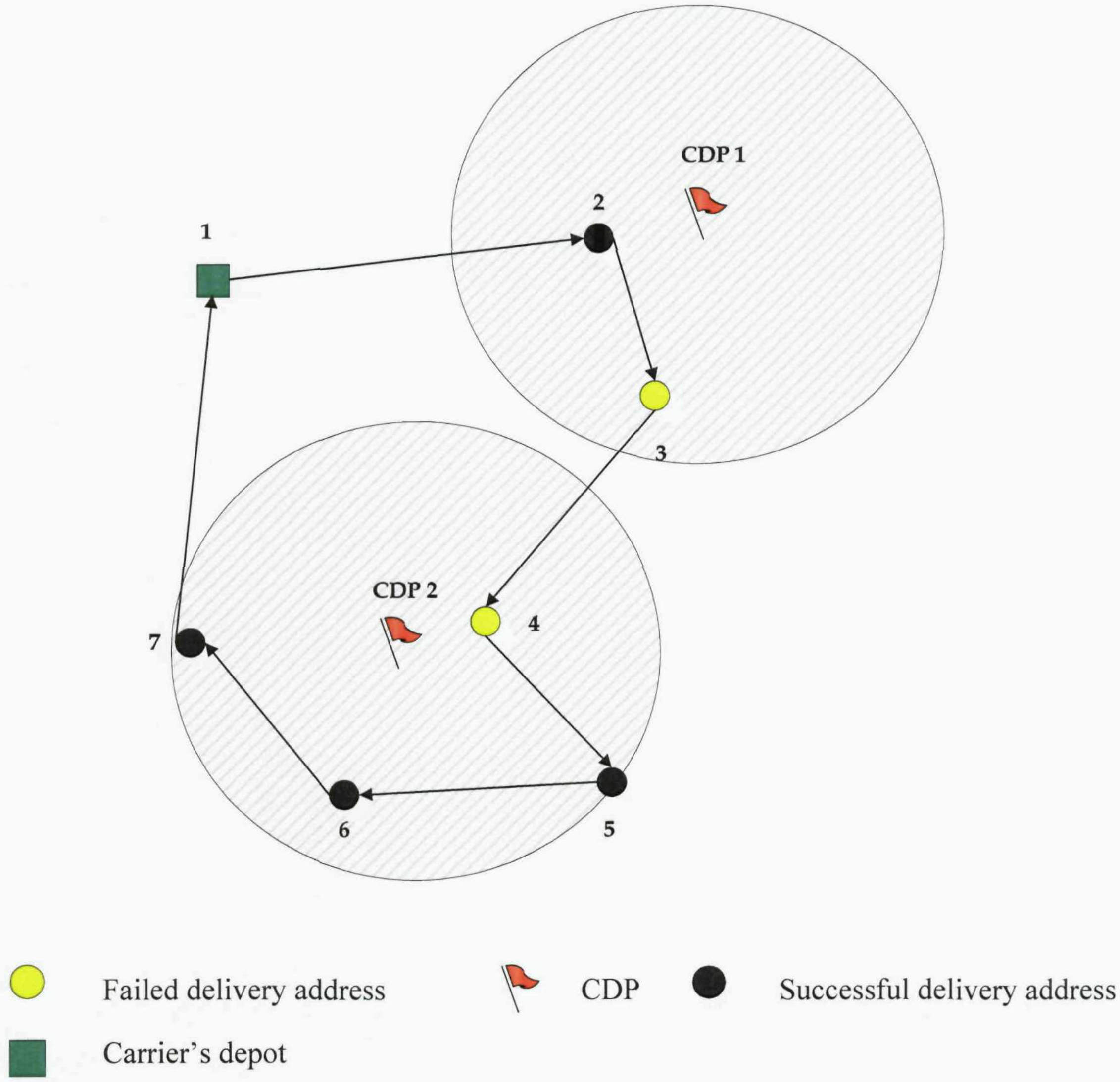


Figure 41 A figure illustrating the existing delivery sequence for the carrier to visit the delivery addresses (black circles) with the failed first-time deliveries (yellow circles)

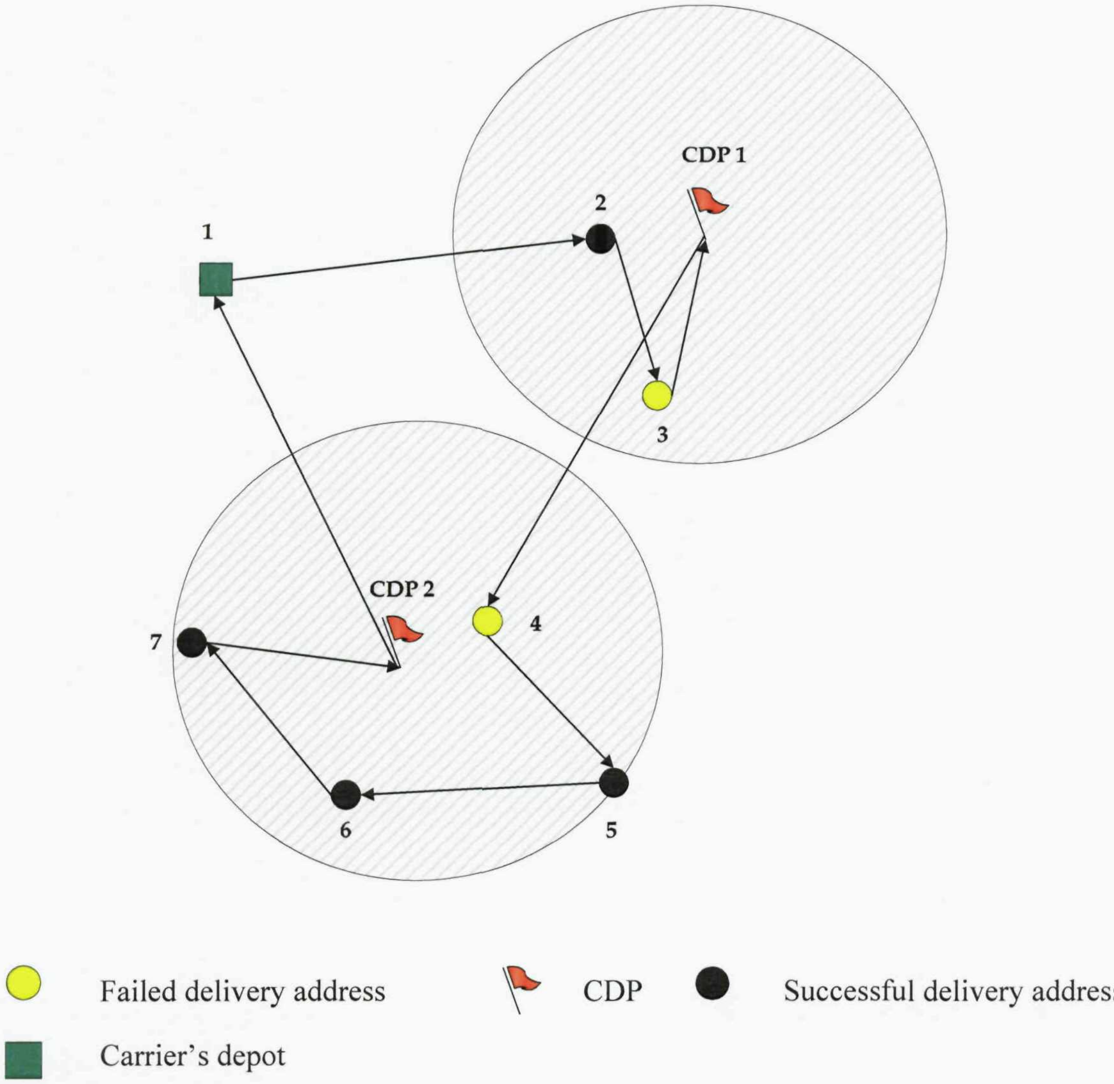


Figure 42 A figure illustrating the delivery sequence for the carrier to visit the CDPs (red flags) among delivery addresses (black circles) with failed first-time deliveries (yellow circles) being automatically diverted to the nearest CDPs (red flags)

In Figure 41, the existing sequence for the carrier to visit the 7 orders in the initial delivery round is provided. If we assume that delivery attempts to householders 3 and 4 failed, under the existing delivery model, those two orders would have to be delivered again on the subsequent day. If the second-time delivery attempts still failed, then they would be returned to the carrier's depot for the householder's later collection or for the householder to pay for an additional delivery attempt.

The visiting sequence in the CDP method is introduced in Figure 42. The shadowed circle indicated the catchments area served by the CDP. There were two CDPs with the first one serving the householder 2 and 3 and the second serving householders 4, 5, 6 and 7. This was determined based on the road distance between each of the 7 householders and 2 CDPs. For each householder, there was one CDP which is the nearest one. Hence, each CDP was visited after all the delivery attempts were made in its catchments area. For example, when the delivery attempt to householder 3 failed, the carrier was expected to visit CDP_1 since the delivery attempts in CDP_1's catchment area were complete. When the delivery attempt to householder 4 failed, the carrier had to continue to make deliveries to householders 5, 6 and 7. After that the carrier would visit the CDP_2 as the final task.

It was assumed in this Winchester study that the variety of products which would be purchased from home could be delivered by one single vehicle to the householders. The growing number of supermarket chains that supply a complete shopping environment, incorporating food, white goods, leisure items, personal services etc means that theoretically, one single retailer could supply the wide variety of products purchased during a typical high-street shopping trip. For example, Tesco.com provides a wide range of products to customer, including electrical, groceries, books, phones, flowers, wines, etc.

To model the carrier's delivery rounds associated with all delivery methods in RouteLogix, the following settings were used:

- Maximum working time is 9 hrs per LGV (Road Transport Directive, 2004);
- Maximum continuous driving time is 4.5 hrs (Road Transport Directive, 2004);
- Drop-off time of 5 minutes per householder address (MIRACLES, 2005);
- Delivery time of 5 minutes at the CDP (Collectpoint Plc, 2002);
- Householder's collection time of 5 minutes at the depot, or local CDP (Collectpoint Plc, 2002);
- LGV's average driving speed in the delivery area is 30 km/hr (Department for Transport, 2004).

5.3.3. Density of delivery addresses

The delivery density clearly affects the distance incurred by the carrier. In a smaller city such as Winchester, a workload of 50 addresses in one delivery round should be typical (Weaver, confidential data). Consequently 50 addresses were randomly selected from amongst the 423 questionnaire respondents.

5.3.4. Distance between householder origin postcodes and CDPs

The individual road distance from each of the 423 households to the modelled CDPs was calculated using Microsoft MapPoint. This was based on the quickest route distance between the householders' origin postcode and the CDP postcode (Table 30).

Table 30 Average road distance from each of the 423 householder postcodes to each of the 24 CDPs (1 Tesco Extra, 5 railway stations, 14 post offices offering 'Local Collect' and 4 other supermarkets) in Winchester

CDP Options	Average Distance from Respondent's Home to Local CDPs (km)
Tesco Extras	26.93
Railway stations	2.83
Local Post Offices	1.13
Supermarkets (ASDA, Morrison, Sainsbury's and Waitrose)	3.24

Since the nearest Tesco Extra from Winchester is located at 26.93km away, compared to the Parcelforce depot (13.3km), it is not realistic for Winchester sample householders to use the Tesco Extra as CDP. Hence, the CDP scenario of using Tesco Extra will not be discussed in this Winchester study. An One-way Analysis of Variance test showed that there were significant differences in the mean distance from individual household to local CDPs ($F(0.05)= 75.286$, $MSe= 234.765$ and $p= 0.000$). A subsequent Scheffé Multiple range test (Table C-1, Appendix C) indicated that there were no significant differences in the individual road distance to supermarket chain (mean distance = 3.24km) and to railway station (mean distance = 2.83km). Individual distance to local post office was significantly shorter than to other 2 CDP outlets at the 95% confidence level.

5.3.5. Distance of the carrier's depot from the delivery area

The survey data suggested that the main carrier the respondents had encountered was Parcelforce. The nearest Parcelforce depot was 13.3km from central Winchester.

5.3.6. Proportion of failed first-time home deliveries

First-time delivery failure rates of 10%, 20%, 30%, 40% and 50% were considered here. It was assumed that 50% of all re-deliveries would fail, based on the assumption that a high percentage of deliveries that failed first time would also fail second time due to the circumstances of the household members.

5.4. Modelling assumptions and parameters used

5.4.1. Householder travel

For the existing delivery method, it was assumed that some householders who suffered two failed delivery attempts by the carrier would travel to the carrier's depot to collect their packages. The proportion of people doing so will directly affect the assumed amount of road traffic associated with failed home deliveries, which will clearly affect the estimate of the reductions on householders' trips by using CDP method. To further explore this problem, a range of proportions of householders collecting from the carrier's depot were modelled here for the existing delivery methods, varying from 10% to 100%. For example, there were a total of 50 first-time delivery attempts on a delivery round. When 30% of those attempts were failures, the number of re-deliveries involved was 15. It was assumed that 50% of all re-deliveries failed again based on the assumption that those deliveries that failed first time would probably also fail second time due to the circumstances of the household members. Hence 7.5 households would suffer two failed delivery attempts. When the proportion of households collecting from the carrier's depot was 50%, 4 households would chose to do so.

Furthermore, it was found that the majority of sample householders (87%) chose to drive to the carrier's depot considering the significant distance to the depot from the resident area. As for their transport mode choices to the local CDPs, it was not surprising to find that only 43% of respondents chose to drive.

5.4.2. Carrier travel

For the existing delivery method, it was assumed that one delivery round involved deliveries to a total of 50 first-time delivery attempts and several second-time delivery attempts. For example, when the proportion of failed first-time deliveries was 30%, the number of re-deliveries involved was 15. Hence all delivery rounds involved deliveries to 65 addresses. To model the delivery round associated with all the delivery attempts, 65 addresses were randomly selected from among the 423 respondents. The delivery sequences for the carrier to visit those 65 addresses were then optimised by RouteLogix, based on the quickest route.

For the CDP delivery method, it was assumed that the carrier only made one delivery attempt to householders and the failed packages were automatically diverted to the nearest CDPs relative to the household address. Consequently, one delivery round involved a total of 50 first-time delivery attempts and a number of visits to the CDPs. Referring to the strategy proposed in Section 5.3.2, the visiting sequence of the carrier was then optimised by RouteLogix based on the quickest route.

5.4.3. Quantify the travelling distances of the carrier and the householders

An Excel spreadsheet was developed which allowed certain parameter values associated with the various home delivery scenarios to be varied and the results compared. An overall classification of the four existing delivery methods and three CDP delivery methods is presented in Table 31. The CDP method was defined by the CDP locations (railway station, post office offering 'Local Collect' service and supermarket chain). The existing delivery method was associated with the proportion of households travelling to the carrier's depot to collect their failed home deliveries.

Table 31 Description of the home delivery methods modelled in the analysis

Scenarios	Home delivery methods	Proportion of households who experienced failed home deliveries would travel to the carrier's depot
CDP1	CDP = Railway station	0%
CDP2	CDP = Other supermarket	0%
CDP3	CDP = Local Collect post office	0%
EXD1	Existing delivery method1	10%
EXD2	Existing delivery method2	30%
EXD3	Existing delivery method3	50%
EXD4	Existing delivery method4	100%

The input parameters for the various scenarios in the spreadsheet are shown in Table 32.

Table 32 Parameters used in the home delivery modelling work. (Individual explanations are given as a footnote to the table)

Input parameters						
A = no. of 1st time deliveries		50				
D1 = no. of railway stations		5				
D2 = no. of Local Collect post offices		14				
D3 = no. of supermarkets		4				
E = average one-way distance from centre of delivery area to carrier's depot (Parcelforce)		13.3km				
F 1 = average one-way distance from individual origin to railway station (Section 5.3.4, Chapter Five)		2.83km				
F 2 = average one-way distance from individual origin to Local Collect post office (Section 5.3.4, Chapter Five)		1.13km				
F 3 = average one-way distance from individual origin to supermarket (Section 5.3.4, Chapter Five)		3.24km				
R1 = proportion of householders travelling to CDP by car (Section 4.2.7, Chapter Four)		43%				
R2 = proportion of householders travelling to carrier's depot by car (Section 4.2.6, Chapter Four)		87%				
Distances travelled by householders and carrier						
B = proportion of failed 1st time deliveries		10%	20%	30%	40%	50%
P = proportion of failed 2nd time deliveries		5%	10%	15%	20%	25%
C = carrier travel distance (Section 5.4.3.1, Chap. Five)	existing method	98.2	103.2	109.2	111.8	114.3
	CDP1 method	103.7	103.7	103.7	103.7	103.7
	CDP2 method	119.8	119.8	119.8	119.8	119.8
	CDP3 method	107.5	107.5	107.5	107.5	107.5
H = householder travel distance (Section 5.4.3.2, Chap. Five)	EXD1 method	5.8	11.6	17.4	23.1	28.9
	EXD2 method	17.4	34.7	52.1	69.4	86.8
	EXD3 method	28.9	57.9	86.8	115.7	144.6
	EXD4 method	57.9	115.7	173.6	231.4	289.3
	CDP1 method	12.2	24.3	36.5	48.7	60.8
	CDP2 method	13.9	27.9	41.8	55.7	69.7
	CDP3 method	4.9	9.7	14.6	19.4	24.3

A (number of first-time home deliveries)

This has been assumed to be 50 throughout the analysis here. It should be noted, however, that variable C is dependent on the value of A, as the distance C must be calculated for the carrier's rounds comprising the number of deliveries stated in A.

B (proportion of failed first-time home deliveries)

This represents the proportion of failed first-time deliveries.

P (proportion of failed second-time home deliveries)

This is expressed as a percentage of those that failed first-time (parameter B). If B is taken to be zero then the value of this parameter is irrelevant. Otherwise, the value is set to be 50% of B.

D (no. of CDPs to be visited)

The CDP options modelled in this research were 1) 14 post offices providing 'Local Collect' service, 2) 5 railway stations and 3) 4 supermarkets from ASDA, Morrison, Sainsbury's and Waitrose chains combined.

E (average one-way distance from carrier's depot to centre of Winchester)

In this research, the average one-way distance was 13.3km between household origins and the Parcelforce depot.

F (average distance from homes to local CDPs)

This is the average one-way distance between 423 households and 23 Local CDPs in Winchester.

C (carrier's travel distance)

The carrier's delivery rounds for the existing delivery method was modelled as starting and ending at the Parcelforce depot and visiting 50 delivery addresses plus a number of re-deliveries, the number depending on the assumed proportion of failed 1st time deliveries.

The carrier's travel distance for the CDP methods was calculated in a similar way to parameter C but with the carrier visiting the local CDPs as the alternative address to the failed first-time packages on the delivery round and a reduced number of overall delivery addresses compared to the existing delivery method.

R1 (proportion of people travelling to the CDP by car)

This parameter was 43% according to the responses from the Winchester survey. It directly affects the assumed amount of car traffic to and from local CDPs for the CDP delivery method.

R2 (proportion of people travelling to depot by car)

This parameter was 87% according to the responses from the Winchester survey. This high percentage reflected the fact that most carriers' depots were quite far away from where people lived and walking was not an option for the vast majority.

5.4.3.1. Carrier travel distance analysis

Nine different carrier round sets were modelled by selecting 9 sets of 50 sample householders randomly from 423 postcodes. In each case the carrier started and ended at the Parcelforce depot and all 50 delivery addresses were visited in the optimal order by using RouteLogix. The number of redeliveries depended on the proportion of failed first-time deliveries. The locations of redeliveries were selected randomly among 423 postcodes, minus the 50 first-time delivery addresses. For the CDP delivery method, a number of visits to households was removed effectively that would otherwise have had to be made. They were replaced with the visits to local CDPs.

The modelled distances were shown in Table C-2 (Appendix C) The length of the carrier's round depended on how spread out the delivery addresses were. Since the delivery addresses were randomly selected among 423 respondents, there were variances among the 9 data sets in the carrier driving distance. To smooth out the variance, the average carrier distances to serve the 50 first-time deliveries and a number of re-deliveries among the 9 data sets were adopted.

As shown in Table 32, the carrier distance incurred in the existing delivery method increased from 98.2km to 114.3km when the delivery failure rate increased from 10% to 50%. This was because the number of second-time delivery attempts to be made by the carrier increased from 5 to 25. Hence the overall delivery attempts on one delivery round increased from 55 to 75, resulting in the extra kilometers on the carrier to make deliveries. However, the carrier driving distance incurred in each CDP delivery method remained constant regardless of the first-time delivery failure rate. For example, the carrier distance incurred in the CDP_3 delivery method was 107.5km for the whole range of delivery failure rates (from 10% to 50%). This was because in the CDP methods, the carrier would visit the local CDPs as the alternative addresses to the failed first-time packages instead of making second-time deliveries. Consequently the number of overall delivery attempts on one delivery round (including 50 first-time delivery attempts and a number of visits to the CDPs) was constant, without any impacts on the carrier driving distance.

5.4.3.2. Householder travel distance analysis

The householder's driving distance incurred in the existing delivery method, was quantified based on the proportion of households who suffered two delivery failures would collect their failed home deliveries from the carrier's depot, their transport mode choices and two-way road distance from household origins to the carrier's depot. The results are presented in Table 33.

Table 33 Total householder driving distances (km) (two-way) associated with collecting failed first-time home deliveries from carrier's depot. 50 sample addresses were used across Winchester to derive the carrier rounds.

Householder travelling distance	**Percentage of failed home deliveries**				
Scenarios	10%	20%	30%	40%	50%
Existing method EXD1 (10% of householders willing to travel to the depot)					
no. of households suffering two delivery failures (**A x P**)	2.5	5	7.5	10	12.5
x two times average road distance from home to carrier's depot (**2xE**)	26.6	26.6	26.6	26.6	26.6
x proportion of people travelling to carrier's depot by car (**R2**)	87%	87%	87%	87%	87%
x proportion of people willing to travel to carrier's depot	10%	10%	10%	10%	10%
Total KM for householders	5.8	11.6	17.4	23.1	28.9
Existing method EXD2 (30% of householders willing to travel to the depot)					
no. of households suffering two delivery failures (**A x P**)	2.5	5	7.5	10	12.5
x proportion of people willing to travel to carrier's depot	30%	30%	30%	30%	30%
x two times average road distance from home to carrier's depot (**2xE**)	26.6	26.6	26.6	26.6	26.6
x proportion of people travelling to carrier's depot by car (**R2**)	87%	87%	87%	87%	87%
Total KM for householders	17.4	34.7	52.1	69.4	86.8
Existing method EXD3 (50% of householders willing to travel to the depot)					
no. of households suffering two delivery failures (**A x P**)	2.5	5	7.5	10	12.5
x proportion of people willing to travel to carrier's depot	50%	50%	50%	50%	50%
x two times average road distance from home to carrier's depot (**2xE**)	26.6	26.6	26.6	26.6	26.6
x proportion of people travelling to carrier's depot by car (**R2**)	87%	87%	87%	87%	87%
Total KM for householders	28.9	57.9	86.8	115.7	144.6

Table 33 continued

Householder travelling distance	**Percentage of failed home deliveries**				
Scenarios	10%	20%	30%	40%	50%
Existing method EXD4 (100% of householders willing to travel to the depot)					
no. of households suffering two delivery failures (**A x P**)	2.5	5	7.5	10	12.5
x proportion of people willing to travel to carrier's depot	100%	100%	100%	100%	100%
x two times average road distance from home to carrier's depot (**2xE**)	26.6	26.6	26.6	26.6	26.6
x proportion of people travelling to carrier's depot by car (**R2**)	87%	87%	87%	87%	87%
Total KM for householders	57.9	115.7	173.6	231.4	289.3

For example, when 40% of a total of 50 first-time deliveries failed, the carrier had to make re-delivery attempts to 20 households. Among those 20 delivery addresses, the deliveries to 10 failed again considering the assumption that a high percentage of deliveries that failed first time would also fail second time due to the circumstances of the household members. In the existing method, the households who suffered two failed delivery attempts had the choice of collecting their failed packages from the carrier's depot. It was then identified that 1, 3, 5 and 10 households would choose to do so in EXD1 (10% of households collected from the carrier's depot), EXD2 (30%), EXD3 (50%) and EXD4 (100%) method, respectively. Based on the one-way road distance from the subjects' homes to the carrier's depot (13.3km) and the proportion of households using a car to the depot (87%), the householders' driving distance when 40% of first-time deliveries failed was quantified as 23.1km, 69.4km, 115.7km and 231.4km incurred in those four existing delivery methods, respectively. In a similar way, the householder's driving distance incurred in the CDP method was calculated based on the proportion of households collecting from the CDPs, their transport mode choices and average two-way distance from the household's origin point to the CDPs in the respective networks (Table 34).

Table 34 Total householder driving distances (km) (two-way) associated with collecting failed first-time home deliveries from local CDPs. 50 sample addresses were used across Winchester to derive the carrier rounds.

