UNIVERSITY OF SOUTHAMPTON

FACULTY OF ENGINEERING AND THE ENVIRONMENT

Civil, Maritime and Environmental Engineering and Science

STRATEGIES FOR GREENER LOGISTICS IN THE CHARITY SECTOR

by

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Thesis for the degree of Doctor of Philosophy

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ABSTRACT

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Charities work throughout the world to raise money for a variety of good causes. Within the UK, the sale of donated used goods is a major stream of revenue for charities. Charities use a range of different logistical methods to collect donations that can run at considerable cost. This study has identified a range of different ways in which charities could change the way in which they operate to find cost, time and environmental savings and maximise use of their assets. One way in which charities can make the most of their existing assets is through improved placement of their donation banks. Of real interest is the impact that bank placement (with respect to the characteristics of the local population) has on stock yield and quality, and what relationships can be derived to realise a more informed bank location and servicing strategy. Donation banks were shown to yield greater amounts during the summer months, and proximity to services such as schools was also found to have a positive effect on donation yields. Areas with an average population age of late 40's and of high affluence were found to yield the best quality donations. Charities can find cost savings by rethinking the ways that they collect, transport, process and distribute donated goods. The efficiency of localised collection strategy against centralised collection strategy has been studied. Existing routes used by the case study charity have been audited and subsequently optimised. Potential savings were found through increasing the number of shop serviced banks rather than servicing through centralised collection, although requiring a larger fleet of vehicles. The use of ICT technology has been considered in further improving charity logistical strategy. Remote monitoring technology can help to quantify donation collection routes, assist in reducing wasted journeys to donation banks and uncover the magnitude of donation bank textile theft. The developed Smartphone App has shown that it can help to promote collaboration and dynamism within the charity logistics supply chain. A cultural shift in the way that profits are measured will be necessary to see real collaboration between shops.

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Declaration of authorship

I, Benjamin Norton, declare that the thesis entitled *Strategies for greener logistics in the charity sector* and the work presented in the thesis are both my own, and have been generated by me as the result of my own original research. I confirm that:

- this work was done wholly or mainly while in candidature for a research degree at this University;
- where any part of the thesis has previously been submitted for a degree or any other qualification at this University or any other institution, this has been clearly stated;
- where I have consulted the published work of others, this is always clearly attributed;
- where I have quoted from the work of others, the source is always given. With the exception of such quotations, this thesis is entirely my own work;
- I have acknowledged all main sources of help;
- Where the thesis is based on work done by myself jointly with others, I have made clear exactly what was done by others and what I have contributed myself;
- none of this work has been published before submission.

Signed:

Date:

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Abbreviations

ANOVA	Analysis of variance
BHF	British Heart Foundation
CAF	Charities Aid Foundation
CCTV	Closed-circuit television
CD	Compact Disc
CRA	Charity Retail Association
CVRP	Capacitated Vehicle Routing Problem
CVRPTW	Capacitated Vehicle Routing Problem with Time Windows
DEFRA	Department for Environment, Food and Rural Affairs
DVD	Digital Versatile Disc
ETI	Ethnical Trade Initiative
FRSB	Fundraising Standards Board
GIS	Geographic Information System
GPS	Global Positioning System
GSM	Global System for Mobile Communications
HGV	Heavy goods vehicle
HMRC	HM Revenue & Customs
HWRC	Household Waste Recycling Centre
ICT	Information and communications technology
ID	Identity document
IRP	Inventory Routing Problem
JSA	Job Seekers Allowance
LIFO	Last-in, first-out
MP	Milton Point
NFC	Near field communication
NHS	National Health Service
NWAI	National Waste Awareness Initiative
PDA	Personal Digital Assistant
PDSA	People's Dispensary for Sick Animals
RCUK	Research Councils UK
RFID	Radio Frequency Identification
RORO	Roll-on, roll-off
SATCoL	Salvation Army Trading Company Ltd
SM	Supermarket
TRA	Textile Recycling Association
UK	United Kingdom
USA	United States of America
VAT	Value Added Tax
VRP	Vehicle Routing Problem
VRPPD	Vehicle Routing Problem with Pickup and Delivery
VRPTW	Vehicle Routing Problem with Time Windows
WEEE	Waste Electrical and Electronic Equipment Recycling
WMC	Waste management companies
WRAP	Waste & Resources Action Programme

Chapter 1: Introduction

1.1 Charity Shops in the retail setting

Charity shops are an established feature of the retail high street in the UK (Revell, 1998), generating around £290million in profit annually and employing over 213,000 volunteers (CRA, 2013a). There are over 10,200 charity shops in the UK (CRA, 2013a), often staffed by volunteers generating revenue by reselling public donations which includes books, clothing, music and bric-a-brac. More recently, charity shops have started selling new goods, including goods such as Christmas cards and fair-trade food products. Charity shopping has become fashionable and acceptable across the class spectrum: some 55% of people use charity shops. In 2012, shops averaged around 20 volunteers per shop and received an average transaction value of £6.50 (Morrish, 2012).

Charity shops are important because they have the potential to serve four purposes. They offer a social service, enable the recycling of goods, help to raise awareness of the charity and provide a fundraising medium (Horne, 1998). Charities use a range of logistical models to service their shops and donation infrastructure. The largest charities often use a network of donation banks located around the country, allowing members of the public to donate items and have adopted complex strategies for collecting and processing donated stock. Smaller charities mainly collect and process donations locally (Horne and Maddrell, 2002). Parsons (2004) split charity shop operations into three categories (Parsons, 2004):

- **Independent**. These types of charity retailers are the least commercial and normally consist of one or two shops.
- **Hospices**. These have a strong regional presence as they tend to be situated close to the organisation they represent and run between 2 and 24 shops. Anecdotal evidence suggests there is a very close relationship between the local community and its hospice shop, providing support by means of donations and purchase of goods (Horne and Maddrell, 2002).
- **Multiples**. Charity operations defined as ‘multiples’ run at least 100 shops. These include the larger charities such as: Oxfam, British Heart Foundation, Cancer Research UK, Age UK and Scope.

All 3 types of charity shop sell the same types of goods, although multiples have a greater capability for own-brand new goods due to their size.

Relating to their income generated, charities can be divided into five groups, Micro charities, Small charities, Medium charities, Large charities and Major charities respectively (Clark et al, 2012). Table 1 shows the range of income and the number of UK charities in each group.

Table 1. Categories of charity organisation (Clark et al, 2012)

Description	**Income of charity**	**Number of UK organisations**
Micro charities	Less than £10,000	87,683
Small charities	£10,000 to £100,000	51,090
Medium charities	£100,000 to £1 million	20,432
Large charities	£1 million to £10 million	4,084
Major charities	More than £10 million	474

Due to their size, Hospices and Independent charity shop operations run at the local level. These operations run using a simple logistics model (Figure 1). These charity shops sell goods donated by the public to the shop such as clothes, books, bric-a-brac, CD's, DVD's and games.

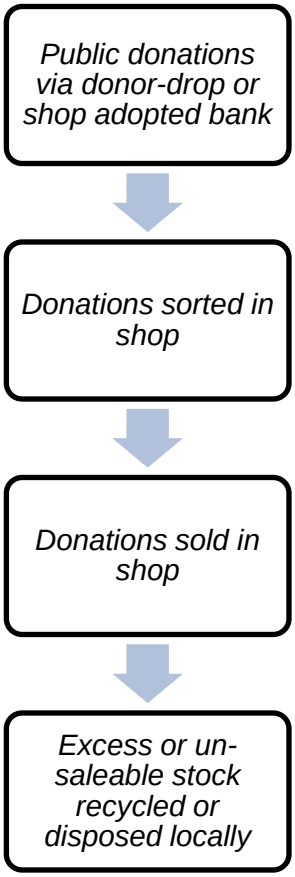


Figure 1. Simple charity logistics model

Multiples can run a similar logistics model where shops collect donations locally and process them on-site before selling them in the same shop. However, multiples are also known to run much more complex operations, including 'cascading' of donations between shops (where an item does not sell, it is transferred to another shop to re-sell), and centralised processing of donations in distribution centres.

Due to the size and complexity of multiple charity operations, their logistics models are usually more complex than independents and hospices, and can include different logistical levels throughout the organisation to move donations between banks, shops, distribution centres and other donation streams. The complexity and range of routes to move stock between these locations results in greater logistical costs than the localised systems used by independents and hospices.

In basic terms, charities make profit by selling donations and fundraising through shops and online channels for more than is spent on running costs (such as site rental, staff and logistical costs). To maximise profit, charities must maximise the value of donations received while ensuring that costs are kept low and manageable. As an example of how charities organise their donations to make profit, textiles

going into Sue Ryder charity shops are allocated to one of three price bands: 'supermarket' (£2.95), 'average' (£4.50) and 'high quality' (£6.95), which includes designer-label merchandise. At the same time, volunteers search for exceptional items that can be sold through other channels such as online sales (Morrish, 2012).

In terms of operating practices, charity shops are typically run by a paid shop manager working with a team of unpaid volunteers (CRA, 2013b). Some charities shops are entirely run by unpaid volunteers: while those employing a paid manager have found that this practice 'pays for itself', as these people can give more time, skills and attention to the role. Charities with several shops often employ an area manager, to oversee all of the shop operations (CRA, 2013a).

Traditionally, charity shops used to occupy unlet or unpopular premises. However, the recession has meant that more than 1 in 10 town centre shops are now empty. Charity shops are able to fill some of these premises (CRA, 2013c). Charity shops generally pay rent for their premises, and bills for services like electricity and gas, like any other business. However, they receive several tax concessions, as all shop profits go to fund the work of the charity, which provides public benefit. The key concessions are 0% Valued Added Tax (VAT) on the sale of donated goods, and 80% mandatory non-domestic rate relief, which is funded by central Government (CRA, 2013d).

1.2 Sources of donations

Charity shops mainly sell donations received by the public (although some are now selling new goods) and use a range of sources to collect donated stock, including:

- Donation banks
- In-store donation channels
- Door to door collection and kerbside collection
- Corporate donations
- Stock transfer (Also known as ‘cascading’, where unsold items are moved to another shop in the system for sale. Items can move across a network of shops before being sold or discarded)

The goods are transported to recycling plants or shops to be sorted. The best quality garments are made available for resale at charity shops and a small number of items are remanufactured to add value and sold as fashionable items. However, the majority of donations are baled and shipped for resale in Eastern Europe, the

Middle-East or Africa. Second-hand garment bales are sold via a commodity market to traders and then to stall merchants for resale at local markets (Allwood et al, 2006).

In the US, around 45% of textile donations are exported and about 20% of the donated clothes and textiles are converted into fibres that are then made into a variety of other products, including carpet padding, insulation for autos and homes, and pillow stuffing (Northam, 2013).

1.3 Challenges associated with charity collections

Charity shops are increasing in number faster than any other major retail sector. In 2013, in the 500 biggest town centres of Great Britain there was a net 142 charity shops opened; whereas for all retailers there was a net fall of 371 (James, 2014). Due to the rapid growth of charity shops and the increasing need for good quality stock, the logistics structure has had to grow alongside it to cope with the quantities of stock needed to be transported. There is a variety of different logistics strategies utilised by charities, usually dictated by their size and ethical policies.

Charities with fewer, more dispersed shops usually survive solely through donations received through the front door. In these cases it does not make sense to travel great distances to cascade stock between shops. Also, the volumes of stock received are small compared to those received by the larger charities (Multiples), so it is more beneficial for this stock to be dealt with locally and in more manageable quantities. The challenges shown in this section will act as the basis for the research questions:

i) Duplication of effort

Two of the largest charity shop operations (Oxfam and The Salvation Army) have seen it necessary to create complex transport strategies spanning the country to collect and distribute donated stock. As an example, Oxfam's network of national and local transport rounds can present problems, where local and national routes overlap. A mixture of 'in-house', 3rd party sub-contracted transport and volunteer led logistics in a region, all undertaking a mix of centralised take-back and localised collection and supply can lead to logistics inefficiencies.

There is also a potential duplication of effort between charities, where rival logistics systems are visiting similar collection infrastructure (e.g. textile donation banks) on

the same sites. It remains to be seen, whether some collaboration could happen here (such as alternating collections between weeks) to save on mileage and costs.

ii) Selling stock unseen

When donation levels are particularly high, some charities sell on stock ‘unseen’, not having the capacity to manually sort and separate out items which may bring greater value. This practice is efficient in terms of speed of throughput and ease of management but does not guarantee the highest rate of return and a knowledge of which donation sources derive the greatest financial value would be advantageous.

iii) Donation bank theft

Millions of pounds worth of stock is being lost by charities through donation bank theft (Hill, 2011). Current suspected donation bank theft levels within a case study area are investigated within this thesis. From a logistics sense, donation banks should be serviced when nearly full but given the probability of theft, there could be justification for visiting banks more frequently if the value returned from the stock is greater than the transport costs expended in collection.

iv) Rigid collection strategies

Donation collection rounds commonly run on a set schedule, where the same shops and donation banks are visited at the same time each week. This can result in some sites being visited too often or not often enough on occasions given the dynamic nature of donations.

If a site is visited too often, this results in the driver not having a worthwhile amount of stock to collect or deliver, which can prove an inefficient use of resources. This results in wasted journeys and cost and time savings could be found through optimising collection schedules to visit sites when needed.

If a shop site is not visited often enough for collection of excess stock, this can result in limited stock space within the shops storage areas. If a donation bank site is not visited often enough, then it can cause the donation bank to overflow, spilling onto the surrounding area. This can result in increased levels of donation bank theft. Through seeing that a donation bank is full, this can attract theft. Also, textiles surrounding the donation bank are easy to steal. Overflowing donation banks can lead to the charity being fined by the landlord of the site depending on the details of the letting contract from the owners of the car park and council. Also, overflowing

donation banks can result in potential donors being lost to rival banks on the same site. Overflowing donation banks also serve as a poor advert for the charity and lead the public to believe that the charity does not value their donations.

1.4 Key questions and research focus

Given the need to identify quality sources of donations in the community and then devise efficient strategies for collecting and processing them, this thesis focuses on four main areas:

- Understand current charity logistics operations – Understand how charities operate to make profit from used textiles.
- Optimising donation bank placement strategy – Understand how charities can receive increased returns from recyclate, by improving the quantities and quality from donation bank stock.
- Assess the merits of alternative localised and centralised collection strategies – Determine in what ways charities could achieve cost savings and increase efficiency in charity logistics to maximise the benefit from public donations.
- The use of technology to improve logistics – Investigate how new technologies could aid community engagement and how this might affect charity collections in the future.

Across these four areas, a series of research questions will be addressed:

1.4.1 Understanding current charity logistics operations

It is important to understand how charities operate to make profit from the collection of used textiles.

The associated objectives are to:

- Understand the key tasks undertaken by a charity and the scale of operations.
- Understand the problem of donation theft within the network and how this may be alleviated.

1.4.2 Optimising donation bank strategy

As charities use more donation banks to receive valuable textiles and other types of goods, donation bank strategy should be scrutinised to understand what could be done to improve their servicing efficiency and thus increase financial return. Placement of banks should also be investigated as this could result in greater yields and therefore, the potential for greater profits. The use of donation banks is an important asset used by charities and these should be exploited to their maximum potential.

- How do charities currently site donation banks?
- Are there any donation patterns through the year and are more donations expected at certain times of year? How can charities maximise profit from this knowledge?
- How can expected peaks in donations throughout the year be exploited by charities?
- What are the key factors that affect where the public donates their used textiles?
- How can charities improve their donation bank placement strategy to gain larger quantities of better quality donations?

The associated objectives are to:

- Understand recurring donation patterns between years and also seasonally.
- Suggest ways in which charities can exploit fluctuating donation patterns to their benefit.
- Qualify the key factors affecting the quantity of donations received to donation banks.
- Determine the key factors affecting the quality of donations received to donation banks.

1.4.3 Alternative collection strategies

As the logistical layers used by charities become more complex as their operations grow in size, it is important to understand the key functions of these systems to identify optimal operating strategy. By investigating the different ways that charities operate it will be possible to give recommendations on best practice.

- What are the different models adopted by charities for the movement of stock?
- What different methods do charities use to receive donations?
- Is centralised management of second hand textiles better than selling at the back door?
- Can collection routes be improved by making them more dynamic?
- Is centralised collection from donation banks more effective than localised collections?
- Is the activity of local level area drivers worth undertaking? Is there sufficient benefit of this service given the associated costs?
- Could donation bank/shop collections be undertaken more effectively, and could the transport footprint be reduced if there was greater visibility (currently and into the immediate future) between their logistics layers, and more flexibility allowed in terms of who undertakes daily donation bank/store servicing?
- Can charities find significant mileage savings by employing shop adopted donation banks?

The associated objectives are to:

- Identify the different logistics models adopted by charities for the collection of donations and movement of stock.
- Understand to what extent charities are duplicating their efforts. For example, centralised and localised routes overlapping.
- Identify how improved visibility of donation bank fill levels can enhance the efficiency and capability of collection operations.
- Investigate how collection routes can be improved by utilising a dynamic strategy.
- Compare and contrast centralised collection of donations with localised collections.
- Scrutinise whether the work carried out by local man-with-van is worth undertaking.
- Understand how remote monitoring of locations can assist in promoting more flexible scheduling.
- Understand the implications of utilising more flexible collection strategies.

Understand the effect on charities on the extensive utilisation of shop-adopted donation banks.

1.4.4 The use of technology to improve logistics

As we move further into the 21st century and with vast improvements in Information Technology, ubiquitous computing and ambient intelligence, this could result in potential uses in the charity logistics sector. By understanding the best use of available and future technologies we can try to understand how they could affect charity logistics for the good.

- Which technologies can be used to advance charity logistics and how should they be used?
- Is there a real need for dynamic scheduling in the charity retail sector?
- How could Smartphone Apps improve community engagement?
- How could Smartphone Apps be used in terms of reporting data and which key stakeholders require such information? What information do they require and when?

The associated objectives are to:

- Fundamentally understand how Smartphone technology could be used in a volunteer led charity setting to better engage staff in the supply of donations.
- Investigate how technology can help improve community engagement.

Understand the extent of donation bank theft and identify ways in which charities can combat this using remote monitoring technology.

1.5 Intended outcomes

Using a specific case study with Oxfam, the research will aim to provide evidence, primarily based upon statistical interpretation from past data and simulation of new methods in charity logistics operations, that will support long-term adoption of better practice within the charity sector and improve the efficiency of the logistics systems used, resulting in cost and environmental savings.

To achieve these cost and environmental savings, the main goals of the research are to:

- To provide evidence based recommendations on donation bank placement. Including information on where donation banks should be placed to maximise quantity and quality of stock likely to be received.
- To quantify the scope for a range of novel techniques in bring-site recycling management.
- To provide recommendations on improvements in logistics strategy.

For Oxfam, the PhD set out to investigate how the logistics system could be made more efficient to reduce cost and potentially increase profit for the charity. On a wider scale, the PhD set out to enhance the worldwide knowledge of 'take-back' logistics. 'Take-back' logistics is the practice of returning used items from the consumer into new sale or recycling streams. The unique contribution comes from gaining a better understanding of 'bring-site' (defined as any facility (usually unstaffed) where members of the public can deposit recyclable materials such as glass, cans, plastics, paper, textiles, shoes etc. (HSE, 2013)) management (how the sites are selected and how they are serviced) which could lead to changes in how charities collect donations and how the public disposes of unwanted items. The knowledge will be based on evidence as given through:

- Statistical analysis
- Evaluation in the use of ICT techniques
- Trialling scenarios

1.6 Outline of the thesis

Following on from the Introduction, Chapter 2 presents a literature review, providing a discussion over a range of topics. Firstly, the charity sector in the UK is introduced. This is followed by a review on the end markets of used textiles in the UK and how charities receive and process these used textiles.

Chapter 3 presents a methodology for each of the research objectives, outlining the steps that have been undertaken to achieve the goals that have been set out.

Chapter 4 shows a review of the case study charity Oxfam in order to understand current charity logistics operations. This chapter shows the range of logistical layers used within the charity and presents the audits that were undertaken to quantify Oxfam's collection and delivery operations, both for localised and centralised systems.

The next chapter presents the research undertaken on optimising donation bank strategy. This part of the study introduces the factors affecting donation bank performance and identifies the importance of donation bank location.

Following on from the study on donation bank locations, the research then looks at how these sites can be more efficiently serviced. Alternative collection strategies are considered and quantified.

To further improve these collection strategies, the thesis then shows the concept of using recent advancements in technology to provide assistance in tweaking these collection strategies to further optimising charity donations logistics.

A range of conclusions are drawn, followed by a breakdown of the key findings from the thesis. Opportunities for future study are also explored. The thesis concludes with a list of references and appendices.

Chapter 2: Literature review

2.1 The charity sector in the UK

Charity shops are increasing in number faster than any other major retail sector. A study of 'multiple retailers' in the 500 biggest town centres of Great Britain showed that 142 charity shops opened in 2013; while for all retailers there was a net fall of 371 (James, 2014). The recent growth in charity shops is considered unsustainable due to the lack of sufficient quality stock to supply the demand (Papworth, 2009), exacerbated by the “unprecedented boom” in people looking for second-hand bargains during the credit-crunch and a general lack of quality donations within the system (Smithers, 2012). Maintaining sufficient levels of donations is vital for keeping charity shops profitable. Also, ensuring the best quality stock is received is important for improving profit margins.

The Charity Shops Survey of 2012 was supported by 74 charities, covering 6,233 shops (Reece, 2012). The survey identified that in 2012, the top 10 UK charities by income collectively operated over 4000 retail outlets, generating over £533 million in income with the average shop making £612 in profit per week (Table 2).

Table 2. UK Charity facts (Reece, 2012)

Ranking by income	Charity (* marks centralised take-back)	Shops at year end 2012	Increase/ (Decrease) in shops on 2011	Total income per year (£)	Number of collection banks	Profit per shop per week £
1	British Heart Foundation	709	35	150,886,149	900	869
2	Oxfam *	685	(1)	93,119,549	1250	811
3	Cancer Research UK	554	(8)	69,304,884	0	712
4	Age UK	451	(8)	46,077,218	0	374
5	Barnardo's	487	57	44,279,576	0	406
6	Sue Ryder	392	36	36,613,047	0	396
7	British Red Cross	318	1	27,540,981	0	372
8	Scope	237	(1)	23,287,054	453	228
9	Salvation Army *	135	18	22,114,998	4800	1725
10	PDSA	179	(2)	20,223,119	0	259
Total		4147	+127 (Net)	533,446,575	7403	6152
Average		415	+12.7	53,344,658	740	612

Parsons (2004) believes that multiple charity retailers could learn much from their smaller counterparts. In 2004, weekly profit among hospice charity shops was a lot higher than the independent shops and multiples. Parsons (2004) showed at the time hospices were making an average of £401 per shop per week profit, compared to independent shops which averaged £277 and with multiples averaging £187. Hospice shops could be excelling here because of making a good balance between running a 'professional' service (well managed and maintained) while keeping running costs and logistical costs down. Many of the larger charities within the UK are now paying wages to the shop managers and this will also have an effect on profits.

Table 3 shows the number of charities that are members of the Charity Retail Association (CRA) and shows a breakdown in the number of shops per charity. Although, it is worth noting that not all charity shops are members of the CRA, it is useful to gain an idea of how many shops the different charity organisations run. This shows that there are very few (14) charities in the UK that run over 100 shops, but these 4353 shops account for over 60% of the total number in the UK. Independent charities (running fewer than 5 shops) are far more numerous, (n=143), with a total of 272 shops and an average of 2 shops per charity.

Table 3. CRA member shop stats (CRA, 2013)

	Number of charities	**Number of shops**	**% of total shops**	**Average number of shops per charity**
Charities with over 100 shops	14	4353	60.5	311
21-100 shops	28	1037	14.4	37
11-20 shops	62	890	12.4	14
5-10 shops	89	653	9.1	7
Fewer than 5 shops	143	272	3.8	2
No shops	25	0	0	0
Totals	**361**	**7205**		

In 2015, charity shop sales suffered a downturn. Sales at Oxfam's chain of nearly 700 high street stores slid 3% from the previous year to £72.5m last (Butler, 2015). This was attributed to the rise of discount retailers, such as Primark, retailing items for cheap prices, Oxfam plan to trial six 'super saver' stores selling donated stock

more cheaply than in its regular outlets. Oxfam plan to sell items from these trial stores for set prices of £1, £2 and £3 in an effort to increase its profits (Butler, 2015).

As a further example of how charity shops are evolving, Tenovus Cancer Care have opened a £1 shop in Newport, Wales that sells on items that had not successfully sold in the charity's regular stores. Traditionally, clothes that didn't sell at normal retail prices would be cascaded to another shop and then sold to rag merchants. However, with rag merchant prices dropping by over 50% in the last 2 years Tenovus Cancer Care felt this was unsustainable and so the 'pound shop' idea was introduced (CRA, 2015a). The idea has proved a success, with £10,000 net profit in the last financial year despite only trading since July 2014. This figure is a much higher amount than more established shops in much more affluent areas. The net profit compares favourably to Tenovus Cancer Care shops that have stock at 300 – 400% higher prices (CRA, 2015a).

2.1.1 Charity shops in other countries

As of 2010, Continental Europe had far fewer charity shops per capita than the UK, however at that they were on the increase (Shaw, 2010).

Within the UK, the love affair with the supermarket has resulted in the closure of many high street shops such as butchers, fishmongers, greengrocers, clothes shops, and hardware stores. The UK is a cash-rich but time-poor society, where shoppers prefer convenience and time saving to personal service and advice. In addition to food, as supermarkets also sell a wide range of non-food goods such as electrical goods and clothes it is more convenient to visit these one-stop shops rather than go to the high street. The result is that British high streets gained much vacant retail space, which is then available for low-profit uses. Charity shops receive tax breaks from the government, while a shop landlord may prefer to have a low-value user in there rather than having the unit empty and prone to squatters and vandalism.

Countries such as France and Italy also have supermarkets; however in these countries there is still a widespread culture to buy food for home cooking at local bakers, butchers and fishmongers. Non-food retailing has not transferred to other European supermarkets to the same extent it has in the UK. Germany and Denmark have, like France, many small discount supermarkets, which remain on their high streets. This results in Continental charity shops often being found in unusual locations, such as industrial estate sheds (Shaw, 2010).

2.2 End markets for textiles

With today's increasing trend of 'throwaway fashion', where clothing has a shorter life, either due to quality or for reasons of fashion, this results in more textiles reaching the end of their life, for alternative uses or reuse. Fast-fashion retailers such as H&M, Zara and Topshop are launching new lines every two to three weeks at very low prices, thus increasing sales through impulse purchasing (Bianchi and Birtwistle, 2010) and encouraging a high turnover of clothes. This results in a larger amount of textiles requiring disposal or resale as fashions change and clothes come to the end of their lives more rapidly. A survey of 6,000 people by Cotton Incorporated (2012) found that 73% of consumers say that clothing does not last as long as it used to (Cotton Incorporated, 2012), supporting the claim that 'throwaway fashion' results in a higher turnover of clothes.

Table 4 shows the end markets for textiles in the UK and how this has changed from 2005 to 2008. Between these years, there was a 199,000 tonne increase in end-of-life textiles. Through time there also shows increases in the percentages of resale in UK, export reuse and export as wiper grade (material suitable for use as industrial rags and wipers with little or no further processing). The greatest decreases in percentages between 2005 and 2008 were wiper grade UK and recycling in the UK.

Table 4. End markets for UK textiles (Oakdene Hollins, 2009)

End use	**2005**		**2008**	
	Tonnage (000s)	**Percentage**	**Tonnage (000s)**	**Percentage**
Resale in UK	41	12.7	106	20.2
Export reuse	174	53.7	316	60.5
Wiper grade UK	28	8.6	17	3.3
Export for wiper	6	1.9	21	4
Recycling - UK	34	10.5	10	1.3
Export for recycling	20	6.2	28	5.9
Waste	21	6.5	25	4.7
Total	**324**	**100%**	**523**	**100%**

Each charity shop saves an average of 40 tonnes of textiles going to landfill every year, by selling them in the shop, or passing them on to textile merchants for recycling or reuse. This grosses to over 347,000 tonnes across all charity shops in the UK; based on 2013-14 landfill tax value at £72 per tonne, the value of textiles

reused or passed for recycling by charity shops in terms of savings in landfill tax is £25,053,000 per annum (CRA, 2013c).

Export reuse accounted for over 60% of end of life UK textiles in 2008 and was by far the most popular way of dealing with such textiles. Oxfam primarily exports clothing to Benin, Gabon, Ghana, Senegal and Togo; 50% of total volume is exported to West Africa, 25% to Eastern Europe and 25% to the Middle East. However, by value three times as much goes to West Africa, including a greater proportion of low-weight and high-value garments (e.g. t-shirts), whereas bulky cold weather items (e.g. coats) are predominantly exported to Eastern Europe (Brooks, 2012). The United States is the largest exporter of textiles and dispatches over 500,000 tonnes of second-hand clothes per annum, to more than a 100 different countries worldwide (Brooks, 2012).

Resale in the UK became more popular between 2005 and 2008 and shows a change in culture of dealing with used textiles. Recycling became a less popular method of dealing with textiles and shows that reuse became a more preferred method. Over 70% of the world's population use second hand clothes (Textile Exchange, 2012). The Charity Retail Association's last estimate was that its members re-used or recycled 373,000 tonnes of clothing every year, generating £300 million and employing 21,000 people (CRA, 2015b). As a further example of the benefit of re-using and recycling, a typical waste incinerator handling similar tonnage costs hundreds of millions of pounds and only employs 50 people (CRA, 2015b).

Only 4.7% of clothing donated to charity shops is discarded as waste. Textiles that cannot be sold are put in a 'rag bag' and sold to a textile reprocessor or 'rag merchant': these goods will either be recycled as fabric or exported as garments for sale overseas. Books and records can also be sold on to commercial collectors in this way. Other items, such as glass or wood can also be recycled. The remainder goes to landfill (CRA, 2013b). The Environmental Protection Act of 1990 states that charity shops must hold a valid Waste Carriers Licence. This is because all goods which have been donated to charity shops but are not sold are considered to be waste. As a producer of waste, all charity shop operators have a legal obligation to ensure that they pass on their waste to entities that are legally authorised to take that waste (TRA, 2009).

To increase revenue some items can be recycled, or used for other tasks. For example, old clothes can be sold and then torn and used as cleaning rags in

industry. Oakdene Hollins (2009) believe attempts by textile reclamation merchants, charities and waste authorities to increase the rate of diversion of clothing and shoes from residual household waste is worthwhile and should be encouraged, particularly since lower value textiles are still worth recycling.

Besides donated stock being sold through various outlets (charity shops or online), donations can leave the charity through a variety of profitable end markets. WRAP (2012a) identified a wide range of end markets for post-consumer textile, shown in Figure 2. However, re-use as clothing is by far the largest in terms of both volume and financial value – accounting for around 80% of the sorted volume of post-consumer textiles.

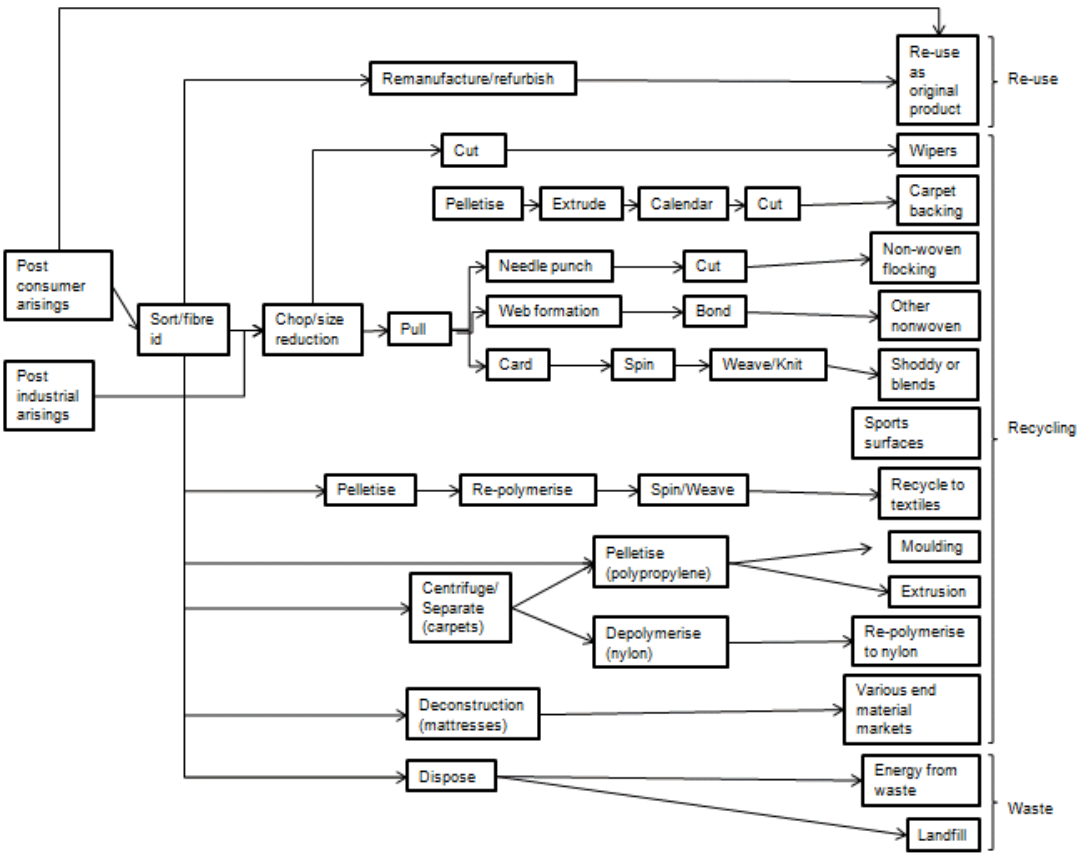


Figure 2. Overview of textile end-of-life management routes (WRAP, 2013)

Approximately 97% of SATCoL's (Salvation Army Trading Company Ltd) clothing collections (both from donation banks and door-to-door bags) is sent overseas (mainly Eastern Europe) as this is the route whereby the largest amount of money can be raised for The Salvation Army (SATCoL, 2012). This has been identified as an extremely cost effective way of generating funds from the donated clothing.