Householder travelling distance	**Percentage of failed home deliveries**				
Scenarios	10%	20%	30%	40%	50%
CDP1 method (CDP=railway station)					
no. of households having first-time delivery failures (**A x B**)	5	10	15	20	25
x two times average road distance from home to railway station (**2xF1**)	5.7	5.7	5.7	5.7	5.7
x proportion of people travelling to CDP by car (**R1**)	43%	43%	43%	43%	43%
Total KM for householders	12.2	24.3	36.5	48.7	60.8
CDP2 method (CDP=supermarket)					
no. of households having first-time delivery failures (**A x B**)	5	10	15	20	25
x two times average road distance from home to supermarket (**2xF3**)	6.5	6.5	6.5	6.5	6.5
x proportion of people travelling to CDP by car (**R1**)	43%	43%	43%	43%	43%
Total KM for householders	13.9	27.9	41.8	55.7	69.7
CDP3 method (CDP=Local Collect post office)					
no. of households having first-time delivery failures (**A x B**)	5	10	15	20	25
x two times average road distance from home to supermarket (**2xF2**)	2.26	2.26	2.26	2.26	2.26
x proportion of people travelling to CDP by car (**R1**)	43%	43%	43%	43%	43%
Total KM for householders	4.9	9.7	14.6	19.4	24.3

For example, when 40% of a total of 50 first-time home deliveries failed, the carrier made 20 deliveries to the CDPs as the alternative addresses to the failed packages. Then 20 households had to travel to the CDPs to collect their failed packages. Based on average one-way road distance from home to the CDPs (2.83km to railway stations, 1.13 to post offices and 3.24km to supermarkets), proportion of householders using car to the CDPs (43%), the householders' driving distances when 40% of first-time home deliveries failed were 48.7km, 55.7km and 19.4km incurred in those three CDP delivery methods, respectively.

The overall results in Table 34 suggested that diverting failed first-time deliveries to the Local Collect post offices would be the most effective CDP option in terms of reducing household kilometers, currently generated when householders travelling to the carrier's depot to collect their failed deliveries, resulting in 91% reductions in householder distance. The CDP methods using railway stations and supermarkets were also able to reduce householder kilometers generated in the existing method EXD4 (by 77% and 74%, respectively).

To further compare the householder distances in the CDP methods with the four existing methods, and explore the impacts of using the CDPs on householders' trips, more discussions were provided in the section below.

5.5. Travel distances and associated environmental costs of the existing delivery systems compared to the CDP options

5.5.1. Travel distances accrued by various home delivery methods

Table 35 presents the changes on distances of householders (car-km) and carrier (van-km) made by the CDP methods, compared to the existing method where each householder who experienced two failed home deliveries would travel to the carrier's depot (EXD4). The changes in overall driving distance (overall-km) are also presented. A negative value indicates that the amount of travelling distance was reduced by respective delivery method. This was done by modelling the home delivery operations around 50 sample households in Winchester.

Table 35 Changes in householder and carrier driving distances associated with various home delivery methods, compared to the scenario (EXD4) where everyone who experienced two home delivery failures would travel to the carrier's depot to collect their failed home deliveries

Scenarios		**Changes in travel distances for householders and carrier**			
		Van-km*	Car-km**	Overall-km	
10% of first-time home deliveries failed:					
CDP1	CDP = railway station	5.6	-45.7	-40.1	(-25%)
CDP2	CDP = supermarket chain	21.6	-43.9	-22.3	(-14%)
CDP3	CDP = Local Collect post office	9.4	-53.0	-43.6	(-28%)
EXD1	Existing delivery method (10% travelling to depot)	0	-52.1	-52.1	(-33%)
EXD2	Existing delivery method (30% travelling to depot)	0	-40.5	-40.5	(-26%)
EXD3	Existing delivery method (50% travelling to depot)	0	-28.9	-28.9	(-19%)
EXD4	Existing delivery method (100% travelling to depot)	—	—	—	
20% of first-time home deliveries failed:					
CDP1	CDP = railway station	0.5	-91.4	-90.8	(-41%)
CDP2	CDP = supermarket chain	16.6	-87.8	-71.2	(-33%)
CDP3	CDP = Local Collect post office	4.4	-106.0	-101.6	(-46%)
EXD1	Existing delivery method (10% travelling to depot)	0	-104.1	-104.1	(-48%)
EXD2	Existing delivery method (30% travelling to depot)	0	-81.0	-81.0	(-37%)
EXD3	Existing delivery method (50% travelling to depot)	0	-57.9	-57.9	(-26%)
EXD4	Existing delivery method (100% travelling to depot)	—	—	—	
30% of first-time home deliveries failed:					
CDP1	CDP = railway station	-5.5	-137.0	-142.5	(-49%)
CDP2	CDP = supermarket chain	10.6	-131.8	-121.1	(-43%)
CDP3	CDP = Local Collect post office	-1.6	-158.9	-160.6	(-56%)

Table 35 continued

Scenarios		Changes in travel distances for householders and carrier		
		Van-km*	Car-km**	Overall-km
EXD1	Existing delivery method (10% travelling to depot)	0	-156.2	-156.2 (-55%)
EXD2	Existing delivery method (30% travelling to depot)	0	-121.5	-121.5 (-43%)
EXD3	Existing delivery method (50% travelling to depot)	0	-86.8	-86.8 (-31%)
EXD4	Existing delivery method (100% travelling to depot)	—	—	—
40% of first-time home deliveries failed:				
CDP1	CDP = railway station	-8.1	-182.7	-190.8 (-54%)
CDP2	CDP = supermarket chain	8.0	-175.7	-167.7 (-49%)
CDP3	CDP = Local Collect post office	-4.3	-211.9	-216.2 (-63%)
EXD1	Existing delivery method (10% travelling to depot)	0	-208.3	-208.3 (-61%)
EXD2	Existing delivery method (30% travelling to depot)	0	-162.0	-162.0 (-47%)
EXD3	Existing delivery method (50% travelling to depot)	0	-115.7	-115.7 (-34%)
EXD4	Existing delivery method (100% travelling to depot)	—	—	—
50% of first-time home deliveries failed:				
CDP1	CDP = railway station	-10.6	-228.4	-239.0 (-58%)
CDP2	CDP = supermarket chain	5.5	-219.6	-214.1 (-53%))
CDP3	CDP = Local Collect post office	-6.8	-264.9	-271.7 (-67%)
EXD1	Existing delivery method (10% travelling to depot)	0	-260.4	-260.4 (-65%)
EXD2	Existing delivery method (30% travelling to depot)	0	-202.5	-202.5 (-50%)
EXD3	Existing delivery method (50% travelling to depot)	0	-144.6	-144.6 (-36%)
EXD4	Existing delivery method (100% travelling to depot)	—	—	—

* carrier round distance; ** total distance travelled by householders

A general observation from Table 35 was that the main benefits of using various CDP methods were earned by householders (car-km) instead of the carrier (van-km). For instance, when 10% of first-time deliveries failed, the CDP method using the Local Collect post offices was able to save householders' distances by 53km but increased the carrier's distance by 9.4km at the same time. Such reductions were even more significant when a large proportion of failed first-time deliveries occurred. For example, under the scenario of 50% delivery failure rate, the householders' distance was saved by 264.9km by the CDP method using Local Collect post offices. Similar trends were found for the CDP methods using railway stations and supermarkets. In general, the CDP methods were beneficial in terms of reducing householder distance, generated in EXD4.

Another observation of Table 35 was that the CDP methods were beneficial to the householders' distance when compared to the existing methods EXD2, EXD3 and EXD4. That was to say, if more than 30% of households who suffered two failed deliveries chose to collect their failed packages from the carrier's depot, the distances generated from those collection trips could be significantly reduced by using the CDP methods. However, if the proportion of households doing so was less than 30%, extra kilometres were incurred on householders of using CDP delivery methods.

To further explore the changes in householder and carrier kilometres made by the CDP methods, more discussions are provided below.

5.5.1.1. Householder distance changes made by the CDP home delivery methods

Figure 43 presents the changes in householder distance (in terms of percentage) by the CDP methods, compared to the respective existing delivery method. A negative percentage suggests that the CDP method reduced the amount of distance travelled.

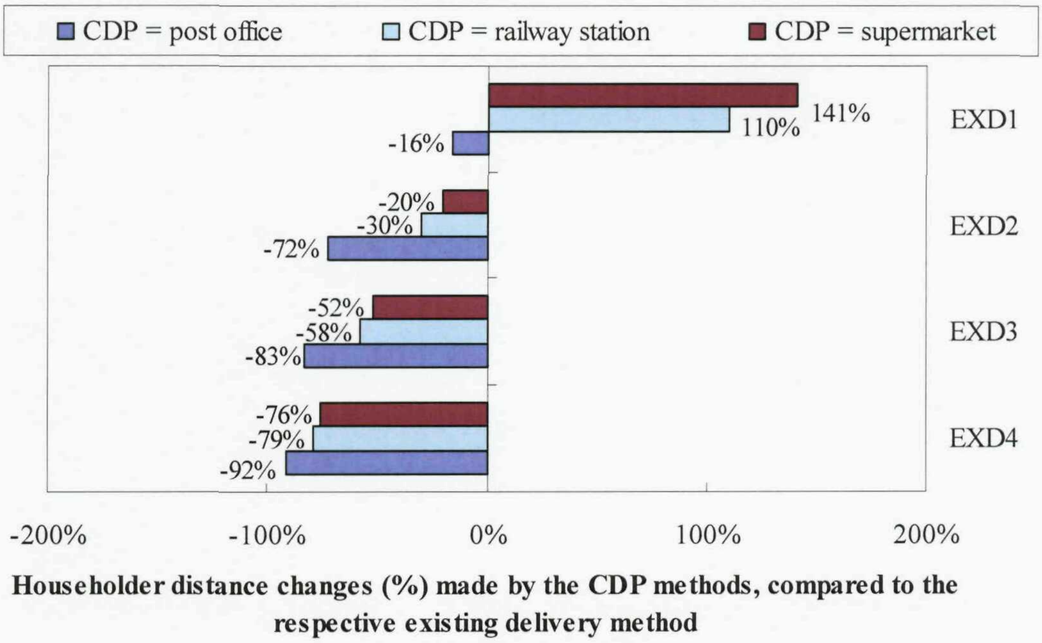


Figure 43 Householder distance changes (%) made by the CDP methods compared to the existing methods, associated with carrier delivering to 50 random households in Winchester ([3]).

As shown in Figure 43, compared to the EXD4 where every household who experienced two failed home deliveries collected their failed packages from the carrier's depot, the householder's driving distances incurred in the CDP delivery methods were significantly reduced. The greatest reductions were achieved when the Local Collect post offices were utilized as CDPs, resulting in 92% reduction in householder distance over the existing system (EXD4). This result was due mainly to the assumptions that the carrier's depot at 13.3km was 5-12 times further away from householders' homes than their local CDPs. The incidence of car travel was assumed to be 87% for travel to the carrier's depot but only 43% for travel to a local CDP. Consequently the householders were able to save significant amount of kilometres by collecting their goods from the CDPs instead of the carrier's depot.

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[3] Under the 3 CDP options, all failed items were automatically diverted to the CDP nearest to the household delivery addresses, and individual household who suffered failed home deliveries travel to the CDPs to collect. The householder travel distances are compared with the four existing methods where 100%, 50%, 30%, and 10% of households who suffered two delivery failures chose to collect their failed packages from the carrier's depot.

When compared with EXD3 and EXD2, the CDP delivery methods were still beneficial to the householder distance. However, the distance reductions made by the CDP methods decreased. For instance, the CDP method using railway stations reduced householder kilometres by 58% compared to EXD3 and 30% compared to EXD2. It implied that the householders experienced less kilometres when they collected the failed packages from the local CDPs instead of the carrier's depot. However, if there were only 10% of households collecting their failed packages from the carrier's depot (EXD1), the CDP methods had negative impacts on householders. As shown in Figure 43, their distances generated in the current situation were increased by the CDP methods utilizing supermarkets or railway stations (by 141% and 110%, respectively). In that case, the householders experienced less kilometres when they collected the failed packages from the carrier's depot instead of the CDPs.

The overall results in Figure 43 suggested that the CDP methods were most effective in terms of reducing householder kilometres when there were at least 30% of householders collecting their failed packages from the carrier's depot in the existing methods. The findings could help to improve the efficiency of the CDP methods by identifying people's responses to the failed home deliveries. In some areas where a significant proportion of people (30% or more) willing to travel to the carrier's depot, the road traffic generated from those trips to make collections would be significantly improved by the CDP methods.

5.5.1.2. Carrier distance changes made by the CDP home delivery methods

Table 35 suggested that the impacts of the CDP methods on carrier's kilometres were fairly minimal, with reductions of 5.5km observed when the railway stations were used as CDPs for 30% of delivery failure rate. At the same time, there were 137km reductions on householder distance. Another finding was that the distance reductions on carrier of using the CDP method increased as the number of re-deliveries to be made increased. For example, changes in carrier distance increased from 6% to -9% by the CDP method using railway stations as the proportion of failed first-time deliveries increased from 10% to 50%. To further explore the changes in carrier kilometres made by CDP methods, and identify the impacts of delivery failure rate, the changes in carrier distance were presented in Figure 44.

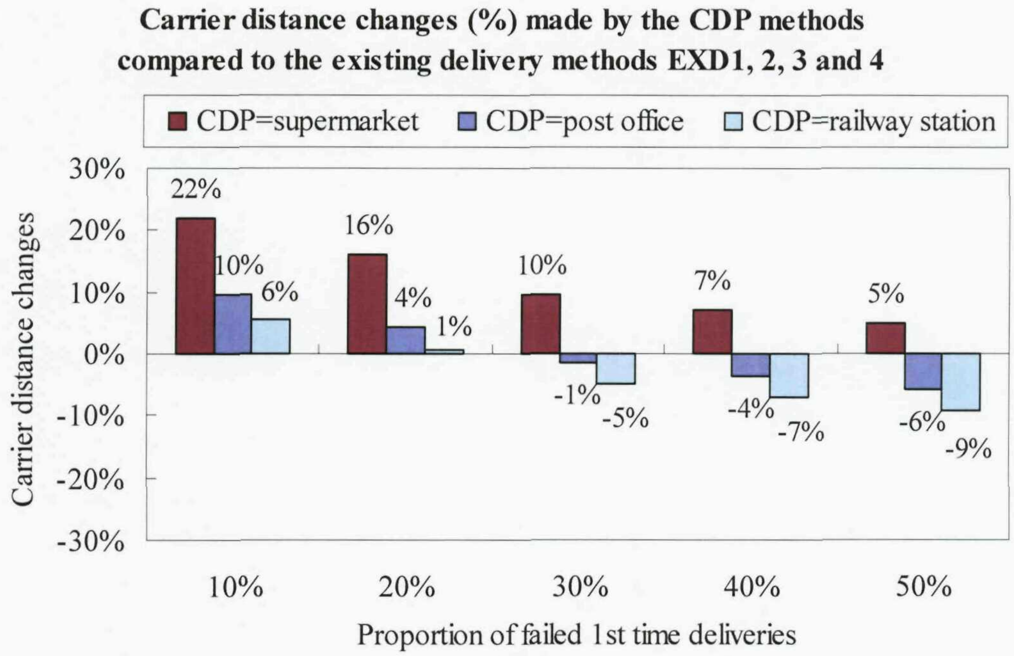

Figure 44 Carrier distance changes (%) made by the CDP methods compared to the existing methods, associated with carrier delivering to 50 random households in Winchester ([4])

It was noted here that the carrier driving distance generated from each CDP delivery methods was constant, regardless the first-time delivery failure rate. This was due to the mechanism of the CDP methods modelled here: carrier made only one delivery attempt to the household and the failed packages were diverted to the CDPs automatically. The carrier visited the CDP in such an optimal sequence that after all the delivery attempts were made in its catchments area, the carrier would drop the packages at the nearest CDP to the recipient's home.

The carrier distance in the existing methods increased with the delivery failure rates, due to the needs to make re-deliveries. However, for each scenario of delivery failure rate, the carrier distances generated from the four existing methods were constant. Consequently, it was not necessary to compare the carrier distance incurred in the CDP methods with all the four existing methods.

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[4] Under the 3 CDP options, all failed items were automatically diverted to the CDP nearest to the household address, and carrier made 50 first-time deliveries and a number of visits to the CDPs. Under the 4 existing delivery methods, the carrier made 50 first-time deliveries and a number of re-deliveries, which was dependent on the proportion of failed first-time deliveries.

As shown in Figure 44, the CDP methods had fairly limited impacts on carrier distance. That was to say, for the existing delivery method, an optimal route, including all the re-deliveries, was used, which was not much longer than the equivalent route excluding the re-deliveries for the CDP methods. This was due to the fact that all the delivery addresses considered were within a relatively compact area. If the delivery addresses were spread over a wider area then the CDP delivery method would tend to become more efficient in terms of the length of the carrier's delivery round. For instance, the carrier distance increased by 9.4km (10% increases compared to the existing delivery method) when introducing the CDP method using post offices. Clearly, this would result in additional costs to the carrier for each delivery round in terms of all standing and running costs as well as an allowance for overheads, which is £0.74/km for a typical rigid delivery vehicle (UK Freight Transport Association, 2007). The Winchester survey suggested that around 20% of first-time deliveries failed. Consequently, based on those carrier travelling distances and an assumed vehicle operating cost, the additional transport costs to the carrier of using CDP methods were £3.2 per round (Local Collect post office), £12.3 (supermarket chain) and £0.4 (railway station). This equals to additional carrier costs of £839, £3194 and £104 annually, considering the assumption that 50 orders per delivery round were typical during any working day.

Although the CDP methods would impose additional costs to the carrier, the cost savings resulting from not having to handle failed first-time deliveries could be significant. IMRG (2006) estimated that a carrier might incur a total cost of £38.50 to deal with each delivery failure, made up of £4 for customer service costs, £5 for handling stock/replacements/damages, £1.50 for one additional re-delivery attempt, and £28 of other potential costs (e.g. answering customer enquiries; escalating complaints, handling claims, recalculating invoices, re-issuing invoices; customer attrition/loss; customer recruitment costs to replace those lost due to delivery problems). By diverting the failed first-time deliveries to the local CDPs, the carrier doesn't have to return the packages to the depot and then make several redelivery attempts on the following working day, which might occur in the existing delivery operations. That is to say, £38.50 can be saved for the carrier associated with handling each delivery failure. Additionally, the customer can nominate the CDPs as the first-time delivery addresses. In that case, the carrier diverts the packages directly to the

CDPs without visiting the customer's home. Hence further reductions on carrier's delivery costs are achievable due to the reduced number of visits during a delivery round.

Based on the estimate of a potential cost of handling each failed package and the number of such failures in Winchester, it was then possible to quantify the overall cost savings made by the CDP methods in that area. In this Winchester study, 50 orders per delivery round were assumed to be typical during any working day. According to the home delivery questionnaire undertaken in Winchester, around 20% of first-time deliveries failed. Considering there were 52 weeks a year, it was then estimated that there were 2600 failed first-time deliveries a year in Winchester, resulting in potentially £100,100 costs for handling those failed deliveries. Obviously, such costs would be even more significant in some areas demanding a significant number of home deliveries, indicating that the CDP methods would be much more positive for the carrier to reduce the costs of handling the failed deliveries. The findings were helpful to identify the benefits of the CDP concept in terms of reducing retailer and carrier's handling costs towards the delivery failures.

5.5.1.3. Overall distance changes made by the CDP home delivery methods

The overall distances incurred in the CDP methods were compared to each existing method (Figure 45 to Figure 48). A negative value indicates that the amount of travelling distance was reduced by the CDP methods. A general observation over the four figures was that the total distance was significantly reduced by the CDP methods when 30% or more of householders would travel to the depot. Another observation was that the overall distance savings made by each CDP method improved as number of failed first-time deliveries increased.

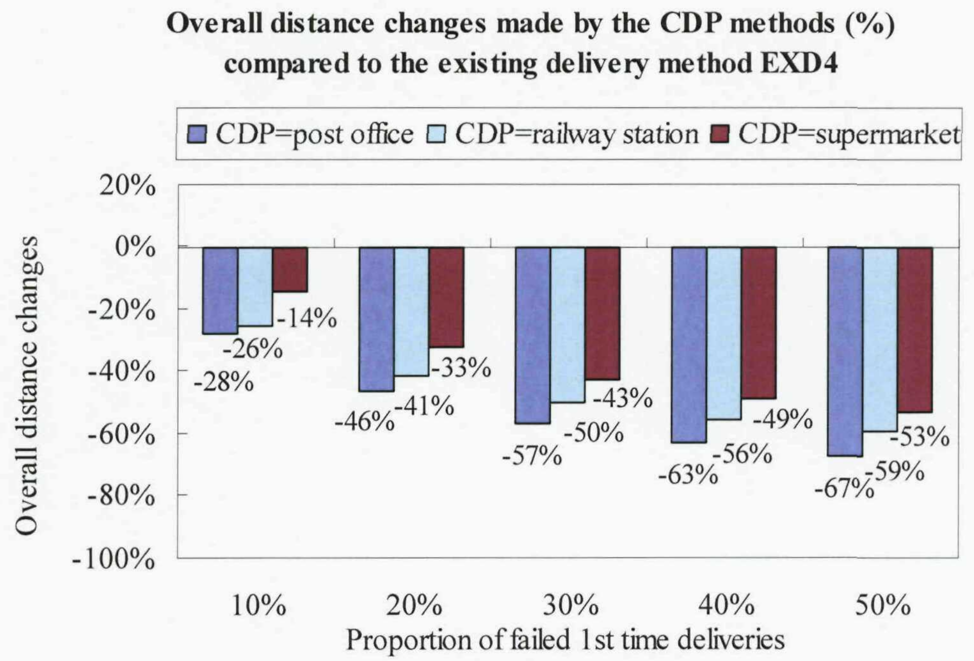


Figure 45 Overall driving distance changes (%) made by CDP methods compared to EXD4, associated with carrier delivering to 50 random households in Winchester ([5])

For the whole range of delivery failure rates, the impacts of CDP methods were positive in terms of reducing overall distance, resulting in maximum 67% reductions observed when the Local Collect post offices were used as CDPs and 53% reductions when supermarkets were used.

[5] Under the 3 CDP options, all failed items were automatically diverted to the CDP nearest to the household address, and carrier made 50 first-time deliveries and a number of visits to the CDPs. Under the existing delivery method, the carrier made 50 first-time deliveries and a number of re-deliveries, which was dependent on the proportion of failed first-time deliveries. The overall travel distances are compared with the existing method where 100% of failures are returned to the depot for collection by the householders (EXD4).

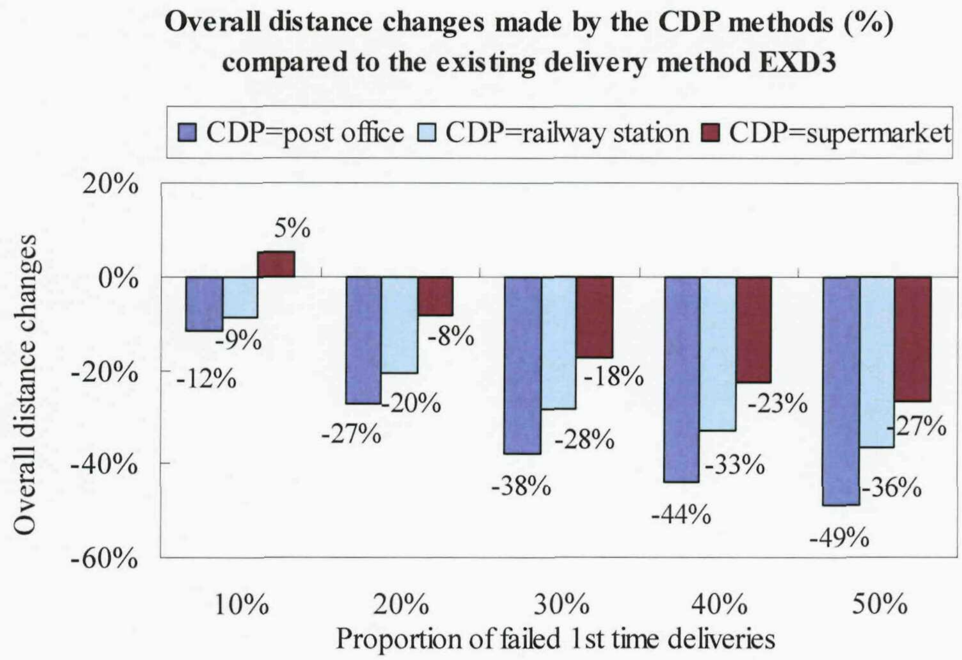


Figure 46 Overall driving distance changes (%) made by CDP methods compared to EXD3, associated with carrier delivering to 50 random households in Winchester ([6])

Figure 46 suggested that when there were at least 20% of failed first-time deliveries, the CDP methods were able to reduce the total driving distance, resulting in maximum 49% reductions when Local Collect post offices were used as CDPs.

[6] Under the 3 CDP options, all failed items were automatically diverted to the CDP nearest to the household address, and carrier made 50 first-time deliveries and a number of visits to the CDPs. Under the existing delivery method, the carrier made 50 first-time deliveries and a number of re-deliveries, which was dependent on the proportion of failed first-time deliveries. The overall travel distances are compared with the existing method where 50% of failures are returned to the depot for collection by the householders (EXD3).

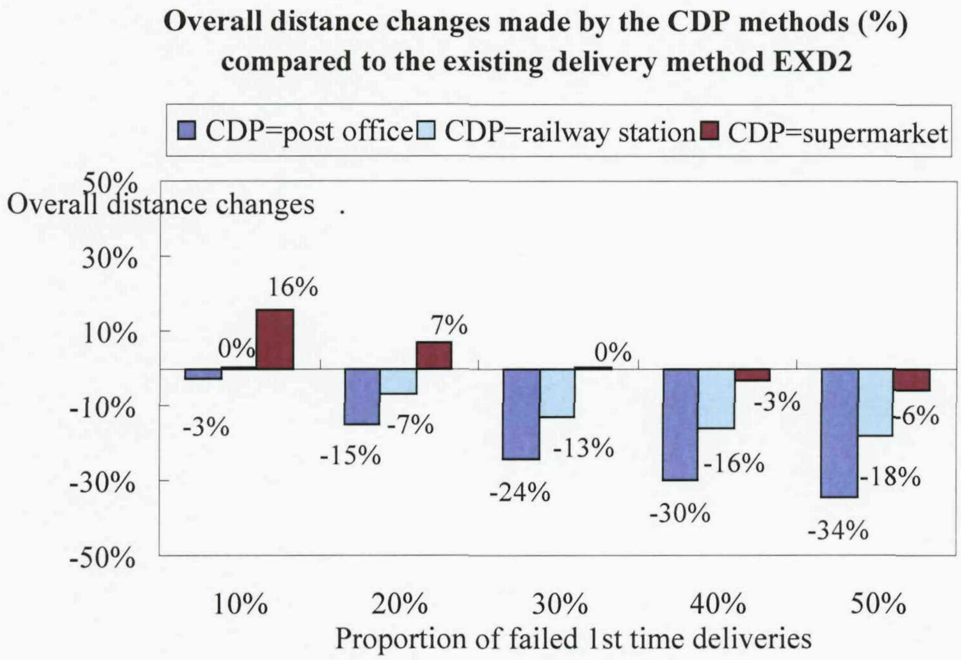


Figure 47 Overall driving distance changes (%) made by CDP methods compared to EXD2, associated with carrier delivering to 50 random households in Winchester ([7])

When there were 20% or more of failed first-time deliveries, the CDP methods were effective in terms of reducing total distance, with maximum 34% reductions observed when the Local Collect post offices were used as CDPs. Generally speaking, the CDP methods using supermarkets had fairly limited impacts on the overall distance, incurred in the existing method where 30% of households collecting from the carriers' depot.

[7] Under the 3 CDP options, all failed items were automatically diverted to the CDP nearest to the household address, and carrier made 50 first-time deliveries and a number of visits to the CDPs. Under the existing delivery method, the carrier made 50 first-time deliveries and a number of re-deliveries, which was dependent on the proportion of failed first-time deliveries. The overall travel distances are compared with the existing method where 30% of failures are returned to the depot for collection by the householders (EXD2).

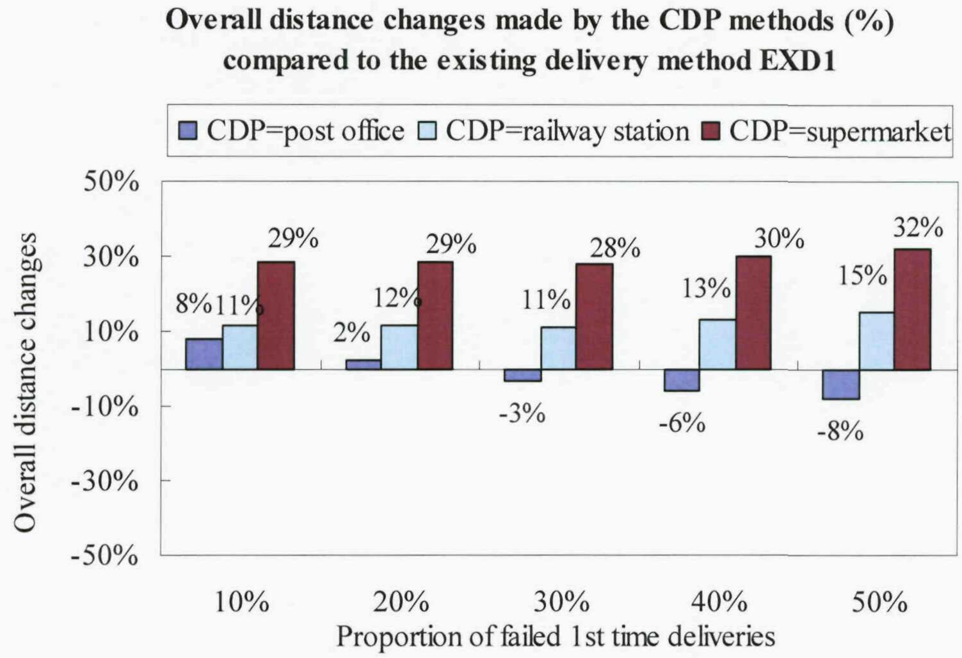


Figure 48 Overall driving distance changes (%) made by CDP methods compared to EXD1, associated with carrier delivering to 50 random households in Winchester ([8])

The results in Figure 48 suggested that the impacts of CDP methods on total driving distance were mostly negative: 15% increases observed when the railway stations used as CDPs and 32% increases when other supermarkets used.

To summarize the results in Figure 45, 46, 47 and 48, the CDP methods were most effective in terms of reducing the overall distance when: 1) 30% or more householders who experienced two failed home deliveries would travel to the depot to retrieve goods; 2) 20% or more first-time deliveries failed. The findings were helpful to improve the efficiency of the CDP methods by identifying people's responses to the failed home deliveries and the circumstances of home delivery failures. In some areas where a significant proportion of people willing to travel to the carrier's depot to collect and a significant number of deliveries being encountered, the road traffic generated from householder trips to collect failed home deliveries would be significantly improved by

[8] Under the 3 CDP options, all failed items were automatically diverted to the CDP nearest to the household address, and carrier made 50 first-time deliveries and a number of visits to the CDPs. Under the existing delivery method, the carrier made 50 first-time deliveries and a number of re-deliveries, which was dependent on the proportion of failed first-time deliveries. The overall travel distances are compared with the existing method where 10% of failures are returned to the depot for collection by the householders (EXD1).

introducing the CDP delivery methods as the alternative addresses to the failed packages.

5.5.2. Quantifying the environmental costs of the existing delivery system against the CDP options

The distance driven, the types of vehicles, and the fuel used have a strong impact on traffic emissions. The potential environmental costs associated with the carrier and householder distances travelled in the existing home delivery and the CDP methods were calculated based on the emission factors for a typical diesel rigid delivery vehicle and a standard petrol family car (Table 36).

Table 36 Road transport emission factors, 2005

Emission Factors		**Householder Car (Petrol Engined)**	**Delivery Vehicle (Diesel Engined) (>3.5 tonnes)**
CO_2	(g/km)	172([9])	268
C	(g/km)	47	73
Methane	(g/km)	0.02	0.00265
NO	(g/km)	0.04	0.01
Carbon Monoxide	(g/km)	1.98	0.48
NO_2	(g/km)	0.33	0.87
Non Methane VOC	(g/km)	0.19	0.14

Source: National Atmospheric Emissions Inventory (NAEI), UK, 2005.

In the calculation, it was assumed that:

- 30% of first-time home deliveries would fail;
- 100% of householders who suffered two home delivery failures would travel to the carrier's depot to collect their failed packages in the existing system (87% by car);
- 43% of householders would drive to the CDP in the various CDP scenarios.

[9] In considering emissions here, factors are expressed as in grams of carbon. To convert grams of carbon to grams of carbon dioxide multiply the grams of carbon figure by 3.667.

The emissions associated with the existing method (EXD4) and three CDP methods are presented in Table 37.

Table 37 Road transport emissions generated from the home delivery operations serving 50 sample householders across Winchester (1 delivery round, 30% of failed first-time deliveries, all householders experiencing two failed deliveries would travel to the carrier's depot to collect the failed items in the existing system)

Delivery Model	Driving distance (km)	Emissions (kg of carbon equivalent)	Emission reductions compared with EXD4
CDP =Post office	122.1	40.0	-47.2%
CDP = Supermarket	161.6	50.3	-33.7%
CDP =Railway station	140.2	43.6	-42.5%
Existing method (EXD4)	282.7	75.9	—

The results indicated that the CDP methods reduced the emissions by between 34% and 47%, reflecting that the total distance saved when using CDPs to re-direct failed first-time deliveries. Assuming the carrier has a regular delivery service every working day and the 50 orders per round are typical, it was then projected that over a 12-month period, the overall emissions could be reduced by between 6.65 tonnes and 9.32 tonnes of carbon equivalent by using the CDP methods. Such reductions in emissions would be even more outstanding in some areas demanding a significant number of home deliveries, indicating that the CDP methods could be serious home delivery options to improve the environment.

5.6. Summary

This study has estimated the potential for the CDP delivery methods to reduce the traffic and the emissions in Winchester. The results indicated that certain benefits might accrue from using various CDP networks, including post offices with 'Local Collect' service, railway stations and other supermarkets chain.

The results obtained through the modelling process were highly sensitive to the parameters and assumptions adopted. A network of CDPs in Winchester would function most effectively in terms of reducing overall vehicle kilometres (carrier and householder combined) associated with handing failed first-time deliveries when: 1) the proportion of first-time delivery failures is over 20%, 2) the proportion of people travelling to depot is over 30%, 3) Local Collect post offices are selected as the CDPs, 4) significant numbers of people walk to their local CDPs.

The best-case and worst-case scenarios for the use of CDPs in Table 38 gave an indication of the wide range of results that might occur in practice from various types of CDP networks. In Winchester, CDPs situated at Local Collect post offices could achieve the largest reductions in overall journey distance (carrier and householder combined, 67.3%) compared to the existing delivery methods. From carrier's point of view, using railway stations as CDPs could be the most beneficial method by making maximum 9.3% reductions in carrier's journey distance. The householders could achieve the most attainable reductions in the travelling distance by having the failed first-time deliveries automatically diverted to the local post offices (91.6%).

Table 38 Best case and worst case scenarios for the use of CDPs to re-direct failed first-time home deliveries (50 sample householders across Winchester, with 1 delivery round).

Parameters	**best case**	**worst case**
proportion of failed first time deliveries	50%	10%
proportion of people collecting from carrier's depot	100%	10%
Overall Journey Distance Changes		
CDP = Railway stations	-59.2%	11.5%
CDP = Other Supermarkets	-53.1%	***28.7%***
CDP = Post offices	***-67.3%***	8.1%
Carrier Distance Changes		
CDP = Railway stations	***-9.3%***	5.7%
CDP = Other supermarkets	4.8%	***22.1%***
CDP = Post offices	-5.9%	9.6%
Householder Distance Changes		
CDP = Railway stations	-79.0%	110.3%
CDP = Other supermarkets	-75.9%	***140.8%***
CDP = Post Offices	***-91.6%***	-16.0%

CHAPTER SIX

QUANTIFYING THE THEORETICAL BENEFITS OF CDP NETWORKS ACROSS WEST SUSSEX

6.1. Introduction

In this chapter, the benefits of using the CDP methods over a wider geographical area are investigated based on the responses from the home-delivery survey undertaken in West Sussex, since Winchester is a small dense sample and might not be representative of the wider population. The reductions in householder kilometers that could potentially be achieved if householders collected failed first-time home deliveries from a local CDP nearest to their home are quantified. The results are compared to the existing delivery system where the carrier may make multiple re-delivery attempts to the householder and householder travels the carrier's depot to retrieve the failed item if all the delivery attempts fail. Similar to the Winchester study, theoretical CDP's using large supermarket chains, railway stations, Tesco Extras and Local Collect post offices are modelled. It was noted that the list of those post offices was obtained from Royal Mail as confidential source.

The structure of this chapter is organized as follows. In Section 6.2, research objectives are introduced and methodologies are described in Section 6.3. In Section 6.4, the carrier and householders travelling distances are modelled using routing and scheduling software, RouteLogix. The environmental costs of CDP methods and existing methods are quantified based on the travelling distance and emission factors. The impacts of failed home deliveries are also identified. Conclusions are proposed in Section 6.5.

6.2. Objectives

The research objectives of this Winchester study were to:

- Quantify the transport costs on carrier of using various home delivery methods by modelling the carrier delivery operations around a sample of householders in West Sussex, using DPS RouteLogix as a base tool;
- Quantify the transport costs on householders of using various home delivery methods by modelling the householders' trips of collecting the failed first-time deliveries either from the carrier's depot or from the local CDPs;
- Quantify the transport benefits to the householders of collecting the failed first-time home deliveries from a range of local CDPs close to their home;
- Identify the impacts of failed first-time home deliveries on the distance incurred by the carrier in delivering goods and the distance travelled by householders in collecting failed deliveries;
- Identify the transport benefits of using various CDP networks, including Tesco Extras, Local Collect post offices, railway stations and supermarket chain from ASDA, Morrison, Sainsbury's and Waitrose combined;
- Compare the CDP benefits on householders in West Sussex with the Winchester study.

6.3. Methodology

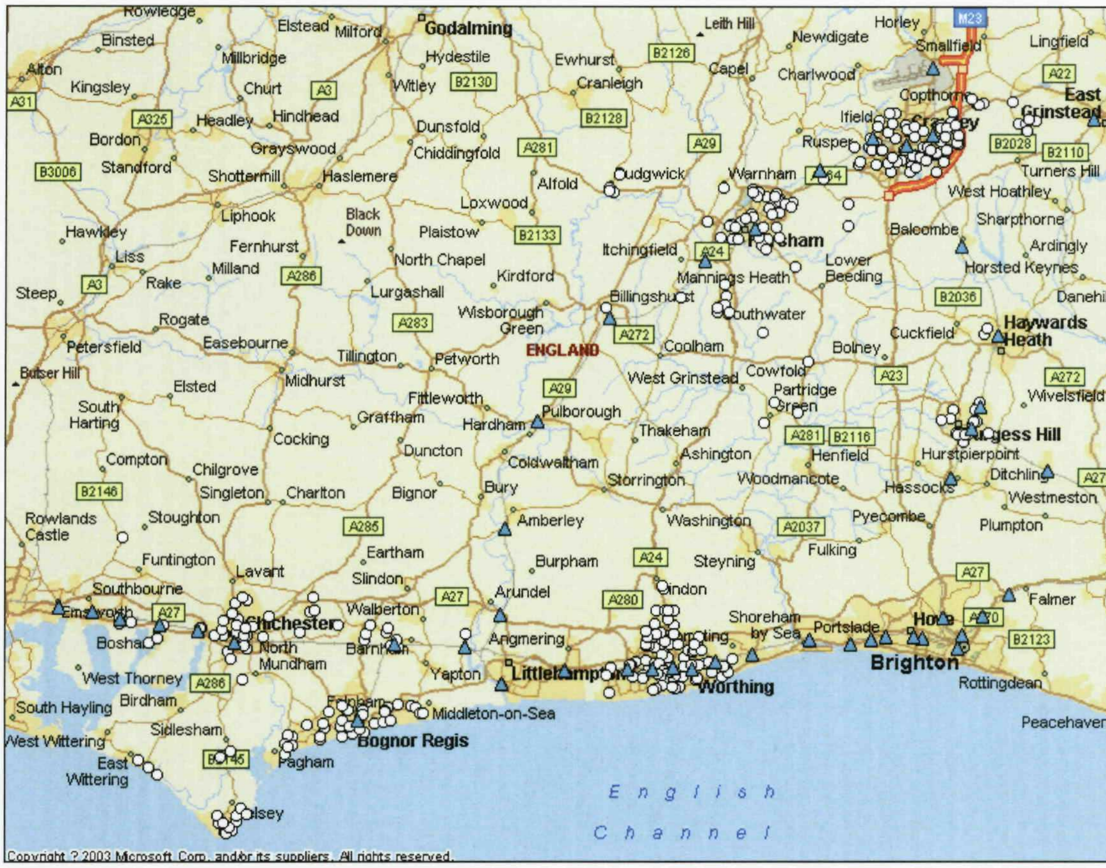
The data used for this study came from the West Sussex 'Home Delivery Survey' undertaken in 2006. One thousand home-delivery questionnaires were distributed to residents who have registered on the West Sussex Residents Panel Database. Three hundred and seventy nine (38%) completed questionnaires were returned. After removing duplicate postcodes (some respondents lived within the same postcode), there were 347 unique postcodes to be modelled in this research. Figure 49 presents a map showing the locations of the respondents.

Figure 49 A map showing the origin points of 347 households to the 2006 'Home Delivery Survey' in West Sussex

The characteristics for the home delivery methods modelled in the West Sussex study were the same as the scenarios adopted in the Winchester study (Section 5.3.1, Chapter Five).

6.2.1. Theoretical CDP networks used across West Sussex

In this study, theoretical networks of CDP's using 12 Tesco Extras, 139 Local Collect post offices, 46 railway stations and 53 supermarkets from ASDA, Morrison, Sainsbury's and Waitrose chains combined were used in the modelling process (Figure 50 to 53).



○ Householder addresses ▲ Railway stations

Figure 50 A map showing the 347 sample household origins (white circles) and 46 railway stations (blue triangles) used as theoretical CDPs in West Sussex

○ Householder addresses △ Local Collect post offices

Figure 51 A map showing the 347 sample household origins (white circles) and 139 Local Collect post offices (yellow triangles) used as theoretical CDPs in West Sussex

○ Householder addresses

▲ Supermarkets including Waitrose, Sainsbury, ASDA and Morrison

Figure 52 A map showing the 347 sample household origins (white circles) and 53 supermarkets (red triangles) from the Waitrose, Sainsbury, ASDA and Morrison chains combined used as theoretical CDPs in West Sussex

○ Householder addresses ▲ Tesco

Figure 53 A map showing the 347 sample household origins (white circles) and 12 Tesco (green triangles) used as theoretical CDPs in West Sussex

The road distance from each of the 347 households to the modelled CDPs were calculated using Microsoft MapPoint, based on the quickest route distance between the householders' origin postcodes and the CDP postcodes (Table 39).

Table 39 Average road distance from each of the 347 household postcodes to each of the 250 CDPs (12 Tesco Extras, 46 railway stations, 139 post offices offering 'Local Collect' and 53 other supermarkets) in West Sussex

CDP Options	Average Distance from Respondent's Home to Local CDPs (km)
Tesco Extras	6.55
Railway stations	3.24
Local Post Offices	1.15
Supermarkets (ASDA, Morrison, Sainsbury's and Waitrose)	4.01

An One-way Analysis of Variance test showed that there were significant differences in the mean distances travelled to the CDPs from the householder origin points (F=29.77, F(0.05)= 3.843, MSe=623.793 and P= 1.37E-18). A subsequent Scheffé Multiple range test (Table C-3, Appendix C) indicated that the average householder lived significantly further away from a Tesco Extra (mean distance = 6.55km) and closer to a Local Collect post office (mean distance = 1.15km) compared to the nearest railways station or combined supermarket chains.

6.2.2. Modelling assumptions and parameters

6.2.2.1. Density of delivery addresses and carrier operating characteristics

In this research, 200 addresses were randomly selected from amongst the 347 questionnaire respondents. In the existing delivery methods, it was assumed that all the carrier delivery rounds involved visits to all 200 householder addresses on the first attempt. In terms of re-delivery attempts, it was assumed that if 30% of the 200 first-time deliveries failed, there would be 60 re-delivery attempts needed during the vehicle rounds. Hence in this example, all the delivery rounds would involve visits to 260 addresses (some twice). Those orders were delivered by up to 8 delivery vehicles.

In the CDP delivery method, it was assumed that the carrier only made one delivery attempt to the householder's home and the failed items were automatically diverted to the nearest CDP relative to the householder's address. An important assumption was that the carrier would visit each CDP not more than once on any round. In the case where there was only one CDP to visit on the delivery round, all the deliveries would be made first and the CDP visited last before the vehicle returned to the depot. If more than one CDP was to be visited, then the strategy was to drop batches of failed deliveries at the nearest CDP to the recipient's home at the optimal point on the delivery round (Chapter Five).

6.2.2.2. Distance from the carrier's depot to the delivery area

The main carrier the questionnaire respondents had encountered was Parcelforce, whose depot was on average 37km away from each householder origin point.

6.2.2.3. Proportion of failed first-time home deliveries

To test the sensitivity of the results, a range of first-time delivery failure rates were considered, varying from 10% to 50%. It was assumed that 50% of all re-deliveries would fail, based on the assumption that a high percentage of deliveries that failed first-time would also fail second-time because a significant proportion of households are empty during the working day.

6.2.2.4. Proportion of householder's collecting items from the carrier's depot

In the existing delivery method, the householders had the option of collecting the failed packages from the carrier's depot, when the carrier had made up to 2 failed delivery attempts. The proportion of householders who would be prepared to make this journey by motorized transports directly impacts on the assumed benefits of the home delivery service. A wide range of proportions was modelled here, from 10% to 100%. The worst-case scenario would be when all households experiencing a failed delivery would use their cars to collect the item from the carrier's depot.

6.2.3. Quantifying the travel distances of the carrier and householders

Similar to the Winchester study, an Excel spreadsheet was developed to allow certain parameter values associated with the various home delivery scenarios to be varied and the results compared (Table 40). Those parameters have been discussed in Chapter Five.

Table 40 Parameters used in the home delivery modelling work. (Individual explanations are explained in Chapter Five)

Input parameters	
A = no. of 1st time deliveries	200
D1 = no. of railway stations across West Sussex	46
D2 = no. of Local Collect post offices across West Sussex	139
D3 = no. of other supermarkets across West Sussex	53
D4 = no. of Tesco Extras across West Sussex	12
E = average one-way distance from centre of delivery area to carrier's depot (Parcelforce)	37.03km
F 1 = average one-way distance from individual origin to Tesco Extra	6.55km
F 2 = average one-way distance from individual origin to supermarket	4.01km
F 3 = average one-way distance from individual origin to Local Collect post office	1.15km
F 4 = average one-way distance from individual origin to railway station	3.24km
R1 = proportion of householders travelling to CDP by car	48%
R2 = proportion of householders travelling to carrier's depot by car	87%

Distances travelled by householders and carrier						
B = proportion of failed 1st time deliveries		10%	20%	30%	40%	50%
P = proportion of failed 2nd time deliveries		5%	10%	15%	20%	25%
C = carrier travel distance	existing method	749.5	792.1	879.5	922.5	957.8
	CDP1 method	868.7	868.7	868.7	868.7	868.7
	CDP2 method	919.1	919.1	919.1	919.1	919.1
	CDP3 method	873.5	873.5	873.5	873.5	873.5
	CDP4 method	877.2	877.2	877.2	877.2	877.2

Table 40 continued

H = householder travel distance	EXD1 method	64.4	128.9	193.3	257.7	322.2
	EXD2 method	193.3	386.6	579.9	773.2	966.5
	EXD3 method	322.2	644.3	966.5	1288.6	1610.8
	EXD4 method	644.3	1288.6	1933.0	2577.3	3221.6
	CDP1 method	62.2	124.4	186.6	248.8	311.0
	CDP2 method	22.1	44.2	66.2	88.3	110.4
	CDP3 method	77.0	154.0	231.0	308.0	385.0
	CDP4 method	125.8	251.5	377.3	503.0	628.8

Six different carrier round sets were modelled by selecting six random groups of 200 householders from the 347 database. In each case the carrier's vehicles started and ended at the Parcelforce depot and all 200 delivery addresses were visited in the optimal order by using RouteLogix. The number of re-deliveries depended on the proportion of first-time failures and the locations of these were randomly selected among the first-time delivery addresses. Under the CDP scenarios, the re-deliveries were re-directed to the nearest CDP relative to the householder's home in the particular network being modelled.

The average carrier driving distances (km) associated with serving six different sets of 200 first-time deliveries and redeliveries are presented in Table C-4 (Appendix C). As shown in Table 40, the carrier distance incurred in the existing delivery method increased from 749.5km to 957.8km when the delivery failure rate increased from 10% to 50%. This was because the number of second-time delivery attempts to be made by the carrier increased from 20 to 100. Hence the overall delivery attempts on one delivery round increased from 220 to 300, resulting in the extra kilometers on the carrier to make deliveries. The carrier driving distance incurred in each CDP delivery method remained constant regardless the first-time delivery failure rate. This was because in the CDP methods, the carrier would visit the local CDPs as the alternative addresses to the failed first-time packages instead of making second-time deliveries.

Consequently the number of overall delivery attempts on one delivery round (including 200 first-time delivery attempts and a number of visits to the CDPs) was constant, without any impacts on the carrier driving distance.

The householder's driving distance incurred in the existing delivery method, was quantified based on the proportion of households who suffered two delivery failures collecting their failed items from the carrier's depot, their transport mode choices and two-way road distance from household origins to the carrier's depot. For example, when 40% of a total of 200 first-time home deliveries failed, the carrier made 80 deliveries to the CDPs as the alternative addresses. Those 80 households who suffered one failed delivery attempt travelled to the CDPs to collect their failed packages. Based on average one-way distance from home to the CDPs, proportion of householders using car to the CDPs (48%), the household driving distance when 40% of first-time home deliveries failed was 492.6km, 243.7km, 88.3km and 301.6km incurred in those four CDP delivery methods, respectively. In a similar way, the householder's driving distance incurred in the CDP method was calculated based on the proportion of households collecting from the CDPs, their transport mode choices and average distance from home to the CDPs in the respective networks (Table 41).