Many charities sell off excess or unwanted stock for use in the cleaning industry (as rags). This provides a useful income stream as a large proportion of donated stock is not suitable for sale. 99% of items donated to the Salvation Army are reused or recycled with up to 80% being re-worn. The rest is shredded or broken down to make mattress filling, industrial wipes, or soundproofing in cars. Less than 1% cannot be used again and is sent to landfill (SATCoL, 2012). All BHF donations are sold locally or, if they cannot be sold, are sent to local Textile Recycling Merchants (Violaris, 2012).

Table 5 identifies the throughput and path-ways for charity shop textiles between 2010 and 2011.

Table 5. Throughput and end path-ways of charity shop textiles (WRAP, 2013)

End Use	**2010**		**2011**	
	Tonnage	**Percentage of Total**	**Tonnage**	**Percentage of Total**
Resale in store	194,200	52	177,600	48
Sold to textile merchants	170,200	46	185,000	50
Disposed of to landfill	7,400	2	7,400	2
Total	370,000	100	370,000	100

Figure 3 shows the price of textiles between 2009 and 2014, broken down into the following three categories:

- Textile banks - this reflects the amount that may be paid to a local authority or a waste management company, usually by a collector for material from textile banks. The payment may be amended if the local authority has to pay a bank hire fee or an element of the collection costs and if a donation is made to a charity.
- Shop collections - this price indicates the amount which may be paid by a collector to a charity shop for clothes the shop has not sold to the public directly. Prices vary on content from poorer quality material through to clothes and leather items.
- Charity rags - this is a general term for material, usually well-presented and often from charity shop collections, delivered to the factory of a larger textile collecting business which often exports used clothing and textiles.

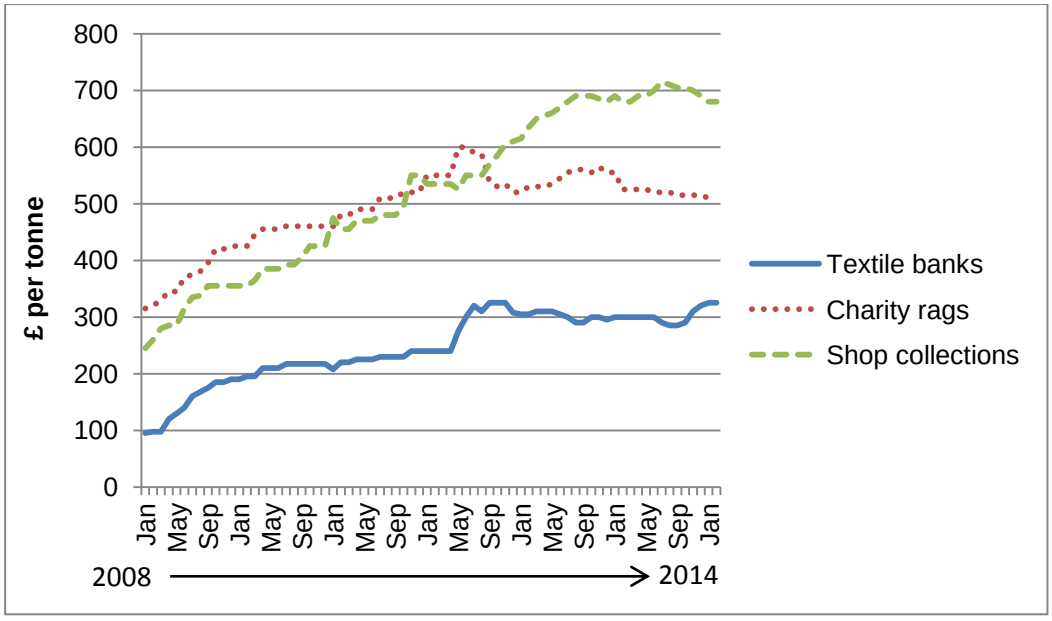


Figure 3. The price of textiles (£ per tonne) (Lets Recycle, 2014)

These prices saw a steady increase between 2008 and 2012, where in 2008 Textile bank stock was worth just £100 per tonne, compared to around £300 per tonne in 2012. The price of shop collections also increased in value from £250 per tonne in 2008, to around £700 per tonne in 2012. Although the price of charity rags and textile bank donations stabilised in 2011, and shop collection textiles stabilised in 2012, these prices have remained high.

Given the high value of textiles, it is of the utmost importance to charities to make the most of this value and keep transport costs low to enable charity shops to profit from used textiles.

There is scope for improvement regarding charity take-back logistics. Many issues are faced by charities when collecting, processing and distributing donated stock, such as: duplication of efforts, selling stock unseen, donation bank theft and rigid collection strategies. These issues will be raised within this thesis and options for a more sustainable approach will be researched.

2.2.1 Clothing disposal and recycling channels

There are various sources (for both the public and commercial) and collection methods (textile donation banks, kerbside sorted, door to door, charity drop off, cash 4 clothes, donations to schools and branded work wear) for textiles. The collection methods vary across all these methods, with varying costs. Clothing is one of the

main types of donations received by charities for sale in shops or selling through other methods. Figure 4 shows the proportions of textiles collected by reprocessors throughout the UK. Scotland has higher than average use of charity shops, with 52% of collections received via this pathway, in comparison to only 4% of reprocessor collections in Wales being sourced from charity shops. Conversely to Scotland, in Walesdoor-to-door collections shows greater popularity, when considering percentage (42%). The method of collection by textile reprocessors in England is more representative of the UK as a whole, than in Scotland and Wales.

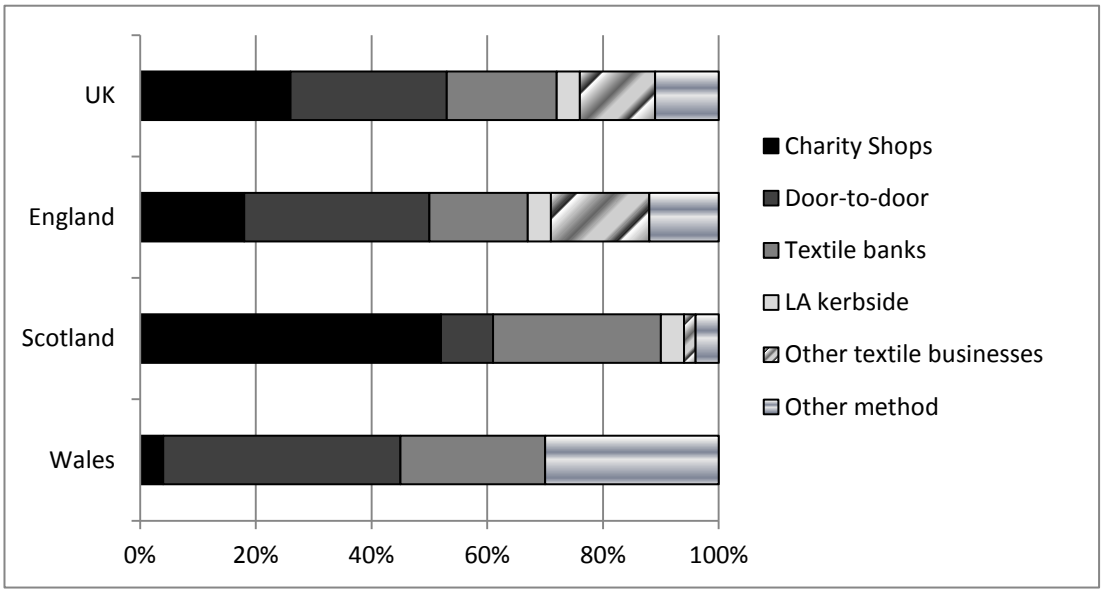


Figure 4. Method of collection by textile reprocessors in 2010, by nation (WRAP, 2013)

Woolridge et al (2006) stated that across England, there has been clear regional differences in terms of quantity of textiles discarded and recovered from the waste stream. Across England, 2.6 kg of textiles were discarded per household in 2003, with the value in the North East being only 1.4 kg compared to 3.7 kg in the East Region, reflecting a wide range of socio-demographic differences.

2.2.2 Reasons for clothing disposal

In 2006, UK consumers discarded on average 30 kg of clothing and textiles per capita (Allwood et al, 2006). Consumers dispose of clothing for a number of reasons such as poor fit, outdated style, boredom and/or wear-out (Koch and Domina, 1999). Indeed, a study by SATCoL concluded that that generally, when clothing is disposed of it still has at least 70% of its useful life left (Woolridge et al, 2006). There is a

recent culture of fast fashion, where ever-changing popular fashion leads to a high turnover of clothes, especially among young people.

This has led to a culture of buying cheap clothes that are of a lower quality to enable a higher turnover of clothes. ‘Fast fashion’ suppliers (e.g. H&M, Zara, Top Shop, etc.) have offered low-priced clothing with a short life cycle (Joung and Park-Poaps, 2011).

The majority of consumers perceive the lifetime of clothing to be shorter than ever before (Oakdene Hollins, 2006). In May 2006, a survey questionnaire by Oakdene Hollins was sent to 250 consumers to help substantiate the perceived trends in consumer purchasing and discard patterns for clothing. Specific results were as follows:

- 63% of respondents agreed that clothing has become lighter in weight over the last three years, and that this trend is accepted as continuing for the foreseeable future.
- On average, 4.1 items of clothing are purchased per household per month, with the highest proportion being children’s clothing (which doesn’t generally wear, but is grown out of).
- 62% of respondents thought that the lifetime of clothing was shorter than it was three years ago. The actual expectation from clothing is less and we are not expecting things to ‘last a lifetime’ any more. Retailers are responding to this in the garment specifications by lowering the standards on fabric, trimmings and manufacturing.
- 47% of total respondents thought clothing was less expensive than three years ago.
- Of the total respondents nearly 40% were buying more at lower prices than in the previous year.
- When ‘having a clear out’, 59% of all respondents take clothing to a charity shop, with 20% giving to friends and family.
- 2% of all respondents regularly sell used clothing, for instance on Ebay: within respondents under 30 years old, this figure rises to 5% being sold.
- The remaining 19% take used textiles to a clothing bank or throw them away.
- 45% of all respondents have a ‘clear out’ of clothing once a year and 42% once every six months.
- 44% of respondents clear out “the same as you used to” and 17% “less often that you used to”.

The ‘Primark effect’, as named by the Environment, Food and Rural Affairs committee, is now a commonly used term to describe the high street’s cheaper clothing, with new, but lower quality garments bought and disposed of more frequently. This occurs as a result of budget retailers manufacturing low-cost garments and items that consumers fully expect to discard within six to 12 months (MRW, 2013). According to Birtwistle and Moore (2007), a trend of ‘throwaway’ fashion attitudes is growing among consumers, especially young fashion leaders. The short fashion life cycle and low price have contributed to the growth of unwanted clothing items. The survey of 6,000 consumers by Cotton Incorporated (2012) found that two decades ago, the majority of consumers agreed they would pay more for better-quality clothing rather than sacrifice quality for a lower price. However, with the increase in low-priced mass merchants, cross-channel shopping, and the adoption of fast-fashion, the percentage of consumers willing to pay a premium for quality eroded. With consumers preferring to buy clothes of lower cost, and thus lower quality, this supports the claim of a high turnover of clothes.

There are several paths for end of life textiles: discard, donate, reuse, trade or sell (Solomon and Rabolt, 2009). Shim (1995) interviewed college students and identified eight clothing disposal motivations and linked each to specific clothing disposal behaviours: (1) economically motivated resale; (2) environmentally motivated resale; (3) charity-motivated donation; (4) environmentally motivated donation; (5) economically oriented reuse; (6) environmentally motivated reuse; (7) convenience-oriented discarding; and (8) unawareness-based discarding. Unawareness-based discarding would apply to discarding textiles through normal waste streams, possibly ending up in landfill, due to a lack of knowledge of the need to discard textiles in an environmentally-friendly manner.

A study of 277 students from a Mid-Western University in the USA by Koch and Domina (1999) indicated that the most frequently used method of disposal was to pass the textile product on to family or friends, followed by use as rags, accounting for 82% and 76% of the sample respectively. Donation to Goodwill or Salvation Army accounted for 64% of the responses to textile disposition methods. The least used methods of textile disposal were church donation (36%), returning to parents for recycling (35%) and lending (30%).

In the UK, eighty seven percent of the goods sold in charity shops are donated by the public (Charity Retail Association, 2010b) with the majority of stock generated from donation banks. Despite containing a lower proportion of quality stock, the

takings from these donation banks are very important for maintaining shop stock levels.

It has been noted that low-priced low-quality garments do not provide adequate justification for recycling and are difficult to recycle (Britten, 2008). Oakdene Hollins (2006) agreed and stated that cheap garments are not of high enough quality to be recycled, and collection costs typically exceed revenue generated. However, charities are willing to accept textile donations of any quality.

The used textiles received by charities can be sorted into 5 main grades (also shown is the proportion of textiles sorted into each grade given by the average between SATCoL and TRA member in 2005) (Oakdene Hollins, 2006):

- UK re-use (3%). Wearable items resold in the UK through retail shops. This is considered the 'cream' of used textiles.
- Export re-use (60%). Wearable items exported for resale in second-hand 'retail' outlets and markets.
- Wiper grade (12%). Material suitable for use as rags and wipers with little or no further processing.
- Recycling grade (19%). Material suitable for pulling or shredding into fibres for use in new end products.
- Waste (6%). Material that cannot be resold or recycled which is disposed to the UK waste stream.

2.2.3 Reasons to shop second-hand

Along with charity shops, the phenomenon to shop second-hand has manifest in the proliferation of garage sales, second-order outlets, specialist second-hand retail chains and the rise of internet auctions (Guiot and Roux, 2010). The rise in second-hand sales and increase in markets brings formidable competition to traditional retail outlets, proving that traditional retail streams do not satisfy all needs of the consumer. Second-hand markets provide various and unpredictable offerings, visual stimulation and excitement due to the plethora of goods, the urge to hunt for bargains, and feelings of affiliation and social interaction (Guiot and Roux, 2010).

2.3 Donation methods

Identified within this section are the methods charities use to receive donations. Some charities use all of these methods, whereas others may only use one method, or a mix of certain methods.

2.3.1 Donation banks

Donation banks are used by charities to receive donated stock from the public, and are placed in a variety of public locations. According to the 2013 CRA Stock Survey (of 37 charities, managing a total of 2826 shops) 4% of donations are received through donation banks (Pudelek, 2014).

One benefit of donation banks to charities is that they can be used by the public at any time. Other collection methods used by charities require someone to physically receive and take the stock, whereas bank stock can be given at any time and collected at the charities convenience. However, this does show a disadvantage, as there is no one to personally receive the stock this takes away the stage of initial vetting of the quality. Because of this, some use donation banks to discard rubbish or soiled goods that are of no use to charities.

Textile donation banks may be operated by charities, commercial collectors or waste management companies. In recent times, with the high price of textiles, charities are under increasing pressure from commercial collectors who are vying to replace charity donation banks on prime sites, such as recycling centres (Hunt, 2012).

According to a survey of textile collectors including the Textile Recycling Association (TRA) members and key large collectors outside the TRA, over 140,000 tonnes of textiles are collected through donation banks each year (WRAP, 2013). With industry estimates placing the number of textile donation banks in the region of 12,000-15,000 (WRAP, 2013), this equates to an average collection per donation bank ranging from 9.3 and 11.7 tonnes per year. Previous research has suggested average donation bank yields at 6 tonnes per year. This therefore may indicate increased use of textile donation banks (WRAP, 2013). Charities also use networks of book and music donation banks to collect stock for sale in shops.

As well as textile donations, charities often use other banks to collect different types of donations which can include books, DVDs, CDs and games, shoes and bric-a-brac.

These banks are generally placed in public areas, such as supermarket car parks, other car parks and waste recycling centres. Banks have to be located where they are easily accessible and do not require the donator to travel too far to make their donation. Donations are often made as a matter of convenience, and the easier and closer it is to make a donation, the more donations are expected.

Donation banks vary in size, and the type and size of bank used differs because of the stock type of donation required and the amount of donations expected. Typically donation banks are constructed from welded metal (sheet steel) that are then painted and added with vinyl signage (Charitybags, 2013). Public donations are placed into the specially designed anti-theft chute. Figure 5 shows standard size (1.6m x 1.6m x 1.6m) textile donation banks for two different charities. In busy waste recycling centres that receive a lot of donations, the charity may decide to utilise a super size donation bank that can hold a greater amount of stock than a standard donation bank.

Figure 5. Charity textile donation banks (Charitybags, 2013)

In some cases, donation banks are set up by private for-profit companies, not by charities as the consumer might assume and thus can mislead both the donator and consumer. As an example, in Germany where the largest second-hand shop chain Humana (19 branches in Germany, 13 in Berlin alone) display the blue-and-green globe logo of a non-profit organisation, “Humana People to People Deutschland e.V.”. In fact, they are a not a charity and are selling for profit, with clothes collected from containers with the charity’s logo (Mösken, 2012).

2.3.2 Direct to shop

According to the CRA 2013 Stock Survey 80% of donations received by charities are given directly to shops, up from 71% in 2012 (Pudelek, 2014). Direct to shop gives the donator the opportunity to ensure that their donation goes exactly where they want it to (ie. for sale in that local shop rather than being transported elsewhere) and that it avoids being missed by the charity (either by being stolen from a donation bank or missed by the charity sorting through the donation bank stock). This method of donation also allows for the donator to claim Gift Aid on their donations.

Research has suggested that the method of collecting stock significantly impacts on the quality of the goods received. In a study of the quality of donations, Oakdene Hollins (2006) found that the best quality used clothing came via 'direct-to-store' donations with an average selling price of £2 to £3 per item yielding between £6,000 and £9,000 per tonne at resale value (post sortation). In contrast, some textile donation banks might only yield £200 per tonne after sorting and clearance of the contaminant (Oakdene Hollins, 2006). According to the Salvation Army in Bristol (2014) a direct donation of one bag of clothing over the counter to a local charity shop yields a significantly larger donation (approximately £12-£15) to the charity than through the use of clothing banks (approximately 60p) where most textiles are either sold overseas or recycled unseen. Donations received over the counter in shops are sorted and sold based on the value of each individual item, however this is not always the case with donation banks due to the contents sometimes not being sorted before sale in bulk to markets abroad.

The public are permitted to add Gift Aid onto their donations if they are UK taxpayers. This allows the charity to claim back the tax on the goods that they sell providing they have been given permission by the donor.

Although originally intended for cash donations alone, charities are now able to add Gift Aid onto donated goods. In the case of Oxfam, they name this scheme 'Tag your Bag', where the charity can raise an extra 25% more from the government following the items sale. In order for the charity to receive this extra 25%, the donor must confirm that they are a UK taxpayer, before a unique personalised donor number is added to each bag of donated stock using a label. When the item is sold it is noted that this item was donated using Gift Aid and the charity is able to benefit from extra revenue. This system allows stock to be tracked from its point of donation

to its point of sale. HM Revenue and Customs state that in order for the additional money raised to be treated as a donation, the charity must send a notification letter to the donor advising them how much their goods have sold for (Robinson, 2010). To account for the administrative costs of the Gift Aid scheme, Oxfam charge 1% of each items sale price as commission (Oxfam, 2015). British Heart Foundation also run a bag tagging scheme to increase the amount raised from each Gift Aid donation.

2.3.3 Door-to-door collection and kerbside collection (Bag-drops)

Traditionally, the main source of donations to charity shops was direct-to-store by members of the public but this method has declined with the advent of pedestrianised high streets in the 1980's. As a result, 'bag drops' (polythene donation bags distributed to households for later collection) became a popular method of obtaining donations (Hibbert et al, 2005) and also allowed charities to target specific demographic groups in particular areas, such as those with more wealthy residents or certain age groups, that may expect to return better quality or particular types of donation. In recent times, the proportion of stock received from door-to-door collections has fallen to a record low according to figures from the CRA (Pudelek, 2014). The CRA's 2013 Stock Survey shows that house-to-house collections made up only 3 per cent of the total stock donated to charity retailers in 2013, which is down from 6 per cent the previous year. It was 19 per cent in 2008 (Pudelek, 2014).

Door-to-door collections are defined within this report as collections by independent agents dropping bags through letter boxes, and returning at a later date to pick up the goods. These are in contrast to kerbside collections, which are typically organised by the local authority, requiring householders to deposit textiles in bags, boxes or other containers (depending on details of the scheme), and are normally collected alongside other household dry recyclables as part of a scheduled collection service. In both scenarios, the agent may be a commercial collector, a charity or charitable organisation, or the local authority.

The exact tonnage collected via kerbside is uncertain, as local authorities typically provide waste statistics for all textiles collected for recycling, re-use or composting – which also includes donation bank collections on local authority property. According to reprocessor survey results (i.e. responses from textile recyclers who sometimes work in partnership with local authorities), kerbside collections accounted for 7,800

tonnes of textiles (Oakdene Hollins, 2009). Based on exclusion calculations from total local authority collections of 148,000 tonnes, total kerbside textile collection is estimated at 21,000 tonnes (Oakdene Hollins, 2009).

Most kerbside (rather than door-to-door) collections are operated by waste management companies (WMCs) or local authorities, however, although there are partnerships with third parties, who may be charities, or dedicated commercial textile collectors; therefore double-counting is considered an issue. Nonetheless, 21,000 tonnes is believed to be an under-representation, with a proportion of the total counted elsewhere (Oakdene Hollins, 2009).

A growing trend is the offer of a return on garments, with money paid for the volume collected, 'cash for clothes' schemes, as seen on the high street, door-to-door and through private operators.

Door-to-door collection is a known method of collection for bogus textile collectors masquerading as legitimate charities. The Fundraising Standards Board (FRSB) (2014) estimated charities lose £15 million each year through the theft of charity bags or by fraudulent collections. However, The City of London police estimates that this activity costs charities £50 million every year and the Charity Retail Association thinks this is likely to be an underestimate, as it is so difficult to measure this kind of theft (Fairbairn, 2013). Legitimate charity collections carry an allotted collection day and often bogus collectors will visit first to take the donated stock. In some, cases bogus collectors will even distribute their own collection bags and profit from the goodwill of the public (MRW, 2013).

The impact of bogus textile collections and theft is not only the great financial loss to charities but leads to a growing sense of mistrust, concern and confusion amongst the giving public (Fairbairn, 2013).

2.3.4 Collection from other sources

The collection routes historically utilised by reprocessors and charities have been seeing greater competition in recent years – not least due to the general public becoming more aware of opportunities to sell clothes and textiles directly themselves. In response, collectors have adopted alternative sources of collection to increase volumes received – such as collection from offices and other businesses, community centres and churches, and schools (WRAP, 2013). School collections are increasingly common and some commercial collectors encourage donation by

offering a reward directly to the school according to the volume raised. Typical rewards include money to fund the school, or payment to a specified charity.

According to a survey of reprocessors (WRAP, 2013), 'other' collection methods accounted for 29,000 tonnes of textiles in 2012. An additional 33,000 tonnes of textiles collected from textile businesses was also noted in responses from the survey of reprocessors. This is most likely to consist of off-cuts and fabric, rather than garments, and therefore is likely to be included under the banner of industrial waste within the 54,000 tonnes manufacturing wastes which are not included in textile consumption for the purposes of the mass balance. Clothing collected by charities from businesses is largely incorporated within Charity Retail Association figures (WRAP, 2013).

2.3.5 Commercial donations

An emerging source of donations is the seeking of 'Goods-in-Kind' from commercial retailers: usually returns or surplus stock such as clothes and toys. Examples of this include the M&S and Oxfam Clothes Exchange and British Heart Foundations agreement with Home Retail Group (British Heart Foundation, 2010; Oxfam, 2010). Although not yet widespread, charities are fostering relations with retailers to unlock these channels (Parsons, 2004).

2.4 The quality of stock expected via each donation method

The 'donation pyramid' (Henderson, 2010) for clothing donations (Figure 6) shows the proportions of each type of donation that are believed to be suitable for sale, ranging from 2% of donation bank stock saleable online and 8% saleable in shop, to around 50% saleable from corporate donations. The pyramid shows that although corporate donations are generally of the best quality, they are received in the smallest overall quantity.

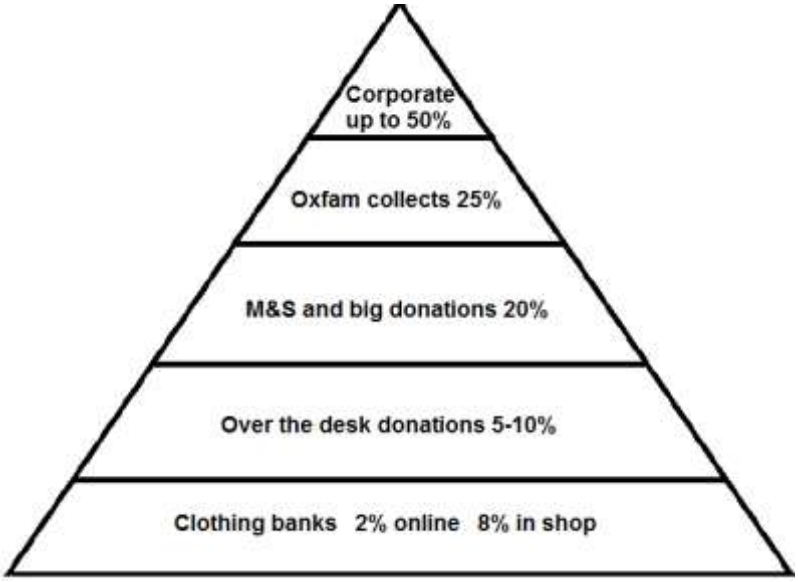


Figure 6. The 'donation pyramid' (Henderson, 2010)

Donation bank stock shows the lowest overall saleable quality, but shows the highest quantity yields which makes this collection method of utmost importance to charities.

2.5 Factors affecting donation yields

WRAP (2012b) identified that across 6 of the 8 sources measured the re-use and recycling rate of the textiles ranged from 80 – 89%, with the waste element accounting for 1.5 – 5.8%. Exceptions to this included the co-mingled textiles which had no value due to contamination and damage, resulting in a disposal cost. The branded work wear provided a lower re-use and recycling proportion albeit of more significant value.

There is limited research related to the placement of charity donation banks and the literature largely discusses attitudes and behaviours towards general recycling of used household goods, rather than donations to charity.

Consumers like to use this range of collection methods, they would appear to choose them for re-use and finally that there is the potential to capture more textiles for recycling through this infrastructure.

Barr, Ford and Gilg (2003) created a framework for recycling behaviour based upon three groups of factors: environmental, situational and psychological. ‘Environmental’ relates to an individual’s underlying orientation towards the environment with concerns in this area being cited as a key reason for participation

in recycling schemes along with convenience (Perrin and Barton, 2001). 'Situational' comprises variables that enable and facilitate recycling activity, such as access to services (donation banks) and socio-demographic factors such as age, gender, education and income. The third factor relates to the many psychological factors which influence an individual's motivation to recycle such as conforming to social norms, response efficacy (a belief that the individual can make a difference), and reacting to perceived threats arising from not being seen to recycle and participate (Barr, Ford and Gilg, 2003). Following a survey of 985 households in Exeter in 1999, Barr, Ford and Gilg (2003) found that environmental values had little effect on recycling participation and that convenient and well-understood recycling schemes had significant behavioural effect. Their study proposed that psychological variables, such as being aware of others' recycling habits and, more significantly, accepting those as the norm, had a great effect on intention and behaviour. It is likely in this situation that placement of kerbside recycling bins outside properties may have motivated other households to take part because of the social pressure that might be involved.

The belief that convenience plays a major part in garnering greater tonnages to donation banks and recycling facilities is widely supported. Martin, Williams and Clark (2006) identify a 'culture of convenience' being prevalent throughout UK society; suggesting that because people feel continually time-starved, recycling goes against the grain by requiring additional effort to sort and store waste in separate containers. Many people perceive domestic tidiness to be more important than recycling when faced with the choice of storing recyclables or discarding them immediately along with the general waste (MORI, 2002). To support the theory of a 'culture of convenience' a survey of Goodwill industries in the US found that people would not go more than 10 minutes out of their way to deposit used recyclables (Solid Waste District of LaPorte County, 2008).

Joung and Park-Poaps (2011) concluded that in order to promote donation and prevent the discarding of unwanted textiles, the recycling industry should place drop-off sites or community collection bins in convenient places for easy access such as convenience stores and petrol stations. Initiatives have also trialled the placement of textile donation banks within buildings (NYC Recycles, 2013) with Re-FashioNYC (a partnership between the City of New York and Housing Works) targeting apartment buildings in New York City, USA believing that people usually decide to throw clothes away rather than recycle as a matter of convenience. This scheme has been considered a success; providing a service within residential

buildings has encouraged tenants to donate their textiles rather than dispose of them and this has led to an increase in donations in the area (NYC Recycles, 2013). In the first year, the program grew to serve 40,000 residential units with 195 textile recycling donation banks. This resulted in 124 tonnes of textiles being diverted from landfills saving an estimated 441 tonnes of CO_2 emissions and providing clothing for homeless shelters (Zimmer, 2012). Encouraging greater recycling is also about changing ingrained habits and promoting the use of recycling facilities as second nature over a single point of disposal (Timlett and Williams (2009). Using an investigation of recycling participation in the city of Portsmouth, Timlett and Williams (2011) identified three significant behaviour clusters that can facilitate effective recycling. They found that once a donation behaviour is started based upon good infrastructure (donation banks with ample parking spaces in a clean, trusted and safe environment such as in a supermarket car park), combined with regular trusted servicing, then regular donation behaviour is formed, linked to a particular site.

Martin, Williams and Clarks (2006) reviewed a wide range of literature regarding the age and family status of those most likely to recycle. Perrin and Barton (2001) believed the more mature, the more affluent, the better-educated and home-owners are more likely to be recyclers. Vencatasawmy, Ohman and Brannstrom (2000) identified the recyclers at 'bring' sites in a small town in northern Sweden were more likely to be married, without children, retired, more affluent, owner occupiers, well educated and concerned for the environment. Tucker, Murney and Lamont (1998) agreed that there was a tendency for recyclers to be older, better-off, more educated and living in single-family dwellings without children. Aylesford (1996) showed that household recycling rates dropped below the average when young children were present though recovered slightly as the children got older. Living with children implies a busy lifestyle that does not allow much time for activities such as recycling, but as the children become more educated on environmental issues this puts more pressure on parents to recycle (Tucker, Murney and Lamont, 1998). However, Coggins' (1994) survey of 1800 people in Sheffield showed the opposite in that young families were the most likely recyclers.

Stantec (2009) identified a range of factors influencing the strategic placement of recycling facilities. They believe that the placement and layout of recycling donation banks is a major factor in promoting waste diversion, stating that one useful tool in determining the best location to place donation banks is often identifying open areas with high throughput of people, or areas that involve activities that are likely to generate a significant volume of waste or litter. Open spaces, such as parks, trails,

beaches, outdoor sports facilities etc, where permanent waste collection installations are appropriate, that are located near densely-populated areas often capture more recyclable materials. The placement of donation banks in areas where people expect to find them also contributes to increasing waste diversion; Examples of these locations include near entrances and exits; near washrooms; in eating areas; and near walkways and intersections.

Literature has largely concentrated on how those involved in recycling can maximise the tonnage received to their collection facilities. The Waste Electrical and Electronic Equipment Recycling (WEEE) recycling guidance by WRAP (2010) aims to improve the quality of recyclables that are collected, primarily through 'quality control', where signage indicating the types of recyclate required in the form of 'yes please' and 'no thanks' alongside a list of accepted materials. Stantec (2009) showed that not only is donation bank location important, but their positioning relative to each other can also impact on the quantity and quality of donations received. Donation banks should always be paired with waste bins to avoid contamination. Donation banks should also be placed side-by-side and not back-to-back, as users may not realise the recycling/waste bin is on the other side, possibly resulting in higher contamination rates and lower diversion rates. This theory was tested in Quinte West and Belleville, Canada by Quinte Waste Solutions in 2005. Both areas had the same amount of promotional/education materials on walls and on entrance ways. The arena in Quinte West received side-by-side placement of waste and recycling bins (12 waste bins / 12 recycling bins). In the Belleville arena, recycling was only available at one-third of the waste bins (34 waste bins / 10 recycling bins). Waste audits showed the diversion rate of recyclables in Quinte West was 54% while the diversion rate in Belleville was only 23%, indicating that side-by-side placement of waste and recycling bins is effective in promoting recycling.