Table 41 Householder driving distances (km) associated with collecting failed first-time home deliveries re-directed to local CDPs by the carrier. 200 sample addresses were used in West Sussex to derive the carrier rounds

Householder travelling distance		**Percentage of failed home deliveries**				
Scenarios		**10%**	**20%**	**30%**	**40%**	**50%**
CDP1	CDP = Railway station	62.2	124.4	186.6	248.8	311.0
CDP2	CDP = Tesco Extra	125.8	251.5	377.3	503.0	628.8
CDP3	CDP = Other supermarket	77.0	154.0	231.0	308.0	385.0
CDP4	CDP = Post office	22.1	44.2	66.2	88.3	110.4
EXD1	Existing method (10% travelling to depot)	64.4	128.9	193.3	257.7	322.2
EXD2	Existing method (30% travelling to depot)	193.3	386.6	579.9	773.2	966.5
EXD3	Existing method (50% travelling to depot)	322.2	644.3	966.5	1288.6	1610.8
EXD4	Existing method (100% travelling to depot)	644.3	1288.6	1933.0	2577.3	3221.6
Overall travelling distance (Carrier and householder)						
CDP1	CDP = Railway station	939.4	1001.6	1063.8	1126.0	1188.2
CDP2	CDP = Tesco Extra	994.5	1120.2	1246.0	1371.7	1497.5
CDP3	CDP = Other supermarket	996.1	1073.1	1150.1	1227.1	1304.1
CDP4	CDP = Post office	895.6	917.7	939.7	961.8	983.9
EXD1	Existing method (10% travelling to depot)	813.9	921.0	1072.8	1180.2	1280.0
EXD2	Existing method (30% travelling to depot)	942.8	1178.7	1459.4	1695.7	1924.3
EXD3	Existing method (50% travelling to depot)	1071.7	1436.4	1846.0	2211.1	2568.6
EXD4	Existing method (100% travelling to depot)	1393.8	2080.7	2812.5	3499.8	4179.4

The results in Table 41 suggested that diverting the failed first-time deliveries to the Local Collect post offices in West Sussex would be the most effective CDP option in terms of reducing householder kilometers incurred in the current situation, resulting in 97% reductions compared to EXD4. The CDP methods using Tesco Extras, supermarkets chain and railway stations were also able to reduce householder kilometers incurred in EXD4 (by between 81% and 90%).

To further compare the householder distances in the CDP methods with the four existing methods, and explore the changes in householders' trips associated with collecting failed packages by using the CDP method, more discussions were provided in the following section.

6.4. Travel distances and associated environmental costs of the existing delivery system compared to the CDP options

6.3.1. Travel distances accrued by the various home delivery methods

Table 42 presented the changes in carrier (can-km) and householder (car-km) travelling distances incurred in a range of CDP home delivery methods, compared to the existing delivery method where everyone who experienced failed home deliveries would travel to the depot (EXD4). The changes in overall driving distance (overall-km) were also presented. This was done by modelling the home delivery operations around 200 sample households in West Sussex.

Table 42 Changes in householder and carrier driving distances associated with various home delivery scenarios, compared to the scenario (EXD4) where everyone who experienced two home delivery failures would travel to the carrier's depot to collect their failed home deliveries

Scenarios		**Changes in travel distances for householders and carrier**			
		Van-km	Car-km	Overall-km	
10% of first-time home deliveries failed:					
CDP1	CDP = railway station	127.7	-582.1	-454.4	(-33%)
CDP2	CDP = Tesco Extra	119.2	-518.6	-399.4	(-29%)
CDP3	CDP = other supermarket	169.6	-567.3	-397.7	(-29%)
CDP4	CDP = Local Collect post office	124.0	-622.2	-498.2	(-36%)
EXD1	Existing delivery method (10% travelling to depot)	0	-579.9	-579.9	(-42%)
EXD2	Existing delivery method (30% travelling to depot)	0	-451.0	-451.0	(-33%)
EXD3	Existing delivery method (50% travelling to depot)	0	-322.2	-322.2	(-23%)
EXD4	Existing delivery method (100% travelling to depot)	—	—	—	
20% of first-time home deliveries failed:					
CDP1	CDP = railway station	85.1	-1164.2	-1079.1	(-52%)
CDP2	CDP = Tesco Extra	76.6	-1037.1	-960.5	(-46%)
CDP3	CDP = other supermarket	127.0	-1134.7	-1007.7	(-49%)
CDP4	CDP = Local Collect post office	81.4	-1244.5	-1163.1	(-56%)
EXD1	Existing delivery method (10% travelling to depot)	0	-1159.8	-1159.8	(-56%)
EXD2	Existing delivery method (30% travelling to depot)	0	-902.0	-902.0	(-43%)
EXD3	Existing delivery method (50% travelling to depot)	0	-644.3	-644.3	(-31%)
EXD4	Existing delivery method (100% travelling to depot)	—	—	—	
30% of first-time home deliveries failed:					
CDP1	CDP = railway station	-2.3	-1746.3	-1748.6	(-62%)
CDP2	CDP = Tesco Extra	-10.8	-1555.7	-1566.5	(-56%)
CDP3	CDP = other supermarket	39.6	-1702.0	-1662.4	(-59%)

Table 42 continued

Scenarios		Changes in travel distances for householders and carrier			
		Van-km	Car-km	Overall-km	
CDP4	CDP = Local Collect post office	-6	-1866.7	-1872.7	(-67%)
EXD1	Existing delivery method (10% travelling to depot)	0	-1739.7	-1739.7	(-62%)
EXD2	Existing delivery method (30% travelling to depot)	0	-1353.1	-1353.1	(-48%)
EXD3	Existing delivery method (50% travelling to depot)	0	-966.5	-966.5	(-34%)
EXD4	Existing delivery method (100% travelling to depot)	—	—	—	
40% of first-time home deliveries failed:					
CDP1	CDP = railway station	-45.3	-2328.5	-2373.8	(-68%)
CDP2	CDP = Tesco Extra	-53.8	-2074.2	-2128.0	(-61%)
CDP3	CDP = other supermarket	-3.4	-2269.3	-2272.7	(-65%)
CDP4	CDP = Local Collect post office	-49.0	-2489.0	-2538.0	(-73%)
EXD1	Existing delivery method (10% travelling to depot)	0	-2319.6	-2319.6	(-66%)
EXD2	Existing delivery method (30% travelling to depot)	0	-1804.1	-1804.1	(-52%)
EXD3	Existing delivery method (50% travelling to depot)	0	-1288.6	-1288.6	(-37%)
EXD4	Existing delivery method (100% travelling to depot)	—	—	—	
50% of first-time home deliveries failed:					
CDP1	CDP = railway station	-80.6	-2910.6	-2991.2	(-72%)
CDP2	CDP = Tesco Extra	-89.1	-2592.8	-2681.9	(-65%)
CDP3	CDP = other supermarket	-38.7	-2836.7	-2875.4	(-69%)
CDP4	CDP = Local Collect post office	-84.3	-3111.2	-3195.5	(-76%)
EXD1	Existing delivery method (10% travelling to depot)	0	-2899.4	-2899.4	(-69%)
EXD2	Existing delivery method (30% travelling to depot)	0	-2255.1	-2255.1	(-54%)
EXD3	Existing delivery method (50% travelling to depot)	0	-1610.8	-1610.8	(-39%)
EXD4	Existing delivery method (100% travelling to depot)	—	—	—	

The results in Table 42 suggested that the main benefits of using various CDP home delivery methods were earned by householders, which was in line with the findings from Winchester study. For instance, when 20% of first-time deliveries failed, the CDP method using railway stations reduced householders' travelling distances by 1164.2km (85.1km increases in the carrier distance at the same time). Those reductions were even more significant when a significant proportion of failed first-time deliveries occurred. For example, under the scenario of 50% delivery failure rate, the householder distance was saved by 2910.6km by CDP method using railway stations. Similar trends were found for the rest of CDP methods.

Another observation of Table 42 was that the CDP methods were beneficial to the householder distance when compared to the existing methods EXD2, EXD3 and EXD4. That was to say, when more than 30% of households who suffered two failed deliveries chose to collect their failed packages from the carrier's depot, the distances generated from those collection trips could be significantly reduced by using the CDP methods. However, if the proportion of households doing so was less than 30%, extra kilometres would be incurred on households of using the CDP methods.

Figure 54 presents the changes in householder distance by the CDP methods compared to each existing method. Each value represents the changes in the journey distance (in terms of percentage) made by the CDP method compared to the respective existing method. A negative percentage suggests that the CDP method reduced the amount of distance travelled.

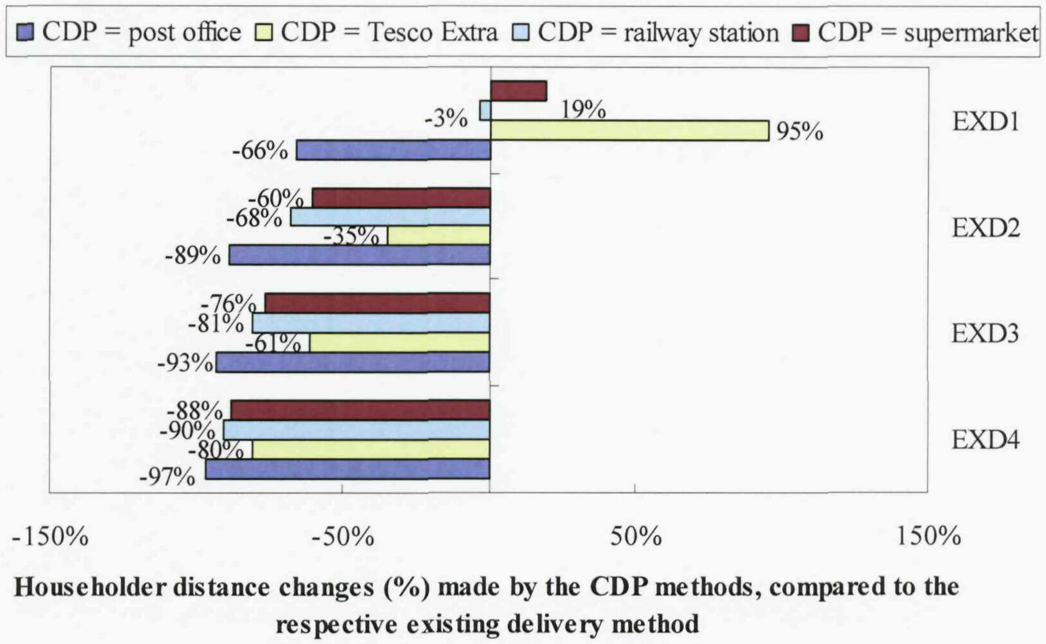


Figure 54 Householder distance changes (%) made by the CDP methods compared to the existing methods, associated with carrier delivering to 200 sample householders across West Sussex ([10])

The overall results from Figure 54 suggested that when at least 30% of householders travel to the depot in the existing delivery method (i.e. EXD2, EXD3 or EXD4), their driving distance could be significantly improved by the CDP methods. The greatest reductions were achieved when the Local Collect post offices were used as CDPs (89% reduction compared to EXD2). Those distance reductions were even more obvious when compared with EXD3 or EXD4, with reductions of 93% and 97%, respectively. However, if there were only 10% of households collecting their failed packages from the carrier's depot, the CDP delivery methods generated negative impacts on householders. In that case, the householders experienced less kilometres when they collected the failed packages from the carrier's depot instead of the CDPs.

The findings were in line with the Winchester study, where the CDP methods would function most effectively (in terms of reducing householder kilometres associated with

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[10] Under the four CDP options, all failed items were automatically diverted to the CDP nearest to the household delivery addresses, and individual household who suffered failed home deliveries travel to the CDPs to collect. The householder travel distances are compared with the existing methods where 100% (EXD4), 50% (EXD3), 30% (EXD2), and 10% (EXD1) of failures are returned to the depot for collection by the householders.

collecting failed first-time deliveries from the depot) when 30% or more of such failed deliveries would result in householder collection trips and Local Collect post offices were used as the CDPs.

It was also found from Table 42 that, the impacts of the CDP methods on the carrier's kilometres were fairly minimal, with reductions of 10.8km (reductions of 1555.7km in householder distance at the same time) observed when the Tesco Extra were used as CDPs for 30% of delivery failure rate. The changes in carrier distance by using the CDP methods are presented in Figure 55. An overall observation was that the distance savings for carrier of using CDP method increased as the number of redeliveries to be made increased, which was compatible with the findings from Winchester study.

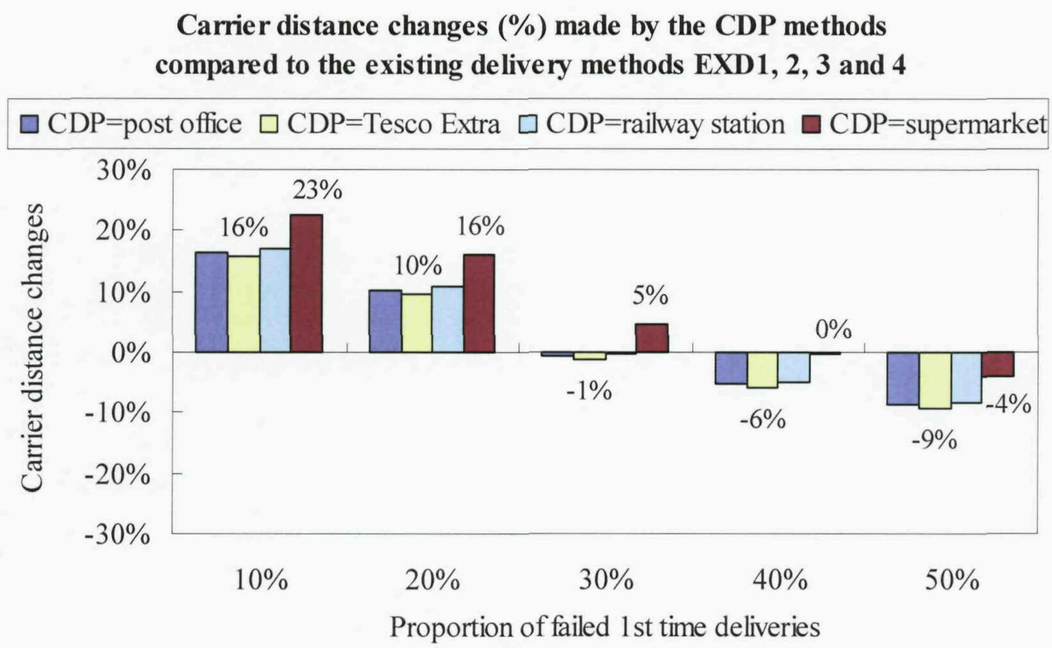

Figure 55 Carrier distance changes (%) made by CDP methods compared to the existing delivery methods , associated with carrier delivering to 200 random households across West Sussex ([11])

From Figure 55, it can be seen that the benefits on the carrier of diverting the failed deliveries to the CDPs outweighed the dis-benefits of making re-deliveries in the existing method, when 40% or more first-time deliveries failed. At the 10%, 20% and

[11] Under the 4 CDP options, all failed items were automatically diverted to the CDP nearest to the household delivery addresses, and carrier made 200 first-time deliveries and a number of visits to the CDPs. Under the 4 existing delivery methods, the carrier made 200 first-time deliveries and a number of re-deliveries, which was dependent on the proportion of failed first-time deliveries.

30% delivery failure rates, the carrier kilometres were greater for the CDP methods, indicating that the added kilometres associated with visiting the CDPs were greater than the added kilometres associated with making the redeliveries. This was due to the fact that the delivery round for the existing delivery method could be optimised to include the redeliveries, whereas for the CDP method the visit to each of the CDPs had to be made after visiting all of the delivery addresses in its vicinity, which could introduce the possibility of the carrier's route containing an element of duplication.

Although the benefits of CDP methods on the carrier travelling distance appeared fairly limited or even negative, the cost savings resulting from not having to handle failed first-time deliveries could be significant. Similar to the analysis in the Winchester study, based on the estimate of a potential cost of handling each failed package (£38.5) and the number of such failures in West Sussex, it was then possible to quantify the overall cost savings by the CDP methods in that area.

In this West Sussex study, 200 orders were assumed to be typical during any working day. According to the home delivery questionnaire undertaken in West Sussex, 26% of first-time deliveries were failed. Considering there were 52 weeks a year, it was then estimated that there were 18928 failed first-time deliveries a year in West Sussex, resulting in £728,728 costs for handling those failed deliveries. Obviously, such costs were higher than Winchester because there was a significantly more demand for home deliveries, indicating that the CDP methods would be much more positive for the carrier to reduce the costs of handling the failed deliveries.

The overall distances incurred in the CDP methods, in terms of carrier and householder distances combined, were compared to each existing method (Figure 56, 57, 58 and 59). Each value represents the distance changes made by the CDP method compared to the respective existing delivery method. A negative value indicates that the amount of travelling distance was reduced by the CDP methods.

A general observation over the four figures was that the CDP methods were able to reduce the total distance significantly, incurred in the current situations where 30% or more of delivery failures were returned to the depot for collection by the householders. Another observation was that the overall distance reductions made by the CDP method increased when there was significant number of delivery failures. The findings are compatible with the results from the Winchester study, where the CDP methods functioned most effectively (in terms of reducing the total driving distance) when at least 30% of householders who experienced failed deliveries would travel to depot.

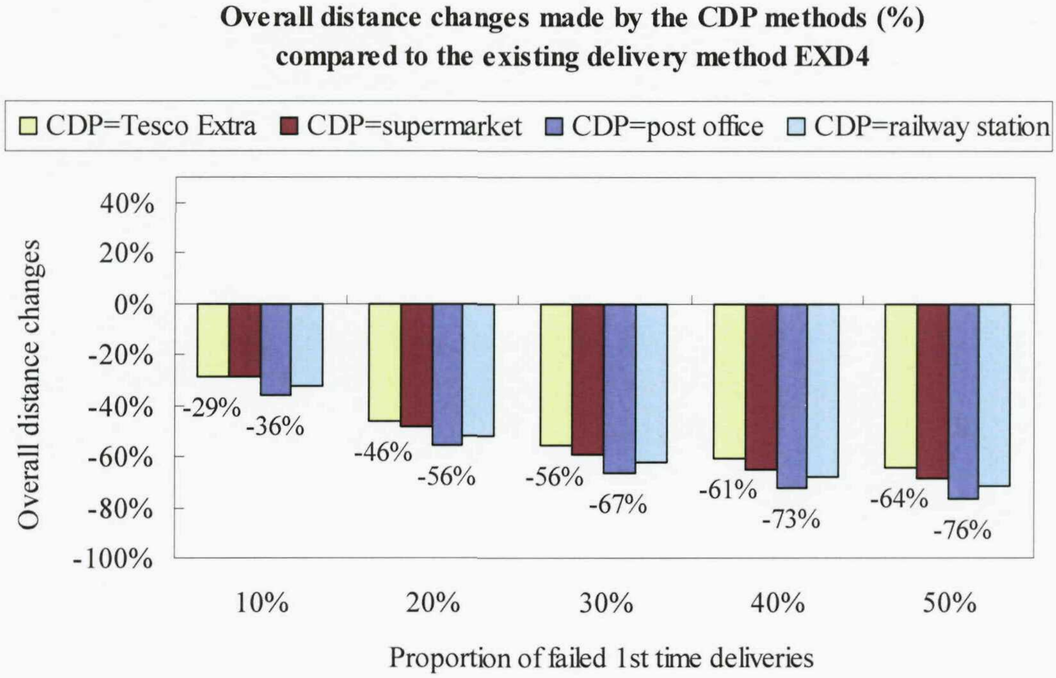

Figure 56 Overall driving distance changes (%) made by the CDP methods compared to the existing method EXD4, associated with carrier delivering to 200 random households across West Sussex ([12])

The CDP methods were able to significant reduce the overall distance incurred in EXD4 for the whole range of delivery failure rates, with maximum 76% reductions observed when the Local Collect post offices were used as CDPs.

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[12] Under the 4 CDP options, all failed items were automatically diverted to the CDP nearest to the household delivery addresses, and carrier made 200 first-time deliveries and a number of visits to the CDPs. Under the existing delivery method, the carrier made 200 first-time deliveries and a number of re-deliveries, which was dependent on the proportion of failed first-time deliveries. The overall travel distances are compared with the existing method where 100% of failures are returned to the depot for collection by the householders (EXD4).

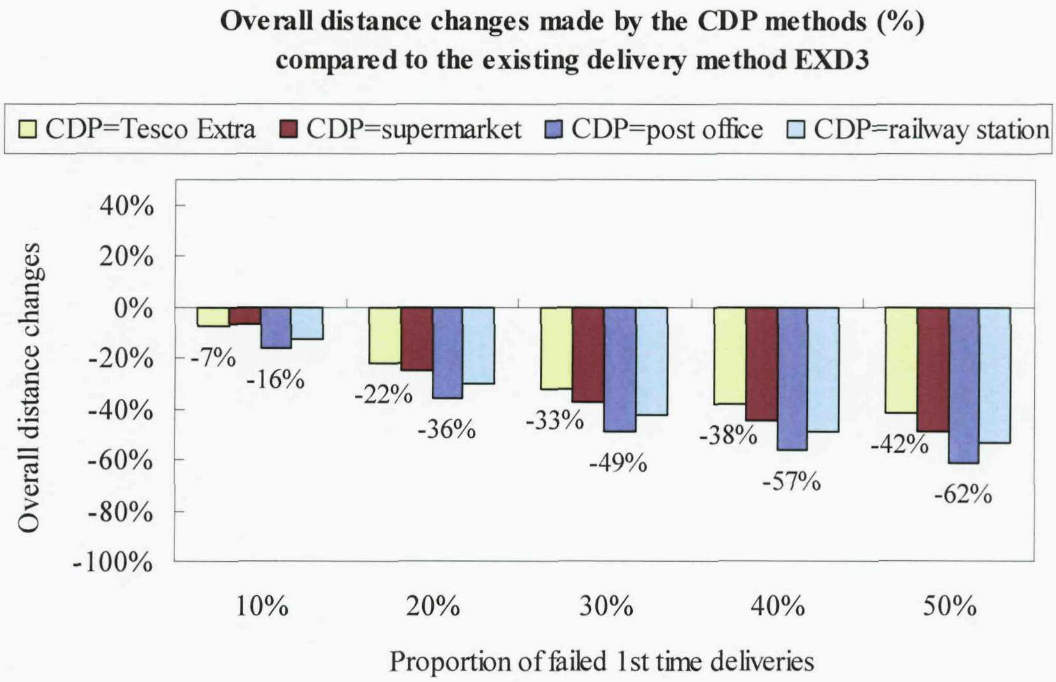

Figure 57 Overall driving distance changes (%) made by the CDP methods compared to the existing method EXD3, associated with carrier delivering to 200 random households across West Sussex ([13])

For the whole range of home delivery failure rates, the CDP methods were more beneficial to the overall driving distance than the existing delivery method (EXD3), with maximum 62% reductions observed when the Local Collect post offices were used as CDPs.

[13] Under the 4 CDP options, all failed items were automatically diverted to the CDP nearest to the household delivery addresses, and carrier made 200 first-time deliveries and a number of visits to the CDPs. Under the existing delivery method, the carrier made 200 first-time deliveries and a number of re-deliveries, which was dependent on the proportion of failed first-time deliveries. The overall travel distances are compared with the existing method where 50% of failures are returned to the depot for collection by the householders (EXD3).

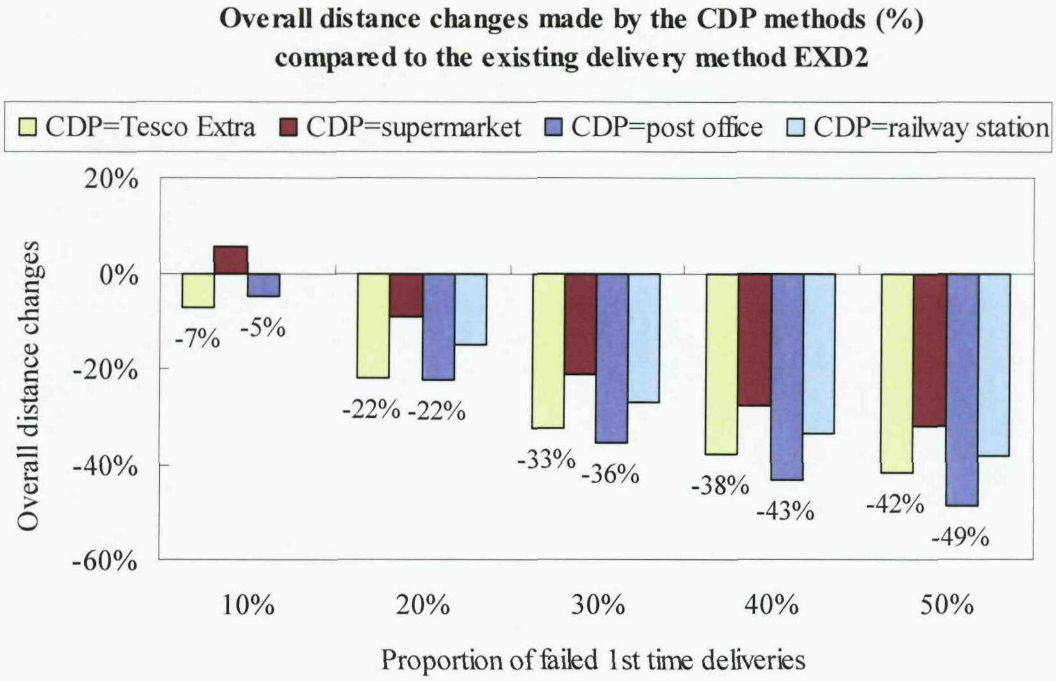

Figure 58 Overall driving distance changes (%) made by the CDP methods compared to the existing method EXD2, associated with carrier delivering to 200 random households across West Sussex ([14])

When there were 20% or more of failed first-time deliveries, the CDP methods were able to reduce the total driving distance, with maximum 49% reductions observed when the Local Collect post offices were used as the CDPs.

[14] Under the 4 CDP options, all failed items were automatically diverted to the CDP nearest to the household delivery addresses, and carrier made 200 first-time deliveries and a number of visits to the CDPs. Under the existing delivery method, the carrier made 200 first-time deliveries and a number of re-deliveries, which was dependent on the proportion of failed first-time deliveries. The overall travel distances are compared with the existing method where 30% of failures are returned to the depot for collection by the householders (EXD2).