Relating to textile donations, Oakdene Hollins (2006) believe that there are no overall regional differences in the quality of clothing donated although within each region there will be less affluent areas which tend to donate less quantity and lower value material.

It has been identified that the quantities of recycling can be increased by placing bins in areas of convenience, with high throughput and ease of visibility. What needs to be studied is the effect of other demographic features on the rates of textile donation and also how this affects the quality of donations. The concept of siting donation banks in areas that are expected to produce more or better quality

donations enables charities to make the most out of the resources available to them. Many charities are struggling to bring in good amounts of quality stock (Papworth, 2009). Understanding where to site donation banks could potentially lead to higher yields and better quality stock which could positively affect charity profits.

2.6 Reverse logistics and its context within a charity organisation

Charity logistics can be included under the broad term of 'reverse logistics' (operations related to the reuse of products and materials). The definitions of reverse logistics from a holistic environmental perspective focus primarily on the return of recyclable or reusable products and materials in the forward supply chain (Meade and Sarkis, 2002). That is, reverse logistics is necessary for the completion of the industrial eco-cycle. Reverse logistics from the environmental perspective supports environmentally sound practices such as recycling, remanufacturing and reclamation, which could be considered at various levels of product and materials reuse (Meade and Sarkis, 2002).

Figure 7 shows the operational lifecycle chain of a product. The general goal is to keep all materials within the operational lifecycle and thus minimise any flow into the external environment. In this case the only strategy that conflicts with this goal and should be minimised is that of disposal.

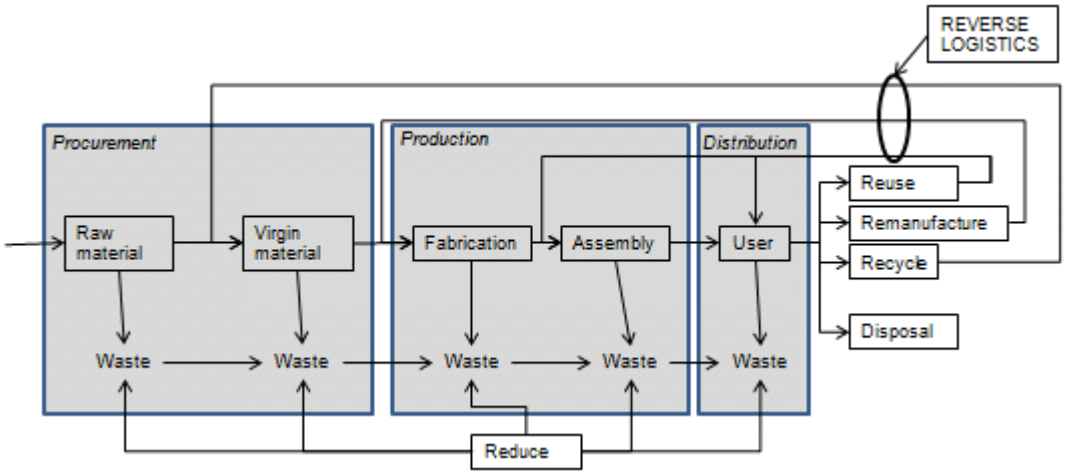


Figure 7. Operational lifecycle of a product and reverse logistics location (Meade and Sarkis, 2002)

Charity shops fit into this classic reverse logistics model by enabling the reuse of products through sales and facilitate the remanufacture and recycle of goods that are unsaleable. Ethical practices are used to dispose of goods that cannot be reused, remanufactured or recycled.

2.7 The need for sustainable practice in charity logistics

The traditional supply chain model (Figure 8), shows the life of a product with the least amount of sustainability in mind. This is shown by the flow of a product going from a producer to the customer, when the good is not further desired by the customer it is disposed of.

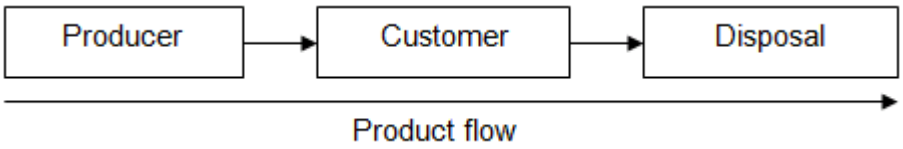


Figure 8. Traditional supply chain model (Barker, 2008)

Charity shops run with the product recovery supply chain model in mind (Figure 9), making profit from selling used goods. Charities provide a channel for goods to be re-used. If items brought into charity shops cannot be sold they are processed for recycling or disposal as a last resort. The processes carried out by charities are in line with The Waste Hierarchy and the Product recovery supply chain model. It is estimated that only 2% of materials donated to charity shops end up in landfill (CRA, 2013c) and that re-use of clothing saves 29 kg CO_2 per kg of clothing compared to recycling and 33 kg CO_2 compared to disposal. UK charity shops' reuse activity alone helps reduce CO_2 emissions by about 6.3 million tonnes per annum.

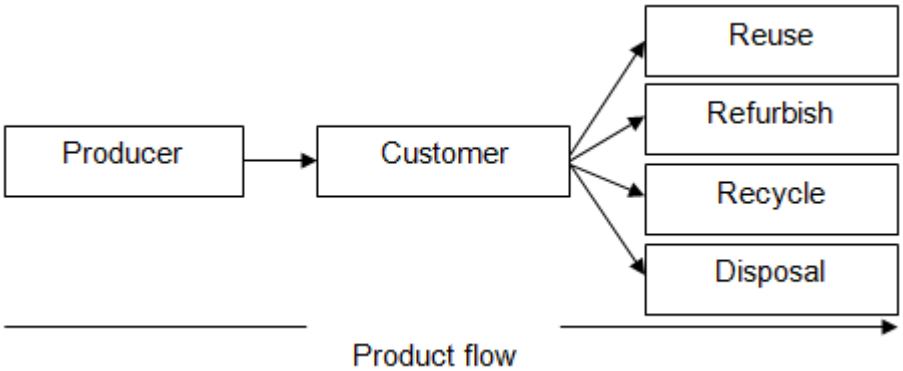


Figure 9. Product recovery supply chain model (Barker, 2008)

Following on from the ‘customer stage’, ‘take-back’ logistics aims to take products that may still be desired by other users from the re-use stage back to the customer stage, thus furthering the life of a product. The item may then be re-used, but by a new customer. Charity shops may also refurbish items to make them suitable for sale. The Salvation Army (2012) showed that over 5% of the UK’s total annual

carbon and water footprints come from clothing consumption and re-using and recycling enables further environmental savings.

In view of the current increasing population trend in the UK, the reuse and recycling of used items is of vital importance. In recent years, the population in the UK has experienced a steady and sustained increase from 59.1 million people in 2001 (IGD, 2012) to 62.3 million in 2010 (the highest annual growth rate since mid-1962) (Office for National Statistics, 2010). The population in the UK is likely to increase to 71 million people by 2031 (IGD, 2012).

McDougall (2010) indentified that the trend in UK population growth is environmentally and economically unsustainable. Raw materials and natural resources are being consumed at a rate deemed unsustainable (Defra, 2007) and under this circumstance, reuse and recycle are of essential importance to promote sustainable development. The way we, in the United Kingdom (UK), produce, consume and waste resources, has generated increasing stress on resources and environmental systems (Defra, 2005). The environmental impacts of the country's consumption and production patterns remain severe, and the inefficient use of resources is a drag on the UK economy and business (Defra, 2005). The need to reuse and recycle has been recognised by the Government and environment agencies with key targets set for the amount of waste sent to landfill which should be 35% of that in 1995 and that 33% of household waste should be recycled or composted by 2015. Because absolute prevention of waste is unrealistic in many areas, an integrated approach to waste prevention, reuse and recycling has been introduced (Defra, 2011). The Government has announced that the percentage of waste collected from both households and business which is recycled should continue increasing, at the very least meeting the revised waste framework directive target—to recycle 50% of waste from households by 2020 (Defra, 2011).

The Government's Waste Strategy for England 2007 reinforced the widely accepted 'Waste Hierarchy' and emphasised that "most products should be reused or their materials recycled" (Charity Retail Association, 2012). Figure 10 shows the several stages involved in the Waste Hierarchy.

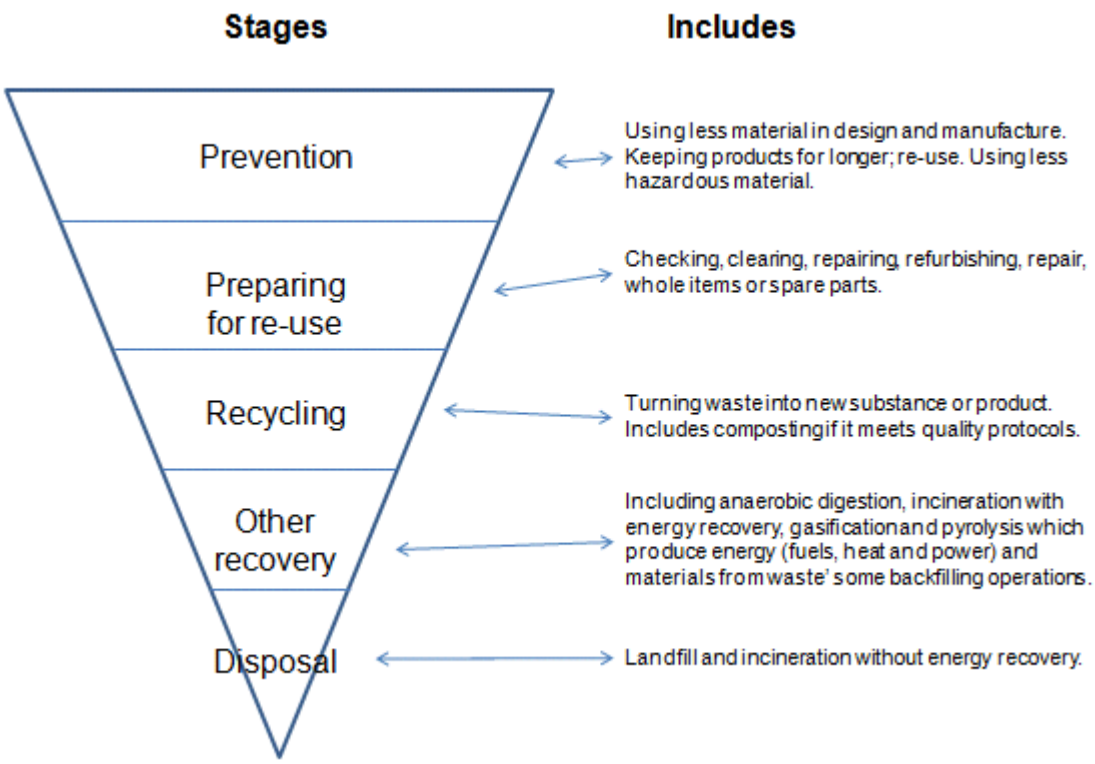


Figure 10. Waste Hierarchy (Defra, 2011)

The waste hierarchy comprises a set of options for attending to waste, preferentially ranked in terms of their perceived environmental benefit (Gregson et al, 2013). Top priority is given to waste prevention, followed by preparing for reuse, then recycling and other types of recovery (including energy recovery) before resorting to disposal (Defra, 2011).

Waste prevention is of utmost importance as this method reduces the need for new raw materials to be used, prolonging the life of a product and saving the sometimes costly process of recycling. Preparing for re-use can be necessary when a product does not need to be totally recycled, and again saves on the cost (monetary and environmental) of processing an item for recycling or disposing as waste. Preparing for re-use can result in an increase of value in a product, which can be beneficial. If the prevention of waste or preparation for re-use is not possible, due to being damaged beyond repair and if there is value in the material then the preferential method of treatment would be recycling. A variety of different materials can be recycled, in a diverse range of ways. This is a method of giving new life to a material and is important to reduce the amount of raw materials being used. If an item is not suitable for recycling then it should be processed to gain energy that can be used elsewhere (such as incineration). Disposal or incineration without energy recovery is the least preferential treatment of waste as it comes to great environmental cost.

WRAP (2012a) estimated that between 2.5 and 2.7 million tonnes of textiles are discarded annually in the UK. Of this, between 1.1 and 1.4 million tonnes are clothing.

In 2010, around 700,000 tonnes of textiles were collected for re-use, recycling or recovery. The largest proportion of this came through charity shops, which handled nearly 400,000 tonnes (56% of total collections) of clothing, footwear and bedding textiles – an increase of 47% since 2007 (WRAP, 2013).

WRAP (2012a) identified the single greatest opportunity, by weight, is to reduce the estimated 0.8-1 million tonnes of textiles sent to landfill from household waste. Clothing accounts for roughly half of the UK's textile waste. An established infrastructure exists for re-use and recycling with end markets at home and abroad. However, in 2010 an estimated £238 - £249m worth of re-usable or recyclable textiles (household textile, clothing, footwear and other textile products) were discarded through kerbside residual waste collections. Recovering just 10% of residual waste would generate a potential sales value of almost £25 million (WRAP, 2013).

2.8 Collection methods and mechanisms

This section of the thesis identifies the steps taken by charities to collect and process donations. Donation structures can firstly be split by the charity type as described in the previous section of this thesis: Independent, Hospices and Multiples.

2.8.1 Independents and Hospices

Independents and hospice charity shops generally run to fund the charitable work of localised causes, such as nearby healthcare and animal rescue centres. Due to the small number of shops run by independents and hospices (less than 5 shops typically per organisation), this intrinsically suggests localised collection methods for donations.

Donations via collection banks are transported directly to the shops via contract, in-house or volunteer drivers and sorted and sold on site. If the charity runs other shop sites, it is possible for a larger shop to be used as a hub for receiving and sorting donations before moving this stock to the other shops.

Local hospice shops attract a loyal group of customers and donors, where the work that the parent charity does is highly visible and can be appreciated by the local community (Benady, 1997) and can therefore generally run profitably on locally sourced donations.

2.8.2 Multiples

Multiples are charity shops that are run to fund the charitable work of large charities that generally work for national or international causes (e.g. Nationwide/worldwide research or projects) and run a range of varying donation structures. These are driven by the size of the charity and through historical practices. Within an individual charity, one can find examples of different operating practices by region. Study into optimal practice could enhance charity donation collections and result in cost savings for these charities.

Charities currently operate a range of different methods for transporting donated stock between their networks of shops, donation banks and sortation centres, generally dictated by the size of the charity and their policies relating to the recycling and onward processing of excess or unsaleable stock. Generally, the larger charities have a greater need for transportation of donated stock, because of the large amount collected and therefore have a greater capability for transportation. Larger charities usually operate using centralised donation collection, shop adopted bank collection or localised collection strategy, as described in the following sections.

2.8.3 Centralised collection of donations

This method of charity logistics involves collections of donation bank stock being returned to a central location for sortation and onward processing (selling/recycling). This follows the Capacitated Vehicle Routing Problem (VRP) as the vehicles used will have a limited carrying capacity (NEO, 2013). Whether this VRP involves Time Windows (e.g. limitations of access to sites constrained by time) depends on where the donation banks are located. Routes carried out with this centralised method often visit shops as well as donation banks in order to collect culled stock. Time Windows for shop collections will exist, due to shop opening times and road/ parking restrictions. Also, the majority of charity shops are located in town centres where there are more stringent rules on access and parking than in other areas.

The vehicles in this method can cover large distances and service a large number of locations. However, this method also requires fewer vehicles than other strategies

because of this. In order to accept collections from numerous donation banks and shops each day, this requires large vehicles with a great carrying capacity. With current centralised collections, a unique issue is the strategy of carrying out fixed shop collections which limits the benefits of dynamic donation bank scheduling. A similar type of problem to that considered here is the so-called 'Team Orienteering Problem' (TOP), whereby the locations to be visited are chosen to maximise a stated objective function. Variations of the TOP have included consideration of time windows and of capacity constraints.

Figure 11 shows the typical flow of textiles in a centralised collection model.

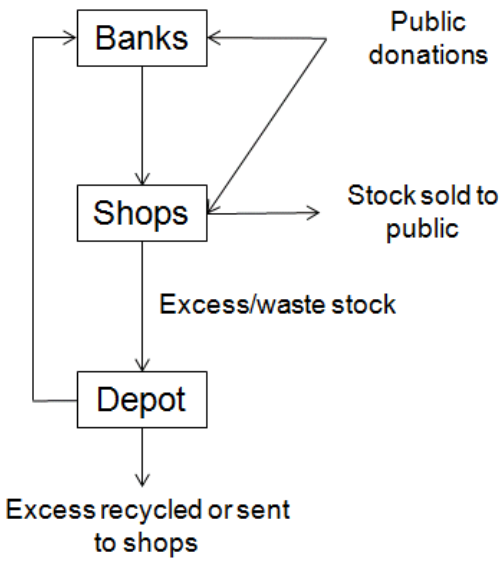


Figure 11. Centralised shop and donation bank collection model

Oxfam and The Salvation Army use centralised logistics to service many of their textile donation banks and are the only charities in the UK to use this model, through the use of in-house and sub-contracted logistics. Stock that is collected from banks and excess stock from shops is taken to the charity's central processing facility. Oxfam use a mix of in-house and sub-contract routes to move donations between banks, shops and depots. Culled stock can be sent abroad to countries in areas such as Eastern Europe and Africa to boost the local economy or processed into cleaning rags and insulation. Only a small percentage of culled stock is disposed of through incineration or land fill.

The Salvation Army

Salvation Army Trading Company Ltd (SATCoL) recycles clothing and textiles via a centralised system by providing a collection and distribution infrastructure for donated second hand clothing, textiles, shoes and accessories. The business has several aspects including over 6300 clothing donation banks in addition to household collection schemes supporting 135 charity shops (Salvation Army, 2013), through collection logistics and distribution of clothing to areas of the world where there is a need for low cost or second hand clothing.

The Salvation Army identified that they collect more clothes than can be used to stock their shops (SATCoL, 2012). The donated clothing is collected and transported to their Processing and Distribution Centre in Kettering where it is screened to remove all non-clothing items and waste (Kettex, 2012). From here goods are either distributed out to their shops or sent abroad.

SATCoL has formal links with over 250 local authorities and receives 10–15% of all the clothing, shoes, textiles and accessories donated in the UK. It facilitates the reuse of clothing by collecting, sorting, baling and transporting it to parts of the world where there is a demand for low cost clothing, in addition to running 135 retail outlets (charity shops) in the UK (Woolridge et al, 2006). Figure 12 shows the clothing recycling activities undertaken by SATCoL.

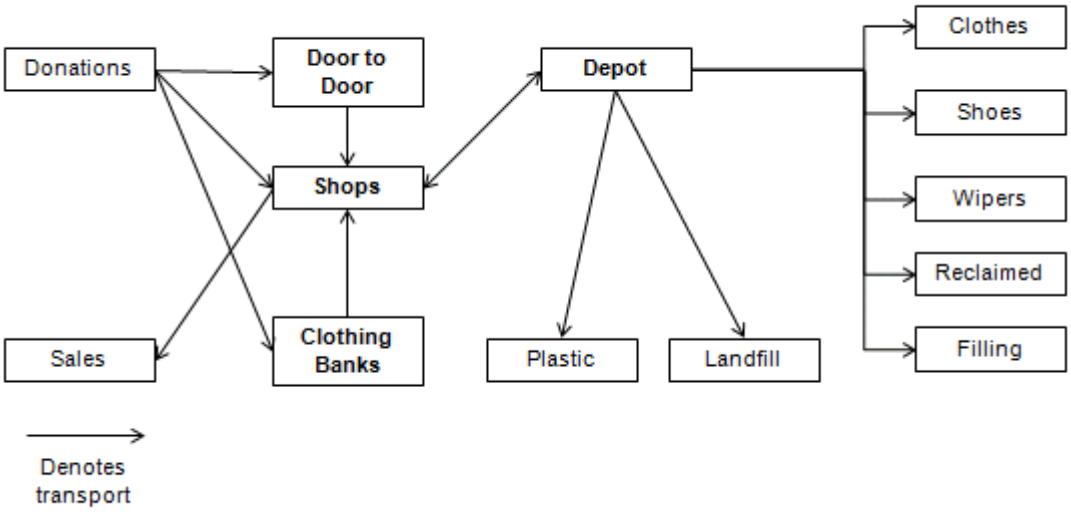


Figure 12. Key processing activities in SATCoL (Woolridge et al, 2006)

2.8.4 Shop adopted donation bank collections

As charities aim for their shops to be more self-autonomous, many are aiming to allow shops to “adopt” donation banks. Shops are then tasked with servicing and maintaining the donation banks rather than relying on centralised or area-level servicing enabling the charity to find mileage savings.

This concept assumes that charity shops will adopt a certain number of ‘local’ donation banks and will service them using their own transport resources (car or small van). This would involve shop volunteers using their own personal transport to service the donation banks if in close proximity to the shop. Currently for shop adopted donation banks, the distance and method of collection depends on the resources the shop has to empty the donation bank(s). Some areas (North Yorkshire and Reading for example) have area van drivers who empty the donation banks for the shops, otherwise the staff and volunteers service the donation banks themselves, using their own vehicles. The rationale behind shop adopted donation banks is that it enables shops to be more self-sustaining, taking away the need for a driver that services the area, potentially saving on mileage and travel running costs. The aim is that shops that can rely on a steady stream of new textile donations from donations direct-to-store and through their own adopted donation banks rather than rely on what the man-with-van delivers on his usually weekly visit. Figure 13 shows the flow of stock for shop adopted donation bank collections.

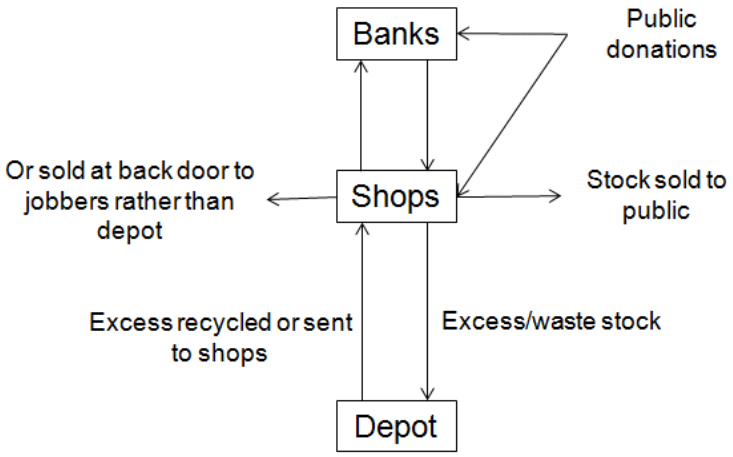


Figure 13. Shop adopted donation bank collection model

This follows the CVRP (Capacitated Vehicle Routing Problem) (NEO, 2013) as transport used will have a limited carrying capacity. Whether this VRP involves Time Windows depends on where the donation bank is located. Many donation bank sites

can be visited at any time of day, so the main limit on Time Windows would be the availability of transport to the donation banks. The transport used with this method of donation bank collection would be a volunteer owned car or small van. Collections from donation banks can occur at any time of the day, although the shop will need to be open to accept the deliveries, unless the driver has out-of-hours access.

This method assists shops in becoming more self-sufficient as they can sell what comes from the donation banks as well as donations that come through the front door. If this strategy is adopted across a range of shops, this can require a large number of small vehicles that each covers a small area.

The validity of using volunteer drivers (possibly in their own vehicles) needs to be studied, with considerations such as costs, insurance and health & safety issues needing to be taken into account.

As an example of shop adopted bank collections, Oxfam estimate that collection distances are around 5 to 10 miles on average (Hart, 2013). This scenario could be more sustainable than centralised collections as it encourages shops to be more self-sufficient, sourcing stock for themselves rather than receiving stock via centralised means. It may also result in shorter distances being travelled to collect from donation banks, which could result in potential CO_2 and cost savings.

2.8.5 Non-centralised processing of recyclate

The non-centralised processing method requires all shop recyclate to be dealt with at the shop back door by rag merchants, as many large scale charities do in the UK. With only around 10% of donated stock coming into charity shops from donation banks and through the door donations being saleable, shops are left with large amounts of excess or waste stock. These companies find alternative uses from used textiles, such as processing into industrial cleaning rags and insulation. This minimises the onwards transport cost of excess and waste stock for the charity.

Oxfam operate a system where this stock is recycled centrally. From all Oxfam shops, the excess textiles are transported to a centralised location, where it is then sent back out to shops, transported abroad or sold to trusted companies. This is in line with Oxfam's ethical policy of only dealing with companies that are trusted under labour conditions that meet the Ethical Trade Initiative Base Code (ETI) and therefore do not involve the abuse or exploitation of any person. Oxfam also seek to

work with those who have the least negative impact on climate change and the environment (Oxfam, 2013).

2.8.6 Localised collection strategies for donations

Localised collection of donation banks is a more common method used by charities to collect from donation banks. Figure 14 shows the flow of stock for localised collection of donations. Localised collection can be used in conjunction with centralised take back. For example, Oxfam use a combination of centralised and localised collections from their donation banks.

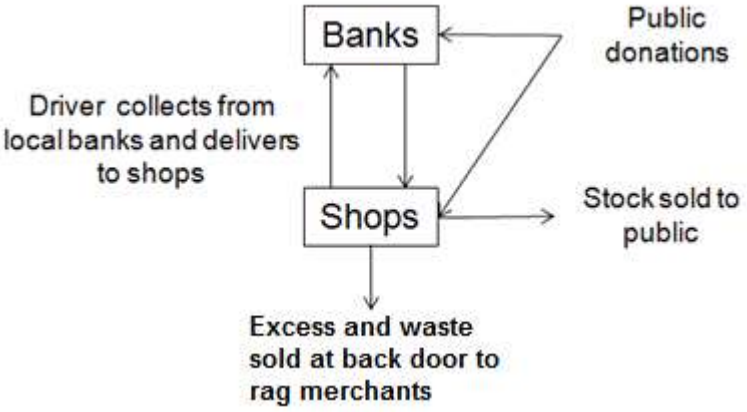


Figure 14. Localised donation bank collection model

Oxfam

Although Oxfam service around 540 textile donation banks through a centralised facility (Wastesaver), the remaining banks are serviced and processed locally out of shops. Each of the Oxfam regions has a driver which will collect from their adopted donation banks before returning to a location within the region.

As an example, in the Dorset region, the local driver collects from 32 donation banks around the area with the majority of the textile donation banks serviced by Oxfam subcontractors. However, the Dorset driver collects from 4 textile donation banks, where the contents are processed and sold locally. The remaining donation banks in the driver's route (28 book and music donation banks) constitute the main focus of the collection rounds and the stock is sorted and processed for local sale at the Winton Distribution Centre. Stock is then distributed to local shops as well as being sold through Oxfam's online retail streams.

Oxfam have seen it fit to cascade stock between shops, enabling them to keep the stock on their shelves ever-changing and exciting for the customer. Without this transport, shops would struggle to refresh their stock for the customer.

While other charities sell excess stock at the back door of shops to rag merchants, Oxfam used centralised collection of waste from shops, through Wastesaver. This ensures that donations are processed ethically.

British Heart Foundation

British Heart Foundation run localised collection of donations between their network of 900 collection donation banks and 700 shops. British Heart Foundation collect from textile donation banks around the country, however this stock is collected, processed, sold and recycled or disposed of locally and therefore run a model similar to that of Hospices and Independent Charity shops (but on a national scale) (Violaris, 2012).

Cancer Research

Cancer Research runs one of the largest charity shop operations in the UK; however, they do not use donation banks and only receive publically donated stock through their shops or 'Donation stations' (Cancer Research, 2012).

2.8.7 Shop servicing

As well as receiving new donations from methods such as donation banks, shops can cascade unsold donations between shops. Within Oxfam, there is often a hierarchy of shops, where shops at the top of the hierarchy receive good quality donations either through the door or from donation banks. There are shops that rely heavily on donated stock that is cascaded from other shops because they do not receive enough good quality stock through the front door or from donation banks. Cascaded stock can be passed through a number of shops before reaching the bottom of the hierarchy; if donations are not sold from the shops at the bottom of the hierarchy then they can be transported to the central processing facility for release back into shops or onward processing, such as recycling.

2.8.8 Processing and distribution centres

The use of centralised collection and distribution centres by charities is not a widely used method of dealing with donations. Currently, The Salvation Army and Oxfam

are the only charities that use such facilities. This could be because of the high costs associated with running these locations and transporting donations between sites.

Oxfam operate a range of centralised locations that process and distribute large qualities of donations. These distribution centres process incoming donations by selling online (via the Oxfam online shop and other retailers such as Amazon), at festivals or by distributing donations back out to shops. Textile donations that are unsaleable are processed for recycling at the national processing facility, Wastesaver (Figure 15).

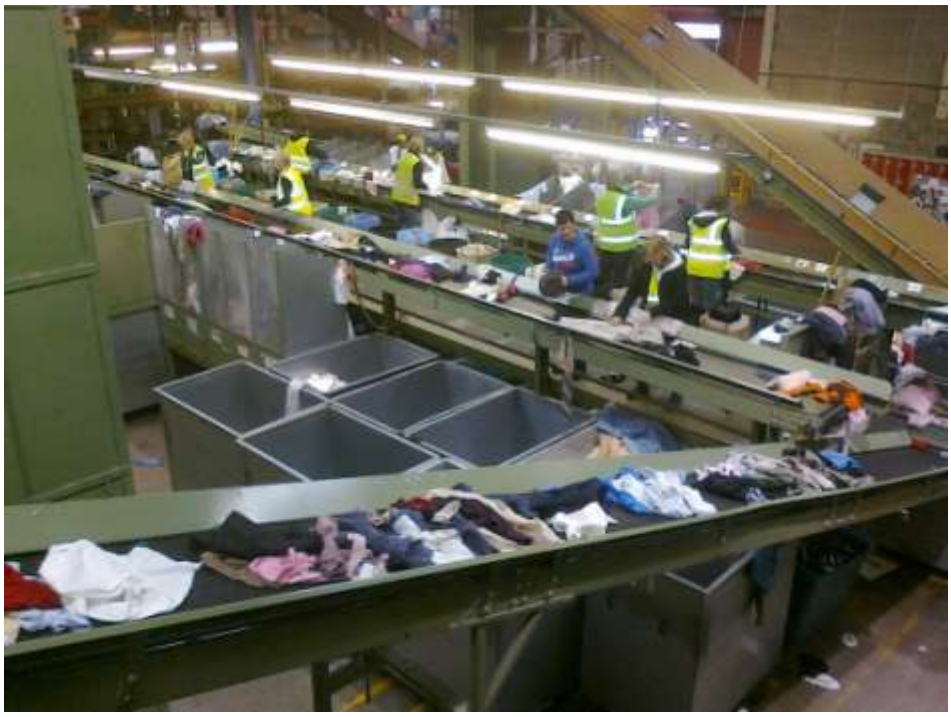


Figure 15. Textile stock sortation at Wastesaver

Book donations are processed for recycling at the nearby Bookbarn in Huddersfield.

Oxfam also use more regional logistics centres, such as in Milton Keynes, which receives donations from banks and shops within the area for onward processing.

Within operation regions, even more localised ways of dealing with donations are used. In some areas, larger shops will be used as hubs for receiving donations before the area driver moves or cascades the stock to other shops. A smaller distribution centre is run in Bournemouth, for this purpose. Although members of the public can buy from this location, the majority of work undertaken here is sorting

through local bank stock, listing items on the online shop and distributing stock to local shops.

2.8.9 Donation theft

Textile theft from charity collection donation banks has been identified as an increasing problem within recent years (MRW, 2009). Indeed, as at mid 2013, unsorted donated clothes were fetching around £1,000 per tonne, three times the price of 2006 (Charity Bags, 2013). There has been a rise in theft in recent years because of the growing price of textiles and the emergence of companies who take in bulk textiles and buy for cash, such as Cash 4 Clothes.

The British Heart Foundation reported losses of around £3million during the 2010 financial year resulting from the theft of doorstep donations and clothing donation banks (British Heart Foundation, 2010) and this is expected to rise. Theft of textiles and bogus collections are important to consider for three reasons:

1. They affect public perception of textile collection, and so can deter the public from supporting door to-door collections, textile donation banks, etc.

2. They can jeopardise the viability of other legal collection schemes.

3. They reduce the volume of textiles officially re-used/recycled.

The British Heart Foundation (2010) highlighted CCTV evidence showing thieves targeting textile donation banks in a variety of ways:

- *Skimming,* where clothes can be pulled out through the donation bank chute. In recent years where theft has been confirmed as a problem, measures have been taken to reduce theft, such as introducing anti-theft chutes (designed specifically to hinder unauthorised access).
- *Breaking the lock:* by drilling, filling with glue or by cutting through the door with oxy-acetylene torches. Metal guards have been placed on the donation banks near the lock to try and reduce theft. Also, different lock types have been introduced to combat theft further. In some cases, the thieves have been known to place their own locks onto the donation banks, so that only they have access to what is inside. They have also been known to glue the lock so that no one has access to the donation bank, except them, through the chute.
- *Sending in small children* through the clothes cute to pass clothes out.

- *Distracting drivers* while the donation bank is open for collection.
- *Tipping donation banks over* for easier access to the clothes inside.
- *Moving the bank* to a private location.