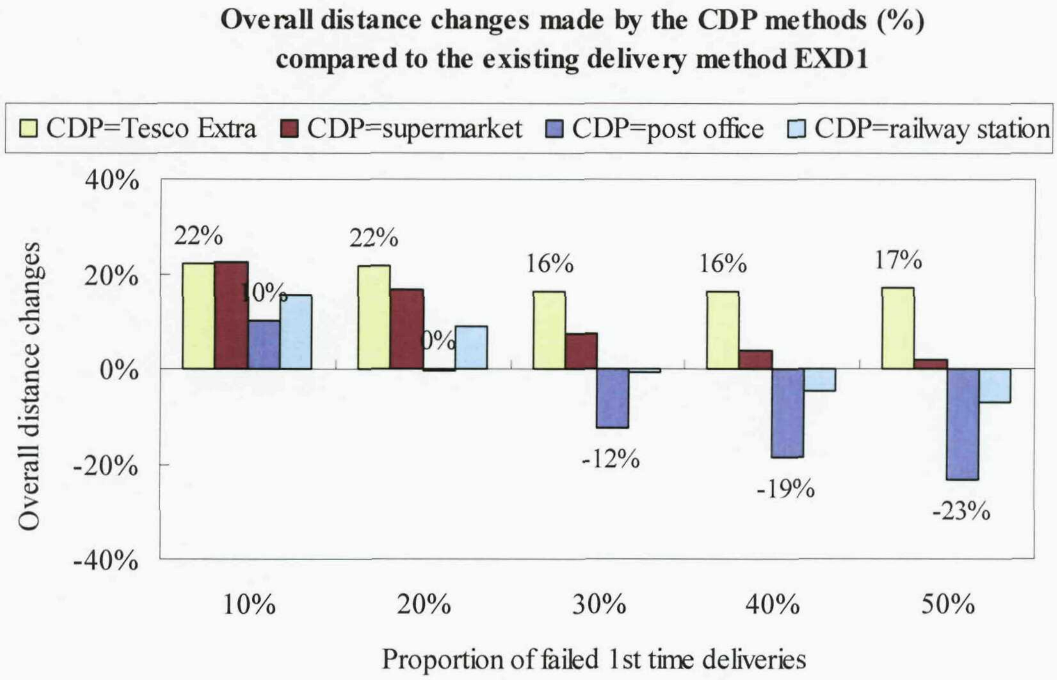

Figure 59 Overall driving distance changes (%) made by the CDP methods compared to the existing method EXD1, associated with carrier delivering to 200 random households across West Sussex ([15])

There could be a negative impact on the overall distance of using CDP methods when compared to EXD1: 23% reductions observed when the Local Collect post offices were used as CDPs and 17% increases when Tesco Extras were used.

To conclude the results in Figure 56, 57, 58 and 59, the CDP methods were most effective in terms of reducing overall driving distance when: 1) 30% or more householders who experienced two failed home deliveries would travel to depot to retrieve goods; 2) 20% or more first-time home deliveries were failed. The conclusions are compatible with the findings from Winchester study.

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[15] Under the 4 CDP options, all failed items were automatically diverted to the CDP nearest to the household delivery addresses, and carrier made 200 first-time deliveries and a number of visits to the CDPs. Under the existing delivery method, the carrier made 200 first-time deliveries and a number of re-deliveries, which was dependent on the proportion of failed first-time deliveries. The overall travel distances are compared with the existing method where 10% of failures are returned to the depot for collection by the householders (EXD1).

6.3.2. Quantifying the environmental costs of the existing delivery system against the CDP options

The potential environmental costs associated with the carrier and householder distances travelled in the existing home delivery and CDP options were determined based on the emission factors for a typical diesel rigid delivery vehicle and a standard petrol family car (Table 36, Chapter Five). In the calculation, it was assumed that: 1) 30% of first-time home deliveries would fail; 2) 100% of householders would travel to the carrier's depot to collect the failed packages in the existing system (87% by car); 3) 48% of householders would drive to the CDP in the various CDP scenarios. The carrier and householder emission generated in the four CDP methods were quantified, and compared to the existing method EXD4 (Table 43).

Table 43 Road transport emissions generated from the home delivery operations serving 200 sample householders across West Sussex ([16])

Delivery Model	Driving distance (km)	Emissions (kg of carbon equivalent)	Emission reduction compared with EXD4
CDP = Local Collect Post office	939.7	309.0	-57.6%
CDP = Supermarket	1150.1	366.0	-49.8%
CDP = Tesco Extra	1246.0	381.1	-47.8%
CDP = Railway station	1063.8	341.8	-53.1%
Existing method (EXD4)	2812.5	729.5	—

It was found that the CDP delivery methods reduced emissions by between 48% and 58%, compared to the existing delivery method. It reflected that the total distance was improved when using CDPs to re-direct failed first-time deliveries across rounds serving 200 householders. From the Winchester study, it was found that the CDP methods saved emissions by between 34% and 47%, generated from the existing

[16] up to 8 delivery rounds, 30% failed first-time deliveries, all householders experiencing failed deliveries in the existing system would travel to the carrier's depot to collect the failed items)

delivery method. It can be seen that the environmental benefits of using CDPs would increase substantially in the area where more home deliveries occurred.

6.5. Summary: Potential impacts of different CDP networks

This study has confirmed that a certain benefits might accrue from using CDP options of Local Collect post offices, Tesco Extras, railway stations and supermarkets chain, compared with the existing delivery method. A network of CDPs across West Sussex would function most effectively (in terms of reducing overall kilometres associated with handing failed first-time deliveries) when:

- The proportion of first-time home delivery failures is over 20%;
- The proportion of householders travelling to the depot is over 30%;
- Local Collect post offices are used as CDPs;
- Significant numbers of people would walk to their local CDP to collect a failed delivery.

The best-case and worst-case scenarios for the use of CDPs are summarised in Table 44. CDPs situated at Local Collect post offices could achieve the largest reductions in overall journey distance (76.5%) compared to the existing method. Using Tesco Extras as CDPs could be the most effective method by making maximum 9.3% reductions in carrier's journey distance. The householders could achieve the most attainable reductions in the travelling distance by having the failed first-time deliveries automatically diverted to the Local Collect post offices (96.6%).

Table 44 Best case and worst case scenarios for the use of CDPs to re-direct failed first-time home deliveries (200 sample householders across West Sussex, with up to 8 delivery rounds)

Parameters	**Best case**	**Worst case**
proportion of failed first time deliveries	50%	10%
proportion of people travelling to depot under the existing system	100%	10%
Overall Journey Distance changes		
CDP = Railway stations	-71.6%	15.4%
CDP = Other supermarkets	-68.8%	***22.4%***
CDP = Tesco Extras	-64.2%	22.2%
CDP = Post offices	***-76.5%***	10.0%
Carrier Distance changes		
CDP = Railway stations	-8.4%	17.0%
CDP = Other supermarkets	-4.0%	***22.6%***
CDP = Tesco Extras	***-9.3%***	15.9%
CDP = Post offices	-8.8%	16.5%
Householder Distance changes		
CDP = Railway stations	-90.4%	-3.5%
CDP = Other supermarkets	-88.1%	19.5%
CDP = Tesco Extras	-80.5%	***95.2%***
CDP = Post offices	***-96.6%***	-65.7%

CHAPTER SEVEN

CDP APPRAISAL USING A CARRIER SCHEDULE IN WEST SUSSEX

7.1. Introduction

Chapters Five and Six presented results of householder behaviour towards failed home deliveries and theoretical networks of CDPs. The main benefits were achieved by householders of using CDPs. There were few kilometers benefits to carrier but the processing costs associated with home delivery failures were reduced significantly by diverting the failed packages to the CDPs. The computational results were generated based on the theoretical analysis of optimising carrier's rounds to make deliveries. Alternatively, the CDP method could be appraised by replicating the exact carrier rounds. In this chapter, the transport and associated environmental impacts of various CDP networks for re-directing failed home deliveries are investigated using the historical delivery schedules obtained from a major carrier.

Specifically, the distance savings to the carrier of having failed first-time home deliveries automatically diverted to a local CDP nearest to the householders' home were investigated. This was compared to the current system where the carrier may make multiple re-delivery attempts to the householder. Theoretical CDP's using Tesco Extra, railway stations, Local Collect post offices, and supermarkets from the ASDA, Morrison, Sainsbury's and Waitrose chains combined have been modelled. These outlets would potentially be able to receive packages in a secure area, manage their storage and through a web based communication system, liaise with the customer via email, text message to arrange collection.

7.2. Objectives

The research objectives were to:

- Quantify the transport and environmental costs of carrier in the existing delivery method and the CDP method by simulating the real carrier delivery operations on a typical working day in October, 2006 using RouteLogix as a base tool;
- Quantify the transport benefits to the carrier of having the failed 1st time home deliveries automatically diverted to a range of local CDPs;
- Project the modelling results of the existing delivery operations in West Sussex for all households over a 12-month period;
- Identifying the practical issues when setting up a CDP system, for example, location problem and capacity issue.

7.3. Background data analysis – A carrier operation in West Sussex

The delivery schedules from an international carrier company representing one week's operation across West Sussex, Hampshire, East Sussex and Surrey (Figure 60) (43559 consignments) were obtained. The database contained the detailed householder delivery information from 10th October to the 16th October 2006, which was taken to represent typical non-peak operations over one week. A consignment was defined as a delivery to the receiver's address and within one consignment, there could be more than one item. The 43,559 consignments made were served by 1243 delivery rounds. The delivery trips started from one of three local carrier depots serving West Sussex, located at Alton, Crawley and Southampton with majority of the deliveries being made between 09:00 and 16:00. The receiver's signature was required at the point of delivery and in the event of first-time failures, (after potentially multiple attempts on the same round) the carrier would leave a notice at the receiver's address stating that the delivery had been attempted and the consignment had been taken back to the depot. The carrier would then try to make one more attempt on the following day. Additional costs could be incurred by the householder for any subsequent re-delivery attempts for returning the consignment to the consignor.

Figure 60 presents a map showing the locations of the 43,559 delivery addresses visited during one week in October 2006 relative to the three depots located in Crawley, Southampton and Alton.

Figure 60 43,559 householders across West Sussex, Hampshire, East Sussex and Surrey (white circle) and 3 depots (red flags) identified from the carrier database over a Week (10th October 2006 – 16th October 2006)

7.3.1. Consignment sizes and characteristics

The database showed that of the consignments destined for households in West Sussex, 14938 originated from the Crawley depot, 13865 from Southampton and 9769 from the Alton depot during the sample week. There was an average of 2.3 items per consignment with an average consignment weight of 2.3 kg. The average number of weekly consignments delivered to each postcode sector was 75 and the average count of households per postcode sector in West Sussex is 77 (National Statistics Postcode Directory, 2006). From this, it was estimated that the average household received 0.97 consignments over a week.

A 3 by 7 homogeneity Chi-square test (Table 45) showed that there were significant differences in the number of consignments emanating from each depot (Alton, Crawley and Southampton) during the sample week ($\chi2$ =61.68 and $\chi2$ (0.05) 12df = 21.03). Significantly more consignments were delivered from Crawley and Southampton during the working days (10/10/2006, 10/11/2006, 10/12/2006, 10/13/2006 and 10/16/2006).

Table 45 Homogeneity Chi-square Test of Consignments made from 3 Depots over a Week (43559 consignments starting from Crawley, Southampton and Alton depots from 10th October 2006 to 16th October 2006)

Date	Depot	Observed N	Expected N	Obs-Exp	Sig.	Proportion
10/10/06	Crawley	2541	2603.54	-62.54	1.50	2.44%
10/10/06	Alton	2027	1950.65	76.35	2.99	4.85%
10/10/06	Southampton	2871	2884.81	-13.81	0.07	0.11%
11/10/06	Crawley	3253	3191.51	61.49	1.18	1.92%
11/10/06	Alton	2391	2391.18	-0.18	0.00	0.00%
11/10/06	Southampton	3475	3536.31	-61.31	1.06	1.72%
12/10/2006	Crawley	3215	3167.71	47.29	0.71	1.14%
12/10/2006	Alton	2341	2373.34	-32.34	0.44	0.71%
12/10/2006	Southampton	3495	3509.94	-14.94	0.06	0.10%
13/10/2006	Crawley	3285	3256.26	28.74	0.25	0.41%
13/10/2006	Alton	2448	2439.69	8.31	0.03	0.05%
13/10/2006	Southampton	3571	3608.05	-37.05	0.38	0.62%
14/10/2006	Crawley	230	247.44	-17.44	1.23	1.99%
14/10/2006	Alton	144	185.39	-41.39	9.24	14.98%
14/10/2006	Southampton	333	274.17	58.83	12.62	20.46%
15/10/2006	Crawley	30	25.55	4.45	0.78	1.26%
15/10/2006	Alton	0	19.14	-19.14	19.14	31.03%
15/10/2006	Southampton	43	28.31	14.69	7.62	12.36%
16/10/2006	Crawley	2691	2752.98	-61.98	1.40	2.26%
16/10/2006	Alton	2071	2062.62	8.38	0.03	0.06%
16/10/2006	Southampton	3104	3050.40	53.60	0.94	1.53%
SUM	—	43559	43559	0	61.68	100%

7.3.2. Delivery characteristics

Across the three depots, 38572 postcodes within West Sussex were delivered to during the sample week through 989 delivery vehicle rounds. The road distances between the 38572 delivery postcodes and their respective depots were calculated using Microsoft MapPoint (Table 46).

Table 46 Mean road distance from each of the 38572 postcodes in West Sussex to their respective serving depots (Crawley, Southampton and Alton)

	Mean Distance (km)	**Std. Dev.**
Distance to Crawley depot	34.62	19.21
Distance to Southampton depot	72.88	36.71
Distance to Alton depot	61.05	56.26

An One-way Analysis of Variance test showed that there were significant differences in the mean distance travelled to the delivery addresses by the carrier's vehicles emanating from each of the three depots (F=3611.639, F(0.05)=3.84, MSe=3.79E+06 and P= 0). A subsequent Scheffé multiple range test (Table C-5, Appendix C) showed that the Southampton depot (mean distance = 72.88km) was significantly further away from its catchments delivery area compared to the Alton depot (mean distance = 61.05km) and Crawley depot (mean distance = 34.62km).

7.4. Methodology

It was considered too complex to replicate the West Sussex home delivery operations involving all 43559 consignments emanating from the 3 depots. Consequently, the home delivery operations, focusing on the failed first-time deliveries originating from one depot over one working day were identified and modelled in this research. Based on the modelled results, the annual carrier transport activities associated with home deliveries across West Sussex were projected.

7.4.1. Choice of depot for detailed modelling

The 38572 consignments destined for households in West Sussex over the sample week were spread across 37 postcode districts covered by 989 delivery rounds. The Crawley depot served most householders in West Sussex and was selected as the depot to be modelled in the research. Delivery rounds made over the weekend of 14th and 15th October 2006 were not considered in the research because the number of consignments delivered was significantly less than during the working week. Consequently, 13581 consignments across 348 delivery rounds were selected over 5 working days (10th, 11th, 12th, 13th and 16th October 2006, Table 47) including details of the failed first-time deliveries by round.

Table 47 Number of consignments emanating from the Crawley depot among 13581 consignments over 5 working days (10th, 11th, 12th, 13th and 16th October 2006) serving households in West Sussex

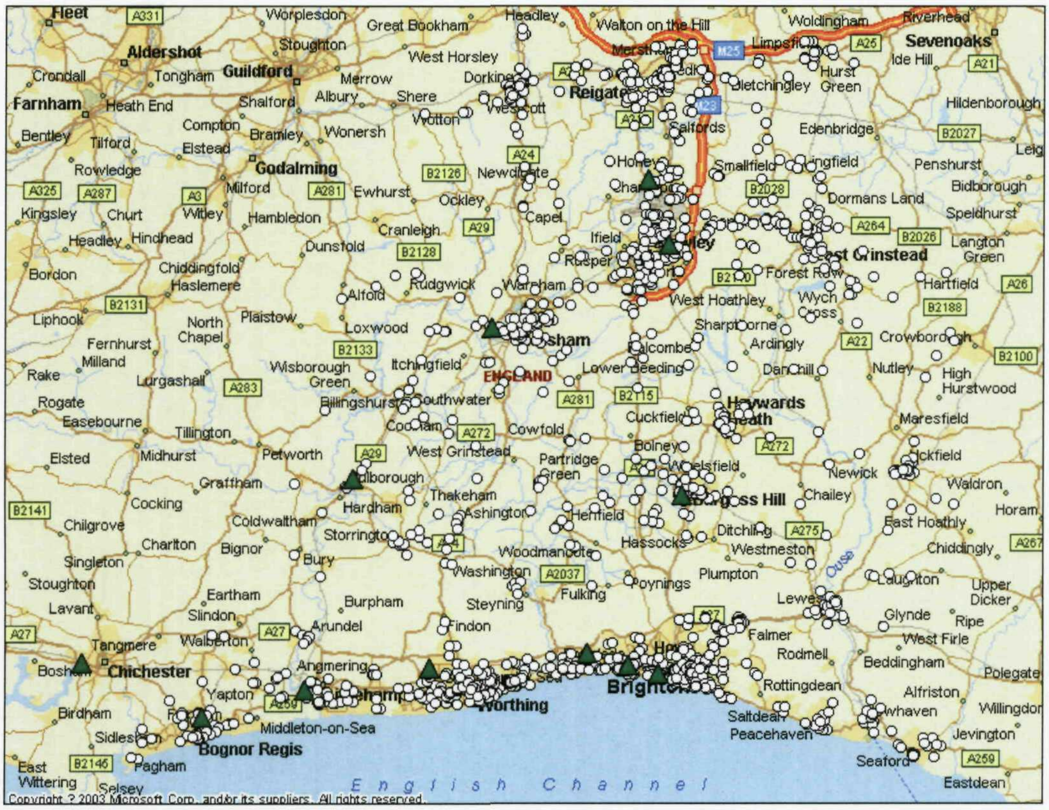
Delivery Date	No. of consignments	No. of failed 1st time consignments	Delivery failure rate
10/10/2006	2307	6	0.26%
11/10/2006	2902	13	0.45%
12/10/2006	2942	16	0.54%
13/10/2006	2934	15	0.51%
16/10/2006	2496	24	0.96%
SUM	**13581**	**74**	—

Table 47 suggested that the carrier had very few failed deliveries during those 5 working days. This was because the delivery options provided by the carrier database were speed delivery, which was constrained by the time requirements. People paid extra for the speed delivery thus were supposed to be home to receive it. As it produced the greatest number of failed deliveries, the data from the 16th October 2006 was focused on in this analysis. On this day, 2496 consignments across 55 delivery rounds were scheduled and amongst these, 13 delivery rounds experienced failed first-time deliveries.

7.4.2. CDPs selected for the modelling work and round design

The CDPs modelled here were 1) Tesco Extras, 2) Local Collect post offices, 3) railway stations, and 4) other supermarkets from the ASDA, Morrison, Sainsbury's and Waitrose chains combined. The strategy for carrier to visit the CDPs on a round was described in Section 5.3.2, Chapter Five.

Figures 61, 62, 63 and 64 present maps showing the locations of the 2496 delivery addresses, 12 Tesco Extras, 46 railway stations, 152 post offices offering the 'Local Collect' service and 53 other supermarkets from the ASDA, Morrison, Sainsbury's and Waitrose chains across West Sussex, respectively.



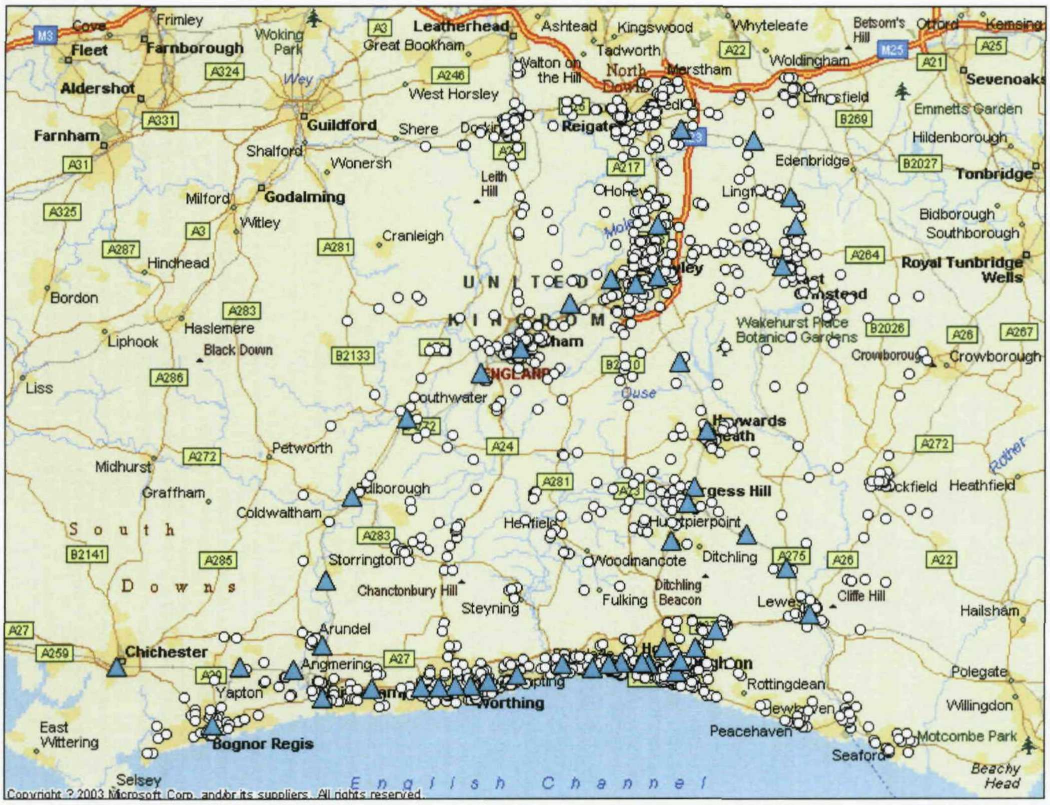
○ Householder addresses ▲ Tesco Extras

Figure 61 Map showing the 2496 consignments (white circles) and 12 Tesco Extras (green triangles) in West Sussex

○ Householder addresses

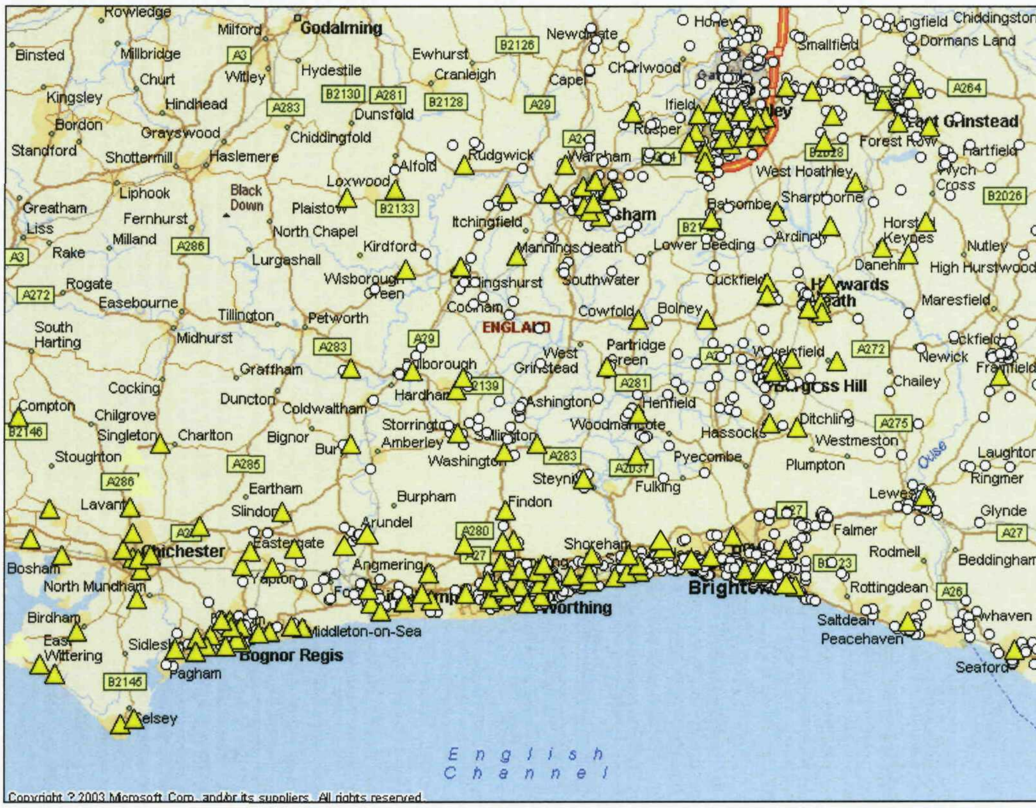
▲ Other Supermarkets from ASDA, Morrison, Sainsbury's and Waitrose chains combined

Figure 62 Map showing the 2496 consignments (white circles) and 53 supermarkets (red triangles) from ASDA, Morrison, Sainsbury's and Waitrose chains combined in West Sussex



○ Householder addresses ▲ Railway stations

Figure 63 Map showing the 2496 consignments (white circles) and 46 railway stations (blue triangles) in West Sussex



○ Householder addresses △ Post offices offering 'Local Collect'

Figure 64 Map showing the 2496 consignments (white circles) and 152 post offices offering the 'Local Collect' service (yellow triangles) in West Sussex

Through the unique consignment ID, the carrier databases provided the delivery address, delivery times for both successful and failed attempts and the consignments originating depot. The actual consignment delivery order making up the round was made available and replicated using DPS RouteLogix routing and scheduling software. The failed first-time deliveries were manually inserted at the point where the CDP was to be visited. The failed first-time deliveries were automatically diverted to the nearest CDP relative to the respective householders' locations after all the delivery attempts were made in its catchment area. In order to illustrate this procedure, the home delivery operations associated with one single vehicle round on the 10th October 2006 are shown in Table 48 and Figure 65.

Table 48 Delivery order for one vehicle round emanating from the Crawley Depot on the 10th October 2006 (failed first-time consignments are highlighted in yellow and successful re-deliveries of failed consignments highlighted in green)

Connote	Description	Delivery Postcode	Actual Delivery / Received Date Time
92154353	DELIVERED SIGNED	RH10 8	10/10/2006 08:12:00
74618590	FAILED ATTEMPT	RH11 0P	10/10/2006 08:25:23
33147910	DELIVERED SIGNED	RH11 0PR	10/10/2006 08:36:00
60775833	DELIVERED SIGNED	RH11 0PJ	10/10/2006 08:41:00
73562866	DELIVERED SIGNED	RH11 0PW	10/10/2006 08:44:00
90900105	DELIVERED SIGNED	RH11 0PQ	10/10/2006 08:49:00
65137283	DELIVERED SIGNED	RH11 0PH	10/10/2006 08:53:00
75871768	DELIVERED SIGNED	RH11 7XA	10/10/2006 09:08:00
94727747	DELIVERED SIGNED	RH11 0	10/10/2006 09:12:00
94882606	DELIVERED SIGNED	RH11 7XA	10/10/2006 09:12:00
41880519	DELIVERED SIGNED	RH11 7SU	10/10/2006 09:15:00
793200	DELIVERED SIGNED	RH11 7XX	10/10/2006 09:26:00
65334715	DELIVERED SIGNED	RH11 7XN	10/10/2006 09:31:00
65351685	DELIVERED SIGNED	RH11 7	10/10/2006 09:31:00
75561641	DELIVERED SIGNED	RH11 7XA	10/10/2006 09:42:00
64706769	DELIVERED SIGNED	RH11 7XN	10/10/2006 09:43:00
68284642	DELIVERED SIGNED	RH10 9XA	10/10/2006 09:53:00
61509022	DELIVERED SIGNED	RH11 7RS	10/10/2006 10:00:00
76126478	DELIVERED SIGNED	RH11 8HW	10/10/2006 10:14:00
99277530	DELIVERED SIGNED	RH11 6EB	10/10/2006 10:22:00
75329358	DELIVERED SIGNED	RH11 8	10/10/2006 10:25:00
73127490	DELIVERED SIGNED	RH11 8PL	10/10/2006 10:25:00
68286483	DELIVERED SIGNED	RH11 8QX	10/10/2006 10:40:00
89981285	DELIVERED SIGNED	RH10 6BG	10/10/2006 10:45:00

Table 48 continued

Connote	DESCRIPTION	Delivery Postcode	Actual Delivery / Received Date Time
472932	FAILED ATTEMPT	RH10 6HQ	10/10/2006 10:54:14
49446879	DELIVERED SIGNED	RH10 6LW	10/10/2006 11:02:00
60733020	DELIVERED SIGNED	RH10 6QQ	10/10/2006 11:10:00
60733027	DELIVERED SIGNED	RH10 1RP	10/10/2006 11:10:00
94293327	DELIVERED SIGNED	RH10 5BQ	10/10/2006 11:17:00
65985493	DELIVERED SIGNED	RH11 9BP	10/10/2006 11:30:00
65176565	DELIVERED SIGNED	RH11 9	10/10/2006 11:30:00
81166975	DELIVERED SIGNED	RH11 9	10/10/2006 11:30:00
74290184	DELIVERED SIGNED	RH11 9NT	10/10/2006 11:38:00
472932	DELIVERED SIGNED	RH10 6HQ	10/10/2006 14:52:00
74618590	DELIVERED SIGNED	RH11 0	10/10/2006 15:06:00

The yellow-highlighted consignments represent the day and time of the first-time failed delivery attempts. The green-highlighted consignments represent the final successful delivery times and days of these previously failed deliveries. This complete delivery sequence was constructed using two databases provided by the carrier and enabled the travel distance and time associated with the current delivery operation to be estimated using RouteLogix.

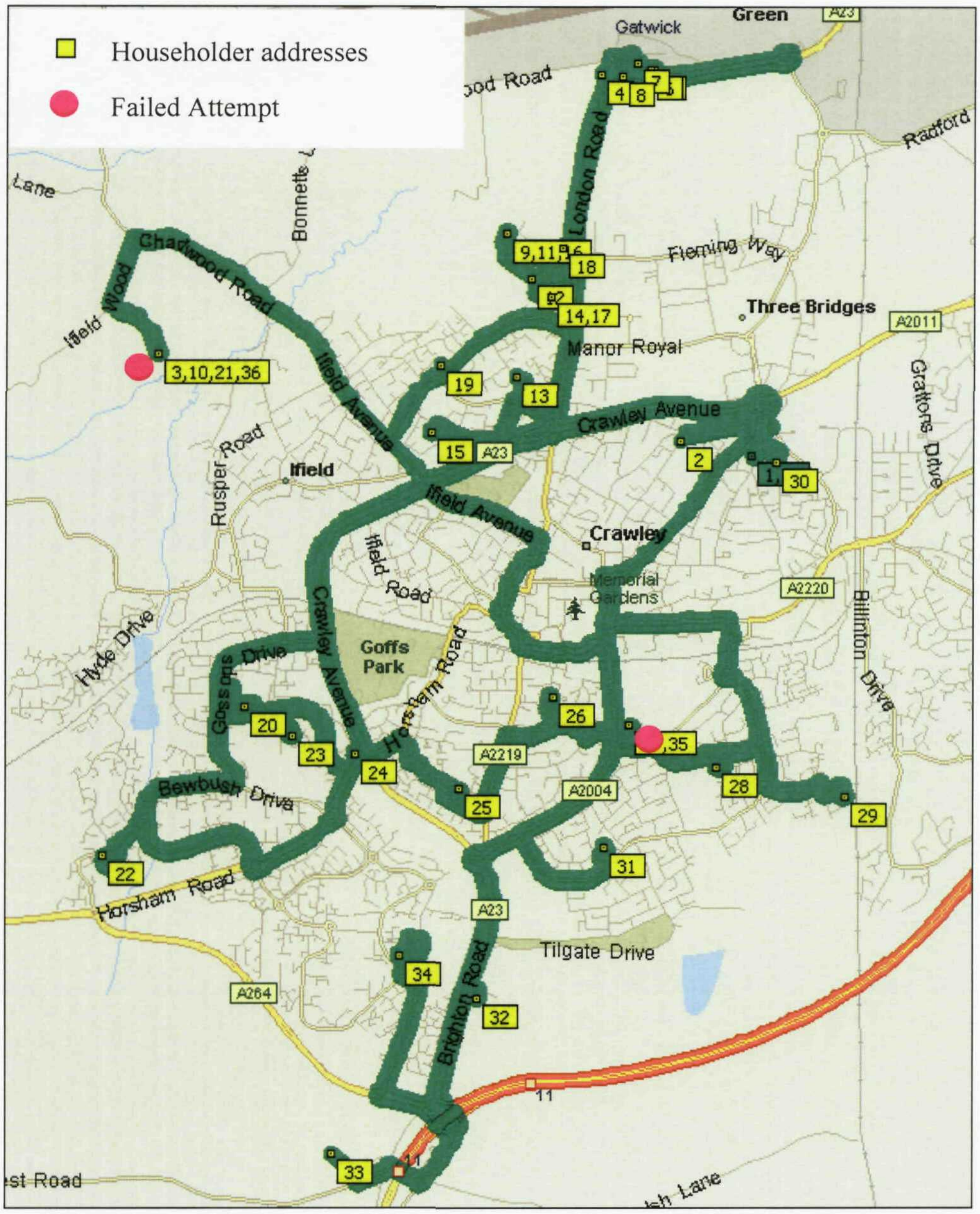


Figure 65 Current visiting sequence (illustrated by the numbered squares) of one delivery round on 16th October 2006 commencing at 08:12 and finishing at 15:06 highlighting the redeliveries for the failed first-time consignments

To replicate the current delivery sequences associated with the 55 rounds in RouteLogix, the following settings were used:

- Maximum working time is 9 hrs per LGV (Road Transport Directive, 2004);
- Maximum continuous driving time is 4.5 hrs (Road Transport Directive, 2004);
- Drop-off time of 5 minutes per householder address (MIRACLES, 2005);

- Delivery time of 5 minutes at the CDP (Collectpoint PLC, 2002);
- Householder's collection time of 5 minutes at the depot, or local CDP (Collectpoint Plc, 2002);
- LGV's average driving speed in the delivery area is 30 km/hr (Department for Transport, 2004, 2004).

Based on the simulation results, the travelling distances associated with the existing delivery method were calculated and the environmental impacts accessed. It was assumed that the simulation results from the 16th October 2006 were an accurate reflection of a typical delivery schedule, and that the carrier's travelling distances could then be projected using this over a 12-month period.

7.5. Results

7.5.1. Quantifying the householder travel distance to the CDPs

The road distance from each of the 2496 postcodes to the modelled CDPs was calculated using Microsoft MapPoint. This was based on the quickest route distance between the householder's origin postcode and the CDP postcode (Table 49).

Table 49 Road distance (km) from each of the 2496 householder postcodes to each of the CDPs (12 Tesco Extras, 46 railway stations, 152 post offices offering 'Local Collect' and 53 other supermarkets) in West Sussex

Average one-way road distance to CDP	Mean Distance km	Std. Dev.
Tesco Extra	5.34	3.48
other supermarket chains	3.07	3.22
Local Collect post office	1.43	1.81
railway station	2.81	3.18

An One-way Analysis of Variance test showed that there were significant differences in the mean distance travelled to the CDPs from the householder's origin points (F=89.768, F(0.05)= 3.843, MSe=602.143 and P= 3.85E-21). A subsequent Scheffé Multiple range test (Table C-6, Appendix C) indicated that on average, the householder lived significantly further away from a Tesco Extra (mean distance=

5.34km) but significantly closer (1.43km) to a post office offering 'Local Collect' compared to the other CDPs.

7.5.2. Quantifying carrier travel distances in the existing delivery System against the CDP options

The existing delivery method was modelled using RouteLogix, with the carrier's vehicles starting and ending their rounds at the depot in Crawley. All 2496 delivery addresses were served by 55 vehicles during the sample week according to the delivery sequence supplied. The theoretical CDP delivery method was then replicated using RouteLogix with the failed first-time deliveries being automatically diverted to the nearest CDPs relative to the households' locations. The results in terms of carrier kilometres and emissions were then compared between the two systems.

The carrier kilometres associated with the delivery operations for the 55 delivery rounds (2496 consignments) on the 16th October 2006 by the current method and the theoretical CDP networks are shown in Figure 66.

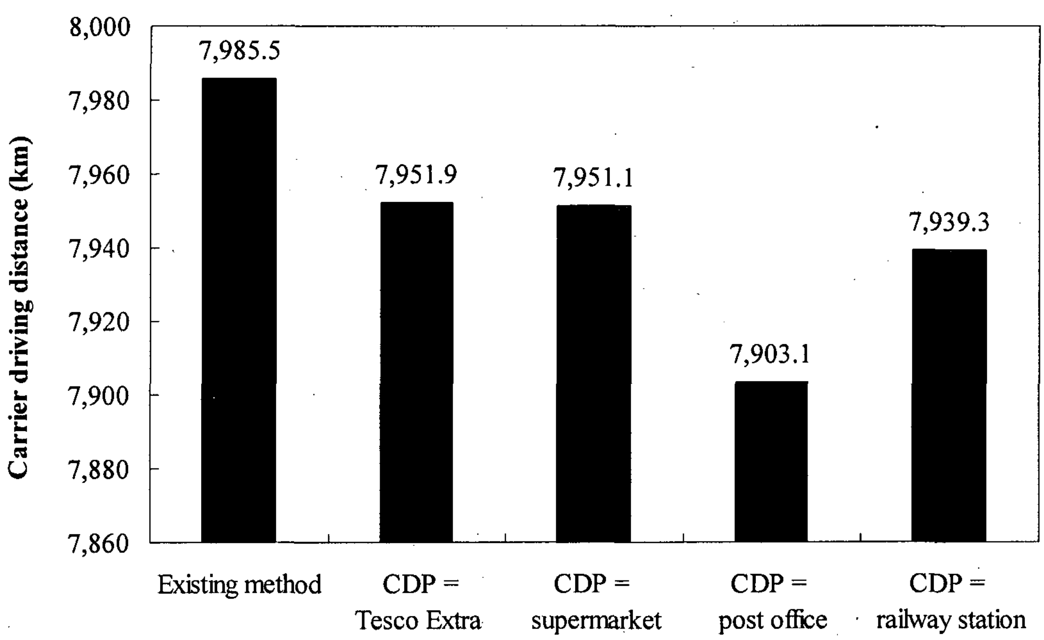


Figure 66 Carrier driving distances on a typical working day (55 delivery rounds across 2496 delivery addresses)

The carrier's current daily kilometres associated with making the deliveries and re-deliveries was estimated by RouteLogix to be 7,986km and among those 55 delivery rounds, 13 of them experienced failed deliveries. The variability in the carrier round distance when incorporating the theoretical CDP networks into the operation is shown in Table 50.

Table 50 Variability in carrier driving distance per round among the 13 rounds on the 16/10/06 which experienced failed first-time deliveries

	Num of Rounds	**Min Round Distance km**	**Max Round Distance km**	**Mean Round Distance km**	**Std. Dev.**
Existing method	13	101.1	276.8	161.8	49.4900
CDP =Tesco	13	90.0	275.7	153.7	48.7214
CDP = Supermarket	13	85.5	280.5	153.6	51.1305
CDP = Post Office	13	81.3	277.3	149.9	50.9889
CDP = Rail Station	13	83.1	279.6	152.79	51.6632

An One-way Analysis of Variance test showed that there were significant differences in the carrier mileage between the five home delivery methods (F=1477.385, F (0.05) = 3.858, MSe=1773.505 and P= 1.1E-157). A subsequent Scheffe Multiple Range Test (Table C-7, Appendix C) indicated that the mileage associated with the current delivery and re-delivery method was significantly longer compared to any of the CDP methods, if they were used to re-direct failed first-time home deliveries.

As can see from Figure 66, the carrier distance in a typical working day was reduced by introducing the CDP concepts. The carrier experienced shorter driving distance when the failed first-time deliveries were diverted to either the Tesco Extras (7,951.9km, 0.42% reduction), railway stations (7,939.3km, 0.58% reduction), and supermarkets combined (7,951.1km, 0.43% reduction). The most significant savings were derived when the Local Collect CDP network was used when the carrier driving distance across 55 rounds was 7,903.1km (an 82km reduction, 1.03% reduction).

Based on these carrier travelling distances and an assumed vehicle operating cost, the transport costs associated with the existing delivery method were calculated. According to the UK Freight Transport Association (2007), the operating costs for a typical rigid delivery vehicle (over 3.5 tonnes) are £0.74 per km, which include all standing and running costs as well as an allowance for overheads. The carrier transport costs for the existing method in a typical working day were estimated to be £5,892 while the transport costs associated with the CDP methods were estimated to be £5,867 (Tesco Extras); £5,858 (railway stations); £5,866 (supermarkets combined) and £5,831 when Local Collect post offices were utilized.

If the results from this sample day could be taken as representing typical operations, then over a 12-month period (260 working days, Monday to Friday), involving 14300 delivery rounds across all the consignments made in West Sussex, 2,027,168km might be travelled. According to the computational results, the CDP methods could reduce the carrier driving distance in a typical working day by between 0.42% and 1.03%. Over a 12-month period, the carrier distance could therefore be reduced between 8,530km and 20,918km, equivalent to a saving of between £6,293 and £15,433.

Although the benefits to the carrier in terms of vehicle kilometrès reduction resulting from introducing the CDP delivery system appear limited, the cost savings resulting from not having to handle failed first-time deliveries could be more significant. According to IMRG (2006), it was estimated that a carrier might incur costs of £38.50 for each delivery failure. Similar to the cost analysis in the Winchester and the West Sussex study, the costs savings on carrier associated with handling home delivery failures are presented here. According to the carrier data, there were an average of 14.7 (round to 15) failed first-time deliveries in a typical working day. If the results from the carrier database could be taken as representing typical operations, then over a week there were 75 failed first time deliveries (5 working days from Monday to Friday), which may result in a re-delivery on the next working day. Consequently, over a 12-month period, it was estimated that there were 3900 failed first time deliveries. By introducing a CDP delivery method, between £40,950 (if the minimum failed delivery cost of £10.50 is assumed) and £150,150 (if the maximum £38.50 is assumed) could be saved annually by the carrier through the use of CDPs.

7.5.3. Quantifying the environmental costs of the existing delivery system against the CDP options

The possible environmental benefits resulting from the CDP methods were estimated based on the carrier driving distances and various emissions factors related to rigid diesel delivery vehicles (Table 51).

Table 51 Road Transport Emission Factors, 2005

Emission Factors		**Delivery Vehicle Diesel Engined LGV (>3.5 tonnes)**
CO_2	g/km	268
C	g/km	73
Methane	g/km	0.00265
NO	g/km	0.01
Carbon Monoxide	g/km	0.48
NO_2	g/km	0.87
Non Methane VOC	g/km	0.14

Source: National Atmospheric Emissions Inventory NAEI, UK, 2005.

The emissions from the CDP home delivery models are summarized in Table 52.

Table 52 Road transport emissions on a typical working day (55 delivery rounds across 2496 delivery addresses in West Sussex)

Delivery Model	**Carrier Driving distance km**	**Emissions tonne of carbon equivalent**	**Emission reduction compared with existing method**
CDP =Local Collect Post office	7,903.1	2.707	1.03%
CDP = Supermarket	7,951.1	2.723	0.43%
CDP =Tesco Extra	7,951.9	2.724	0.42%
CDP =Railway station	7,939.3	2.719	0.58%
Existing method	7,985.5	2.735	—

These results showed that the CDP delivery method had a mainly positive impact on emissions, reflecting the fact that total distances travelled were reduced. The daily emissions were reduced by between 11 and 28 kg of carbon equivalent. Assuming the carrier has a regular delivery service every working day and the 55 delivery rounds per day are typical, it was projected that over a 12-month period, the carrier emissions could be reduced by between 2.86 tonnes and 7.28 tonnes of carbon equivalent through the use of a CDP system. There would also be a potential emissions reduction resulting from householders choosing to walk/cycle to the CDP instead of travelling by motorized transport (covered in Chapter Five and Six).

7.6. Economic feasibility of CDP system

One of the obstacles faced by all the CDP systems is cost. Customers don't tend to pay £100 or more for the reception boxes, for example, the price for Hippobox is £194. It is even more expensive to implement the communal reception boxes, such as BearBox and ByBox for customers. The initial set-up fee for each BearBox is around £400 with £18 rental per week (www.bearbox.com). The economic feasibility of such unattended reception boxes have been explored by Punakivi *et al.* (2001), which suggested that 1000 EUR investments per customer would last 8-10 years before it was paid back. In a consumer market, it is difficult to persuade people to buy such expensive products they may not frequently use.

Since customers are not expected to pay more for parcel delivery in the e-commerce market, carrier companies and e-retailers have to pay more to use the innovative delivery channels as part of alternative delivery options provided to the customers. For example, the DHL PACKSTATION service is free for registered customers. Kiala charges around £2 per customer to use its service. At the same time, carrier needs to pay around £1000 service fee for the CDP service provider (MIRACLE, 2006). Due to the extensive investments and limited market segment, several CDP service providers have stopped working. For example, Collectpoint once was a byword in the home shopping market for unattended delivery, operating pick-up points through a network of third-party outlets such as convenience stores and petrol station forecourts, and also expanded into the B2B market. Unfortunately, like others in this sector, it has ceased its business and has recently been taken over by RedPack Network Inc.

Concerning the implementation of the CDP hardware and possibly a supporting electronic communicating system, the costs for CDP system could differ heavily. For example, Kiala invested €5 million in setting up its technological platform. Kiala's success indicates some potential successful factors when setting up such mechanism. Carefully monitoring the investments and managing partnership among retailer, service providers and carrier companies, the CDP service is possibly able to survive considering the promising future of home delivery market and people's increasing demand for solving the failed home deliveries.

The simulation results of this study suggested that there were limited improvements in the carrier travel distance through the use of CDPs (Figure 66). However, the significant cost savings could be achieved associated with not having to deal with the home delivery failures (Section 7.5, Chapter Seven). Based on the carrier exact delivery schedule on a typical day, 13 of them experienced failed deliveries among those 55 delivery rounds across 2496 delivery addresses in West Sussex. It is then estimated that additional daily £500.5 associated with handling those delivery failures is imposed on the carrier, considering that a carrier might incur costs of £38.50 for each delivery failure (IMRG, 2006). Assume the operations in the modelled working day are representative, the cost savings for one carrier in one year would be £136,619.6 across West Sussex (5 working days from Monday to Friday and 52 weeks a year).

The computational results are generated based on one carrier database. According to the UK Competition Commission (2002), Parcelforce, DHL and TNT are the top three parcel carriers in the UK, accounting for 50% of total home delivery market share (Table 6). Assuming that the carrier which was modelled in this research is a typical carrier and all leading carriers have the similar operations in West Sussex since they have similar size and type of operations, the overall cost savings associated with home delivery failures would be around £410,000 a year in West Sussex for all the three leading carriers. Those savings in operational cost as well as the increases in customer satisfaction should be able to overcome in the medium term the expenses for the installation of a CDP service. For example, Kiala (launched in Belgium in 2000) has justified its initial investment (€5 million) with turnover growing by 170% to €16.3 million since 2004.

Several other factors when setting up the CDP need to be considered:

- **Location**

The location choice should be based on the consideration of 'where are the most frequent places by the users?'. Several promising places were proposed by the CDP service providers, including superstores, newsagents, petrol station, post office, convenience stores, business parks, shopping centres.

The questionnaire survey undertaken in this research also asked people where the most suitable CDP location is. 46% of them prefer post office and 30% of them prefer convenience store.

- **Types of goods**

The CDP system is used to handle small products including books, DVDs, CDs, computer software, tickets and clothing, which would not fit through a letterbox or items that required a signature. It is unlikely to be suitable for handling groceries because this would require large refrigeration space, and large, heavy parcels as these require significant storage space since convenience stores tend to have limited free storage capacity.

- **Technical requirements**

Facilities often needed for the implementation of a CDP system normally include electrical power, telephone access, modem, and 24-hour accessibility.

- **Service charge**

A survey undertaken by Peter Brett Associates (2005) suggested that an average charge of £1.15 was acceptable for the potential customers (Table 53).

Table 53 Acceptable payments for the CDP service

Charge	Number of responses	Percentage
Free	296	54.51%
50p	25	4.60%
£1	79	14.55%
£2	52	9.58%
£3	34	6.26%
£4	3	0.55%
£5	42	7.73%
£7	4	0.74%
£10	8	1.47%

Source: Sustainable Deliveries, home deliveries survey analysis, Peter Brett Associates, 2005.

Currently Kiala charges customer €3.99 per delivery and DHL PACKSTATION is free for the registered customers.

- **Capacity issue**

For most of the existing CDP premises, a reasonable storage space is required. For example, an area of 3 x 2.5 x 2.5 m (width/depth/height) is necessary to set up a DHL PACKSTATION in Germany. Kiala point needs space of 2m wide x 2m high for the box.

The historical delivery schedule obtained from a major carrier in West Sussex suggested that there was an average of 15 failed first time deliveries in a typical working day (Section 7.3, Chapter Seven). If the results from the carrier database could be taken as representing typical operations, then over a week there were 75 failed first time deliveries (5 working days from Monday to Friday), which may result in a re-delivery on the next working day. Assuming that the carrier which was modelled in this research is a typical carrier and all leading carriers have the similar operations in West Sussex (DHL, Parcelforce and TNT) (UK Competition Commission, 2002), it is predicted that those three leading carriers will divert 225 failed 1st time consignments to CDPs weekly.

The CDP outlets modelled in this research included 19 Tesco Extra supermarkets, 55 railway stations, 152 post offices with 'Local Collect' service and 104 other supermarkets from ASDA, Morrison, Sainsbury's and Waitrose chains combined in West Sussex. Assume that all customers are evenly spread among the CDPs. Hence for the 225 failed consignments, each Tesco Extra will receive an average of 12 consignments per week, with 5 packages being received by each railway station, 2 received by each Local Collect post office, and 3 received by each supermarket.

The exact delivery information of the carrier which was modelled in this research suggested that there was an average of 2.3 items per consignment. The average weight of each consignment was 2.3 kg, indicating that a normal package could be small in terms of weight. A consignment was defined as a delivery to the receiver's address and might consist of more than one item. The items could be of varying size but each consignment would require only one stop. CDPs are used to handle small packages; however, little evidence has suggested the average size of packages handled by CDP service providers. Hence, the maximum package size required by Collectpoint was assumed here, 0.75m by 0.75m by 1m (Collectpoint, 2005). Based on the weekly number of failed packages received by each CDP outlet and the maximum size of package required by the CDP service provider, the storage space for those failed packages could be estimated. For example, each railway station will receive 5 failed home deliveries a week, taking up to 2.8 m^3, or each Tesco Extra will receive 12 deliveries per week, taking up to 6.8 m^3. This indicates that the capacity issue should not be a problem for the CDP outlets modelled in this research.