In recent times, the problem of bank theft has been highlighted and steps have been taken to reduce it. The BIU Group (who run recycling banks for their charity partners, such as Air Ambulance) addressed this by developing and rolling out the UK's first electronic, no-key textile bank with a new chute and locking system, making them extremely secure and near impossible to break into (MRW, 2013). Since the first electronic banks were trialled in 2009, all 1,100 banks have now been upgraded. This has resulted in an estimated 20% increase in yields in areas where old banks were being targeted. Since upgrading, theft has been virtually eliminated, so BIU is able to guarantee tonnages to customers throughout the year, who in turn can offer a stable price all year.

2.9 Current use of ICT in charity logistics

In recent years there has been an increase in ICT usage in the logistics sector. This section of the thesis investigates the key technologies that are being and could be used by charities to aid their logistics management.

2.9.1 Satellite navigation

Satellite Navigation (Sat-Nav) uses a system of satellites that provide autonomous geo-spatial positioning with global coverage (Penn State, 2007). It allows electronic receivers to determine their location to within with a few metres using time signals transmitted along a line-of-sight by radio from satellites. This allows users to map their position on an electronic device that also creates directions to the desired destination. With the widespread availability of satellite navigation and tracking technologies via the use of satellites, it has become more possible for a wide range of companies and associations to use this type of technology.

Mapping and Sat-Nav can firstly aid collection strategy on the most basic level. Sat-Nav devices can enable drivers to enter destination locations, using their postcode, into the device and will enable the shortest/fastest route to that destination to be identified. Sat-Nav can also assist in avoiding traffic incidents, congestion charges and toll roads. Sat-Nav technology has the ability to show the severity and effect on travel times live and subsequently identify faster routes. This technology can be of use to charity collection strategy, where routing can be improved to follow the

shortest or fastest route between sites. Research by the AA (2012) indicated that drivers using a Sat-Nav system drive 16% less miles and spend 18% less time driving than those without Sat-Nav. Also, drivers are likely to spend 35% less time stuck in traffic.

Issues with Sat-Nav technology have been identified, and have caused significant problems especially in the logistics industry. Sat-Nav devices have been known to send large goods vehicles on routes that are impossible to navigate. For example, the road may be too narrow to navigate, or the vehicle may come up against a low bridge. Out of date or incorrect directions have often misdirected traffic. Figure 16 shows a heavy goods vehicle (HGV) that has been directed down a road that is unnavigable.

Figure 16. Use of GPS results in unintelligent routing (Baltimore Sun, 2012)

This problem is being combated by updates to the Sat-Nav systems. As an example, TeleType has produced a Smartphone Application called SmartTruckRoute that recognises the specialised needs of HGV drivers by creating HGV friendly routes with the added benefits of live map updates and live traffic (PR, 2012). The software takes into account commercial truck restrictions and helps drivers avoid costly tickets and provides additional safety.

Some Sat-Nav systems have been developed with the needs of HGV drivers in mind, including the capability for routing based on the vehicle specifics such as weight, width, height and load being carried to help drivers avoid hazards such as low bridges and narrow lanes.

Although, the driver's knowledge of local roads is important for avoiding problems such as this, Sat-Nav can assist in visiting locations not known by the driver. Sat-Nav can also assist in changing a driver's attitude towards the possible shortest/quickest route on his journey.

2.9.2 Personal Digital Assistants

In recent years, along with other sectors involved in collections and deliveries, charities can use Personal Digital Assistants (PDAs) to help with their logistics effort. These come in the form of small handheld computers that can be used to track collections and deliveries on the go. This technology is useful because it reduces the need for paperwork and allows collections and deliveries to be logged straight onto a central system once the route has been completed. This allows the company/organisation to keep track on the movement of all stock and to quantify their logistics effort. Commercial grade Smartphones are now being used within the industry as they include all the features and functionality of a rugged PDA.

The PODFather system has been employed by Oxfam to realise time and cost savings by streamlining the workload of the driver (PODFather, 2009). The system allows the charity to understand the types of collections made – clothes, books, shoes – and the weight of each bag collected. It results in optimised recycling processes and records all daily practices remotely, that can then be viewed online. The system is only currently used by the drivers of centralised collections, where the more localised man-with-van still operates using paper records.

2.9.3 Remote monitoring

Remote monitoring allows the stakeholder in a system to view its assets and track their status and efficiency remotely. Within the logistics industry more specifically, remote monitoring can be used for a range of purposes.

Established in 2003, Smartbin is a major player in remote monitoring and management systems for the waste management industry (Smartbin, 2010). Other companies such as BinMaster and APG Sensors also produce similar devices. The technology aims to cut costs and emissions for its users by optimising business processes. This is achieved through remote monitoring of donation bank fill levels for all forms of waste. Remote donation bank-fill level technology allows donation bank levels to be read from a central system that automatically alerts the user that a donation bank is reaching a full level and should be considered for collection.

This technology can help to alter logistics practices with the aim of optimising operations. Remote donation bank-fill level technology can be used to target donation banks for priority logistics and allows donation banks to be emptied when they are reaching near-full levels. With knowledge of donation bank fill levels, the charity can aim to optimise collections and with an incorporated understanding of donation bank theft, adjust their collections accordingly. Remote monitoring allows unauthorised bank servicing to be recorded and can help to provide estimates on the amount of donations being stolen.

Using Smartbin's advanced donation bank-monitoring technology, Wilcox Textile Reclaimers achieved a 37% reduction in the cost of collecting materials from its bins throughout the United Kingdom (LAWR, 2011). Based on the efficiencies derived from a 10-week trial covering 14 of its strategically positioned textile recycling donation banks, Wilcox has extended the use of remote donation bank-fill level technology and services to all of their 1,500-plus donation banks throughout its entire collection system.

Wilcox immediately saw the advantages of remote donation bank-fill level, including: up-to-the-minute, real-time information about the exact level of fill in all collection donation banks; dramatically reduced collections costs; indisputable documentation of chain of possession and disposition of materials; and help with compliance with ever-stricter waste management regulations.

The use of remote donation bank-fill level technology demonstrated that previously many donation banks were being serviced/emptied when the donation banks were only 25-percent to 50-percent full, and that on some occasions the donation banks were overflowing and site clean-up was necessary in addition to bin servicing, which at times exposed Wilcox to fines from the site owners. Instead of collecting on a 'milk-run' basis (once per week, twice per week, etc), the collector can collect the maximum amount of material with the minimum cost of collection. Also, this technology allows theft levels within donation banks to be identified and quantified; something that has not been possible in the past. Aside from the scheduling benefits, remote monitoring of banks can also help charities quantify their performance in terms of average yields by area and time of year. This can also aid bank placement strategy, which could be optimised by understanding temporal yields, theft rates and the changing characteristics of the local population (McLeod et al, 2014).

Arebey, et al. (2011) described a system combining RFID (Radio Frequency Identification) tags, cameras, GPS (Global Positioning System) and GSM (Global System for Mobile Communications). Cameras on collection vehicles measuring waste levels before and after collection by monitoring black pixels, indicating the number of bin bags present. This data links to the GPS location of vehicles and identity read from RFID tags on bins. This data combination was proposed to predict fill levels and optimise collection vehicle routing.

A study in Pudong, China (Rovetta et al, 2009) investigated the deployment of prototype bins using various technologies and captured real time data for enhancing vehicle routing and scheduling. Sensors used included ultrasonic fill detectors, cameras viewing type of waste, temperature/humidity sensors and weighing scales.

In another deployment case study, the fill levels of 3300 Swedish donation banks were monitored using hourly updates. Operators were found to lack IT knowledge through a lack of training, so strategies involving the data were not adopted. However if adopted the system was estimated to produce cost savings of 10-20% (Johansson, 2006).

Many new large scale bin monitoring systems are now adopting RFID tags to increase collection efficiency. Californian based AMCS uses RFID to tag bin locations using GPS, helping optimise vehicle fleets and making bins identifiable, furthermore damaged or missed bins can be recorded (Waste Management World, 2012a). Other companies use RFID to accurately record billing and service events; SSWR use this for waste collection from a city with a population of 130,000 (Waste Management World, 2012b). While several mobile phone manufactures have begun integrating near field communication (NFC); a variation of RFID into their handsets allowing: tag emulation, peer-peer transfer and tag read/write via App based interfaces (Kurt, 2011).

2.9.4 Route and schedule optimisation

In more recent years, companies have tried to use technology to provide even more opportunities to further efficiency and reduce costs.

The vehicle routing problem (VRP) is a combinatorial optimization and integer programming problem seeking to service a number of customers with a fleet of vehicles (NEO, 2013). Proposed by Dantzig and Ramser in 1959, VRP is an important problem in the fields of transportation, distribution and logistics. Often the

context is that of delivering goods located at a central depot to customers who have placed orders for such goods. Implicit is the goal of minimizing the cost of distributing the goods. Many methods have been developed for searching for good solutions to the problem, but for all but the smallest problems, finding global minimum for the cost function is computationally complex.

Several variations and specializations of the vehicle routing problem exist:

- Vehicle Routing Problem with Pickup and Delivery (VRPPD): A number of goods need to be moved from certain pickup locations to other delivery locations. The goal is to find optimal routes for a fleet of vehicles to visit the pickup and drop-off locations.
- Vehicle Routing Problem with last-in, first-out (LIFO): Similar to the VRPPD, except an additional restriction is placed on the loading of the vehicles: at any delivery location, the item being delivered must be the item most recently picked up. This scheme reduces the loading and unloading times at delivery locations because there is no need to temporarily unload items other than the ones that need to be delivered.
- Vehicle Routing Problem with Time Windows (VRPTW): The delivery locations have time windows within which the deliveries (or visits) must be made.
- Capacitated Vehicle Routing Problem (with or without Time Windows): CVRP or CVRPTW. The vehicles have limited carrying capacity for the goods that must be delivered.

The problem class that combines vehicle routing with inventory management is the so-called Inventory Routing Problem (IRP). This is relevant to charity logistics because the choice of routing is determined by how full each site is and the benefits of choosing a certain route. In an IRP, the following trade-off decisions are considered:

- At which point in time should a donation bank be serviced to empty its stock? (selection)
- How much ought to be collected in that situation? (demand determination)
- What is the best order and therefore route to service the set of selected donation banks? (routing)

The IRP differs from the VRP because it is based on the donation banks rate of demand rather than just the number of customer orders. As a result, solution

methodologies for the IRP are suitable for planning the collection servicing of sensor-equipped waste containers (Mes 2012). The containers, ideally, should be full when a collection decision is made, but at the same time they should not overflow. If a donation bank site is not visited often enough, then it can result in the donation bank overflowing, spilling onto the surrounding area. This can result in increased levels of donation bank theft. Through seeing that a donation bank is full, this can attract theft. Also, textile donations that are left surrounding a full donation bank are easy to steal. Donation banks overflowing can lead the charity to be subject to fines from the owners of the car park and council. Also, overflowing donation banks can result in missed donations, where the donator will be unable to drop their textiles due to lack of space in the donation bank. Overflowing donation banks also serve as a poor advert for the charity and lead the public to believe that the charity does not value their donations. The most important decision here is when to service a donation bank.

Whilst showing drivers the best route from point-to-point, this technology can also be used to show drivers the best route to visit a range of points. Route optimisation software packages (such as DPS Logix, Paragon and Truckstops) can be used in this way to increase operational efficiency. By giving the software a point of origin and final destination as well as a range of other sites to visit, the software can help to ascertain the most efficient way of visiting these locations. Numerous different software packages are available for the purposes on route optimisation.

Many organisations have used route optimisation to increase performance and improve efficiency. As an example, Jeppesen has for over 70 years grown from the supply of navigational tools for the aviation industry. Jeppesen (2008) identified that Cadbury Schweppes (an international beverage and confectionery company with worldwide revenues in excess of £7.9 billion in 2007) had a complex delivery operation. Prior to the implementation of PlanOp (a software toolbox for transport, logistics and distribution network design and analysis), planning was conducted manually by sorting all deliveries by location code and dividing them into logical shipments. This process did not deliver the desired routing efficiency. The challenge for Jeppesen was to minimise the number of trucks required and also minimise the number of kilometres travelled by Cadbury Schweppes in their daily deliveries in the Sydney and Melbourne (Australia) metro areas. By using PlanOp's Vehicle Routing Optimiser on the operations of Cadbury Schweppes, Jeppesen identified that there was a significant reduction in delivery costs associated with an increase in efficiency of their delivery operations. Savings in excess of 40% could be achieved (Jeppesen,

2008). PlanOp operates by cataloguing details of vehicle fleets, point to-point travel times, product types and service standards, depot and transport hubs, driver regulations and availability, product flows, and vehicle and crew schedules. PlanOp combines these data into the one network model (Jeppesen, 2008).

Apaydin and Gonullu (2005) identified significant potential distance savings (24.7%) and collection and hauling time (44.3%) for a municipal solid waste management system in Trabzon, Turkey. The Route View Pro software package was integrated with Geographic Information System (GIS) elements such as numerical pathways, demographic distribution, container distribution and solid waste production was used as an optimisation tool.

In Nigeria, Ogwueleka studied the problem of solid waste collection within the city of Onitsha. Ogwueleka (2009) identified that in most Nigerian cities, solid waste collections are done in an ad hoc manner, which contributes to high solid waste collection cost. Solid waste collection vehicles are assigned to zones without any serious demand analysis, route construction being left to the drivers. Every time the vehicle is filled up, it heads to the disposal site to unload and then returns to the zones. The technique for optimisation combined computer and heuristics approaches. The adoption of the proposed heuristic in Onitsha resulted in reduction of the number of existing vehicles, a 22.86% saving in refuse collection cost and 16.31% reduction in vehicle distance travelled per day (Ogwueleka, 2009). Route optimisation allowed for the number of vehicles to be cut from 4 to 3 per day. Because of the shorter operational time and reduced runs for trucks, reductions in operational and labour cost were achieved. In the proposed algorithm, it is easier to pull a truck off the road for repair and maintenance, thus helping to extend vehicle life. Efficient routing of solid waste collection vehicles would reduce costs by reducing the labour expended in collection. The algorithm would provide optimal route, conserve energy, and reduce working hours and vehicle fuel consumption.

Significant distance and time savings have been found across a range of countries and organisations by using route optimisation techniques. Any organisation that operates a complicated and extensive logistics structure could benefit from using route optimisation.

Route optimisation allows for the efficiency of the current donation bank collection strategy to be identified by comparing the base case to alternative routing methods. Furthermore, the technology allows for alterations to be made to the strategy and the benefits/disadvantages of such strategies can be tested. Changes to how

collections are made will inevitably have some impact on the efficiency of the system.

2.9.5 On-the-go decision making tools

With the advent of Smartphones, this opens up the possibility for further improvements in logistics strategy. Devices such as the iPhone enable on the go and informed decision making. Whilst route optimisation allows for improved efficiency, technology that allows on -the-go decision making can improve the dynamism and reactivity in an operation, particularly in a charity setting which relies on volunteers working through a mixture of strong and weak social ties.

Until recently, most Applications (also known as 'Apps') have been targeted at consumers (Graat, 2011). For example, FedEx and UPS run mobile applications for iPhone and Android, where the main feature is for the customer to track and trace packages. A wide range of companies are now using Smartphone Apps in a variety of ways to assist in their logistics efforts with almost 20 times as many transportation applications available for mobile devices in 2011 as there were the year before (Johnson, 2012). Popularity of these Apps is set to increase due to the prevalence of Smartphones and the ability for staff to use their own devices for work purposes as part of their existing tariff, therefore providing a cost efficient tool. The versatility, portability and growing functionality of these device platforms is set to increase their use further.

The director of Central Freight Lines Inc in America says that "these mobile Apps give us a better way to handle drivers rather than just answering radio and telephone calls" (Johnson, 2012). For example, Smartphone Apps can allow a fleet of vehicles to be easily tracked, and if a change to any scheduling is deemed necessary, the drivers can immediately be contacted and informed through the App. Examples of tracking Apps include FleetMatics Mobile (FleetMatics, 2015), Contigo GPS Fleet Tracker (Contigo, 2013), MyCarTracks (MyCarTracks, 2015), TSO Fleet Pro (TSO Mobile, 2015), Fleet101 K2 Mobile (Fleet101, 2014), MiX Fleet Mobile (MiX Telematics, 2014), GPS Insight (GPS Insight, 2015).

Commercial grade Smartphones now offer a simple, cheaper alternative to having to purchase bespoke PDA systems for logistics and stock management. This technology could be useful for organisations such as charities, whereby the use of personal devices means that they can participate in more informed inventory management at no additional cost to the charity.

2.10 Summary

Charity shops are increasing in number faster than any other major retail sector. They make profit by selling a range of used goods that are donated by the public (while some also sell new goods in addition to the used goods). Of real interest is how charities receive their donations and move them around the system in order to sell and make profit.

In order for charities to make profit from used donated goods, the public has to provide a steady stream of donations. One of the most popular goods for sale in charity shops is clothing. The public disposes clothes for a number of reasons, such as changing fashions and boredom with their clothing as well as wear and tear. The public can choose to donate their old clothes to charity shops and can do so via a range of different options, such as direct to shop or through donation banks that are located in a range of public places, such as car parks and waste recycling centres.

Charities place these donation banks in areas that are projected to receive donations through exposure to the public. Charities use a range of different methods to collect stock from these donation banks and move it to shops and processing facilities. Localised collection is a popular method used by charities.

This section of the thesis has highlighted the different methods that charities use to receive public donations of textiles, books and other types of goods. This includes:

- The use of donation banks
- Kerbside and door-to-door collection
- Direct to shop
- Other types of collection; such as temporary school and work donation centres.

The types of goods that charities accept as donations include:

- Textiles
- Books
- Music, DVDs, videos and games
- Bric-a-brac

Charities use a variety of different methods to transport this stock from the point of donation to their shops or sortation centres. In recent times, ICT technology has been brought in to help optimise logistics practices, with methods such as:

- Satellite navigation
- Route optimisation
- On-the-go decision making tools, such as Smartphone Apps
- Remote monitoring of assets

There has been very limited study in the charity sector as to how these technologies can help optimise reverse logistics collections. This study has looked into how charities can optimise their logistics through two main methods:

1. Improve the quality and quantity of donations received to donation banks.
2. Optimise the way in which donation banks and shops are serviced.

The majority of donations received by charities such as Oxfam are received through donation banks. If the way in which donation banks placement is found to be affected by a range of local socio-demographic factors, then this could result in a significant increase in the value of donations taken via this method.

It has been identified that the quantities of recycling can be increased by placing bins in areas of convenience; with high throughput and ease of visibility (Stantec, 2009). It is also important to promote a culture of recycling and reusing.

In terms of increasing the quality of recyclables, recyclers have identified the importance of reducing contamination of general waste and unwanted items to collection facilities. This can be managed through effective donation bank placement and signage notifying the public of desired and undesired deposits.

Little research has been done into understanding how charities and other sectors use demographic data postcode profiling and population statistics to work out where to site collection facilities in order to maximise yields and this paper tackles that issue. The concept of siting donation banks in areas that are expected to produce more or better quality donations enables charities to make the most out of the resources available to them. Many charities are struggling to bring in sufficient amounts of quality stock. Understanding where to site donation banks could potentially lead to higher yields and better quality stock. Any increase on the amount of donations and quality of stock would have a positive effect on charity profits.

Chapter 3: Methodology

This section of the thesis looks into how the gaps in knowledge have been tackled and what processes have been undertaken to meet the objectives. The methodology adopted to meet the research aims and objectives of this study is split into four main areas:

1. **Understanding current charity logistics operations**: Examine how charity logistics operations currently function in the UK
2. **Donation bank placement strategy**: Determine what factors affect the quantity and quality of charity donations
3. **Alternative collection strategies**: Quantify current logistics practices and identify options for making them more reactive and sustainable
4. **The use of technology to improve logistics**: Quantify the potential benefits of alternative operating practices

3.1 Understanding current charity logistics operations – a case study on Oxfam

Initially the study aimed to understand how charities operate using Oxfam as a case study. The first part of the methodology therefore addressed how charity logistics function on the ground, relative to the various operating models identified in the literature review. Several linked activities were designed in an attempt to quantify the impacts of current operations and identify how a major charity services its infrastructure and facilities:

Data regarding Oxfam's operations were obtained relating to their donation bank and shop servicing activities at the local level (a specific case study in Dorset) and as part of a centralised take-back system (Milton Point case study).

3.1.1 Investigation localised collection strategy – understanding business as usual trends

This activity involved understanding the daily activities of a man-with-van driver, which is replicated in 32 Oxfam regions across the country. This involved studying the routes taken by the driver on a day to day basis and recording and quantifying the activities undertaken to build up a 'business-as-usual' base case from which alternative operating scenarios could be modelled. The routes undertaken by the

man-with-van driver in Dorset were mapped and quantified using Logix route optimisation software.

Initial discussions with Oxfam suggested that little formal data were recorded on the localised collection operation and as part of a Research Councils UK (RCUK) funded research project, '6th Sense Transport', an opportunity arose to aid in the design and development of a Smartphone App to gather the operating data needed for this part of the research. The Smartphone App (described in Section 3.4) enabled the activity of the local area man-with-van driver and his interaction with the area donation banks, shops and additional collections to be monitored in real-time to understand bank and shop performance, mean fill levels of donation banks, transaction histories and the stock transfer relationships between shops and between banks and shops.

The Smartphone App was trialled in a variety of Oxfam operating areas to gather the data necessary for the research (Figure 17):

- W14. Routes starting and finishing at the Winton Distribution Centre in Bournemouth, serving the surrounding area and north towards Bristol and Bath.
- S05. Routes starting and finishing in Watford, serving the surrounding area and south-west towards Reading.
- C01. Routes serving Cambridge and the surrounding area east towards Ipswich.

Figure 17. Smartphone App trial regions

3.1.2 Investigating centralised collection strategy – understanding business as usual trends

Data were taken from the PODFather system for one working week (3/9/12 – 7/9/12) from Milton Point shop and bank collection routes. PODFather is the system used by Oxfam whereby drivers record collection and delivery data into a handheld system that feeds into a centrally held record. Data was downloaded through the Oxfam PODFather website to determine the time and duration of site visits along with kg collected at each site. This data was then compared against mean statistics from between September and November 2012. This week was chosen as the amounts collected were generally greater than the mean statistics, to show that the system can cope with peak periods.

A base case of business as usual was created using Logix route optimisation software to compare against alternative collection strategies as shown in chapter 3.3.2.

3.2 Optimising donation bank placement strategy

The literature suggested that quantities of recycling can be increased by placing bins in areas of convenience; with high throughput and ease of visibility (Stantec,

2009). It is also important to promote a culture of recycling and reusing (Martin, Williams and Clark, 2006). In terms of increasing the quality of recyclables, recyclers have identified the importance of reducing contamination of general waste and unwanted items to recycling collection facilities (WRAP, 2010). This can be managed through effective recycling donation bank placement and signage notifying the public of desired and undesired deposits.

From the literature review, little research appears to have been done into understanding how charities use demographic data postcode profiling and population statistics to determine where to site collection facilities in order to maximise yields. The concept of siting donation banks in areas that are expected to produce more or better quality donations enables charities to make the most out of the resources available to them. Many charities are struggling to bring in sufficient amounts of quality stock. Understanding where to site donation banks could potentially lead to higher yields and better quality stock. Any increase on the amount of donations and quality of stock would have a positive effect on charity profits.

3.2.1 Identifying factors affecting donation quantity and quality

In order to understand the factors influencing the value of donated textile stock to charity donation banks it was important to break this down into two separate approaches:

- The factors affecting the quantity of textiles donated
- The factors affecting the quality of textiles donated

These two approaches were then combined to give an overall idea of the factors affecting influencing donation values.

This study was approached with the hypothesis that the demographics of an area can have an effect on the quantity and quality of textiles donated to local donation banks.

Firstly, the study aimed to identify the key factors influencing the quantity of textiles donated to charity donation banks. This was achieved through using historic donation bank collection data (2010-2011) from Oxfam for 488 donation bank sites to develop an analytical framework to explore the variability in charity collection donation bank weights countrywide.

The study of literature and preliminary discussions with the Oxfam donation bank manager identified two possible groups of explanatory variables that were used to predict donation bank site collection weights, physical factors related to the location (or relative location) of the donation bank and socio-economic factors related to the characteristics of the local population. Overall 11 explanatory variables were included in this analysis as follows:

Physical Factors

i) Region

Although the precise location (postcode) of each donation bank site was known, for practical (and Oxfam administrative) purposes the donation banks were grouped by county. Exploratory analysis within the dataset however suggest that higher average monthly weights were typically found in more southern counties (donation banks in the south received donations around 400 kg more per month than donation banks in the north) and that the counties could be effectively clustered into six regional groupings (Figure 18).

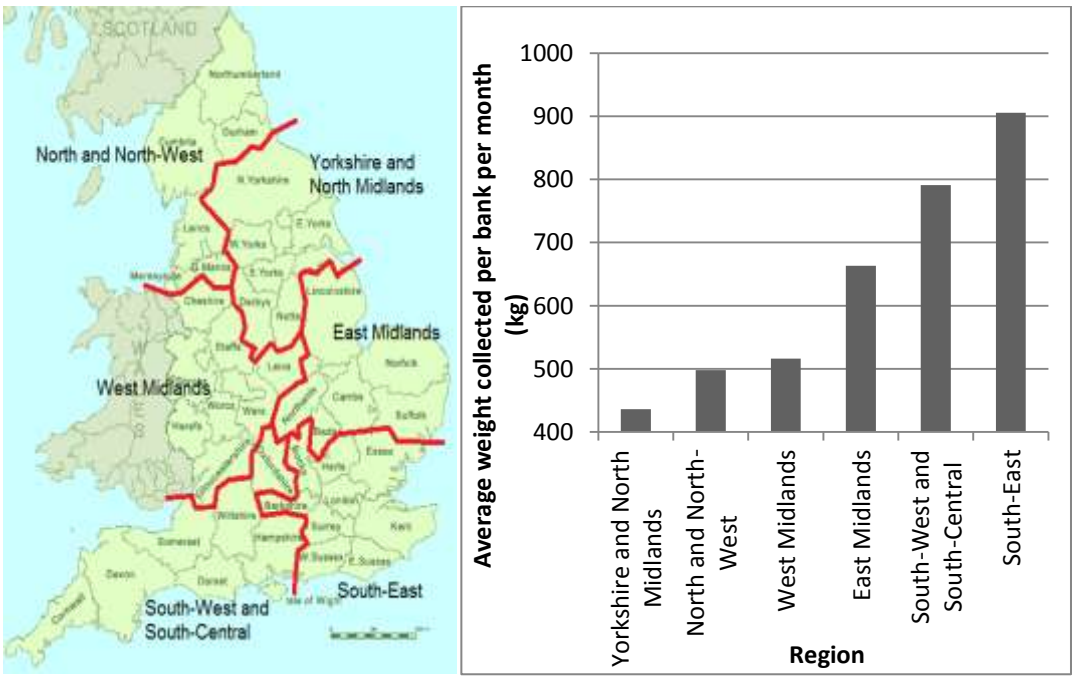


Figure 18. Regional Groups

ii) Population Density

As it could be expected that areas of higher population density would provide greater potential donation volumes within the 'catchment area' of a donation bank, population density data was derived from 2001 Census Data 'Neighbourhood Statistics' website (Office for National Statistics, 2012). The population density (number of persons per hectare) for each donation bank site was identified from the most detailed level for which data was available, usually the 'Super Output Area Middle Layer' (a geographic hierarchy designed to improve the reporting of small area statistics in England and Wales (NHS, 2010).

iii) Supermarket

Exploratory analysis of the dataset identified that supermarket car-park locations were often associated with higher monthly weights. Further examination identified that this effect was primarily due to three main supermarket brands (Asda, Tesco and Sainsbury's) where the average monthly donation bank weight was 770.1 kg (**Error! Reference source not found.**); these three brands were therefore combined into a 'Major Supermarket' Group.

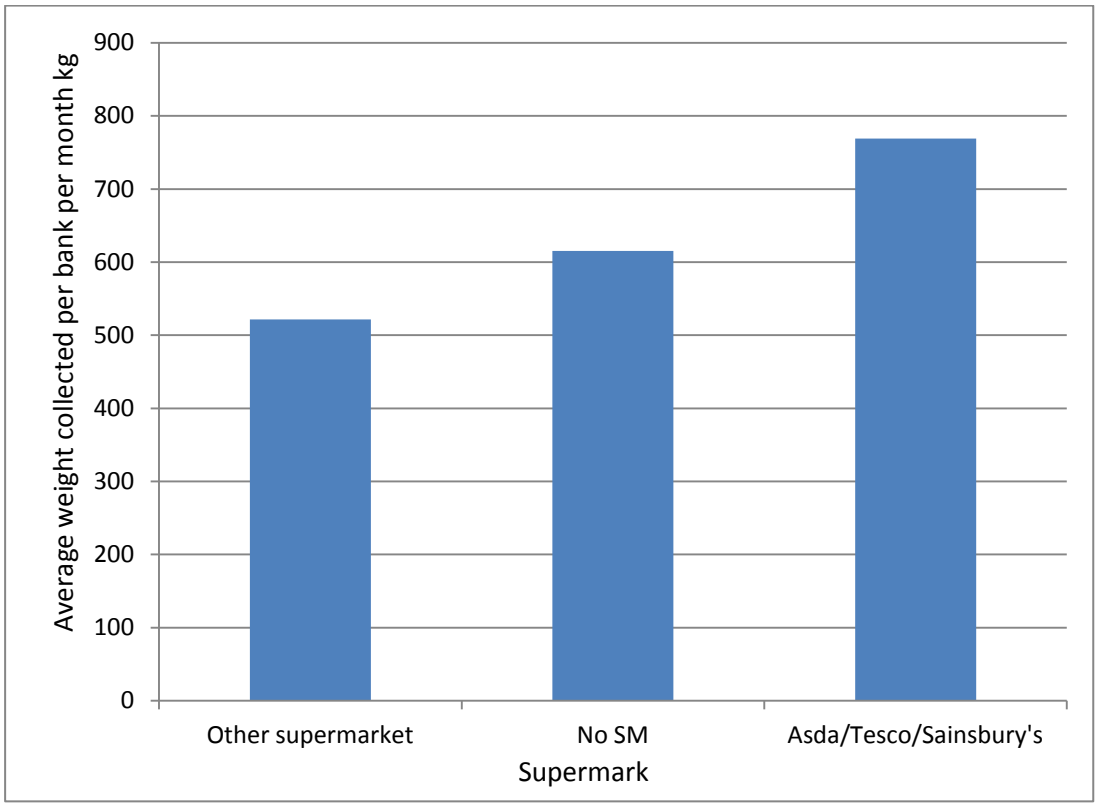


Figure 19. Donation bank performance based on supermarket

This grouping appears reasonable, as supermarkets in this group could be expected to have the largest car parks with the easiest level of access and visibility to services including textile recycling donation banks.

The remainder of the supermarket brands (a 'Minor Supermarket' group including Morrisons, Waitrose, etc.) seemed to have less impact overall (when taken in isolation from other explanatory variables at least) with an average monthly donation bank weight of 522 kg, similar to donation banks in the final 'Non-Supermarket' group with an average monthly weight of 616 kg.

iv) Proximity to Alternative Recycling

The nearest alternative textile recycling point for each donation bank site was found from an online recycling facilities site (Recyclenow, 2012). This site calculates crow-fly distances to the nearest textile (and many other) recycling facilities and by entering the postcode of each donation bank site the distance to the nearest alternative textile recycling facility could be identified. It should be noted here that occasionally there are alternative textile recycling facilities (other charities) at the same donation bank site, but these would not have been identified in this way.

v) Proximity to Schools

The nearest school to each donation bank site was found using the Government school finder website (Directgov, 2012). While a fuller analysis could take into account the number of schools in close proximity of the donation bank site, the difficulty in establishing the boundary of such a catchment area led to the use of two explanatory variables, the distance to the nearest first/middle school and the distance to the nearest upper school as proxies for the overall impact of local schools.

Because it could be expected that textile donation banks with closer proximity to schools should result in higher amounts of stock donations as they are passed more frequently (similarly in effect to supermarkets), it was deemed necessary to only include schools with over 100 pupils in this assessment as smaller or specialist schools could therefore have only a limited effect on the amount of textiles received to nearby donation banks.

Socio-Economic Factors

vi) Mean Age of Local Population

These were derived from 2001 Census Data (Office for National Statistics, 2012).

vii) Average Value of Property Sales

The average value for local property sales was derived from 2001 Census Data, found on the Office for National Statistics 'Neighbourhood Statistics' website (Office for National Statistics, 2012). It is of interest to the study to understand what effect local property value has on stock donation, with higher house price areas expected also expected to produce better quality stock as well as greater volumes.

viii) Local Postcode Deprivation Index

Postcode Deprivation Index is used by the Office for National Statistics. Ranked from 1 (most deprived) to 32,482 (least deprived) are all of the neighbourhoods in England. This Index is the result of combining a number of indicators including income, health, employment, education deprivation, barriers to housing and services, levels of crime and living environment deprivation into a single deprivation score.

ix) Percentage of Local Population on Job Seekers Allowance

These were derived from 2001 Census Data (Office for National Statistics, 2012). The percentage of local population on Job Seekers Allowance has been included as it provides another way of viewing local 'deprivation' and seeing its effect on textile donation bank donations.