To evaluate the feasibility of a CDP scheme, several scenarios associated with various first-time delivery failure rates and CDP take-up levels are discussed here (Table 54). Here, the Royal Mail 'Local Collect' service was used as CDP example. Royal Mail sorting office acted as the carrier's depot where the postman's daily round starts and finishes. Maximum size of a package (0.75m by 0.75m by 1m) was used in the analysis as the worse-case scenario in terms of CDP capacity. All the failed home deliveries were returned to the sorting office and a notification card left with the householder advising of re-delivery/personal collection options. These are:

- Contact the carrier and arrange a re-delivery to the home address or work/alternative address at a mutually convenient time during normal working hours (Monday to Saturday);
- Travel to the Royal Mail sorting office personally to collect the package;
- Contact the carrier and arrange a re-delivery to a post office offering the 'Local Collect' service (see Section 2.2.5).

In the analysis, the proportion of people travelling to the Local Collect post office to collect a package (CDP take-up level) was modelled as a variable parameter. According to the responses from West Sussex survey (Question C6), 7% of households were collecting their failed packages from Local Collect post offices with 31% travelling to the carrier's depot. In the questionnaire, people were also asked whether they would take the CDP service and 79% of respondents were positive (Question D3).

It was then assumed that potentially 79% of households would be CDP users. Consequently, a range of parameter values for CDP take-up level were considered in Table 54 (10%, 20%, 40%, 60% and 80%). Furthermore, the proportion of first-time delivery failure rates was also modelled as a variable parameter in the analysis.

Table 54 Feasibility analysis of CDP scheme under various first-time delivery failure rate and CDP take-up levels, 2496 (round to 2500) consignments were assumed to be typical for one single carrier a day in West Sussex. Assume all leading carriers have the similar operations across West Sussex (DHL, Parcelforce and TNT). Each package takes up to 0.75m by 0.75m by 1m as the worse case scenario.

	Scenario 1	**Scenario 2**	**Scenario 3**	**Scenario 4**	**Scenario 5**
Average number of first-time deliveries a day made by one carrier	2500	2500	2500	2500	2500
Total number of first-time deliveries a day made by three leading carriers	7500	7500	7500	7500	7500
No. of Local Collect post offices	152	152	152	152	152
CDP take-up level([17])	10%	20%	40%	60%	80%
10% of first-time delivery failure rate					
No. of packages diverted to all Local Collect post offices a day	75	150	300	450	600
No. of packages to each Local Collect post office a day	0.5	1.0	2.0	3.0	3.9
Storage space required for each Local Collect post office a day (m^3)	0.3	0.6	1.1	1.7	2.2
20% of first-time delivery failure rate					
No. of packages diverted to all Local Collect post offices a day	150	300	600	900	1200
No. of packages to each Local Collect post office a day	1.0	2.0	3.9	5.9	7.9
Storage space required for each Local Collect post office a day (m^3)	0.6	1.1	2.2	3.3	4.4

[17] : The percentages of households using the CDP service. Various take-up levels were considered in this research. It should be noted that the CDP take-up level determines the number of failed first-time deliveries which will be diverted to the CDPs. For example, under the scenario of 10% of first-time delivery failures and 20% of CDP take-up level, 50 packages will be diverted to CDPs.

Table 54 continued

	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
30% of first-time delivery failure rate					
No. of packages diverted to all Local Collect post offices a day	225	450	900	1350	1800
No. of packages to each Local Collect post office a day	1.5	3.0	5.9	8.9	11.8
Storage space required for each Local Collect post office a day (m^3)	0.8	1.7	3.3	5.0	6.7
40% of first-time delivery failure rate					
No. of packages diverted to all Local Collect post offices a day	300	600	1200	1800	2400
No. of packages to each Local Collect post office a day	2.0	3.9	7.9	11.8	15.8
Storage space required for each Local Collect post office a day (m^3)	1.1	2.2	4.4	6.7	8.9
50% of first-time delivery failure rate					
No. of packages diverted to all Local Collect post offices a day	375	750	1500	2250	3000
No. of packages to each Local Collect post office a day	2.5	4.9	9.9	14.8	19.7
Storage space required for each Local Collect post office a day (m^3)	1.4	2.8	5.6	8.3	11.1

The results in Table 54 suggested that the most challenging scenario for CDP capacity was that 50% of first-time deliveries were failing and 80% of householders were using Local Collect post offices as CDPs, with 20 packages being received by each Local Collect post office per day (equivalent to 11 m^3 storage spaces). This should not be a problem for the Local Collect post office branch. According to the CDP trial undertaken in Nottingham (Department for Transport, 2004), the highest volume of re-delivered items received by one Local Collect post office was around 20 per day. On average, around five items were re-delivered to each branch a day. The items targeted by the trial were either items that required a signature and parcels larger than the mailbox. However, capacity issues, in terms of storage space at the Local Collect post office branches, didn't occur in the trial expect during the seasonal shopping rush.

Capacity problems due to obvious seasonal factors could be solved in two ways: 1) A reminder card could be sent to the customers, reminding them that their parcels had not been collected yet. By doing this, customer may be able to collect the goods soon and the storage space may be released. 2) A planning system is suggested so that some of the items could be redelivered to neighboring CDP premises which received less parcels.

7.7. Summary

Using the real operating data from a carrier on a typical working day in October 2006, the computational results presented in this chapter have validated the theoretical analysis based on the West Sussex survey data. The existing home delivery operations for 2496 consignments were simulated by means of a routing and scheduling software, RouteLogix. Using the routing strategy proposed in Chapter Five, the delivery operations for the CDP method were modelled by diverting the failed first-time deliveries to Tesco Extras, post offices offering the 'Local Collect' service, railway stations and other supermarkets from ASDA, Morrison, Sainsbury's and Waitrose chains combined. It was found that the CDP method could reduce the carrier delivery distance by between 0.42% and 1.03% (reducing daily carrier vehicles emissions by between 11 and 28 kg of carbon equivalent). It is in line with the results in Chapter Six, indicating that the CDP method is more cost efficient when the proportion of failed first-time deliveries is significant. It was projected that over a 12-month period, the carrier emissions could be reduced by between 2.9 tonnes and 7.3 tonnes of carbon equivalent through the use of CDPs to drop failed first-time deliveries.

CHAPTER EIGHT

CONCLUSIONS AND LIMITATIONS

8.1. Thesis summary and key findings

The home shopping and home delivery service offers the opportunities for customers to purchase goods from home and receive deliveries to their home rather than having to travel to the high-street stores. Home delivery issues have been explored in numerous academic publications and are very important in logistics and retailing literature. This thesis has identified the transport and environmental implications of home delivery operations particularly for small packages, where there has been very limited research. Of major concerns are the home delivery failures when no one is home to receive the package(s). The impacts of failed first-time home deliveries on additional carrier journeys (repeat deliveries), or householder trips to retrieve the failed goods have been assessed in this research. The Collection/Delivery Points (CDP) concept emerges as one of the solutions to deal with those delivery failures, using Convenience Stores, petrol stations, post offices etc. as the alternative addresses to receive the deliveries. This study appraises the transport impacts of various CDP networks on carriers and householders. The CDP networks modelled in this research were Tesco Extras, post offices offering a 'Local Collect' service, railway stations and the supermarket chains with ASDA, Morrison, Sainsbury's and Waitrose chains combined.

A six-step research method was developed in this study (Chapter Three). Various home delivery methods were identified from the literature in the first research step. The second stage consisted of conducting two home delivery surveys in two areas (Winchester and West Sussex, respectively), in order to reach a wide cross-section of householders and identify their experiences of home delivery services (Chapter Four).

Based on the Winchester survey, a carrier's theoretical delivery route around a group of the respondents' delivery addresses was optimised using DPS RouteLogix in the third stage. The transport and environmental benefits incurred from reduced carrier and customer activity of using the CDP concept were then analyzed. Winchester is a small dense city and may not be representative of the wider population. Hence in the fourth stage, the theoretical analysis of CDP benefits on carrier and householders was undertaken again in West Sussex, based on the survey data. Instead of theoretically optimising carrier's rounds, the exact delivery schedules obtained from a major carrier were replicated in the fifth stage. Based on that, the CDP benefits for the carrier were appraised. The feasibility of the CDP system was discussed in the last stage.

The main conclusion from this study is that the major benefits of using CDPs are achieved by householders (Chapter Five and Chapter Six). This is because currently householders have to collect their failed first-time deliveries from the carrier's depot. It is more convenient for them to travel to the local CDPs to make collections. The theoretical analysis in Winchester study and West Sussex study suggested that CDP method could reduce householders' travel distance by around 90% (Section 5.6, Chapter Five and Section 6.6, Chapter Six). The reduction in distance traveled to the carrier is much less but the processing costs associated with home delivery failures are reduced significantly by diverting the failed packages to CDPs. The overall distances in terms of carrier and householders combined are reduced significantly by using CDP methods, by around 70% (Section 5.6, Chapter Five and Section 6.6, Chapter Six). Consequently diverting the home delivery failures to CDPs will enable householders to reduce their travel distance and help the carrier save on operating costs.

Another finding from the current study is that the CDP methods are able to reduce emissions generated in current home delivery operations. It indicates that although the impacts on emissions generated from carrier delivery rounds of using CDPs are very limited, the overall emissions from carrier and householder's travel combined can be reduced significantly (Section 5.5.2, Chapter Five and Section 6.4.2, Chapter Six).

To further identify whether CDP method is a potential solution for handling home delivery failures, this study evaluated the impacts of failed first-time packages on additional carrier journeys or householder trips to retrieve failed packages. The key finding is that the CDP method will function effectively in terms of reducing overall vehicle kilometres incurred in the current situation (carrier and householder combined) when the proportion of first-time home delivery failures is over 20% and the proportion of people travelling to depot is over 30%. The CDP method is more cost efficient when the proportion of failed first-time deliveries increases (Section 5.5, Chapter Five and Section 6.4, Chapter Six). Further reductions on overall distances will be achieved from householders choosing to walk/cycle to the CDP instead of travelling by motorized transport.

In summary, the CDP concept is theoretically cost-effective in terms of reducing householder's travel distances and carrier's operating costs associated with home delivery failures. However, very few CDP systems have been implemented with success. Hence the economic feasibility of a CDP scheme is discussed and several practical suggestions about CDP outlet design are proposed in terms of capacity, service charge, technical requirements and locations (Section 7.6, Chapter Seven). Although the analysis is undertaken in a very simple and straightforward way, it gives the CDP service providers some hints about the promising future of the CDP market considering people's increasing demand for solving failed home deliveries.

8.2. Contribution of Current Research

The current research presents the work for promoting a new cost-efficient home delivery strategy (CDP). As discussed in the literature review part, most of the previous research in this field has focused on the transport benefits of directly substituting the high-street shopping trips with home delivery journeys. The feasibility of CDP home delivery strategies have seldom been investigated before. Consequently, the current research has created new knowledge supporting the developments of both efficient and environmentally-friendly home delivery operations. The results have been published in several academic papers.

Compared to the work in this field, the current study has made the following contributions.

- The research increases the body of knowledge by introducing the CDP delivery operations;

- The CDP concept is appraised based on both carrier's theoretical delivery rounds (Chapter Five and Chapter Six) and exact delivery information obtained from a major carrier company (Chapter Seven). The benefits on carrier and householders of using CDPs are presented in terms of carrier' travel distance to make deliveries and householder' journey distance to make collections;
- The current study undertakes detailed cross-population analyses to identify the differences in home shopping behaviour among different population groupings. The results are compared between two demographical areas (Winchester and West Sussex);
- Several practical issues when implementing a CDP outlet are discussed.

8.3. Managerial implications of the research

The study has significant practical managerial implications for retailers and carriers on how to improve their home delivery service by promoting a better delivery strategy. The results of this thesis were generated in one journal paper and circulated in the Home Delivery Forum organized by IMRG, the most prominent industry body in the online retailing and home delivery operations.

Firstly, the research analysed the home delivery problems encountered by carriers and customers, and identified an efficient home delivery strategy (CDP method) to solve these problems. However, the CDP concept has not been widely recognized by public. The research is helpful for carriers/retailers to make decisions of setting up a CDP system. They can refer to home delivery survey results to see what customers actually want from a CDP concept, including preferred locations, collection times, transport mode choices to a CDP and reasons for not using it. They can also benchmark their performance against the simulation results based on the historical carrier delivery schedules. The research is also helpful for customers to adopt the CDPs as alternative addresses either for first-time or second-time deliveries, based on theoretical analysis of their travelling distance in the CDP delivery method against the existing method.

Secondly, this research explored the benefits of using a range of CDP options, which are located to offer great convenience to the customer with extended opening hours.

The examples include Tesco Extras, railway stations, post offices offering 'Local Collect' service and supermarket chain. The results would help carriers/retailers to identify the potential CDP locations and see what benefits would be generated by using them. Apart from locations, most important aspects of setting up a CDP scheme were discussed, in terms of technical requirements, service charge, and capacity issue.

8.4. Limitation of Current Research

There are several limitations of the current research, in terms of the modelling method and the data collected.

- Modelling used in this research provides a simplistic view of the home delivery problem. A limitation of the results is that they only apply to the situations modeled. For example, delivery failure rate and re-delivery failure rate, the depot distance from the delivery area, the number of CDPs, the modes of transport used in making collections, the delivery density, etc. The parameter values for each of these factors vary according to local circumstances and then affect the results from the current modelling work. Nevertheless, there was some consistency between results from the two survey areas, which gives some confidence that findings are reasonably robust.

- For the CDP delivery method, it is difficult to determine the carrier's optimal delivery round due to the requirement of having to visit one or more CDPs. The CDPs can not be treated as ordinary delivery address because each CDP may only be visited after visiting the delivery addresses in its vicinity. A method was then devised in this research (Chapter Five). This was considered to be an intuitively reasonable method, and, perhaps, one that would be adopted by the carrier, although it is recognised that it does not guarantee the optimum route. It was outside the scope of this research to investigate optimum vehicle routing methods for this particular problem.

- The analysis of home delivery methods were implemented using only one vehicle routing and scheduling tool, whilst this tool is believed to provide a very good optimization. The computational results are related on the heuristics and the parameter selection adopted in the software.

- The drop-off time in the household, the CDP and the carrier's depot was assumed to be 5 minutes. However, in reality, in the CDP delivery method, some customer services and communications are included and will probably take more time in the CDP than the time spent in the household in the traditional delivery method.
- Sufficient data is necessary for the modelling work in order to gain a precise picture of home delivery services. According to the Retail Logistics Task Force (@Your home, 2001), the type of data most desired should include consumer preference data on the types of home delivery methods, delivery time options; operating information of the carrier; characteristics of householder's shopping trips; and environmental impact data. The collected data could meet the requirements of the Retail Logistics Task Force. However, using the data from the survey restricts the validity of the computation results. For example, the precision of people's perception need to be adjusted. The reason for using the survey data was straightforward. When the research work was implemented, no data from carrier was available.

8.5. Directions for Future Research

It was assumed that the variety of products that would be purchased from the various stores by an individual on a town centre shopping trip could be purchased from home and delivered by one vehicle to the householder. The growing number of supermarket chains that supply a complete shopping environment, incorporating food, white goods, leisure items, personal services etc means that theoretically, one retailer could supply the wide variety of products purchased during a typical supermarket shopping trip. In reality, several different supply chains, involving multiple delivery vehicles could be involved with sourcing and delivering the variety of high-street products purchased on the average shopping trip to the householder in a home delivery operation.

Consequently, it is important to include various carriers to deliver different types of products in the future work.

Furthermore, in order to identify the potential of overall traffic reduction, the extent to which home shopping would save householder's time and to which the more vehicle trips are generated using the saved time, have to be estimated. Home delivery service may reduce the number of journeys to purchase goods, or it may not. Home shopping and delivery customers may use the saved time by home shopping to generate more vehicle trips for the purpose of leisure, visiting friends, etc. However, this topic is not covered in the current research. In the future research, the extent to which home shopping would save householder's time and the householders would use the saved time to generate more vehicle trips, need to be explored.

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Appendix A:

Home Delivery Questionnaire (MIRACLES)

Home Delivery Questionnaire

If your address or personal details are incorrect, please change them

This survey is part of Hampshire County Council's continuing work to develop sustainable travel solutions for people living and working in and around Winchester. Following on from the travel questionnaire you kindly completed last year, this survey is investigating the problems that households experience with home deliveries, particularly goods ordered either by telephone, mail order or through the Internet. We are interested to know whether:

- **Members of your household regularly miss home deliveries because they are out at work?**
- **Members of your household often travel to the carrier's local distribution depot to collect parcels they have missed?**
- **You would consider using your local convenience store as an alternative delivery address where deliveries to your home could be re-directed in the event of no-one being in to receive them?**

The questionnaire is divided into two sections and should take around 15 minutes to complete. The first section asks you about <u>your household's</u> home-shopping habits (items you collectively purchase from retailers through the Internet, mail order catalogues or by using the telephone). The second part asks for <u>your personal opinion</u> on a new Collectpoint service which allows you to use local convenience stores as alternative delivery addresses in the event of deliveries being made to your home when no-one is in.

a) **All information you supply will be confidential and anonymous.**

It would be most helpful if you could use the *FREEPOST* envelope provided (no stamp needed) to return your completed questionnaire by **Friday 3 September**. When you return your completed questionnaire you will be automatically entered into a free prize draw for a £50 shopping voucher. If your address or personal details shown above have changed since the last time we contacted you, please correct them.

This survey is being undertaken by the University of Southampton for Hampshire County Council. If you have any problems completing the questionnaire, please call Tom Cherrett at the University of Southampton on (023) 8059 4657 during office hours. Thank you for your time and co-operation.

Hampshire County Council

CIVITAS
Cleaner and better transport in cities

MIRACLES
MULTI INITIATIVE FOR RATIONALISED ACCESSIBILITY AND CLEAN LIVEABLE ENVIRONMENTS

The CIVITAS Project is Co-Financed by the European Union

Section A: Your household's home shopping habits

A1) In addition to physically going shopping, how else do members of your household purchase goods and how often?

(Please tick one box per row)	Never	Rarely (1-2 times a year)	Occasionally (3-11 times a year)	Frequently (1-2 times a month)	Very Frequently (once a week or more often)
Via the Internet from a computer at home	☐	☐	☐	☐	☐
Via the Internet from a computer at work	☐	☐	☐	☐	☐
Telephoning an order to a retailer	☐	☐	☐	☐	☐
Through Interactive television	☐	☐	☐	☐	☐
Sending an order form by post (mail order)	☐	☐	☐	☐	☐
Other (please specify):	☐	☐	☐	☐	☐

↳ ______________________________

If you answered 'Never' to all of the above, please move onto Section B.

A2) What type of goods do members of your household purchase through the various mechanisms you indicated in Question A1, and how often do they buy them?

(Please tick one box per row)	Never	Rarely (1-2 times a year)	Occasionally (3-11 times a year)	Frequently (1-2 times a month)	Very Frequently (once a week or more often)
Travel, accommodation or holidays	☐	☐	☐	☐	☐
Tickets for events	☐	☐	☐	☐	☐
Books or magazines	☐	☐	☐	☐	☐
Sports goods and toys	☐	☐	☐	☐	☐
Flowers	☐	☐	☐	☐	☐
Insurance	☐	☐	☐	☐	☐
Music CDs	☐	☐	☐	☐	☐
Videos or DVDs	☐	☐	☐	☐	☐
Clothes	☐	☐	☐	☐	☐
Computer software (e.g. games)	☐	☐	☐	☐	☐
Computer hardware	☐	☐	☐	☐	☐
Electronic equipment	☐	☐	☐	☐	☐
Food and groceries	☐	☐	☐	☐	☐
Household goods	☐	☐	☐	☐	☐
DIY goods	☐	☐	☐	☐	☐
Other (please specify):	☐	☐	☐	☐	☐

↳ ______________________________

A3) Please give some names of companies that members of your household have ordered goods from (for home delivery) over the past 12 months.

(These could be high street retailers who have home delivery websites, catalogue companies, or purely Internet based companies, including auction sites.)

A4) Do you or a member of your household receive deliveries for a business operating out of your home? (Please tick one box only)

Yes ☐ No ☐

A5) Referring to all the different types of goods purchased by members of your household in Question A2, and thinking about the frequency of those purchases, approximately how many deliveries would this equate to in total over a 12 month period, delivered to:

(Please tick one box per row)	None	1-2 deliveries a year	3-11 deliveries a year	12-24 deliveries a year	More than 24 deliveries a year
1. Your home	☐	☐	☐	☐	☐
2. A place of work	☐	☐	☐	☐	☐
3. Another location	☐	☐	☐	☐	☐

If you answered 'None' to all of the above, please move onto Section B.

A6) Referring to the response you gave in Question A5 (1. Your home), how many home deliveries arrive when there is no-one in to receive them? (This applies to packages that cannot fit through the letter box or require a signature.) Please tick the appropriate box.

None (Always someone in)	Few	Some (Around 1 in 4 deliveries)	Many	Most (More than half of the deliveries)
☐	☐	☐	☐	☐

If you have never received any home deliveries, please move onto Section B.

A7) How often have you or other members of your household experienced the following situations regarding home deliveries that you have missed?

(Please tick one box per row)	Never	Rarely (1-2 times a year)	Occasionally (3-11 times a year)	Frequently (1-2 times a month)	Very Frequently (once a week or more often)
1. The goods are left with a neighbour and a card put through our door to say where they are	☐	☐	☐	☐	☐
2. The goods are left outside our home (concealed) and a card put through our door to say where they are	☐	☐	☐	☐	☐
3. The goods are left outside our home (visible)	☐	☐	☐	☐	☐
4. The goods are taken back to the depot and a card put through our door to say where they are	☐	☐	☐	☐	☐
5. Other (please specify):	☐	☐	☐	☐	☐

A8) How have you or other members of your household typically responded to a home delivery that has been missed, where the carrier returned the package/s to the depot and put a notification card through your door?

(Please <u>tick</u> one box per row)	Never	Rarely (1-2 times a year)	Occasionally (3-11 times a year)	Frequently (1-2 times a month)	Very Frequently (once a week or more often)
1. Contacted the carrier and arranged an alternative delivery time/day to our home address	☐	☐	☐	☐	☐
2. Contacted the carrier and arranged an alternative delivery time/day to a work/alternative address	☐	☐	☐	☐	☐
3. Contacted the carrier and had the package/s delivered to our local post office	☐	☐	☐	☐	☐
4. Travelled to the carrier's depot personally to collect the package/s	☐	☐	☐	☐	☐
5. Other (please specify):	☐	☐	☐	☐	☐

A9) Referring to Question A8, please give some names of carriers who have delivered/attempted to deliver packages to your home over the past 12 months.
(e.g. DHL, UPS, TNT, Parcel Force, Lynx Express, Securicor Omega Express)

A10) How long does it typically take to receive a package that a member of your household has previously missed because no-one was at home? (Please <u>tick</u> the appropriate box)

Same day	Next day	2-5 days later	Next week or longer
☐	☐	☐	☐

A11) If a member of your household travelled to the carrier's depot to collect a package, what is the main method of transport they would typically use? (Please <u>tick</u> one method of transport only)

Walking	☐	Train	☐	Cycling	☐	Bus (excluding park & ride)	☐
Motorbike	☐	Car	☐	Park & Ride	☐	Van	☐

A12) If <u>you</u> have travelled to the carrier's depot to collect a package, would this typically be a specific trip or would you try and combine it with another activity? (Please <u>tick</u> the most appropriate box)

Specific trip from home	Collect whilst Shopping /other leisure activity enroute (e.g. gym)	Whilst travelling to/from work	Specific trip from work
☐	☐	☐	☐

Section B: Your personal views on an alternative collection service

A new solution to the problem of missed home deliveries is to use local, 7-day 'seven-till-eleven' type convenience stores and forecourts as collection points. You could designate one of these as an alternative delivery address when ordering goods, to be used in the event of you not being at home when a courier arrived to deliver a package. You would then be able to collect the package at a time convenient to you.

Such a service is offered by Collectpoint plc who have over 1600 Collectpoints nationally (please see the enclosed Collectpoint fact sheet '*Are you sick of home delivery headaches?*'.)

You can find your nearest Collectpoint location by going to http://www.collectpoint.com and entering your postcode.

collect point www.collectpoint.com

B1) Were you aware of the Collectpoint service prior to reading the information pack?
(Please tick one box only)

Yes ☐ No ☐

B2) If you were to use this service, what would be the most convenient option for you?
(Please rank the following three options in order of your preference, with your most preferred option as 1 and your least preferred as 3. Please also tick the most convenient collection time/s and day/s for each of the three options.)

Your preferred collection option	Rank (1-3 below)	**Your preferred collection time/s** (Please tick the appropriate time/s for each option) 07:00-09:00	09:00-12:00	12:00-14:00	14:00-17:00	17:00-19:00	19:00-23:00	Your preferred collection day/s (Please tick) Mon to Fri	Sat or Sun
Use a Collectpoint near my home		☐	☐	☐	☐	☐	☐	☐	☐
Use a Collectpoint near my work		☐	☐	☐	☐	☐	☐	☐	☐
Use a Collectpoint at an alternative location		☐	☐	☐	☐	☐	☐	☐	☐

B3) With relation to your first choice option in Question B2, what method of transport would you most likely use to collect your package/s? (Please tick your preferred method of transport)

Walking	☐	Cycling	☐
Motorbike	☐	Park & Ride	☐
Train	☐	Bus (excluding park & ride)	☐
Car	☐	Van	☐

B4) In order to determine how far people would have to travel to a Collectpoint, it would be very helpful if you could supply your home postcode and your work postcode (if applicable).
(Please write in)

Home postcode |__|__|__|__| |__|__|__|

Work postcode (if applicable) |__|__|__|__| |__|__|__|

B5) Would <u>you</u> consider using a Collectpoint if one was located near to your home or place of work?
(Please <u>tick</u> one box only)

Yes ☐ **(Go to B7)** No ☐ **(Go to B6)**

B6) If you would not consider using Collectpoint, please state your reasons in the space below.

B7) Do you have access to a computer with a printer and connection to the Internet:

At home?	Yes ☐	No ☐
At work?	Yes ☐	No ☐

B8) Would you be willing to take part in a free Collectpoint trial?
(Please <u>tick</u> one box only)

Yes ☐ No ☐

(Please note, that to take part in the Collectpoint trial you will need to have access to a computer with a printer and connection to the Internet.)

(ii) Thank you for your time and cooperation

Data Protection Act 1998. The information you provide will only be used for the purposes of helping to improve the environment and access to Winchester. Your address will only be processed if you volunteer to take part in the Collectpoint trial. The winner of the prize draw will be contacted before publication of the results. This research is being carried out on behalf of Hampshire County Council by the University of Southampton and no other organisation will have access to your personal data.

Appendix B:

West Sussex Panel Survey
'home delivery questionnaire'

University of Southampton

Unique ID: «Panel_No»

west sussex county council

April 2006

West Sussex Panel Survey
'Home Delivery Questionnaire'

Dear «Resident Name»,

This survey is part of West Sussex County Council's continuing work to develop sustainable travel solutions for people living and working in the county. The overall aim of the survey is to build an accurate picture of current home delivery services, and identify the problems households currently experience with these, particularly goods ordered either by telephone, mail order or through the Internet. We are interested to know:

- Whether members of your household regularly miss home deliveries because they are out at work?
- Whether members of your household often travel to the carrier's local distribution depot to collect parcels they have missed?
- Whether you would consider using a local convenience store, post office, garage or a secure 24-hour locker bank as an alternative delivery address where deliveries to your home could be re-directed in the event of no-one being in to receive them?

The questionnaire should take approximately 10-15 minutes to complete and consists of four sections. Section A asks for information about your household. Section B quantifies your household's current shopping habits with Section C focussing specifically on goods that are ordered from and delivered to the home. Section D asks for your opinion on an alternative delivery service which would allow you to nominate local convenience stores, garages, post offices and secure 24-hour locker banks as alternative delivery addresses, to be used in the event of deliveries being made to your home when no-one was in.

Please take the time to complete this questionnaire, as your views are important and will be used to help the County Council better understand the problems people currently face with home deliveries and what methods might be appropriate to improve the movement of goods in urban areas.

All information you supply will be confidential and anonymous.

It would be most helpful if you could use the FREEPOST envelope provided (no stamp needed) to return your completed questionnaire by 12 July. If you cannot find or did not receive the pre-addressed envelope, please return the completed questionnaire to Shirley Song, Transportation Research Group, School of Civil Engineering and the Environment, University of Southampton, FREEPOST LICENSE NO. SO286, Southampton, SO17 1BJ. (No stamp is required)
When you return your completed questionnaire you will be automatically entered into a free prize draw for a £50 shopping voucher. If your address or personal details shown above have changed since the last time we contacted you, please correct them.

This survey is being undertaken by the University of Southampton for West Sussex County Council. If you have any problems completing the questionnaire, please call Shirley Song at the University of Southampton on (023) 8059 3871 during office hours. Thank you for your time and co-operation.

SECTION A: Information about your household

A1) Please indicate how many males and females there are in your household by age group. (*Enter the **number** of persons by age category and gender and remember to include yourself*)

	Under 16	16 to 21	22 to 25	26 to 34	35 to 44	45 to 54	55 to 64	Over 65
Female	☐	☐	☐	☐	☐	☐	☐	☐
Male	☐	☐	☐	☐	☐	☐	☐	☐

A2) How many *cars* are regularly available for use by members of your household? (*Please tick one box only*)

None ☐ One ☐ Two ☐ Three or more ☐

A3) Please *describe* the type of house you live in? (*Please tick one box per column*)

Detached	☐	One bedroom	☐
Semi detached	☐	Two bedrooms	☐
Terraced	☐	Three bedrooms	☐
Flat	☐	Four bedrooms	☐
Other	☐	More than four bedrooms	☐

A4) What are the occupations of your household members over 18 years old? (*Please tick all that apply*)

Professional/senior management	☐	Office worker	☐	Student	☐
Middle management	☐	Shop worker	☐	Armed forces	☐
Skilled worker/Trade	☐	Self Employed	☐	Retired	☐
Manual worker	☐	Housewife/Home-maker	☐	Unemployed	☐
Clerical/secretarial worker	☐	Academic	☐	Other	☐

A5) Do you have access to the Internet from:

Your home? Yes ☐ No ☐ Your workplace? Yes ☐ No ☐

SECTION B: Information about your household's current shopping habits

B1) How often do members of your household make specific trips to purchase the following goods? (*Please tick one box only for each category*)

Groceries:		Other goods (entertainment, clothes, gifts, etc):	
Less than once a month	☐	Less than once a month	☐
Once or twice a month	☐	Once or twice a month	☐
Three times a month	☐	Three times a month or more	☐
Once or twice a week	☐	Once or twice a week	☐
Three times a week or more	☐	Three times a week or more	☐

B2) Which mode of transport do members of your household typically use for the following shopping trips **starting from your home**? (*Please rank the 4 options with 1 as the most common, 4 as the least common*)

Groceries:		Other goods (entertainment, clothes, gifts, etc):	
Walking	☐	Walking	☐
Car	☐	Car	☐
Bus	☐	Bus	☐
Other	☐	Other	☐

B3) To what extent are your shopping trips combined with other activities? (*Please state the* **percentage** *frequency against each option below which describes your typical behaviour)*

Groceries:		Others goods (entertainment, clothes, gifts, etc):	
Specific trip from home	%	Specific trip from home	
Shop while travelling to/from work	%	Shop while travelling to/from work	%
Shop while combining with other activity	%	Shop while combining with other activity	%
	Total = 100%		Total = 100%

B4) Please give the names and locations of two supermarkets your household normally use. *(Please put the one your household most commonly uses as your first choice)*

Name and location (road name, area) of your first and second choice supermarkets
1st choice:
2nd choice:

SECTION C: Information about your household's home shopping habits

C1) In addition to physically going shopping, how else do members of your household purchase goods and how often?

(Please tick one box per row)	Never	Rarely (1-2 times a year)	Occasionally (3-11 times a year)	Frequently (1-2 times a month)	Very Frequently (once a week or more often)
Shop via the internet from a computer at home	☐	☐	☐	☐	☐
Shop via the internet from a computer at work	☐	☐	☐	☐	☐
Telephoning an order to a retailer	☐	☐	☐	☐	☐
Shop via interactive television	☐	☐	☐	☐	☐
Sending an order form by post (mail order)	☐	☐	☐	☐	☐
Other (please specify)	☐	☐	☐	☐	☐

↳ ______________________________

If you answered 'never' to all of the above, please move onto Section D.

C2) Retailers sometimes provide several delivery options for your home shopping, depending on how quickly you want the goods to reach you. (Please rank the **top 3** delivery options you have experienced from the 10 options listed, with 1 as your most frequent and 3 as the least frequent)

Standard delivery during the working day *Packages arrive in daytime within 2 -14 days*	☐	Next Day AM delivery (7:00 – 12:00)	☐
Next Day delivery (No time mentioned)	☐	Next Day PM delivery (12:00 – 18:00)	☐
Next Day before 09:00	☐	Saturday delivery	☐
Next Day before 10:00	☐	Overnight delivery (18:00 – 23:00)	☐
Next Day before 12:00	☐	Other (Please specify)	☐

↳ ______________________________

If you have never experienced a choice of delivery options, please tick this box ☐

C3) What type of goods do members of your household purchase through the various methods of home shopping you indicated in Question C1? (Please rank the **top 5** according to how frequently you order them, with 1 as your most frequent shopping item and 5 as your least frequent item. If possible, please also specify the names of e-retailers you typically use for each category)

	Ranking (1-5 below)	**Please give details below of a typical e-retailer you use for each category**
Food and groceries	☐	
Travel, accommodation or holidays	☐	
Tickets for events	☐	
Books or magazines	☐	
Flowers	☐	
Clothes, sports goods and toys	☐	
Music CDs, Videos or DVDs	☐	
Computer software (e.g. games) and hardware	☐	
Electronic equipment (e.g. TV)	☐	
Other (please specify)	☐	

C4) Referring to all the different types of goods purchased by members of your household in question C3, and thinking about the frequency of those purchases, approximately how many **home deliveries** would this equate to over a 12-month period? (*Please tick one box only for each category)*

Groceries:		**Other goods (entertainment, clothes, gifts, etc):**	
None	☐	None	☐
1 to 2 deliveries a year	☐	1 to 2 deliveries a year	☐
3 to 11 deliveries a year	☐	3 to 11 deliveries a year	☐
12 to 23 deliveries a year	☐	12 to 23 deliveries a year	☐
24 to 35 deliveries a year	☐	24 to 35 deliveries a year	☐
More than 36 deliveries a year	☐	More than 36 deliveries a year	☐
		What percentage of these will not fit through the letterbox?	%

C5) Referring to your response in Question C4, how many deliveries arrive when **no-one is in** to receive them? (This applies to packages that cannot fit through the letter box or require a signature.) Please tick the appropriate box.

None (Always someone in)	Few	Some (Around 1 in 4 deliveries)	Many	Most (More than half of the deliveries)
☐	☐	☐	☐	☐

C6) How do the members of your household typically respond to a missed delivery, where the carrier returned the package/s to the depot and left you a notification card? (*Please tick one box per row*)

(Please tick one box per row)	Never	Rarely (1-2 times a year)	Occasionally (3-11 times a year)	Frequently (1-2 times a month)	Very Frequently (once a week or more often)
Contacted the carrier and arranged an alternative delivery time/day to our home address	☐	☐	☐	☐	☐
Contacted the carrier and arranged an alternative delivery time/day to a work/alternative address	☐	☐	☐	☐	☐
Contacted the carrier and had the package/s delivered to our local post office	☐	☐	☐	☐	☐
Travelled to the carrier's depot personally to collect the package/s	☐	☐	☐	☐	☐
Other (please specify):	☐	☐	☐	☐	☐

C7) Please indicate some names of supermarkets and carriers who have made deliveries to your house over the past 12 months.

Supermarkets:	**Carriers:**

C8) Do you find that you now make less physical journeys to purchase goods because of home shopping? (Please tick the appropriate response)

Strongly Agree	Agree	Uncertain	Disagree	Strongly Disagree
☐	☐	☐	☐	☐

SECTION D: Your personal views on an alternative home delivery service

A new solution to the problem of missed home deliveries is to use local convenience stores, garages, post offices or secure 24-hour locker banks as local 'collection points'. You could designate one of these as an alternative delivery address when ordering goods, to be used in the event of you not being at home when a courier arrived to deliver a package. Collection points could take packages up to 75cm by 75cm by 75cm and you would be notified of the arrival of your package through a text message to your mobile phone, email or phone call. Examples are Royal Mail and Parcelforce, which allow customers to choose delivery to one of 16,000 Post Office branches through their 'Local Collect' service. If you are interested, please visit http://www.royalmail.com/portal/rm/content3?mediaId=600011&catId=14800159 *for more details.*

D1) Which type of outlet would be **most convenient** for you to use as an alternative delivery point? (*Please tick one box only*)

Convenience Store ☐ Post Office ☐

Petrol Station ☐ Locker Bank ☐

Other ☐ (Please specify)

D2) If you were to use this service, what would be the **most convenient** option for you? Please rank the collection options in order of preference, with 1 as your first preference and 3 as your last preference.

Your preferred collection option	Rank (1-3 below)	**Your preferred collection time/s** (Please tick the appropriate time/s for each option) 07:00 — 09:00	09:00 — 12:00	12:00 — 14:00	14:00 — 17:00	17:00 — 19:00	19:00 — 23:00	Your preferred collection day/s (Please tick) Mon — Fri	Sat or Sun
Near my home	☐	☐	☐	☐	☐	☐	☐	☐	☐
Near my work	☐	☐	☐	☐	☐	☐	☐	☐	☐
At an alternative location	☐	☐	☐	☐	☐	☐	☐	☐	☐

D3) If a service was offered by retailers where you could nominate an alternative delivery address (using one of the outlets in D1), to be used in the event of you not being at home when a courier arrived to deliver a package, would you consider signing up to it? (*Please tick one box only*)

Yes ☐ No ☐ Don't know ☐

D4) If you would not consider nominating an alternative delivery point for missed home deliveries to your house using one of outlets stated in D2, please state your reasons in the space below

D5) With relation to your first choice option in Question B2, what method of transport would you most likely use to collect your package/s? (Please tick your preferred method of transport)

Walking	☐	Cycling	☐
Motorbike	☐	Park & Ride	☐
Train	☐	Bus (excluding park & ride)	☐
Car	☐	Van	☐

D6) In order to determine how far people would have to travel to a Collection point, it would be very helpful if you could supply your home postcode and your work postcode (if applicable).

(Please write in)

Home postcode ☐☐☐☐ ☐☐☐

Work postcode (if applicable) ☐☐☐☐ ☐☐☐

D7) Would you be willing to participate in a trial of an alternative delivery point scheme for handling missed home deliveries in your area? (Please tick)

Yes ☐ No ☐

Thank you very much for taking part in this survey.

Data Protection Act 1998. The information you provide will only be used for the purposes of helping to improve the environment and the transport infrastructure in West Sussex. This research is being carried out on behalf of West Sussex County Council by the University of Southampton and no other organization will have access to your personal data.

Appendix C:

Extra Tables for People's Home Delivery Characteristics in West Sussex

Table C-1 Scheffé multiple range tests on the individual distances between 423 households and 23 CDPs (5 railway stations, 14 post offices with 'Local Collect' service and 4 other supermarkets) in Winchester

(I) CDP	(J) CDP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Other supermarket	Post office	2.1037(*)	.34466	.000	1.1347	3.0728
	Railway station	.4024	.34466	.714	-.5666	1.3714
Post office	Other supermarket	-2.1037(*)	.34466	.000	-3.0728	-1.1347
	Railway station	-1.7013(*)	.34466	.000	-2.6704	-.7323
Railway station	Other supermarket	-.4024	.34466	.714	-1.3714	.5666
	Post office	1.7013(*)	.34466	.000	.7323	2.6704

Based on observed means.

* The mean difference is significant at the .05 level.

Table C-2 Carrier driving distances (km) associated with serving the 9 different sets of 50 first-time deliveries and a number of re-deliveries in Winchester (one delivery round)

Carrier travelling distance			**Percentage of failed first-time home deliveries**				
Scenarios			10%	20%	30%	40%	50%
EXD	Existing delivery method	Set 1	76.7	78.8	81.4	83.1	84
		Set 2	103.7	124.6	125.6	132	129.4
		Set 3	121.9	123.3	136.9	139.9	143
		Set 4	122	131.9	133.8	135.3	137.9
		Set 5	70.9	75.4	101.5	103	105.3
		Set 6	97.6	100	99.4	105.3	108.3
		Set 7	78.9	79.8	82.2	83.5	87.1
		Set 8	100.5	101.5	103.3	105.6	115.4
		Set 9	111.2	113.3	118.4	119.5	122.2
		Mean	98.2	103.2	109.2	111.8	114.3
CDP1	CDP = railway station	Set 1	87.7	87.7	87.7	87.7	87.7
		Set 2	126.7	126.7	126.7	126.7	126.7
		Set 3	122.4	122.4	122.4	122.4	122.4
		Set 4	119.5	119.5	119.5	119.5	119.5
		Set 5	60.6	60.6	60.6	60.6	60.6
		Set 6	119.5	119.5	119.5	119.5	119.5
		Set 7	79.6	79.6	79.6	79.6	79.6
		Set 8	96	96	96	96	96
		Set 9	121.5	121.5	121.5	121.5	121.5
		Mean	103.7	103.7	103.7	103.7	103.7

CDP2	CDP = Supermarket	Set 1	95.7	95.7	95.7	95.7	95.7
		Set 2	160.0	160.0	160.0	160.0	160.0
		Set 3	126.2	126.2	126.2	126.2	126.2
		Set 4	123.3	123.3	123.3	123.3	123.3
		Set 5	85.4	85.4	85.4	85.4	85.4
		Set 6	124.9	124.9	124.9	124.9	124.9
		Set 7	98.7	98.7	98.7	98.7	98.7
		Set 8	109.6	109.6	109.6	109.6	109.6
		Set 9	153.6	153.6	153.6	153.6	153.6
		Mean	119.8	119.8	119.8	119.8	119.8
CDP3	CDP = Local Collect Post office	Set 1	83.8	83.8	83.8	83.8	83.8
		Set 2	119.6	119.6	119.6	119.6	119.6
		Set 3	138.3	138.3	138.3	138.3	138.3
		Set 4	126.6	126.6	126.6	126.6	126.6
		Set 5	69.2	69.2	69.2	69.2	69.2
		Set 6	113.1	113.1	113.1	113.1	113.1
		Set 7	90.3	90.3	90.3	90.3	90.3
		Set 8	112.8	112.8	112.8	112.8	112.8
		Set 9	114.2	114.2	114.2	114.2	114.2
		Mean	107.5	107.5	107.5	107.5	107.5

Table C-3 Scheffé multiple range tests on the individual distances between 347 households and 250 CDPs (12 Tesco Extras, 46 railway stations, 139 post offices with 'Local Collect' service and 53 other supermarkets) in West Sussex.

(I) CDP	(J) CDP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Post office	Railway station	-2.0920(*)	.36591	.000	.8707	2.7533
	Other supermarket	-2.8604(*)	.36591	.016	.1491	2.0317
	Tesco Extra	-5.4310(*)	.36591	.001	-2.3723	-.4897
Railway station	Post office	2.0920(*)	.36591	.000	-2.7533	-.8707
	Other supermarket	-.7716	.36591	.199	-1.6629	.2197
	Tesco Extra	-3.3130(*)	.36591	.000	-4.1843	-2.3017
Other supermarket	Post office	2.8604(*)	.36591	.016	-2.0317	-.1491
	Railway station	.7716	.36591	.199	-.2197	1.6629
	Tesco Extra	-2.5414(*)	.36591	.000	-3.4627	-1.5801
Tesco Extra	Post office	5.4310(*)	.36591	.001	.4897	2.3723
	Railway station	3.3130(*)	.36591	.000	2.3017	4.1843
	Other supermarket	2.5414(*)	.36591	.000	1.5801	3.4627

Based on observed means.

* The mean difference is significant at the .05 level.

Table C-4 Carrier driving distances (km) associated with serving the six different sets of 200 first-time deliveries and re-deliveries

Carrier travelling distance			**Percentage of failed home deliveries**				
Scenarios			10%	20%	30%	40%	50%
EXD	Existing delivery method	Set 1	776.3	788.8	875.3	903.1	944.1
		Set 2	725.8	780	849.4	903	952
		Set 3	701.9	744.7	807.1	859.3	889.6
		Set 4	712.6	763.5	892.7	903.1	943.1
		Set 5	801.2	851.3	967.5	987.8	1002.3
		Set 6	779.4	824.5	885.2	978.7	1015.4
		Mean	749.5	792.1	879.5	922.5	957.8
CDP1	CDP = railway station	Set 1	783.9	783.9	783.9	783.9	783.9
		Set 2	761.2	761.2	761.2	761.2	761.2
		Set 3	1020	1020	1020	1020	1020
		Set 4	877.7	877.7	877.7	877.7	877.7
		Set 5	920.5	920.5	920.5	920.5	920.5
		Set 6	900	900	900	900	900
		Mean	877.2	877.2	877.2	877.2	877.2
CDP2	CDP = Tesco Extra	Set 1	733.6	733.6	733.6	733.6	733.6
		Set 2	727.5	727.5	727.5	727.5	727.5
		Set 3	1037.8	1037.8	1037.8	1037.8	1037.8
		Set 4	869.8	869.8	869.8	869.8	869.8
		Set 5	934.3	934.3	934.3	934.3	934.3
		Set 6	909.3	909.3	909.3	909.3	909.3
		Mean	868.7	868.7	868.7	868.7	868.7

CDP3	CDP = Other supermarket	Set 1	807.7	807.7	807.7	807.7	807.7
		Set 2	807.0	807.0	807.0	807.0	807.0
		Set 3	1099	1099	1099	1099	1099
		Set 4	866.7	866.7	866.7	866.7	866.7
		Set 5	976.9	976.9	976.9	976.9	976.9
		Set 6	957.2	957.2	957.2	957.2	957.2
		Mean	919.1	919.1	919.1	919.1	919.1
CDP4	CDP = Post office	Set 1	784.9	784.9	784.9	784.9	784.9
		Set 2	755.3	755.3	755.3	755.3	755.3
		Set 3	1030.8	1030.8	1030.8	1030.8	1030.8
		Set 4	835.4	835.4	835.4	835.4	835.4
		Set 5	927.6	927.6	927.6	927.6	927.6
		Set 6	907.1	907.1	907.1	907.1	907.1
		Mean	873.5	873.5	873.5	873.5	873.5

Table C-5 Scheffé Multiple Comparisons output for individual distances between the 38572 households in West Sussex served by the 3 depots (Crawley, Southampton and Alton)

(I) Depot	(J) Depot	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Alton	Crawley	26.4251(*)	1.37422	.000	23.0612	29.7889
	Southampton	-1.8319	1.36068	.404	-5.1626	1.4989
Crawley	Alton	-26.4251(*)	1.37422	.000	-29.7889	-23.0612
	Southampton	-28.2569(*)	.33320	.000	-29.0726	-27.4413
Southampton	Alton	1.8319	1.36068	.404	-1.4989	5.1626
	Crawley	28.2569(*)	.33320	.000	27.4413	29.0726

Based on observed means.

* The mean difference is significant at the .05 level.

Table C-6 Scheffé Multiple Tests on the individual distances between 2496 households and 263 CDPs (12 Tesco Extras, 46 railway stations, 152 post offices with 'Local Collect' service and 53 other supermarket chains across West Sussex.

(I) CDP	(J) CDP	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Tesco Extra	Other supermarkets	2.276131(*)	.1618931	.000	1.823281	2.728982
	Post office	4.027521(*)	.1618931	.000	3.574670	4.480371
	Railway station	2.545827(*)	.1618931	.000	2.092977	2.998678
Other supermarket	Tesco Extra	-2.276131(*)	.1618931	.000	-2.728982	-1.823281
	Post office	1.751389(*)	.1611825	.000	1.300527	2.202252
	Railway station	.269696	.1611825	.424	-.181166	.720559
Local Collect Post office	Tesco Extra	-4.027521(*)	.1618931	.000	-4.480371	-3.574670
	Other supermarkets	-1.751389(*)	.1611825	.000	-2.202252	-1.300527
	Railway station	-1.481693(*)	.1611825	.000	-1.932556	-1.030831
Railway station	Tesco Extra	-2.545827(*)	.1618931	.000	-2.998678	-2.092977
	Other supermarkets	-.269696	.1611825	.424	-.720559	.181166
	Post office	1.481693(*)	.1611825	.000	1.030831	1.932556

Based on observed means.

* The mean difference is significant at the 0.05 level.

Table C-7 Scheffé multiple range tests to determine where the significant differences in carrier mileage lie between the five delivery methods (existing delivery method, CDP delivery methods using Tesco Extras, local post offices offering Local Collect, railway stations and other supermarkets across West Sussex)

(I) Delivery method	(J) Delivery method	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Existing method	CDP=post office	-17.3385	18.73566	.886	-70.0592	35.3823
	CDP=railway station	-20.1231	18.73566	.819	-72.8438	32.5977
	CDP=supermarket	-21.0308	18.73566	.794	-73.7515	31.6900
	CDP=Tesco Extra	-21.0923	18.73566	.792	-73.8130	31.6284
CDP=post office	Existing method	17.3385	18.73566	.886	-35.3823	70.0592
	CDP=railway station	-2.7846	18.35713	1.00	-54.4402	48.8709
	CDP=supermarket	-3.6923	18.35713	1.00	-55.3479	47.9633
	CDP=Tesco Extra	-3.7538	18.35713	1.00	-55.4094	47.9017
CDP=railway station	Existing method	20.1231	18.73566	.819	-32.5977	72.8438
	CDP=post office	2.7846	18.35713	1.00	-48.8709	54.4402
	CDP=supermarket	-.9077	18.35713	1.00	-52.5633	50.7479
	CDP=Tesco Extra	-.9692	18.35713	1.00	-52.6248	50.6863
CDP=supermarket	Existing method	21.0308	18.73566	.794	-31.6900	73.7515
	CDP=post office	3.6923	18.35713	1.00	-47.9633	55.3479
	CDP=railway station	.9077	18.35713	1.00	-50.7479	52.5633
	CDP=Tesco Extra	-.0615	18.35713	1.00	-51.7171	51.5940
CDP=Tesco Extra	Existing method	21.0923	18.73566	.792	-31.6284	73.8130
	CDP=post office	3.7538	18.35713	1.00	-47.9017	55.4094
	CDP=railway station	.9692	18.35713	1.00	-50.6863	52.6248
	CDP=supermarket	.0615	18.35713	1.00	-51.5940	51.7171

Based on observed means.

* The mean difference is significant at the 0.05 level.