Temporal Factor

x) Month

The final possible explanatory variable is the month of collection that the donation bank weight data relates to. Exploratory analysis (shown in Figure 55) suggests that although generally higher levels of donations occur through the summer months, it is not appropriate to simply group the months into seasons due to the occurrence of peaks at different times during the year. These peaks include January (possibly reflecting a post-Christmas / New Year clear-out), March and April (when people will most likely be clearing out used winter clothing to make space for summer clothes) and September (the reverse, but also possibly the impact of the new school year).

A traditional analysis of variance approach was used to identify which factors had the greatest effect on the weight of donations received from each site.

Other explanatory factors

Other explanatory factors were considered and could have been used in the analysis, such as local crime rates. In a future study, a different range of factors could be used as part of a similar analysis. The 11 factors used were thought to be able to produce an effective predictive model and more factors used in this analysis could have complicated the model.

Data were collected for all Oxfam textile donation bank sites for all of the explanatory variables listed above. A model was created that enabled predictions to be made on the quantity of stock received from a site based on its attributing factors. Traditional analysis of variance (ANOVA) approaches to identify which explanatory variables should be included in a predictive model for the weight of items donated were unsuitable, as the volume of data leads to even the smallest random effects appearing highly significant.

However, it was possible to use a variant of forward variable selection techniques to develop an appropriate model structure. Whereas traditional forward variable selection techniques (Brant, 2004a) assess inclusion based on highest significance (lowest p-value), when all variables are highly significant an alternative criteria based on greatest increase in model fit (R^2) is appropriate. This approach is best illustrated by Maynard, Cherrett and Waterson (2009) who sequentially identified the explanatory variable (and its 2-way interactions with other variables already in the model) which most improved model fit.

Specifically this becomes an iterative procedure starting with a model only including a constant term. At each subsequent iteration, (a) all non-entered variable main effects and (b) all non-entered two way interactions between main effect variables already entered in the model, are individually assessed for inclusion. The additional variable or interaction that leads to the greatest increase in model fit R^2 (equivalent to the greatest reduction in error mean square) then is added into the model and this becomes the basis for the next iteration.

3.2.2 Case study locations

Certain areas have been studied within England to test the efficiency and performance of Oxfam's systems and to recommend potential improvements to their logistics strategy.

Nationwide donation bank data has been used to identify overall trends in donation bank performance and to understand the factors affecting donation bank performance. Also, the following locations have been used as case study areas:

- Winton, Bournemouth (Dorset): Oxfam operating region W14. Used for initial audit of Oxfam localised level collection from shops and donation banks. Also, an initial audit of donated stock quality was undertaken. This area has also been used to trial the Smartphone App Smartphone App. This area was chosen because the Winton sortation depot provided an excellent location to hold an audit of stock quality. The activities of the driver based from Winton were indicative of most Oxfam localised collection strategies.
- Milton Point, Milton Keynes (Southern Distribution Centre): To undertake an audit of donation bank performance in order to understand the factors affecting the quality of donated textiles to donation banks. This area has also been used to audit centralised shop and donation bank collection performance. The Southern Distribution Centre is the main location for stock sortation and processing by Oxfam in the South of England. This location held an ideal opportunity as a base for the stock quality audit (good capability to hold the sufficient amount of stock to provide a representative survey) and an audit of centralised collection strategy.
- Watford (Hertfordshire): Used to trial the Smartphone App.
- Cambridge (Cambridgeshire): Used to trial the Smartphone App.

Watford and Cambridge were used as areas to trial the Smartphone App because their regional area managers registered their interest in the Smartphone App. This allowed trials to be conducted with the shop managers, volunteers and drivers encouraged to fully test the capability of the App. The App was offered to a wide range of Oxfam area managers.

3.2.3 Measuring stock quality and linking to bank placement strategy

While looking at donation weights received from textile banks is important, it was also important to consider that some banks may show very low yields but contain very valuable stock. Conversely, banks that show heavy yields may contain very low value, such as through high levels of waste. Weight alone cannot be a good proxy for end-sale value.

A stock quality audit for a selection of donation banks took place at Milton Point to determine what factors affect the quality of donations. From the locations Milton

Point serves, nine donation banks in the Cambridgeshire area (Table 6) were chosen for their close proximity to one another (to limit the effect of region) and their range of attributing physical and socio-demographic factors:

- High / low house price areas
- High / low ACORN rating (described following Table 6)
- Located / not located at Supermarket

Table 6. Milton Point stock quality survey donation banks

Site No	Site Name	County	ACORN	ACORN Group ID	House price (£)	Super market
C-0310-A	RC Elsworth	Cambridgeshire	3	A	180000	No
E-3534-A	Gerrards Cross	Buckinghamshire	4	A	430000	Yes
E-0619-A	Amersham	Buckinghamshire	14	C	341500	Yes
E-3606-A	Beaconsfield	Buckinghamshire	19	E	437500	Yes
C-5713-A	Northampton 1	Northamptonshire	39	L	110000	Yes
C-5715-A	Kettering	Northamptonshire	42	M	87500	Yes
C-3069-A	Northampton 2	Northamptonshire	43	M	125000	Yes
C-5669-A	Caledon Community Centre, St Albans	Hertfordshire	50	O	218000	No
E-3602-A	Dome Roundabout, Watford	Hertfordshire	52	O	215000	Yes

The ACORN rating is a consumer classification that segments the UK population, by analysing demographic data, social factors, population and consumer behaviour (CACI, 2012). ACORN is used to understand consumers' lifestyle, behaviour and attitudes, together with the needs of neighbourhoods and public service needs. It is used to analyse customers, identify profitable prospects, evaluate local markets and focus on the specific needs of each catchment and neighbourhood (CACI, 2014). The ACORN rating was used within this study as one method of gauging the demographics within an area.

ACORN Group 'A' describes generally households with lavish lifestyles, which corresponds with the high house prices in Gerrards Cross (£430,000). However, the same does not show with RC Elsworth with house prices of £180,000. ACORN Group 'C' describes 'mature money', which are generally older citizens with wealth. Amersham shows high house prices, so that fits well. ACORN Group 'E' are

described as ‘career climbers, who are generally career driven young families. However, out of all of the case study sites this shows the highest house prices (£437,500). ACORN Group ‘L’ are usually those with ‘modest means’ such as those living in low cost flats in suburban areas, and this corresponds with the relatively low house prices of £110,000 at Northampton 1. ACORN Group ‘M’ are described as ‘striving families’, and categorised such as struggling young families. The Kettering and Northampton 2 sites show the lowest house prices of all the case study sites, so this appears to fit. ACORN Group ‘O’ are usually those of young hardship. House prices for our two Group ‘O’ case study sites are £215,000 and £218,000, where house prices may be inflated by being within the London commute catchment-area. One of the limitations of the ACORN rating, is that it does not focus in as close on an area as the Office for National Statistics data does, and therefore can show contradicting results. It also ‘pigeon-holes’ areas into describing them as being a certain way, whereas in reality there can be great diversity even within a small geographic area.

Collection of stock for the audit commenced on the 25th June 2012 and finished when the stock audit began on the 12th July, totalling 13 days worth of collected stock (collected Monday to Friday). Stock collected from this half month period allowed for a good representative sample to be collected. In June 2010, the average amount of stock collected from an Oxfam textile donation bank was 620 kg. As the audit was sorting through a half months worth of stock (310 kg), around 2800 kg of stock was expected.

All of the stock collected from these donation banks was tagged with the donation bank code before being taken to Milton Point. Upon arrival to the Southern Logistics Centre, this collected stock was deposited into a separate area in the facility from normal, where it awaited sortation by the stock quality auditors. Stock collected from other donation banks on the drivers’ route was deposited and sorted as normal.

Bags of stock were weighed on industrial weighing scales and this value was recorded on the bag and onto a spreadsheet. These weights were totalled up following the audit. When each of the bags had been weighed, they were then sorted by bank into separate piles.

Once the stock was sorted into these piles the stock valuation then took place. Each bag of stock had its contents scrutinised. Good quality stock was valued on a per item basis and totalled up. The stock was valued by a professional stock auditor throughout the audit, and this ensured that valuations remained consistent.

Valuations were based on an items potential ‘top sale’ value either online, or if not suitable for online sale, through local shops. The total values for the retail stock were then quartered to allow for expected stock culling.

The good quality stock was then weighed. This also allowed for the weight of rejected stock to be deduced. Rejected stock was valued at £650/tonne (the price that Oxfam would sell the goods for wholesale). Once the stock had been sorted through, it was then suitable for returning to the normal donation stream for selling or dealing with otherwise. The process was repeated for all 9 donation banks stock over the two day period.

This stock quality audit was designed to understand the factors affecting the quality of donated stock received into Oxfam textile donation banks. The analysis of donation bank weight data identified some of the main factors affecting the quantity of stock received into donation banks and this is part of the study primarily focussing on stock quality issues. Enabling better stock quality and greater stock quantities are elements that will attribute to greater profits for Oxfam’s charitable cause. If a greater understanding of optimal locations for donation bank placement is found regarding higher stock quality, then this can only be of benefit to charities.

By comparing the socio-economic and location factors attributed to each donation bank that the stock was derived from, this enabled a range of conclusions on the factors affecting stock quality to be derived and the scope for tracking stock from donation point to sale appraised. Future donation bank placement can be assisted by these studies with the aim of increasing revenue for charities through optimised logistics strategy.

A predictive model of donation stock quality was produced. Using the sites studied within the stock quality audit allowed for a smaller dataset than the predictive model for donation bank weights. The much smaller number of data points enabled a more traditional analysis of variance approach to be used, called the backward variable selection (Brant 2004b). Under this approach, a model is created using all the variables of interest. Then the least significant variable is dropped, so long as it is not significant at our chosen critical level (a significance level of 0.05 is used within this study). This process continues by successively re-fitting reduced models and applying the same rule until all remaining variables are statistically significant.

3.2.4 Donation bank theft

The literature review highlighted the problem of theft from donation banks and how this might be an influencing factor in donation bank placement strategy. To address this, data were obtained from the Smartbin trials of 100 textile donation banks in December 2011 and February 2012 to study potential theft levels. Smartbin (described in Section 2.9.3) is a remote monitoring technology used to identify and monitor donation bank fill levels. Infra-red technology within a small device planted in each trial donation bank allowed the donation bank fill level to be monitored centrally.

Using Smartbin data in conjunction with Oxfam collection records allowed us to identify where some driver collections have been recorded by the driver but not necessarily through Smartbin as well. This enabled us to make a more informed approximation of the amount of stock that has been potentially stolen from Oxfam collection donation banks.

Smartbin maps the fill levels of banks over time and allows the user to identify potential theft events, because actual service events are recorded. Therefore where the system showed a negative change in fill level without a service event taking place, this showed the bank has been emptied by an unauthorised third party (Figure 20). On Smartbin records, a service event would be marked by a yellow dot, therefore as there are no yellow dots present, the negative change in fill level on the 13 and 31 December would be treated as theft events and not as a legitimate servicing of the donation bank.

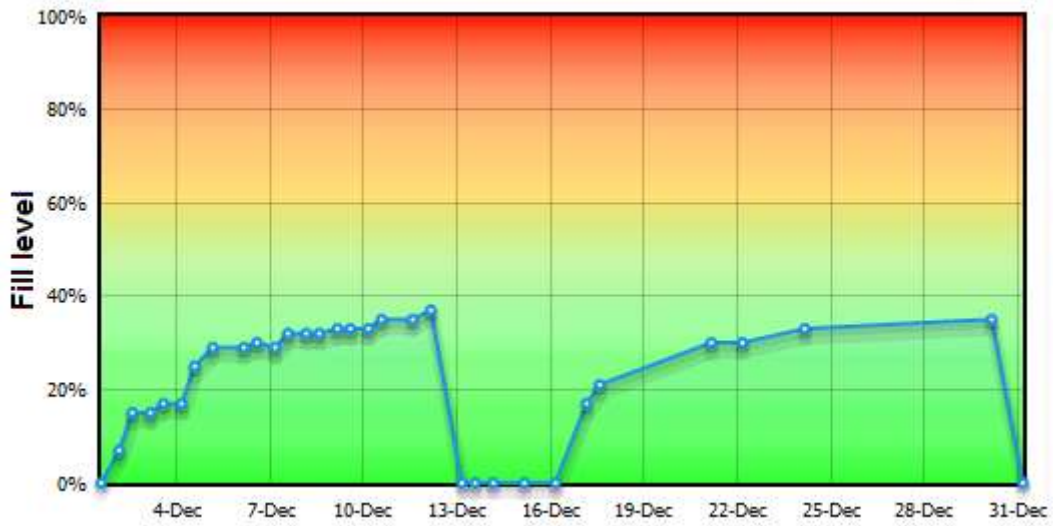


Figure 20. Smartbin fill level graph (Smartbin, 2012)

The frequency and locations of potential high-theft banks were identified including an estimate of the weight of donated textiles stolen from each bank. This was approximated by multiplying 2.7 (derived from the contents of a 100% full bank being taken as 2700 kg) by the negative change in fill level percentage.

Results were found from December 2011 and February 2012, and these two time periods were studied to recognise any continued patterns in suspected donation bank theft.

The value of stock within a donation bank can be calculated as 2700 kg multiplied by £0.70 (The price at the time of textiles per kg given by Oxfam). Therefore the value of textiles in a full donation bank can be approximated as £1890 (and 1% full taken as £18.90).

3.3 Assessing the merits of alternative localised and centralised collection strategies

To quantify the potential benefits of alternative operating practices, it was important to quantify Oxfam's current logistics practices, in terms of efficiency for both localised and centralised collection strategies. This was achieved by studying Oxfam shop and donation bank collection records to ascertain business-as-usual patterns, specifically:

- Times taken at each location related to the weight of stock collected and delivered broken down by the type of stock moved.
- Routes taken, round times (looking into the time taken at each site and time travelled between sites) and distances travelled.

These data were studied to create a detailed view of current practice such as use of time and resources in Oxfam collection donation bank logistics.

Historically donation banks have been emptied on a milk run basis. This is the method of donation bank collection that has been used (before remote monitoring and route optimisation), where donation banks are emptied on a fixed interval. This method may result in some donation banks being visited too frequently (empty donation bank resulting in a wasted journey), or not frequently enough (donation banks overflowing). This method primarily serves shops on a regular basis as part of Oxfam's managed stock transfer between shops. Donation banks are serviced as

minor detours from shop servicing. With the advent of remote monitoring and route optimisation, this allows for collection strategies to be more dynamic and reactive.

Alternative options for a more sustainable approach were considered for both localised and centralised collections. The use of route optimisation software combined with remote donation bank monitoring allowed a range of scenarios to be identified and tested. If significant cost and environmental savings could be found, that may achieve profit maximisation.

3.3.1 Logix

'DPS Logix Route Optimiser' is a commercial route optimisation tool based on the Capacitated Vehicle Routing Problem with Time Windows (CVRPTW) was used to compare the relative merits of different operating scenarios. Many companies, across a range of sectors, have employed DPS Logix to inform and understand how their transportation scheduling can be improved. Sectors include logistics, parcels/post, retail, food & drink, people and health & hygiene. As a case study example of its use, the bathroom retailer 'Bathstore' used DPS Logix to improve their transport scheduling. Use of Logix allowed "a significant reduction in vehicles used and kilometres travelled, while maintaining high levels of customer service. According to the Bathstore Head of Logistics these efficiencies led to substantial savings in labour, equipment, and fuel spend" (DPS International, 2008).

The DPS Logix Route Optimiser software is highly configurable and capable of handling the wide range of transport constraints that arise in logistics operations. The optimisation system uses details of customer addresses, delivery quantities, time windows, vehicle sizes, driver shift details, and many other transportation parameters such as speed limits and constraints related to commercial vehicle traffic.

Logix calculates the shortest and quickest paths and optimal call sequence using the principles of The Travelling Salesman Problem (Malkevitch, 2015). The software calculates the most effective delivery and collection sequences with journey times, allocating loads to appropriate vehicles and drivers accordingly, using an algorithm designed specifically for optimising road-based transport operations. Logix ensures that schedules are geographically feasible to meet promised arrival time windows, while improving fleet utilisation and productivity through efficient routes with minimal total mileage incurred and empty running reduced (DPS International, 2015).

The transport planning software allows routes to be planned with multiple depots for any number of vehicles and drivers as a single planning task. Depot boundaries can be adjusted dynamically to ensure calls are routed from the most suitable depot according to fleet availability and the geographic spread of orders on the day. This improves overall transport efficiency and avoids having vehicles and drivers standing idle at one depot while using extra resources at another (DPS International, 2015).

Logix uses a standard mapping package that includes a base road map network for the UK. This is translated into the system in terms of links and nodes. Links are roads and these have different characteristics attributed to them within the software, such as length, capacity and free-flow speeds. Nodes are the junctions between these links. Sites visited are then described as zone centroids and are joined to the main link network by zone connectors. Logix recreates the network based on these parameters.

Vehicles are attributed speeds and capacities. The user then has scope to change inputs to the system, such as average road speeds, vehicle types, cargo types and location dwell times. In order to represent congestion, certain roads that are known to be problematic can be attributed delays.

Route optimisation allows for the efficiency of the current donation bank collection strategy to be identified by comparing the base case to alternative routing methods. Furthermore, the technology allows for rules to be imposed on the routing such as fixed route order where necessary.

Figure 21 identifies the steps taken to adapt the necessary data needed to perform the round optimisation.

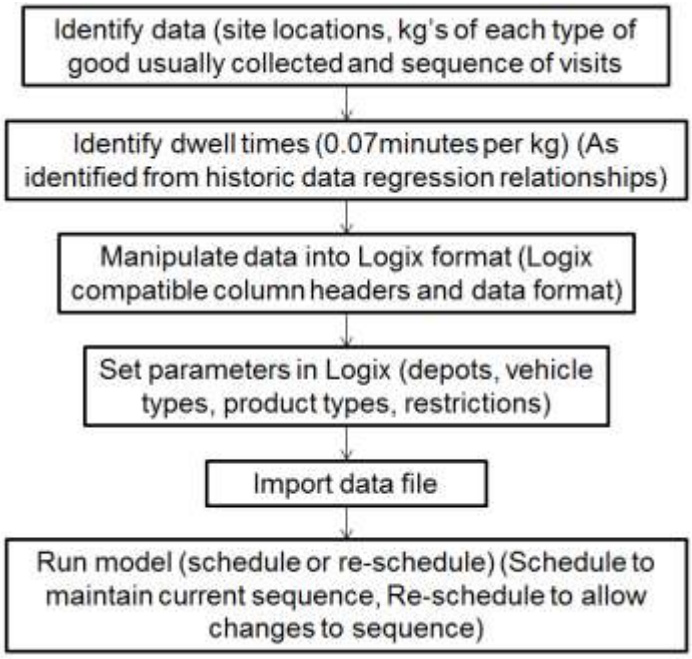


Figure 21. Logix functionality

Firstly, the locations of sites to visit were presented to Logix by postcode. The expected amounts for collection and/or delivery at each site were added to the data import file, creating an origin-destination matrix for all collections and deliveries. When replicating the case study week, the observed case study week collected and delivered weights for each site were added to the spreadsheet. Some scenarios modelled in Logix required that selected sites were visited on the same days as others or visited in a certain order. Sites that were required to be visited on the same day as other sites were attributed the same BOOKDAY within the Logix import data spreadsheet. Sites that were required to be visited in a certain order were provided an order SEQUENCE (e.g. 1,2,3) within the import data spreadsheet. Some scenarios allowed Logix to devise its own preferred sequence of visits. Where BOOKDAY or SEQUENCE was left blank, Logix had the freedom to decide which day and in what sequence sites should be visited.

Dwell times at locations were then given which were taken as 0.07 minutes per kg collected, as taken from Milton Point 2012 August – November collection records using data regression relationships (McLeod and Cherrett, 2012). The 0.07 minutes multiplied by kg to calculate dwell times was obtained (using simple linear regression) when considering bank and shop dwell times together (i.e. not considering them separately). Ideally dwell times were given as 0.046 x kg + 10, however this was not possible to use as Logix requires the regression to be forced through the origin. Data were then manipulated into the format needed by Logix and

the parameters needed were also set, including factors such as vehicles used and the product type for collection. The data was then imported into Logix and the model was run.

To create a realistic base case to compare against alternative modelled scenarios, the base case had to be calibrated to match the real collection records. This was managed by adjusting the vehicle speeds and then rerunning the model. Vehicle speeds were adjusted by 10% higher or lower at each increment. This was repeated until route times matched best between the Logix mode and the real collection times.

Limitations of DPS Logix

A number of limitations can be noted from using DPS International Logix software to optimise routing. Firstly, Logix does not take into account the locations of breaks. Suitable locations for breaks may not be found on the scheduled route. Therefore a deviation from the optimised route may need to be made to find a break location, this may add to the mileage.

When looking at travel times, Logix does not automatically take into account traffic and peak hours of travel. Some routes identified may have involved travelling through particularly busy areas which may result in longer travel times than shown by Logix. Roads that were shown to display unrealistic travel times were attributed a slower vehicle speed to take into account this congestion,

Dwell times were not calculated separately between shop and bank visits, which would show some difference. Shop visits would generally take longer to service than donation banks, due to access limitations and proximity to parking, however Logix did not have the capability to split dwell times. Also, it would have been more accurate to use the full dwell time formula (dwell time = 0.046 x kg + 10), but this was not possible due to Logix limitations. Logix requires the regression to be forced through the origin.

3.3.2 Alternative collection strategies for localised collections

The 2011 man-with-van audit allowed the creation of a base case scenario modelled using Logix route optimisation software. This base case was compared against the following two scenarios:

Scenario A – Same day collection / delivery route optimisation

This scenario uses the same collection and delivery weights as the base case and adheres to the same days for donation bank and shop visits. This scenario introduces the possibility for Logix to optimise the collection sequence from donation banks and shops. This allows us to identify whether the routes used by the driver could be improved even if collections from shops and donation banks are undertaken on the same day as they are currently.

Scenario B - Logix optimised delivery/collection schedule

This scenario is similar to Scenario A, in that the same collection and delivery weights are used, as well as adhering to the same day to undertake select shop visits. It can be essential for shops to be visited on a regular basis and this scenario takes that into account. The difference from Scenario A is that this scenario allows Logix the freedom to choose which day to undertake donation bank visits, while still ensuring the same number of donation bank collections is undertaken every week.

This scenario allowed us to identify whether donation bank collection routes could be improved by visiting donation banks on different days when compared to the base case, while still maintaining existing collection frequencies.

3.3.3 Modelling impacts of a minimum fill level collection strategy

With the development of the Smartphone App, this created the opportunity to track bank fill levels over time. This allowed the creation of a Scenario C to model the effects of visiting donation banks at minimum fill levels. The base case was updated in 2013 using Smartphone App data. Scenario A and Scenario B were also updated to allow comparison with the new Scenario C.

Scenario C – Visiting donation banks at approximately 50%-80% full

By taking donation bank fill levels into account (which are recorded by the driver through the App upon each donation bank collection), Scenario C shows whether visiting low performing donation banks less frequently could aid in increasing routing efficiency. This is achieved by studying the average donation bank fill levels. Visiting donation banks as often as needed (so that they are around 50%-80% full upon servicing) could result in extra cost savings. In theory this method of collection should result in the maximum amount of material to be collected with the minimum cost of collection, as identified by Smartbin. Remote monitoring allows for a range of

donation banks to be identified that require emptying on a specific day, thus removing the possibility of wasted journeys to donation banks. However, this scenario still includes fixed visits to shops.

Visiting donation banks at around 75% full will enable donation banks to be used to their potential without the possibility of them spilling over, which could result in fines for the charity. This method would be less time intensive for the driver than visiting at lower fill levels; however this does leave the potential for a greater amount of stock to be stolen by thieves.

Donation banks that have shown low fill levels over the trial period will be modelled to be serviced less frequently. Appendix 1 shows the performance of donation banks in the W14 area between 3/5/13 and 22/7/13. Out of the 28 donation banks, 16 showed average fill levels of over 50% upon servicing. The remaining donation banks shall be considered for visiting less frequently. Donation banks that require fewer visits, will have the weight that was collected in June amalgamated into the necessary number of visits. For example, if a donation bank yields 10 bags every week, this could be condensed into one visit every three weeks that yields 30 bags.

Donation banks showing average fill levels of between 25% and 40% can be recommended for visiting half as often as during the trial period, so that they would then expect to show average fill levels of between 50% and 80% upon servicing. This means that within the modelling, rather than being visited every week, these donation banks would be visited fortnightly.

Donation banks showing average fill levels of between 17% and 25% can be recommended for visiting a third as often as during the trial period, so that they would then expect to show average fill levels of between 50% and 75% upon servicing. This means that within the modelling, rather than being visited every week, these donation banks would be visited once every 3 weeks. The implications of visiting donation banks less often will be discussed.

Visiting donation banks at low fill levels (~ 25%) would ensure that donation banks never reach an amount whereby a great amount is available for stealing. This would also help to ensure that the stock is not held for long and will therefore not degrade as much as stock that is held for longer periods of time. This would require donation banks to be visited more frequently however, and may prove to be too time consuming for the driver to cover all donation banks.

3.3.4 Alternative centralised collection strategy

The alternative centralised collection scenarios were modelled using the collection of unsold stock from 43 shop sites and donated goods from 31 donation bank sites (Figure 22) feeding into a regional depot near Milton Keynes, UK (these sites can contain multiple donation banks, e.g. Book and textile donation banks, and multiple shops, e.g. Book shop and clothing shop). The region lies just north of London and comprises an area of approximately 8,000 km^2 with routes operating Monday to Friday.

Figure 22. Shops and donation banks serviced by Milton Point

For modelling purposes, vehicle routes were required for Monday to Friday, to make collections from 31 donation bank sites and 43 High Street stores, subject to time windows, vehicle capacity and driving constraints. Each vehicle could undertake one route each day, starting and ending at a single depot. Each location could only be visited by one vehicle on any given day. The objective was to maximise profit, defined as the value of goods collected minus the associated transport costs and minus any penalty costs imposed as a result of donation banks overfilling.

The base case was modelled and also three different 'mini' scenarios, where stock was collected and transported for onward sale or recycling in different ways:

- Shop adopted donation bank collections
- Shop adopted donation bank collections with centralised shop and remote donation bank collections
- Shop adopted donation bank collections with centralised shop and remote donation bank collections (with centralised collection of donation bank stock from shops)

Scenario 1 - Shop adopted donation bank collections

This scenario involves shops "adopting" nearby donation banks rather than collecting on Milton Point routes. The shops would empty nearby donation banks on a regular basis and transport the donation bank stock back to their shop for sortation and selling. By studying the sites visited by Milton Point, donation banks (within a 10 mile radius) were assigned to shops (maximum 3 per shop). Between September and November the mean amount of stock collected from each donation bank visit was 210 kg. Therefore from 3 donation banks, a total collection of around 630 kg per week (equating to around 84 bags) would be expected. Depending on how full the donation banks are, the collector may need to make more than one trip to their adopted donation banks; however, due to the short distances between the shops and their donation banks this would not result in much additional travel.

This model set out to assign all Milton Point textile donation banks to nearby shops. If shops took on donation banks then it may help them to become more self-sufficient. Collecting over shorter distances may also help to reduce overall mileages travelled by Oxfam collection drivers. Each shop that was selected to adopt donation banks was added as a 'depot' within Logix (a point where a round starts and finishes and where the collected stock is delivered to at the end of each route).

In this first scenario, usual Milton Point shop visits are not taken into account in this scenario. Currently, shops are visited at least once a week by Milton Point drivers to collect excess and waste stock. In this scenario, once stock is taken to the shop, stock that cannot be sold is sold to rag merchants at the back door (a model that is used by some other large charities, such as British Heart Foundation). This means that the charity does not have to deal with the onward transport costs associated with the excess stock. One problem with this scenario is that there are some

donation banks that are too remote to be taken on by shops (Oxfam say that generally the furthest distance travelled to shop adopted donation banks is around 10 miles) and therefore these donation banks would not be scheduled for servicing. Figure 23 identifies the flow of stock within Scenario 1.

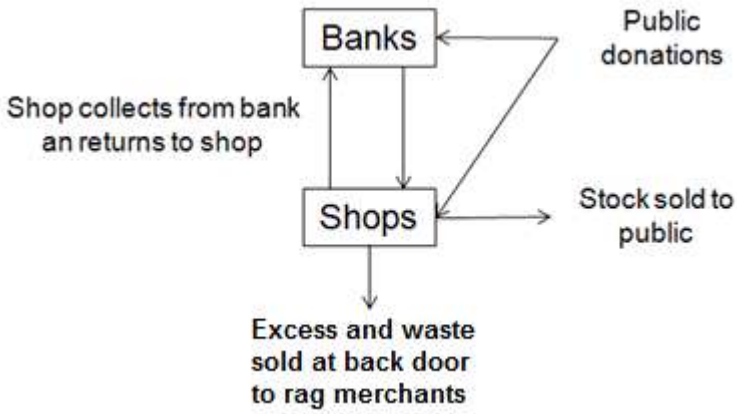


Figure 23. Scenario 1 (flow of stock)

Each shop within this scenario requires transport to each donation bank with enough capacity to collect 3 donation bank sites worth of stock. The collections are likely to be undertaken by a volunteer at each shop therefore a medium sized car will be modelled as transport for the shop adopted donation banks. For shop adopted donation bank routes, medium sized cars/vans would be most suitable due to the smaller amounts of stock being collected. Therefore the average between 182g CO_2/km and 192g CO_2/km for Non-urban travel were used (187g CO_2/km) for this transport (derived from Table 26 on page 158).

For this model the same day for donation bank collections as in real life was adhered to, to allow the model to be compared between days with the base case, however Logix was given the freedom of choosing the sequence of visits. In reality, shops could change the day that they visited the donation bank as long as it was visited frequently enough to satisfy the demand (ie. once per week).

By studying the shop and donation banks sites, all donation bank sites were assigned to nearby shops, with the exception of 6 sites that were located further than 10 miles away from the nearest shop (shown in Figure 24):

Haverhill C-5719-A (CB9 7YL), March C-2254-A (PE15 8SY), March 2 C-2199-A (PE15 9JJ), Letchworth C-5668-A/D (SG6 2HX), Baldock C-3452-A (SG7 6BN) and Royston C-3484-A (SG8 5UA)

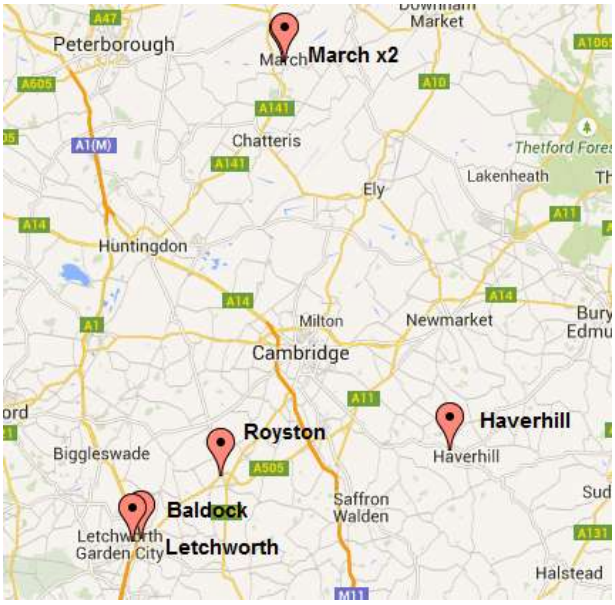


Figure 24. Scenario banks located over 10 miles to the nearest shop

Within this first scenario, as there is only shop vehicles running collection routes these donation banks were not considered for servicing and would thus be removed.

Scenario 2 - Shop adopted donation bank collections with centralised shop and remote donation bank collections

This scenario involves, localised donation bank servicing by shops (as in Scenario 1) and includes a centralised service to collect culled shop stock and waste and from remote donation banks. Figure 25 identifies the flow of stock within Scenario 2.

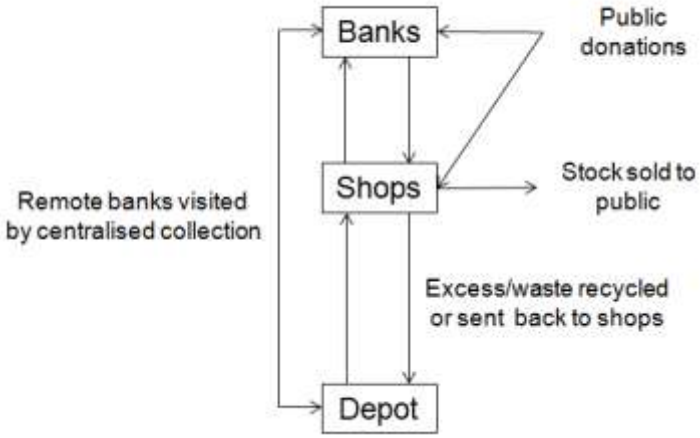


Figure 25. Scenario 2 (flow of stock)

By combining the findings from this centralised collection service within this scenario with the shop adopted donation bank collections from Scenario 1 we can understand the overall efficiency of using this potential method of collection against the base

case. The same set of shop adopted donation banks is used as in Scenario 1. The remaining donation bank sites and shop visits are modelled to be visited on the same day as they would be visited in the base case; however, Logix has freedom in picking the sequence of visits.

As within Scenario 1, the stock collected by shops from their donation banks would be processed for sortation within the shop. Within this scenario, donation bank excess would be sold to a jobber at the back door. The centralised service would just be collecting the culled shop stock and waste.

Scenario 3 - Shop adopted donation bank collections with centralised shop and remote donation bank collections (with centralised collection of donation bank stock from shops)

This scenario involves localised donation bank servicing by shops with a centralised service to service shop waste and remote donation banks. This scenario differs from Scenario 2, where the stock that shops collect from their adopted donation banks is not processed on site, but added to the culled and excess stock that is collected by the centralised service. This means that the stock from donation banks is collected and transported on two separate occasions. This scenario leaves the shop with the opportunity to utilise some of this stock if required, before the rest is collected by the centralised service. Figure 26 shows the flow of stock within Scenario 3. All excess waste is accounted for in this scenario.

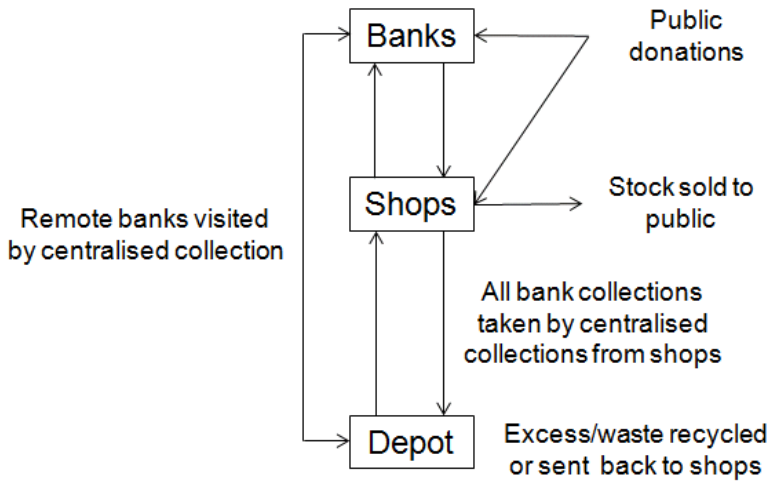


Figure 26. Scenario 3 (flow of stock)

3.4 The use of technology to improve logistics

The author was involved in the planning, design and testing process in the development of a Smartphone Application (App). The App was developed by the University of Edinburgh in conjunction with the University of Southampton. During the design and testing stages of the App, the author gave input into the design of the App and sought opinions from Oxfam drivers' and managers' on additional functionality that would add value to the system.

The App was trialled with Oxfam in range of operational areas to give the area managers, shop managers, paid and volunteer drivers a tool which enabled them to visualise stock profiles in banks, stock demand from shops and live collection/delivery activity being undertaken by drivers to aid business decision making. For Oxfam, this involved viewing collection/delivery vehicles, donation banks and shops as parts of one social network. This allowed data regarding their status to be transmitted for others in the network and receive data about possible opportunities, enabling better logistical decisions to be made.

The study involved testing the App against a range of different Oxfam collection/delivery routes in different locations. The study looked into how the driver and managers used the App, also considering functions they did not use and why. Post trial interviews with the drivers and managers were used to understand how the App affected their routes and how they might adapt in the future. The App could assist in improving routing decisions by informing on where stock is needed or where donation banks were full or empty.

The App was designed to improve visibility of all parts of the logistics system and facilitate collaboration among Oxfam shop managers and their area managers. By being able to share a collective view of the state of assets in the local Oxfam community it allowed dynamic scheduling decisions to be made that could result in improved business decisions.
For example, this could occur by the driver undertaking a potentially lucrative house clearance rather than emptying a number of donation banks that the driver knows are empty. Alternatively, valuable donated goods could be notified to the community and the optimal sale outlet could be identified and transport arranged.

Using the App, drivers could record all collections from shops, donation banks, businesses and private households and all deliveries/cascades to shops. Drivers could also record the fill level of banks upon emptying in order to gain knowledge of

bank fill levels over time. Managers (shop managers and area managers) were able to view the driver's location in real time, view assets and transactions, and identify the driver's potential round for the rest of the day using historic data. All users of the App can share messages, photographs and offer/request stock with the aim of increasing collaboration and gain knowledge of the systems and its assets.

Of real interest is how such visualisations of vehicle, donation bank and shop status viewed by Oxfam staff might enable more effective decision making and reactive stock management to save time and fuel. The trial areas used were located in Cambridge, Dorset and Watford.

App development

The App was designed to have functionality for two separate user groups; managers and drivers. Drivers gather the core information within the system recording data from each donation bank collection (Figure 22). The appropriate bank was selected from the map and the data from the collection was added into the App. This included the percentage fill of the donation bank on arrival and end of collection, the number of bags of stock generated, the quality of the stock collected (a gauge ranging from 1 (poor) to 5 (excellent)) and any other comments regarding the collection (including functionality to post photographs). At each shop, the driver was able to record the number of bags of each type of stock delivered or collected for cascade (Figure 22). At the location of ad-hoc collections, the driver had the ability to add a new site into the system, declaring its name and category and recording the number of bags collected.

Each time a stock collection was made from a donation bank, the members of the community were notified via a push notification giving the site origin and message 'stock collected available for cascade' (Figure 27).

a) b) c) d)

Figure 27. Smartphone App showing a) the main screen view of shops (S) and donation banks (B) and drivers (D) in the network b) the bank collection screen c) the shop delivery screen d) a push notification of collection

Managers were able to view the driver's current position and visualise where the driver should be at hourly intervals throughout the day, using historical time and location data. This feature was designed to allow managers to understand the driver's likely movements in order to plan potential ad-hoc visits around the drivers existing schedule.

A key feature of the App was the messaging system which allowed the members of the community and assets within it to message each other with requests and notifications. In the case of shops, each manager was registered under their shop and messages were posted to that location address in the network. This approach was taken rather than using named individuals because the personnel running the shop varied from day-to-day resulting in the need for a more flexible message board. Messages to drivers were attached to their map icon by users as they moved around the network. Drivers also had the ability to take and post photographs at each donation bank/shop site which are then added to the message and transaction history of that location.

As well as being able to view the contents of the drivers van in terms of the stock held at any point in time, and the transactions as they occur at donation banks, shops and other locations, managers could also view the collection/delivery history of each asset in the system. The App allows this information to be shared by the members of the community where in the case of 'shop adopted donation banks', the shop manager can make a better informed decision as to whether a volunteer needs to visit a donation bank to prevent it from over flowing.

3.4.1 Effect of community engagement on collection strategy

By combining information on donation bank fill rates and shop input/output, with the location of each site, the efficiency of the collections and deliveries of these sites was determined. This information was then tied in with previous research on donation bank location analysis, predicting the quantity and quality of yields from charity donation banks.

Conclusions were then drawn regarding whether these collection routes were being undertaken as efficiently as possible and make recommendations for future policy changes. This involved options for moving donation bank sites to areas that may provide greater yields, or recommending that certain donation banks are visited less often to save on wasted journeys.

The data from the App also provided a record of house collections and corporate donations. Analysis of this data, combined with knowledge of the typical value of such donations, was used to help determine if these ad hoc collections are a good use of time. House collections could be prioritised for collection if they are found to be of high value to the charity.

Pre and post-trial interviews were undertaken with these stakeholders to gain their thoughts on the App and how it helped with their asset management, stock movement and control. Also recorded by the App were conversations between the driver, shop managers and area managers. These conversations were also used to determine how effective the App is for driving dynamic routing and scheduling.

Running themes were found from these interviews identifying how the use of this technology has affected (improved or negatively affected) their work schedules, stock control and collection/delivery routes.

A series of semi-structured interviews using questions scored via a five point Likert scale (‘strongly agree’ – 5; ‘agree’ – 4’; ‘uncertain’ – 3; ‘disagree’ – 2; ‘strongly disagree’ – 1), were undertaken with the Cambridgeshire shop managers before, during and after the trial to gauge opinion on usability and understand how the App aided communication and collaboration.

Chapter 4: Understanding current charity logistics operations – a case study on Oxfam

4.1 Oxfam: The case study charity

Oxfam was chosen as a case study charity because of its large scale and varied operations (centralised take-back and localised collection), and the wide range of logistical techniques employed. Running centralised and localised logistics is unique in the charity sector and provides a holistic view in order to allow best practice to be studied.

Oxfam runs one of the largest charity shop operations in the UK, servicing 1456 donations banks (987 sites; 919 Clothing and 537 Book), 670 shops and 7 online hubs, along with the Winton Distribution Centre (on-line books) and the festivals team (managing the supply of vintage textiles and clothing to primarily large music festivals).

Oxfam's 670 shops are divided between 32 operating regions across the UK, each region having an area driver and manager (Figure 28). The operating regions cover most of the UK, but vary greatly in size and shape. Each region is denoted by a three digit code of the form "A##", where the letter A represents which part of the country the operating region is in and the two numbers are unique identifiers. There are four divisions for the country used- N for North, C for Central, W for West and S for South.

Figure 28. Oxfam operating regions (Crossland, 2010)

As shown in Figure 29, there are a similar number of shops in each region but a large variation in the number of donation banks which the area driver must service. The majority of donation banks serviced at a local level are book donation banks.

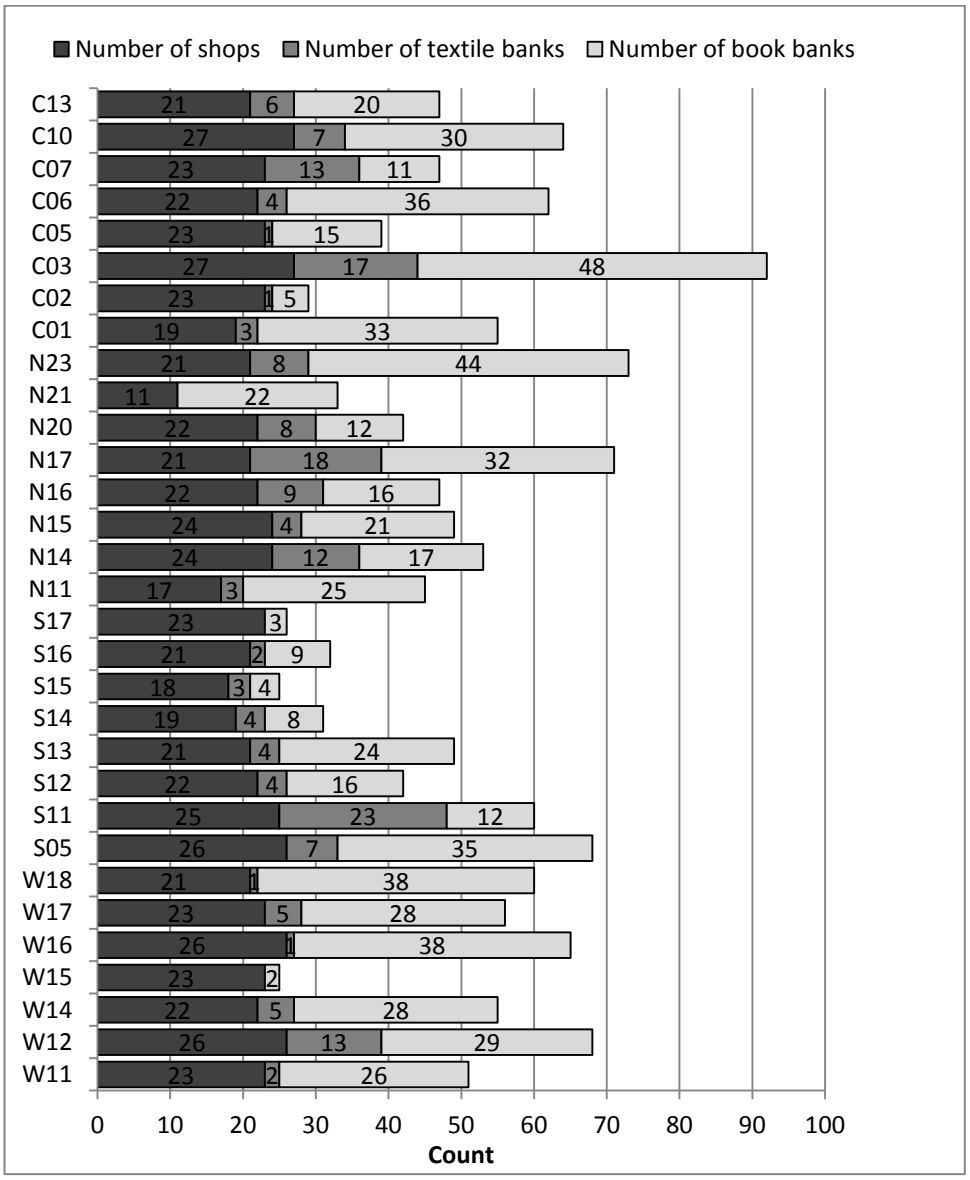


Figure 29. Number of shops and donation banks in each operating region

4.1.1 Logistical layers

Oxfam runs a network of 7 online hubs (centres dedicated to selling clothing and accessories through the Oxfam Online Shop), 670 shops and 1456 donation banks serviced by a complex range of logistics strategies.

This system is summarised in Figure 30.

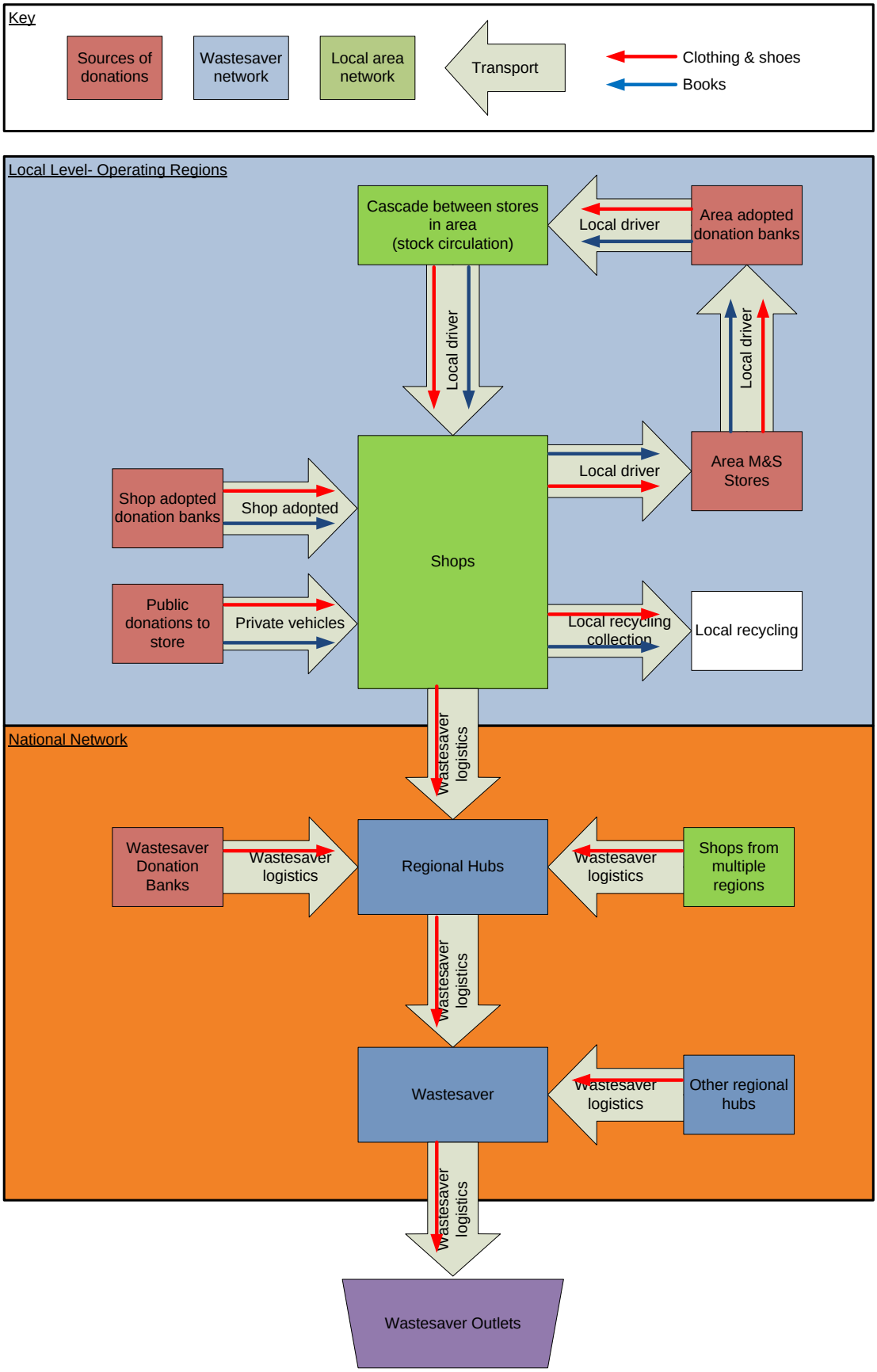


Figure 30. Overview of Oxfam logistics system (Crossland, 2010)

Oxfam's logistical layers are mainly split into two main areas: Local drivers and National (Wastesaver) logistics. Both of these logistical layers serve the network of Oxfam shops, donation banks and distribution centres in different ways.

4.1.2 Shops

Shops receive donations from the public at the store, as well as goods delivered from donation banks and other shops in the region. They require pickup of unsold textiles and shoes for 'Wastesaver', the national sortation facility, as well as unsold books, plastics and other recyclables. Wastesaver is an Oxfam operated facility where items are sorted for reuse or resale in other markets. Goods such as plastics, books and electrical items are often disposed of through local recycling collections. Wastesaver collections are completed by a network of private contractors, each transporting goods from stores and donation banks to regional hubs. Goods at these regional hubs are then transported to the Wastesaver facility in Huddersfield. These contractors also empty a number of donation banks, from which donations bypassing stores and go directly to Wastesaver.

To facilitate Wastesaver, each shop is serviced by:

• The local driver who visits the store to cascade products to other stores in the region and to deliver new donations from other stores and donation banks in the region;

• Wastesaver collections, completed by a third party contractor, which take bags of unsold textiles and shoes to the Wastesaver facility in Huddersfield;

• Recycling collections take material such as paper, plastics, metals and electronics to be processed;

• Volunteer transport, or "shop collections" to service any donations donation banks which have been adopted by the store.

The amount of demand that each store exerts on the logistics system is influenced by a number of factors such as; shops sell a mix of clothing, books, music, furniture and other specialist items (e.g. bridal wear) and so desire different types of donations; the quantity and quality of donations varies depending on the demographics of the area the shop is situated in; and the size of the shop.

Oxfam also operates a number of different shop types besides the "general" shops which sell a full range of goods from clothes and books to bric-a-brac. Specialist

shops include those selling books, music, bridal ranges and furniture. This adds further variability to the logistics system since donations received at each store are not necessarily appropriate for sale in that store and must be cascaded.

Each shop is denoted by a unique 4 digit code preceded by a letter “F” in the form “F####”, for example the Derby High Street store has code F1402.

Each of Oxfam’s operating regions operates its own logistics layer through the local driver(s) and shop collections. The local driver is primarily responsible for cascading stock between shops and servicing non-Wastesaver donation banks. The local driver also facilitates the collection of corporate donations of M&S retail stock and donations of used textiles accrued through the “Schwopping” scheme (SOFII, 2013). This scheme rewards M&S shoppers who donate used clothes in-store with vouchers to spend on new clothes.

Shops also generate their own logistics layers through collections from donation banks which are “shop affiliated” i.e. are only serviced by volunteers from a particular store. Some stores also have their own van, such as furniture stores which need to provide a delivery service.

There can be a “hierarchy” of shops within an area. This can result in the best quality stock being taken to the shop at the top of the chain. If an item does not sell here after a period of around 3 weeks, it is “culled” (taken off sale and deemed superfluous to requirements) and then taken to a shop that is the next stage down in the hierarchy. If an item does not sell throughout its cascade through to the end of the hierarchy, then it is transported to Wastesaver for processing (released back into sale, sold abroad or processed for recycling).

While shops can receive donations from cascade from other shops, many shops receive adequate amounts of donations through the front door. Within Oxfam there are shops that receive enough donations through the front door that they can be completely reliant on these donations to provide enough good quality stock for the shop to run profitably. Conversely, there are shops that rely on cascaded stock coming in from other shops in order to run profitably. These shops do not receive enough good quality through the front door and thus require an extra stream of donations. Figure 31 shows the flow of donations into and out from Oxfam shops.

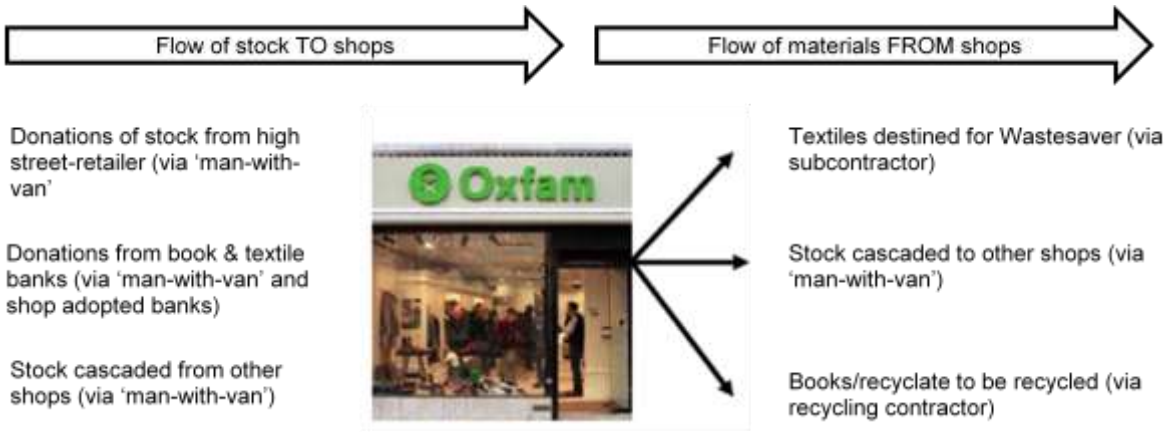


Figure 31. Summary of the transport layers responsible for the flow of stock/materials to and from Oxfam shops

The area driver collects goods from donation banks, excess stock from M&S stores through a partnership arrangement and circulates stock between stores in a process called cascading. Each shop receives donations from the public at the store and through the area driver. Shops may also receive donations by shop volunteers servicing local donation banks, but not all stores do this.

Donations, mostly clothing, shoes and books are sorted in store by a team of volunteers before being put out for sale. Any donations which are not sold, or not suitable for sale, are sent to Wastesaver.

4.1.3 Donation banks

Oxfam has a network of over 1400 donation banks where members of the public can give products to the charity. These come in a variety of sizes (Table 7), but all essentially consolidate books or textiles (Figure 32).

Table 7. Oxfam donation bank types and sizes

Type	Height	Width	Depth
Standard Book & Music	4ft 3in (1.29m)	3ft 4in (1.01m)	2ft (0.61m)
Midi Book bank	4ft 3in (1.29m)	4ft (1.21m)	3ft 3in (0.99m)
Book & Music Banks: Approx 100 kg empty and approx 500 kg full			
Standard Clothing & Shoe	6ft (1.82m)	5ft (1.52m)	4ft 2in (1.27m)
Maxi Clothing	5ft (1.52m)	Front 6ft (1.82m) Middle 7ft (2.13m)	6ft (1.82m)
Clothing Banks: Approx 200-250 kg empty and approx 900 kg full			
Roll On/Roll Off (RORO)	Highest 6ft 6in (2m) At side 6ft2in (1.9m)	13ft (4.01m)	6ft 4in (1.96m)

Figure 32. Standard Oxfam Textile and Book & Music banks

As summarised in Table 8, the majority of textile donation banks are Wastesaver-affiliated and collections from these are made using the Wastesaver logistics network.

Table 8. Designation of donation banks by Oxfam by donation bank type and destination (Crossland, 2010)

		Donation bank Type		
		Textile/shoe donation bank	Book Donation bank	Total
Collection Type	Wastesaver Collection	545	0	545
	Shop Adopted/ Local driver collection	189	690	879
	Total	734	690	1424

The stock in the remaining donation banks (including all book donation banks) is taken directly to shops in the local logistics level. The donations are taken to be sorted in stores by either the local area driver or by a shop collection. Figure 33 shows the flow of stock into and out from Oxfam donation banks.

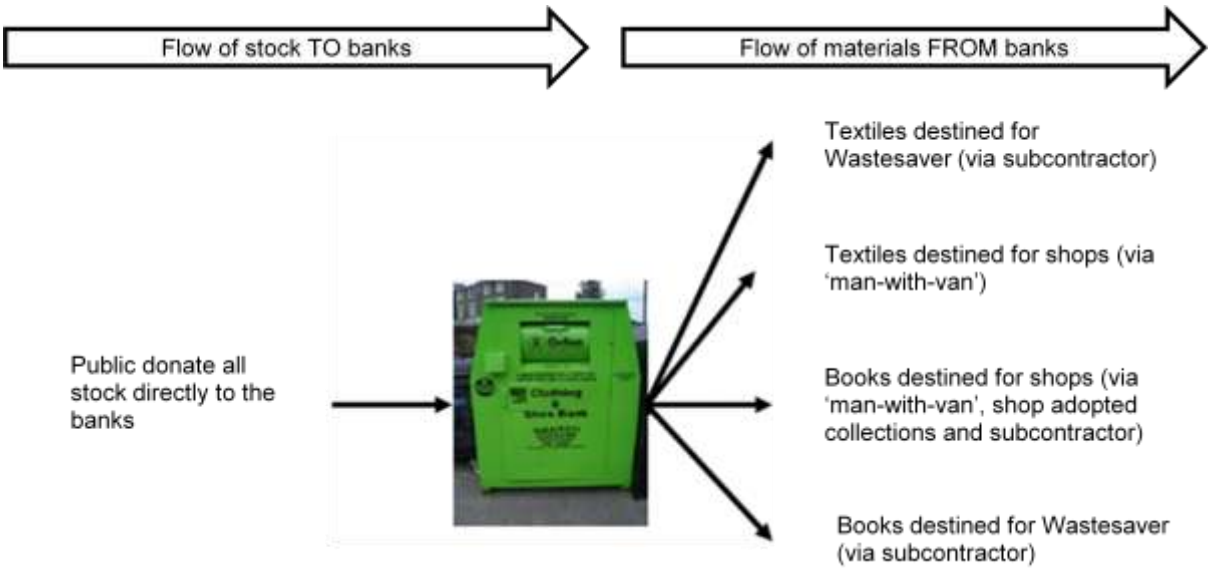


Figure 33. Summary of the transport layers responsible for the flow of stock to and from textile and book donation banks

As shown in Figure 34, there is a wide variation in the number of donation banks in each region meaning the costs and effort in servicing will vary between areas.

Figure 34. Location of Oxfam donation banks in England

Donation banks are denoted by a five digit number e.g. D-1143-D as summarised in Table 9.

Table 9. Donation bank code derivation

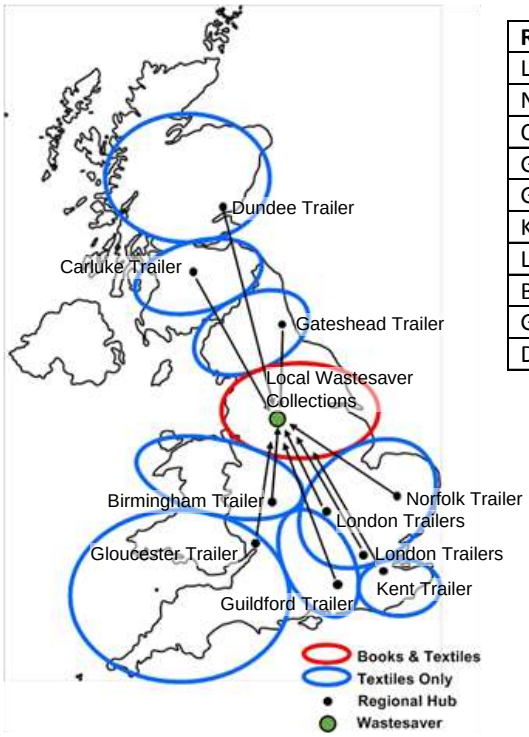
D	**-**	**#**	**#**	**#**	**#**	**-**	**D**
Area of country	-	Unique identifying number				-	Donation bank type by code
A: Scotland B: Northern England and North Wales C: Midlands D: Southwest and South Wales E- Southeast	-	1	1	1	1	-	Donation bank codes include: A (clothing bank), B (maxi clothing bank), C (Midi book bank), D (Book bank)

4.1.4 National collections

Wastesaver collections are made from every shop and around 540 of Oxfam's donation banks by a number of subcontractors. Each subcontractor is assigned a number of shops and Wastesaver-affiliated donation banks. These contractors collect sacks of clothing and shoes on a fixed schedule and deliver them to a regional hub/trailer. These trailers are then transported to Wastesaver.

The route taken and number of vehicles used is decided by the contractor and influenced by the particular nature of their business. Some contractors will also serve other customers using the same vehicle and consequently, it may be impossible to accurately measure and predict their routes or calculate the carbon footprint. This will also have an effect on the cost per tonne. Due to the different size of these regions and the location of the trailers, the cost of service is highly variable. For example, it is 145% more expensive per Tonne to service the Dundee trailer than the London trailer (Figure 35). This could be attributable to the large region size or the large distance to travel to Wastesaver. The trailers act as consolidation points to move stock in bulk to Wastesaver.

In Figure 35, the regions circled in blue only supply textiles to Wastesaver. The region that includes Wastesaver is the only region that provides books to Wastesaver, in addition to textiles. The locations of regional hubs are also shown where textiles are bulked into containers for transport to Wastesaver.



Regional Trailer	£ / Tonne
London Trailers (inc. Northampton)	£148
Norfolk Trailer	£168
Carluke Trailer	£177
Gloucester Trailer	£197
Guildford Trailer	£223
Kent Trailer	£224
Local Wastesaver Collections	£242
Birmingham Trailer	£291
Gateshead Trailer	£323
Dundee Trailer	£362

Figure 35. Wastesaver collection network and trailer costs (Accenture, 2009)

Supporting the Wastesaver facility is a huge logistics effort, since donations are collected from shops and donation banks all over the UK. Consequently, it is not surprising that the majority of Oxfam's transport costs are associated with supporting Wastesaver (Figure 36). The 'New Product' spend is attributable to the transport costs of brand new products sold in shops such as Fairtrade food and greetings cards. 'Local Area Spend' are the costs related to collection and delivery of donated stock between shops and donation banks. 'Online Hubs' (centres selling more valuable items online), 'Bookbarn' (the book sortation facility in Huddersfield) and 'Bank Placement', account for the remaining transport spending.

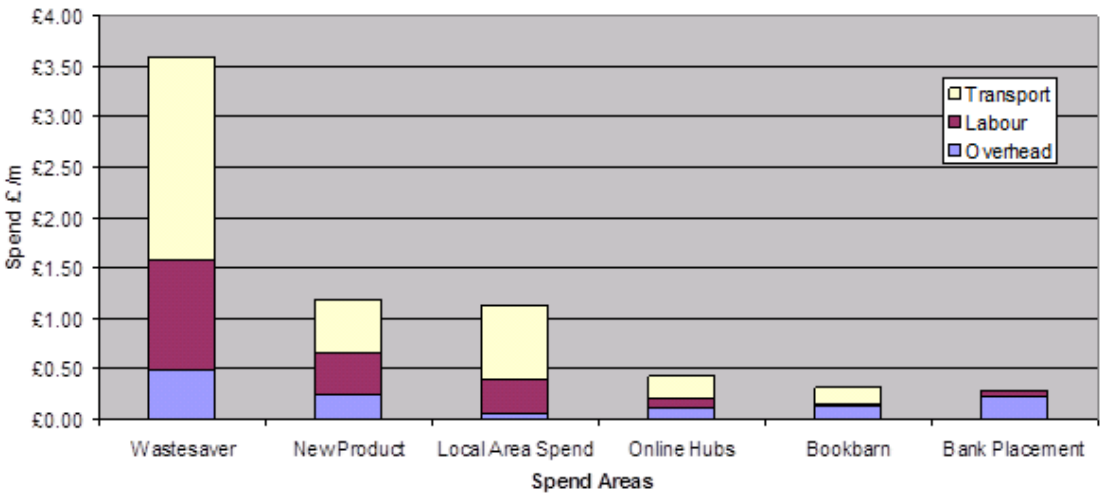


Figure 36. Oxfam logistics spend per stream, financial year 2008 (Satinet, 2009)

4.2 Investigating localised collection strategies – understanding business as usual trends

Oxfam's localised collections run in conjunction with their national collections, to service the network of donation banks and assist with stock movement between shops and Online Hubs. The Dorset area has been used as an example of the work undertaken by localised collections and to demonstrate the scale of their operations.

4.2.1 2011 W14 Man-with-van audit assessment

The research was primarily informed by field work carried out at Oxfam's distribution centre at Winton, Bournemouth. The audit took place in order to: 1) gain an initial view of how the system works at the local level, 2) gain an appreciation of donation bank performance and the quality of stock received to donation banks and 3) investigate the feasibility of future activities in the future.

The audit involved a week shadowing the 'man-with-van' activities with the aim of evaluating the efficiency of the current donation bank and shop servicing schedule in the Oxfam W14 region, particularly proportions of saleable stock, carbon footprints from routes and average bag weights.

The collection/delivery driver for the Winton Distribution Centre was shadowed for a working week (31 January – 4 February 2011).

A man-with-van activity audit spreadsheet was developed (Appendix 2) and was completed for each day's activities: (The routes taken and mileage for each section of the journey were recorded.)

1. Donation bank and shop visits were recorded by donation bank or shop ID along with the arrival and departure times and the purpose of each journey leg (collection/delivery/cascading).
2. At each donation bank or shop, the number of bags of each type of good collected or delivered was recorded. Both textiles and books were measured by numbers of bags.
3. Donation bank fill levels were recorded before and after collections.
4. After each collection or delivery, the van fill level was noted.
5. Reference photographs of the locations visited, stock collected and van fill levels were taken.

6. At each donation bank, every bag of stock collected was tagged with a label to identify the donation bank of origin, bag number and collection date (Figure 37).

Figure 37. Tag for bag tracking

On return to the Winton Centre, each bag was taken from the van and weighed on a set of electronic scales (Figure 38).

Figure 38. Weighing scales used at the Winton Centre

Labelled bags were then stored in pens for sorting the following day (Figure 39). During the sorting process, extra care was taken not to mix the stock between bags.

Figure 39. Bags stored prior to sorting

Following the sortation process, the stock that was deemed acceptable for sale was kept in boxes with stock from the same donation bank (Figure 40). These boxes were then weighed to find the total amount of good stock.

Figure 40. Accepted stock boxed separately

The ratio of ‘accepted’ stock against total stock was then found for each donation bank by day of collection. The paper audit spreadsheets were transcribed into

Microsoft Excel daily. The saleable value of one day's stock was estimated by the Winton Manager as part of this process.

Driver's weekly tasks

The driver would typically undertake three primary tasks. This involves the servicing of donation banks and taking stock to the online hub for sortation, delivering sorted product from the online hub to certain shops and collecting culled stock from shops and transporting it to the online hub or other shops.

Secondary tasks included collection of corporate donations (such as Marks & Spencer), house collections and waste disposal from shops and hubs (collecting excess boxes, kitchen refuse and transporting refuse to local trade waste recycling centres). The driver may also collect donation bank stock for specific shops; such as the Swanage shop receiving donations from its local bank.

As well as a paid driver; the routes are always assisted by an unpaid volunteer. The assistant will only help with physical work, such as filling sacks, lifting and loading/unloading the van. The assistant's expenses, such as travel costs, are paid for by Oxfam.

4.2.2 Shops serviced by Winton

Shops in the Bournemouth area are visited weekly whilst the shops in Wiltshire and the Bristol areas are visited on a fortnightly rotational basis. On the week of the audit, the shops in Andover, Marlborough, Chippenham and Devizes were visited. During the next week the shops and donation banks around Bristol would be serviced. The location of these shops is shown in Figure 41.

Figure 41. Shops serviced by W14 man-with-van

The shop names are linked to shop codes (Table 10).

Table 10. W14 area shop names and codes

Shop	Shop code
Andover	A
Argyle Street	AS
George Street	GS
Bath	B
Boscombe	BO
Blandford	BL
Broadstone	BR
Chippenham	C
Corsham	CO
Devizes	D
Frome	F
Keynsham	K
Marlborough	M
Parkstone	P

Poole	PO
Salisbury	S
Salisbury Book	SB
Shaftesbury	SH
Swanage	SW
Trowbridge	T
Warminster	W

Culled stock is also normally collected from these shops for delivery to Winton or cascading to other shops.

4.2.3 Donation banks serviced by Winton

Figure 42 shows the locations of the 32 clothing and books & music donation banks serviced by the Winton driver. Stock collected from these donation banks is mainly taken back to Winton for sorting. Some donation banks such as the one in Swanage deliver the stock straight to the local shop.

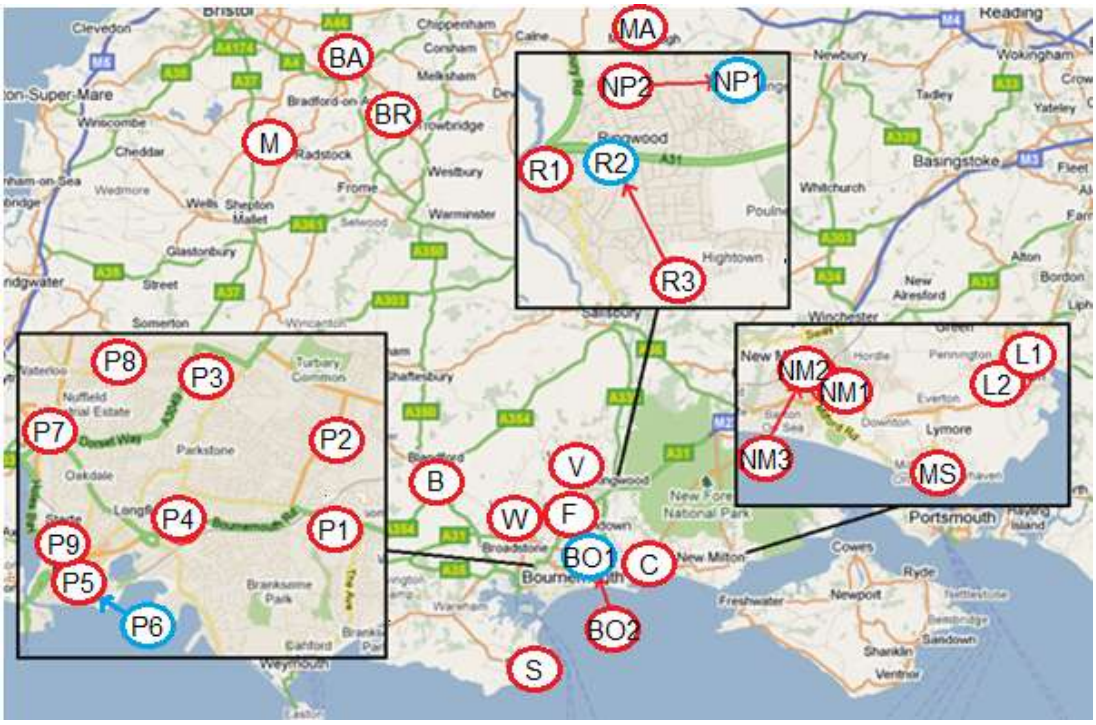


Figure 42. Donation banks serviced by W14 man-with-van

The donation bank names are linked to the donation bank codes as shown in Appendix 3. Circles outlined in red indicate book and music donation banks, while circles outlined in blue indicate textile donation banks.

4.2.4 Van running costs

In order to calculate the efficiency of each route and compare the costs to different scenarios, the van running costs had to be considered. Excluding the cost per km, the daily running cost of the van was approximately £83.86. This was added to running costs to ascertain the total cost of using the van each day. The approximate cost per km (of the fuel, tyres, repairs and maintenance) for the van (£0.15/km or £0.24/mile) were estimated based on a Post-2009 Ford Transit 2.2 Diesel.

A breakdown of the costs is shown below:

Van cost

The cost of the van lease was £4800 per annum based on a four year contract negotiated centrally by Oxfam with ALD Automotive (vehicle leasing company). Therefore the cost of leasing the van can be taken as £92.30 per week (£18.46 per day).

Drivers wages

The average wage for a van driver in the UK is assumed to be £16,000 per annum (Totaljobs.com, 2011). From this we extrapolated that the driver's wages were roughly £307 a week (£61.40 per day). Wages were estimated due to the sensitivity of actual wage values from Oxfam. Wages for van drivers are also likely to differ between charities; therefore an average wage value shows a good representative figure to base modelling upon.

Other costs

Assistant's expenses and equipment costs amounted to £20 per week (£4 a day).

4.2.5 Routing and scheduling

In addition to gaining an initial understanding donation bank quality and quantity yields, the W14 assessment was also tasked with investigating routing and scheduling. By recording the routes taken by the W14 man-with-van and using routing software it was possible to identify if the routes could be changed to attain better economy including fuel and time savings without negatively affecting the amount of donated stock moved.

W14 man-with-van Monday Route

Monday's route was primarily focussed on collecting and delivering stock to shops in the Bournemouth area (Figure 43). Three donation banks in the Bournemouth area were also emptied, containing donations to be taken back to the Winton centre.

A large proportion of the day (50 miles) was spent on the journey to Swanage where the local donation bank was emptied with stock for the Swanage book shop (Table 11). A collection was also made from the Marks & Spencer store in Poole with stock for Winton. The total distance for Monday's route was 79 miles, with a total running cost of £102.82 (£83.86[1] + £0.24[2] x 79[3]) equating to £1.30 per mile.

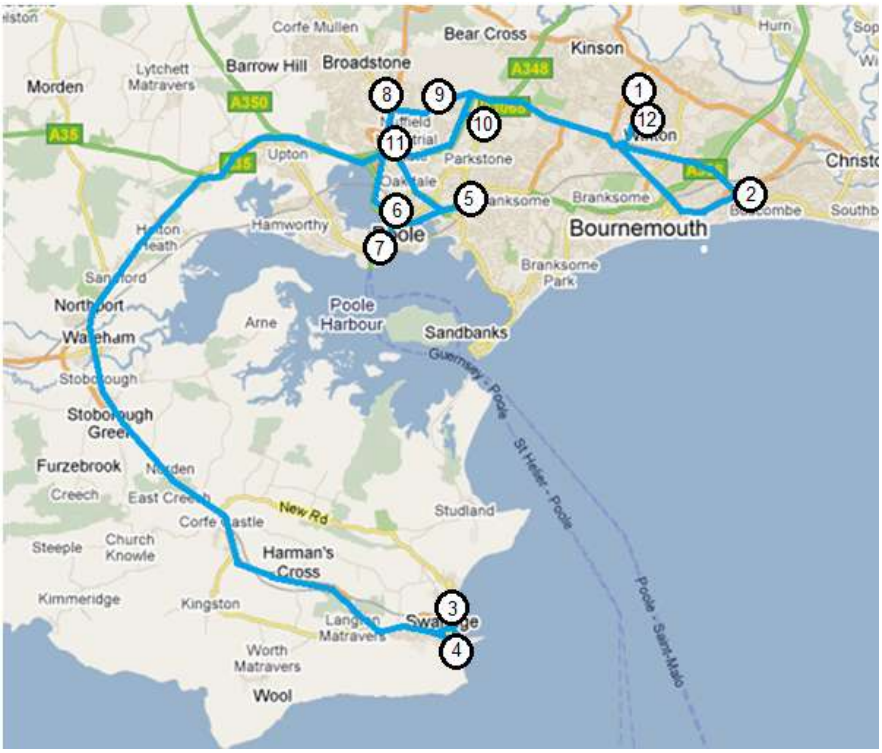


Figure 43. W14 man-with-van Monday route

[1] The daily cost of the van, including driver's and assistants wages and costs and van lease
[2] The cost per mile, taking into account fuel, tyres, maintenance and repairs
[3] The number of miles covered by the route

Table 11. W14 man-with-van Monday routes and mileages

Leg	Description	Type	Miles	Cost
1-2	Winton BH9 2RE -	Delivery of Winton stock (26)	5	£6.50
2-3	Boscombe shop BH7 6AA -	Donation bank collection (for	28	£36.40
3-4	S donation bank BH19 1NT	Deliver books (24) and collection	1	£1.30
4-5	Swanage shop BH19 1BT -	Collection of cascading stock for	21	£27.30
5-6	Parkstone shop BH14 0JD -	Delivery of stock from Parkstone	2	£2.60
6-7	Poole shop BH15 1DN -	Collection of M&S donation (12)	3	£3.90
7-8	M&S Poole BH15 1SU -	House collection (large donation	6	£7.80
8-9	House collection - P8	Donation bank collection (11)	2	£2.60
9-10	P8 donation bank BH17	Donation bank collection (19)	2	£2.60
10-	P3 donation bank BH12	Donation bank collection (13)	2	£2.60
11-	P7 donation bank BH17	Return to depot (unload van)	7	£9.10
			79	**£102.82**

nb. Number of bags/boxes delivered is shown in **red**. Number of bags/boxes collected is shown in **blue.**

Bags/boxes delivered[4]	64
Miles per bag/box delivered	1.23
Bags/boxes collected[5]	98
Miles per bag/box collected	0.81

W14 man-with-van Tuesday Route

The remainder of the Poole and Bournemouth donation banks were emptied on Tuesday, with the exception of two donation banks (P5 and P6 donation banks located at Pitwine Close, Sainsbury's).

The donation banks in Christchurch, Ringwood, Verwood, Ferndown and Wimborne were also emptied. A visit to Marks & Spencer's in Bournemouth was also made to accept another donation (Figure 44). The total distance for Tuesday's route was 64 miles (Table 12), with a total running cost of £99.22 (£83.86 + £0.24 x 64) equating to £1.55 per mile.

[4] Total number of bags/boxes delivered to shops, either from Winton stock on board van at the start of the day or stock transferred between shops

[5] Total number of bags/boxes collected from shops (for transferring) or donation banks

Figure 44. W14 man-with-van Tuesday route

Table 12. W14 man-with-van Tuesday routes and mileages

Leg	Description	Type	Miles	Cost
1-2	Winton BH9 2RE - BO1 & BO2	Donation bank	3	£4.65
2-3	BO1 & BO2 donation banks BH8 9UP -	Donation bank	6	£9.30
3-4	C donation bank BH23 4RY - NP1 &	Donation bank	13	£20.15
4-5	NP1 & NP2 donation banks BH24 1UB	Donation bank	2	£3.10
5-6	R2 & R3 donation banks BH24 1PX -	Donation bank	1	£1.55
6-7	R1 donation bank BH24 1AT - V	Donation bank	5	£7.75
7-8	V donation bank BH31 6UQ - F	Donation bank	7	£10.85
8-9	F donation bank BH22 9AL - W	Donation bank	5	£7.75
9-10	W donation bank BH21 - M&S	Collection of M&S	10	£15.50
10-	M&S Bournemouth BH2 5RW - P1	Donation bank	2	£3.10
11-	P1 donation bank BH12 1AU - P4	Donation bank	1	£1.55
12-	P4 donation bank BH14 0JD - P9	Donation bank	2	£3.10
13-	P9 donation bank BH15 2BP - P2	Donation bank	4	£6.20
14-	P2 donation bank BH12 4BA - Winton	Return to depot	3	£4.65
			64	**£99.22**

nb. Number of bags/boxes collected is shown in brackets

Bags/boxes delivered	0
Miles per bag/box delivered	N/A
Bags/boxes collected	122
Miles per bag/box collected	0.52

W14 man-with-van Wednesday Route

Wednesday was used to service the donation banks located in New Milton, Lymington and Milford-on-Sea. Upon return to the Winton centre, the bags of collected stock were emptied from the van. A trip to the local trade waste recycling centre was made to dispose of the refuse that had built up at the depot over a two week period (Figure 45). The total distance for Wednesday's route was 49 miles (Table 13), with a total running cost of £95.62 (£83.86 + £0.24 x 49) equating to £1.95 per mile.

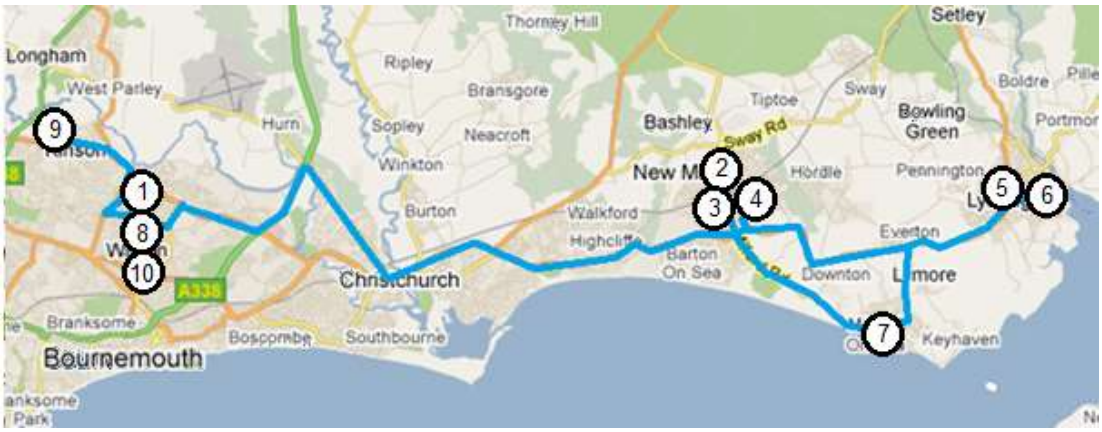


Figure 45. W14 man-with-van Wednesday route

Table 13. W14 man-with-van Wednesday routes and mileages

Leg	Description	Type	Miles	Cost
1-2	Winton BH9 2RE - NM3 donation	Donation bank collection	14	£27.30
2-3	NM3 donation bank BH25 6HE -	Donation bank collection	0	£0.00
3-4	NM2 donation bank BH25 6DL -	Donation bank collection	1	£1.95
4-5	NM1 donation bank BH25 6BP -	Donation bank collection	5	£9.75
5-6	L2 donation bank SO41 9GF - L1	Donation bank collection	1	£1.95
6-7	L1 donation bank SO41 9GN - MS	Donation bank collection	5	£9.75
7-8	MS donation bank SO41 0DA -	Return to depot (unload	15	£29.25
8-9	Winton BH9 2RE - Millham's	Deposit refuse	4	£7.80
9-10	Millham's Recycling BH10 7LQ -	Return to depot	4	£7.80
			49	**£95.62**

nb. Number of bags/boxes collected is shown in brackets

Bags/boxes delivered	0
Miles per bag/box delivered	N/A
Bags/boxes collected	58
Miles per bag/box collected	0.85

W14 man-with-van Thursday Route

Thursday involved the longest driving distances of the week. Visits were made to the shops in Andover, Marlborough, Chippenham and Devizes in order to collect culled stock and to deliver cascaded stock. A collection was made from the book and music donation bank in Marlborough (Figure 46). The total distance for Thursday's route was 158 miles (Table 14), with a total running cost of £121.78 (£83.86 + £0.24 x 158) equating to £0.77 per mile.

Figure 46. W14 man-with-van Thursday route

Table 14. W14 man-with-van Thursday routes and mileages

Leg	Description	Type	Miles	Cost
1-2	Winton BH9 2RE - Andover	Delivery of Winton stock (30)	45	£34.65
2-3	Andover shop SP10 1LS - MA	Donation bank collection (13)	28	£21.56
3-4	MA donation bank SN8 -	Collection of culled books for	1	£0.77
4-5	Marlborough shop SN8 1HU -	Miscommunication (No	19	£14.63
5-6	Chippenham shop SN15 1HA -	Collection of culled books and	12	£9.24
6-7	Devizes shop SN10 1AH -	Return to depot (unload van)	53	£40.81
			158	**£121.78**

nb. Number of bags/boxes delivered is shown in **red**. Number of bags/boxes collected is shown in **blue.**

Bags/boxes delivered	30
Miles per bag/box delivered	5.27
Bags/boxes collected	60
Miles per bag/box collected	2.63

W14 man-with-van Friday Route

Friday involved collections from the two remaining Poole donation banks and from the donation bank in Blandford. Shops in Poole and Blandford were visited in order to collect and deliver stock (Figure 47). The total distance for Friday's route was 42 miles (

Table 15), with a total running cost of £93.94 (£83.86 + £0.24 x 42) equating to £2.23 per mile.

Figure 47. W14 man-with-van Friday route

Table 15. W14 man-with-van Friday routes and mileages

Leg	Description	Type	Miles	Cost
1-2	Winton BH9 2RE -	Delivery of Winton stock (3) and	4	£8.92
2-3	Parkstone shop BH14 0JD -	Delivery of stock from Poole (14)	2	£4.46
3-4	Poole shop BH15 1DN - P5	Donation bank collection (22)	2	£4.46
4-5	P5 & P6 donation banks	Donation bank collection (7)	14	£31.22
5-6	B donation bank DT11 9PU -	Delivery of empty boxes and	1	£2.23
6-7	Blandford shop DT11 7AU -	Return to depot (unload van)	19	£42.37
			42	**£93.94**

nb. Number of bags/boxes delivered is shown in **red**. Number of bags/boxes collected is shown in **blue**.

Bags/boxes delivered	17
Miles per bag/box delivered	2.47
Bags/boxes collected	54
Miles per bag/box collected	0.78

Summary of W14 man-with-van weekly activity

Table 16 shows a breakdown of the distances and collections/deliveries over the audit week. Over the week, the total distance travelled was 392 miles delivering a total of 111 bags/boxes of books, textiles and bric-a-brac (3.53 miles per bag/box delivered). A total of 392 bags/boxes of stock were collected from the donation banks in the area and also from shops for cascading (1 mile per bag/box collected). In addition to the collection of donation bank and culled stock other activities such as a house collection, refuse disposal and Marks & Spencer's collections also took place.

Table 16. Distances and collections/deliveries

Day	Distance travelled (miles)	Bags/boxes delivered	Miles per bag/box delivered	Bags/boxes collected	Miles per bag/box collected
Monday	79	64	1.23	98	0.81
Tuesday	64	0	N/A	122	0.52
Wednesday	49	0	N/A	58	0.85
Thursday	158	30	5.27	60	2.63
Friday	42	17	2.47	54	0.78
Total	**392**	**111**	**3.53**	**392**	**1**

Thursday recorded the greatest mileage per bag of stock collected and delivered due to the large distances travelled between donation banks on that day. Other day's collections were more local. Monday, Tuesday and Wednesdays routes all stayed within close proximity of Bournemouth whilst collecting and delivering more boxes, recording lower values for miles-per-bag/box delivered and collected.

Tuesday appeared to be the most efficient round in terms of stock volumes delivered/collected with respect to mileage driven.

The break-down of van running costs is shown in Table 17. Costs are based on those shown in Section 4.2.4.

Table 17. Audit week van running costs

Day	Miles	Fuel, tyres, repairs and maintenance	Van cost	Drivers wages	Assistants expenses and equipment	TOTAL
Monday	79	£18.96	£18.46	£61.40	£4.00	£102.82
Tuesday	64	£15.36	£18.46	£61.40	£4.00	£99.22
Wednesday	49	£11.76	£18.46	£61.40	£4.00	£95.62
Thursday	158	£37.92	£18.46	£61.40	£4.00	£121.78
Friday	42	£10.08	£18.46	£61.40	£4.00	£93.94
TOTAL	392	£94.09	£92.30	£307.00	£20.00	£513.39

Table 18 shows the efficiency of collections relating to costs rather than solely by the distances travelled. The increased distances travelled on Thursday equate to the best value in terms of cost per mile for running the van (£0.77). However, the efficiency of a day's collection would be better judged by relating it to the cost per bag delivered/collected. Monday was the most efficient day with 162 bags/boxes delivered/collected over a distance of 79 miles, resulting in a cost of £0.63 per bag/box. In contrast, Wednesday was the least efficient day, transporting 58 bags/boxes of stock over a distance of 49 miles (£1.65 for each bag/box).

Table 18. Costs per bag delivered/collected

Day	Distance travelled (miles)	Total van running cost	Van running cost per mile (£/mile)	Bags delivered/ collected	Cost per bag delivered/ collected
Monday	79	£102.82	£1.30	162	£0.63
Tuesday	64	£99.22	£1.55	122	£0.81
Wednesday	49	£95.62	£1.95	58	£1.65
Thursday	158	£121.78	£0.77	90	£1.35
Friday	42	£93.94	£2.23	71	£1.32

4.2.6 Carbon emissions

According to Carbon Footprint.com, 392 miles in a 2009 Ford Transit, Post 2009 Model Year 2.2 Duratorq TDCi Diesel (115PS) produces a total of 149 kg of CO_2. This is the total amount of carbon produced by the van during the audit week, equating to 0.38 kg of CO_2 per mile.

Each day's round was investigated to determine the carbon footprint of the activities, linked to the number of bags of stock collected and delivered (Table 19).

Table 19. Carbon emissions

Day	Miles	Carbon emissions (kg of CO_2)	Bags delivered	Carbon footprint per bag delivered (kg of CO_2)	Bags collected	Carbon footprint per bag collected (kg of CO_2)
Monday	79	30	64	0.469	98	0.306
Tuesday	64	24	0	N/A	122	0.197
Wednesday	49	19	0	N/A	58	0.328
Thursday	158	60	30	2	60	1
Friday	42	16	17	0.941	54	0.296
Total	392	149	111		392	

From these results we can tell that the most efficient way of collecting stock is to visit more donation banks in a day over a more local area. We can see that the carbon emissions on Thursday were far greater per bag than on the other days, and this was due to the large distances covered with a relatively low amount of stock moved. The ideal situation would be to carry out more local deliveries and collections, however due to the lack of a driver in Wiltshire it was necessary for Winton to service these shops and donation banks. Re-evaluating the areas of jurisdiction for donation bank collections and shop servicing could be an area for future study to optimise the current man-with-van rounds to see what savings could be made across the network. Cost savings could also be realised if donation banks in the more distant locations (such as Marlborough) were serviced by Wastesaver or transferred to other areas.

Carbon emissions by bag related to donation bank

A number of steps were taken in order to calculate the carbon footprint for each bag of stock acquired. Firstly, the routes taken were studied in order to calculate the total emissions for transporting stock from each donation bank to the Winton depot, taking into consideration the whole distance that stock remained on board the van. The value for the total emissions for each donation bank visit was then linked to the number of bags of stock collected and this allows the carbon footprint per bag collected to be ascertained.

Table 20 shows the rank of carbon footprints for each donation bank per bag collected during the audit week. Also shown are the distances left on the route until the stock is unloaded at the Winton depot. The carbon footprint for each bag of donation bank stock was derived by taking the amount of CO_2 that would be produced until the round was completed (the distance left until arriving at the depot to unload), and dividing it by the number of bags that was collected at that site. The limitation to this method is that it does not take into account what stock is already on the van and how many site visits are conducted after each visit. The donation banks carbon footprint was directly related to its location on the round and the relative travel distance for the number of bags available. Textile donation banks tended to show higher carbon footprints when there was a small amount of stock collected. The two donation banks with the largest carbon footprints were both textile donation banks (B&Q Castle Point, 4.8 kg CO_2 per bag where only 22.4 kg of textiles were collected and Ringwood RYC, 5.2 kg CO_2 per bag where only 18.8 kg of textiles was collected), however this trend was contradicted by the textile donation bank located at Sainsbury's, Talbot Heath which showed the third smallest carbon footprint (0.293 kg CO_2 per bag) due to the comparatively large amount of stock collected and short distance back to the depot.

Table 20. Rank table of carbon footprints per bag of stock by donation bank

Donation bank	**Distance from Winton on route (miles)**	**Carbon footprint (kg CO_2 per bag)**
Tesco, Tower Park, Poole (Books)	9	0.185
Tesco, Waterloo Road, Poole (Books)	7	0.210
Sainsbury's, Talbot Heath, Poole (Textiles)	3	0.293
Recycling Centre, Milford-on-Sea (Books)	15	0.293
Asda, Canford Heath, Poole (Books)	11	0.390
Poole Stadium, Poole (Books)	7	0.455
Allenview Centre, Wimborne (Books)	22	0.477
Barfields, Lymington (Books)	20	0.488
Tesco, Poole Road, Branksome, Poole (Books)	10	0.557
Commercial Road Car Park, Poole (Books)	9	0.702
Morrison's, Verwood (Books)	34	0.884
Tesco, Blandford (Books)	20	1.086
Sainsbury's, Pitwine Close, Poole (Textiles)	33	1.170
Sainsbury's, Pitwine Close, Poole (Books)	33	1.170
Furlong Car Park, Ringwood (Books)	39	1.170

Tesco, New Milton (Books)	26	1.268
RYC Butlers Lane, North Poulner (Textiles)	42	1.365
Waitrose, Lymington (Books)	21	1.365
Spencer Road, New Milton (Books)	27	2.106
B&Q, Castle Point, Bournemouth (Books)	61	2.163
Marlborough (Books)	85	2.550
Sainsbury's, Ferndown (Books)	27	2.633
Sainsbury's, Christchurch (Books)	55	2.681
RYC Butlers Lane, North Poulner (Books)	42	3.276
Elm Avenue Car Park, New Milton (Books)	27	3.510
Ringwood RYC, Ringwood (Books)	40	3.900
B&Q, Castle Point, Bournemouth (Textiles)	61	4.758
Ringwood RYC, Ringwood (Textiles)	40	5.200

Donation banks that were visited earlier on a day's route resulted in a higher carbon footprint as the stock had travelled greater distances compared to donation banks that were visited at the end of the day. The Elm Avenue Car Park book and music donation bank in New Milton showed a large carbon footprint (3.510 kg of CO_2 per bag) despite the low mileage left to Winton. This was because of the low amount of stock collected from this site (only 19 kg).

Donation banks within the Poole and Bournemouth areas generally recorded smaller carbon footprints because of the shorter distances driven to deliver the stock to Winton. Table 20 shows this with five out of six of the smallest carbon footprints originating from donation banks in Poole. Despite the relatively large distance of 15 miles distance from the depot on the route, The Milford-on-Sea book donation bank shows a small carbon footprint per bag due to the large amount of stock collected during the audit week (165.1 kg).

4.2.7 Modelling the base case operation

The 2011 audit was used as the base case to compare against two alternative operating scenarios (shown in Section 3.3.2). This base case was compared against Logix optimised routes whereby the software was firstly given the freedom to decide route order (Scenario A). A second scenario allowed Logix the freedom to determine what day each site should be visited to create an optimal collection schedule (Scenario B).

The developed Smartphone App (described in Section 3.4) allowed the opportunity to track donation bank fill levels over time. With this newly available functionality, an updated base case was needed (using the same routes as the original base case but modelled over a longer period) to compare against a scenario whereby donation banks were only to be visited when they reached a certain fill level (75% full). The requirement for banks to be visited at 75% full for more efficient collection strategy was described in Section 3.3.3. An updated base case was created using data derived from the Smartphone App trial in 2013. Four weeks data (2/6/13/-28/6/13) enabled the modelling to cover two full rotations of the collection schedule and allowed us to identify potential benefits from studying a minimum bank fill level collection scenario. These routes were based on scheduled visits to donation banks and shops and include recurring cascade channels between shops. This four week period was modelled using:

- Actual collection and delivery weights from the four week period.
- Actual scheduled days of visits to shops and donation banks, and in the same sequence as it occurred.

All routes started and finished at the Distribution centre in Winton. The time of each route does not include the loading and unloading time at Winton.

Appendix 1 shows the performance of donation banks in the W14 area between 3/5/13 and 22/7/13. Appendix 4 shows the performance of shops in the W14 area between 3/5/13 and 22/7/13.

Table 21 shows a breakdown of statistics for the week of Dorset localised collections in June 2013 to use as the updated base case in comparison to the alternative collection strategy of visiting donation banks at a minimum fill level (shown in Section 6.3). The routes repeat on alternate weeks (Week 3 repeats Week 1); however Table 21 shows that these routes are not exactly replicated, with some additional sites visited between weeks. This is because of additional house collections and corporate donations that occur on an ad hoc basis.

Within Week 1 a total of 44 sites were visited, with a total distance travelled of 967 km and 4522 kg of textiles moved (the combined total of textiles delivered and collected). More sites (47) were visited in Week 3 and a greater amount of textiles moved as well (6120 kg) however the total distance travelled was less, at 768 km. This shows for greater efficiency in Week 3 over Week 1.

Within Week 2, 46 sites were visited, travelling 773 km and moving 3802 kg of textiles. Week 4 showed the same number of visits and a similar total distance (809 km). A total of 5127 kg of textiles were moved in Week 4.

Within this one month period the man-with-van driver delivered and collected nearly 20 tonnes of donations costing the charity £2174 in running costs and wages. The number of visits remained consistent between each week, but with variability in the distances travelled and the amount of textiles moved.

Base case

Table 21. W14 June 2013 collection routes (Updated base case)

Week	Route	Day	kms	No. of sites visited	Time	Kg delivered	Kg collected	Total kg moved	Cost to run	Cost per kg moved	CO_2 emissions (kg)
1	3/6/13	Mon	138	11	03:53	481	548	1029	£104.56	£0.10	33.12
	4/6/13	Tue	265	6	05:48	435	526	961	£123.61	£0.13	63.6
	5/6/13	Wed	255	5	05:16	210	405	615	£122.11	£0.20	61.2
	6/6/13	Thu	85	13	03:10	68	797	865	£96.61	£0.11	20.4
	7/7/13	Fri	224	9	05:21	421	631	1052	£117.46	£0.11	53.76
2	10/6/13	Mon	136	10	03:27	406	331	737	£104.26	£0.14	32.64
	11/6/13	Tue	66	9	02:43	0	541	541	£93.76	£0.17	15.84
	12/6/13	Wed	253	6	05:10	270	256	526	£121.81	£0.23	60.72
	13/6/13	Thu	72	15	03:06	105	1142	1247	£94.66	£0.08	17.28
	14/6/13	Fri	246	6	05:17	15	736	751	£120.76	£0.16	59.04
3	17/6/13	Mon	130	10	03:23	421	248	669	£103.36	£0.15	31.2
	18/6/13	Tue	263	7	06:18	315	1090	1405	£123.31	£0.09	63.12
	19/6/13	Wed	104	10	04:58	1500	428	1928	£99.46	£0.05	24.96
	20/6/13	Thu	48	12	02:04	120	767	887	£91.06	£0.10	11.52
	21/6/13	Fri	223	8	05:34	458	773	1231	£117.31	£0.10	53.52
4	24/6/13	Mon	138	11	03:43	473	399	872	£104.56	£0.12	33.12
	25/6/13	Tue	95	14	03:48	0	987	987	£98.11	£0.10	22.8
	26/6/13	Wed	253	5	05:02	23	405	428	£121.81	£0.28	60.72
	27/6/13	Thu	246	4	05:03	0	563	563	£120.76	£0.21	59.04
	28/6/13	Fri	77	12	04:28	120	2177	2297	£95.41	£0.04	18.48
			3317	183	87:32	5841	13750	19591	£2,174.75	£0.11	796.08

These routes are mapped in Appendix 5

4.2.8 Understanding the efficiency of localised collections

Shops

Table 22 shows the performance statistics of shops serviced by the W14 man-with-van between 3/5/13 and 22/7/13. The highest number of bags delivered and cascaded from a single shop (Andover) was 369 bags, 366 of which were delivered which shows that this shop relied heavily on cascaded stock. In contrast, all of the 317 bags of stock moved from Marlborough were cascaded which shows that this shop had high amounts of excess stock available for other shops to receive.

To show a comparison of the number of bags moved by the Winton Distribution Centre during this period; 3820 bags of stock were delivered and 1228 bags were collected.

Table 22. W14 Oxfam shops performance (3/5/13 – 22/7/13)

Shop	Number of bags delivered	Number of bags cascaded	Bags moved (delivery + cascade)	Delivery / cascade ratio	Visits	Delivery / visit	Cascade / visit
Winton Distribution Centre	3820	1228	5048	3.1	96	39.8	12.8
Andover	366	3	369	122	6	61	0.5
Poole	347	13	360	26.7	19	18.3	0.7
Marlborough	0	317	317	0	10	0	31.7
Bath 1	171	125	296	1.4	9	19	13.9
Swanage	208	69	277	3	9	23.1	7.7
Bath 2	162	88	250	1.8	11	14.7	8
Blandford Forum	8	189	197	0	10	0.8	18.9
Shaftesbury	0	108	108	0	6	0	18
Bournemouth	95	6	101	15.8	9	10.6	0.7
Bristol	31	44	75	0.7	4	7.8	11
Bath 3	30	41	71	0.7	5	6	8.2
Devizes	0	66	66	0	4	0	16.5
Chippenham	1	60	61	0	4	0.3	15
Salisbury 1	0	9	9	0	2	0	4.5
Salisbury 2	0	9	9	0	3	0	3
Frome	0	3	3	0	1	0	3

Figure 48 shows the location of shops serviced by the W14 area man-with-van and the total number of bags moved (delivery and cascade) between 3/5/13 and 22/7/13.

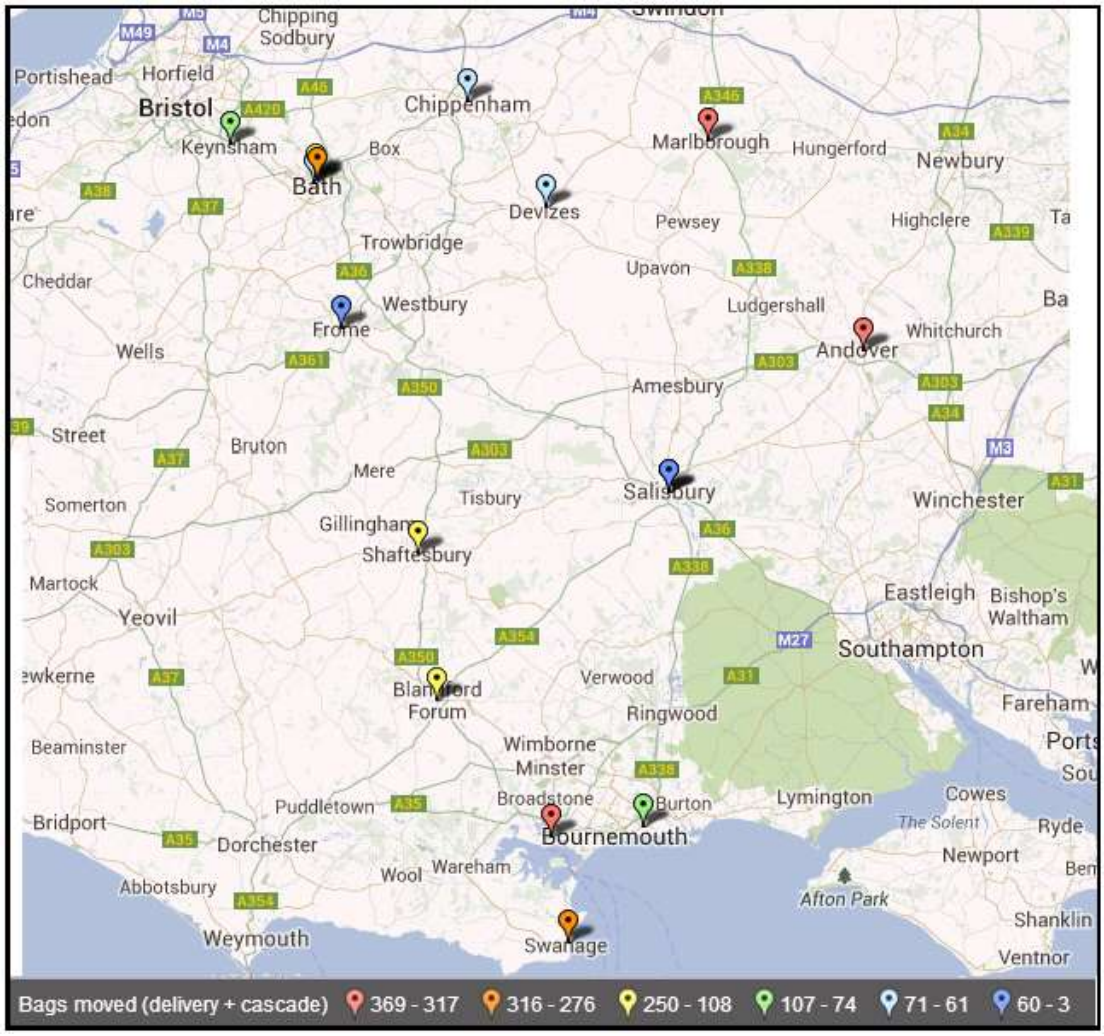


Figure 48. W14 Oxfam shops (with total bags moved between 3/5/13 and 22/7/13)

Figure 49 shows the number of bags moved (accumulation of delivery and cascade) from shops against the total number of visits to that shop in W14. There is a correlation between the figures (n = 16, R^2 = 0.6074) where generally, the more the shop is visited, the more bags are moved as is to be expected.

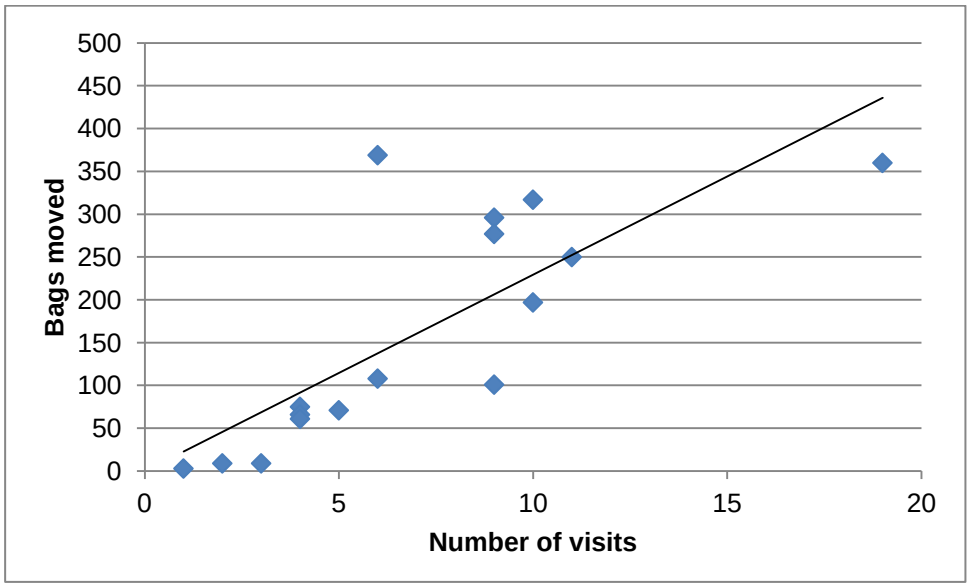


Figure 49. Number of bags moved (delivery + cascade) from shops against number of visits (W14)

Donation banks

Figure 50 shows the location of donation banks serviced by the W14 area man-with-van and also how many bags of donated stock were collected from each site between 3/5/13 and 22/7/13. Donation banks showing the highest yields were spread across the region. The Swanage and Melksham banks are located in areas requiring large travel distances and showed low yields. The donation banks to the east of Bournemouth showed low yields (less than 79 bags collected over the 11 week period) with the exception of one donation bank in Lymington.

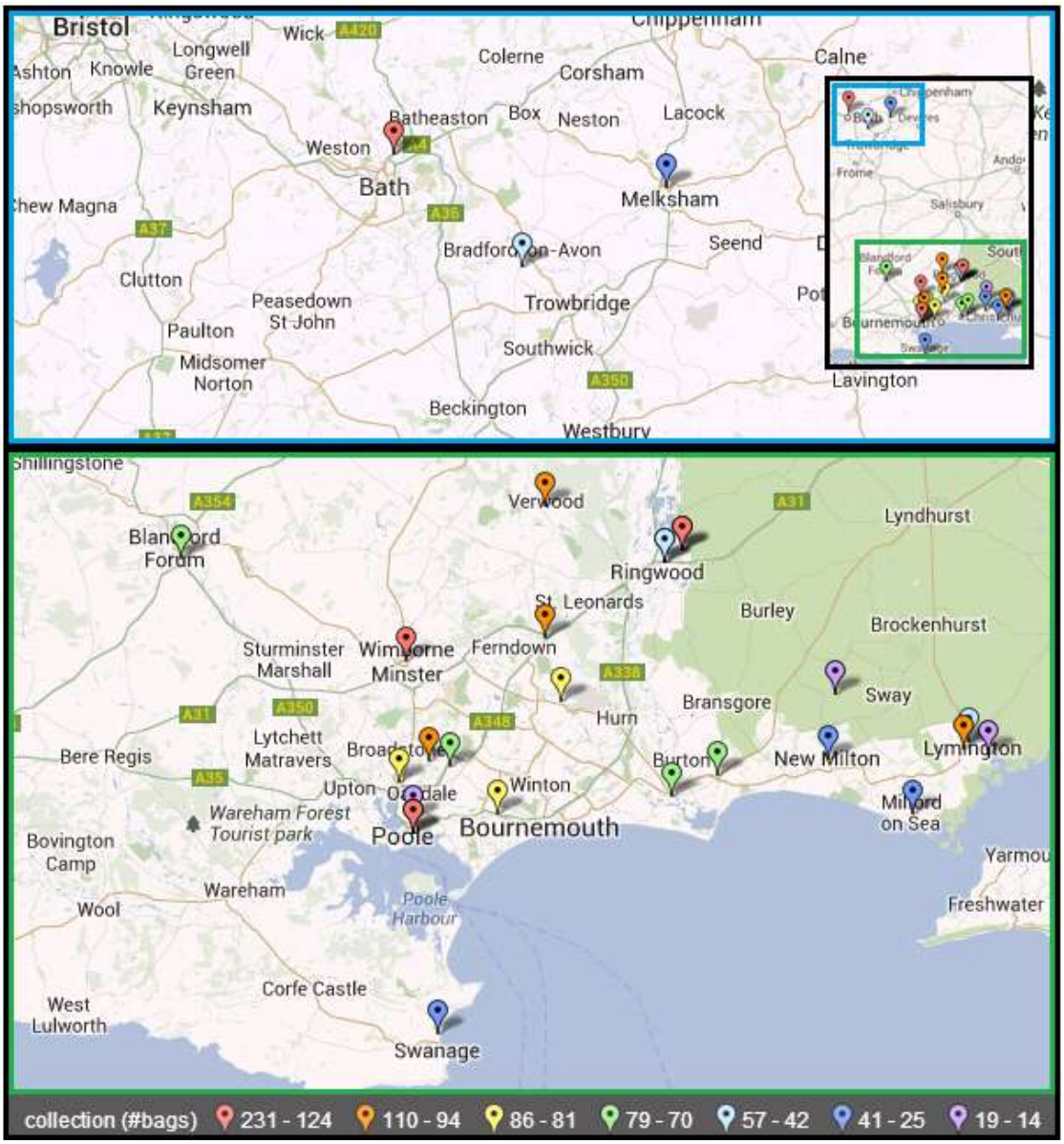


Figure 50. W14 Oxfam donation banks (with number of bags collected between 3/5/13 and 22/7/13)

Figure 51 shows the number of bags collected from donation banks against the total number of visits to that donation bank in W14. The relationship is not so clear here (when compared to shop visits). There does not appear to be a correlation between the number of bags collected and the number of visits. This shows that there is potential to optimise donation bank visits, where in theory the more a donation bank is visited, the more is collected. Donation banks that are visited many times, while only showing low yields, do not demonstrate an efficient use of resources.

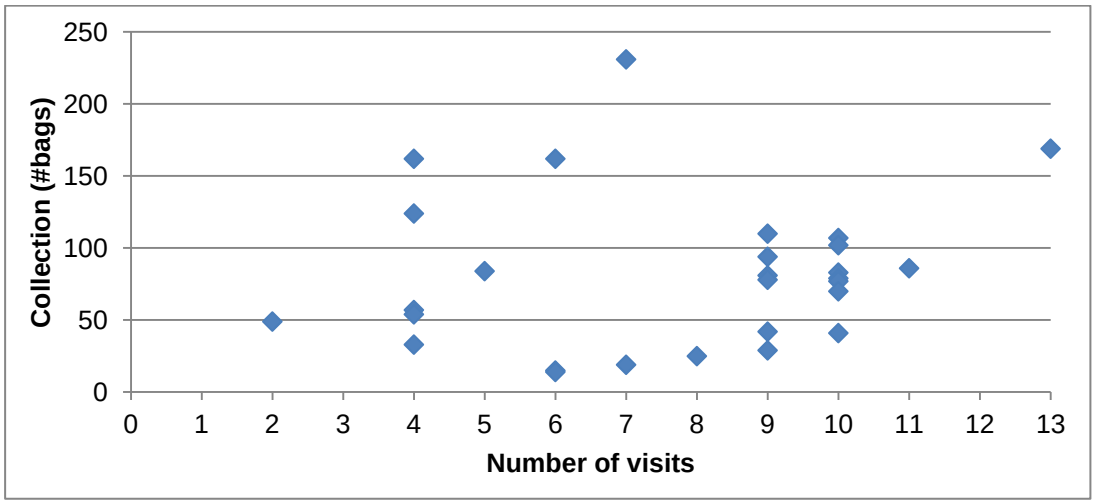


Figure 51. Total number of bags collected from donation banks against number of visits

Figure 52 shows the average fill level of donation banks upon emptying against the total number of visits to that donation bank in W14. There does not appear to be a correlation (R_2 = 0.133) between the average fill level of a donation bank at its service event and the number of visits. This shows that donation banks are visited without any knowledge of how full they are. Using remote monitoring technology could help the charity to avoid wasted journeys to donation banks that are only around 20% full on average.

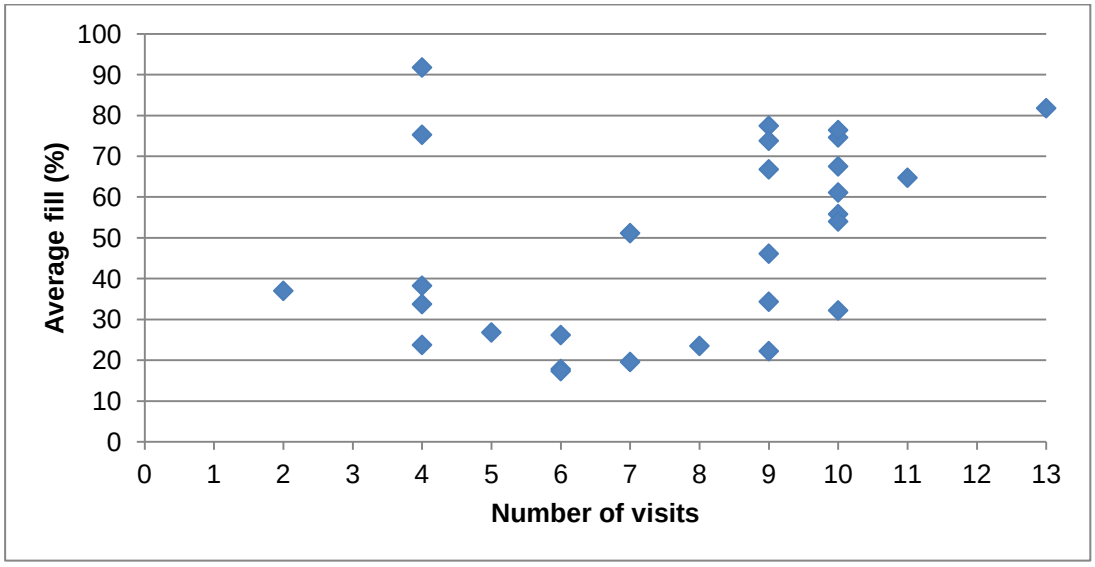


Figure 52. Average fill level of donation bank at emptying against number of visits

Figure 53 shows the correlation between the average fill level of a donation bank upon emptying and the total number of bags collected from that donation bank in W14. In general, the higher the average fill level upon collection, the higher the number of bags collected. In theory, charities should aim to empty all donation

banks when they are between 50% and 80% full. Oxfam bank managers identified that this was an optimal fill level to visit banks at because this results in less wasted journeys to donation banks, whilst still allowing some space to avoid overflowing. This also results in more efficient routing. The challenge is judging when to empty banks for this to occur, and avoiding the problem of overflowing. Fourteen of the donation banks showed an average fill level of below 50%, which shows inefficiencies. These banks should be considered for visiting less often.

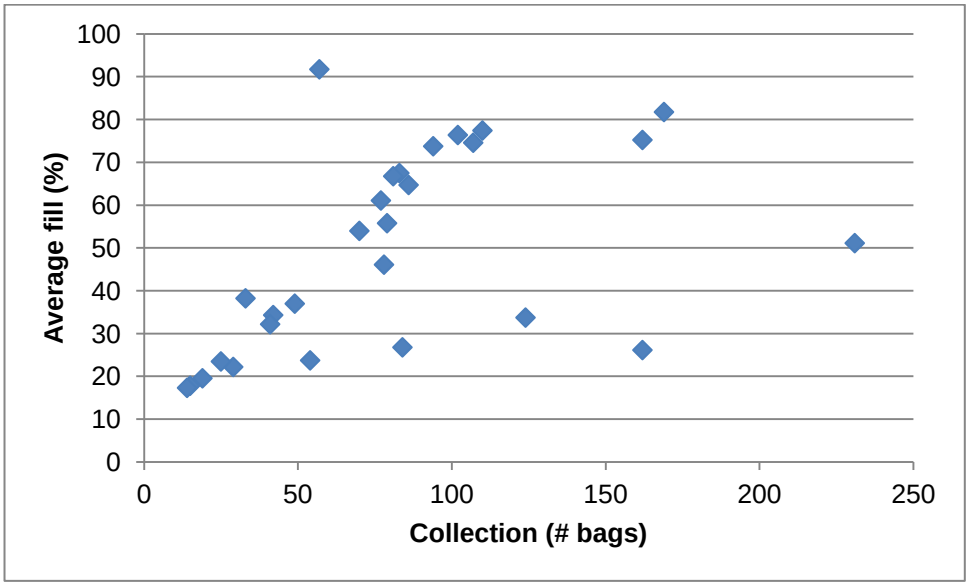


Figure 53. Average fill level of donation bank at emptying against total number of bags collected

4.3 Investigating centralised collection strategy – understanding business as usual trends

4.3.1 The case study week

The base case operating scenario in the investigation of the centralised collection strategy was quantified using a week's data of Milton Point routes. From this base, a range of other scenarios were tested (described in Section 3.3.3). Figure 54 shows that the distance travelled by each of the 23 routes (shown in Table 27. Milton Point routes) during the case study week remained consistent with the corresponding mean average km travelled for each route over the September to November 2012 period (R^2 = 0.8826).

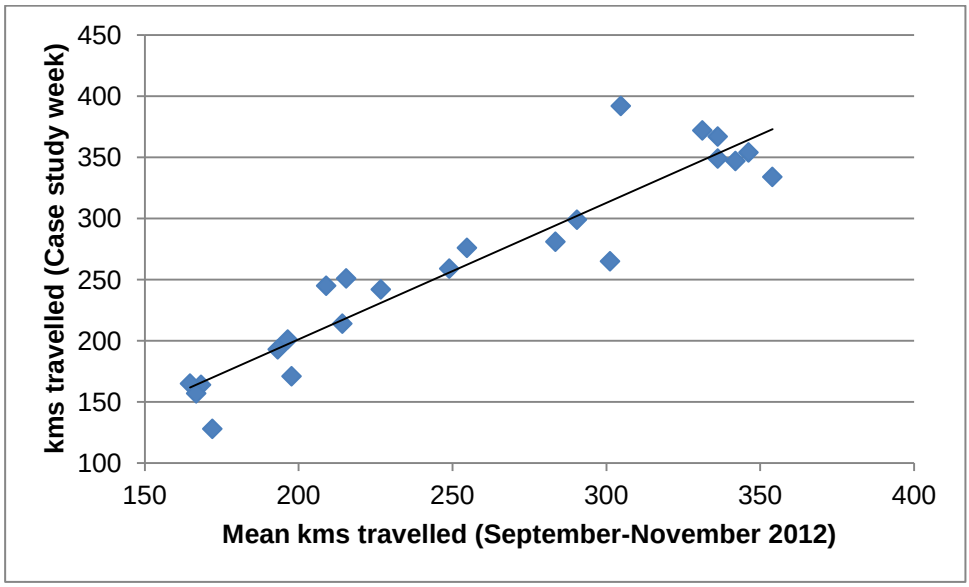


Figure 54. Mean km travelled for each route (September-November 2012) against the case study week

The weights collected from week to week vary as charities are subject to peaks and troughs in donation amounts throughout the year. An illustration of the variability of weights collected between April 2010 and March 2011 is shown in Figure 55.

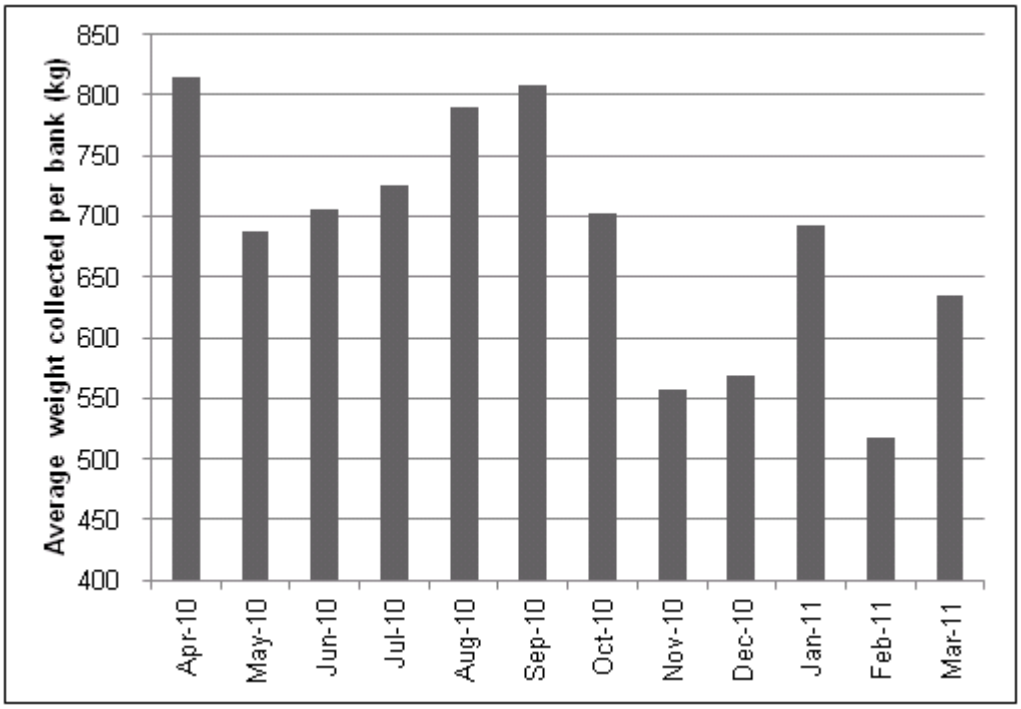


Figure 55. Average collected donation bank weights by month

The case study week (3/9/12-7/9/12) was chosen as the distances travelled were similar to the mean proven by using an ANOVA single factor test between the case study week and mean distances travelled over a 3 month period (F = 0.12, F crit = 4.06).

Figure 56 plots the weights collected from the 23 routes (shown in Table 27) run during the case study week against the corresponding mean average for each route over the September to November period (R^2 = 0.3859). The weights collected during the case study week were generally greater than the mean average over the 3-month period. This is proven by an ANOVA single factor test where the difference between the mean observed weights of the two datasets were statistically significant (F = 5.05, F crit = 4.06). It was important to test the scenarios at collection levels greater than the mean to show that the system can cope with the large amounts of stock that can be transported by Milton Point routes.

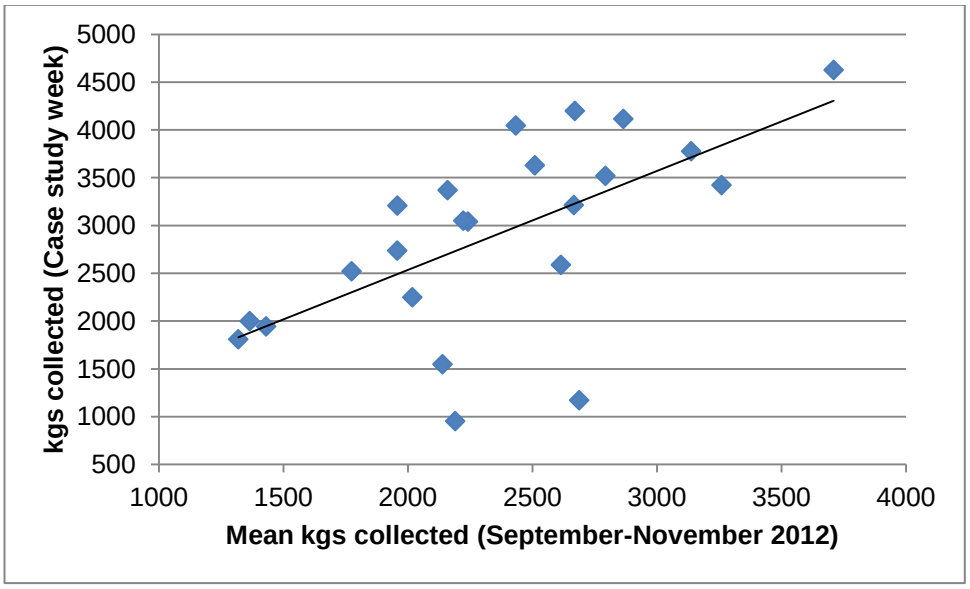


Figure 56. Mean kg collected for each route (September-November 2012) against the case study week

Firstly, data for the case study week (3/9/12 – 7/9/12) were obtained from PODFather, a data management system used to record stock deliveries and collections. Table 23 shows the weights collected and distances travelled for each day in the case study week against the mean values over the period of September to November 2012. In the case study week, the distances for Monday, Tuesday and Wednesday were greater than the mean average for the September to November 2012 period. Conversely, the distances travelled on Thursday and Friday in the case study week were less than the mean average. Weights collected during the case study week were consistently greater than those found in the mean average for the September to November 2012 period. It was important to model the routes during peak periods to show how the system copes at its busiest. The standard deviation shows that there is greater variability for route distances on Monday (114.5 km), than the other days of the week. This suggests that Monday includes more ad-hoc

tasks and changes in schedule. Standard deviation of weights collected were generally high over the September to November 2012 period (ranging from 1171.8 kg – 2628.6 kg).

Table 23. Average statistics for each day

	Case study week		**Mean average (Sept-Nov 2012)**		**Standard Deviation (Sept-Nov 2012)**	
Day	km	kg	km	kg	km	kg
Monday	1331	15371	1265	13949	114.5	2040.3
Tuesday	1171	14968	1115	9856	57.5	2628.6
Wednesday	1153	10474	1043	8315	76.6	1311.2
Thursday	1148	12262	1186	7779	60.0	1171.8
Friday	1223	13639	1247	12798	36.0	1645.3

Each route begins and ends at the centralised sortation depot (Milton Point). Route distances can depend on which driver has taken the route each week as drivers have the flexibility to decide their routes (order sequence and path taken) and some use different routes than others. Variations may also occur where drivers have to change their route to avoid congestion. Appendix 6 shows the breakdown for each separate route, the statistics of km travelled and kg collected against the mean between September and November 2012.

4.3.2 Dwell times

Modelled dwell times at shops and donation banks (in minutes) have been given as 0.07 x kg collected as derived from regression relationships from August to November 2012 Milton Point data (described in Section 3.3.1). Using the Milton Point data between August and November allowed dwell times to be correlated against the amount of donations collected. Table 24 shows a comparison between the mean combined dwell times at shops and banks between routes between September and November 2012 and those found in the case study week. The figures in red show where the case study week dwell times were found to be less than the mean dwell time between September and November. The results show that 8 routes showed shorter dwell times in the case study week than over the 3 month period. 15 routes showed greater dwell times in the case study week than over the 3 month period. The mean total dwell times over the 3 month period are expected to be indicative of more realistic dwell times as this takes into the account variability over time.

Table 24. Case study week total dwell times against the mean total dwell times (September – November 2012)

Route	Mean total dwell time (Sep-Nov 2012) (minutes)	Case study week total dwell time (minutes)	Difference (minutes)
Berkhamsted Thurs	259	165	94
Cambridge Wed	224	134	90
Northampton Thurs	231	172	59
Cambridge Fri	245	188	57
Reading Mon	172	150	22
Bishop Stortford Fri	231	210	21
Watford Wed	201	185	16
Bishop Stortford Mon	215	203	12
Peterborough Thurs	219	242	23
Peterborough Tues	197	221	23
Reading Wed	166	205	38
Oxford Thurs	166	210	43
March Tues	183	230	46
Bishop Stortford Wed	199	252	53
Beaconsfield Tues	221	280	58
March Thurs	185	248	62
Berkhamsted Mon	219	282	62
Watford Fri	250	324	73
Cambridge Mon	248	325	76
Reading Fri	178	274	95
Beaconsfield Fri	231	349	117
Northampton Tues	181	330	148
Watford Mon	203	412	208

4.3.3 Creating the base case

These separate routes were then made into a spreadsheet suitable for using in Logix to model the impacts of the alternative scenarios. For each type of item moved, a product code ('PROD') is needed for use within Logix (Table 25). The weights for each type of stock are determined by Oxfam average bag weights. Oxfam derived the numbers for weights of bags from an audit of actual bag weights and determined these as the preferred maximum weights for health and safety reasons. As those handling bags of donated stock range from driver's carrying the bags potentially large distances, to volunteers picking the bags up to sort through

stock, the bags must be kept at a manageable weight for all staff handling donations.

Table 25. Logix product codes

Product type	Logix product type	Weight per bag (kg)
Textile donation bank stock	PROD1	7.5
Books	PROD2	6.5
Textile black sacks	PROD3	6.4
Other (Electricals, metals, homewares, metal, music, plastic, shoes)	PROD4	Weighed per item

When creating the input file for Logix, care was taken to make sure that collections were modelled for the same day as in real life, allowing the user to set a specific day for when the order must be completed and also which depot must serve it. Models also followed the same sequence as used by the Milton Point drivers. This function allows the user to give the sequence of an order within a route. This function is only used for Pre-Allocated routes (ie. The base case). All routes started and finished at Milton Point.

One way of identifying the efficiency of a routing strategy is to look at the relative CO_2 emissions compared to the base case. CO_2 emissions directly result from route distance, which is intrinsically linked to route cost, where identifying potential savings are a primary focus for Oxfam. Statistics for CO_2 (gram/km) emissions were taken from the STREAM International Freight study (Table 26) by den Boer et al (2011) who provided a comprehensive review of vehicle-based freight transport emissions per tonne-kilometre for the various market segments of international freight carriage.

Table 26. CO_2 emissions, by vehicle type (den Boer et al, 2011)

	Vehicle type	Urban	Non-urban	Motorway
CO_2 (gram/km)	Small van < 2 tonne	280-297	182-192	251-258
	Large van > 2 tonne	325-355	211-229	293-305
	Truck < 10 tonne	488-552	373-412	391-417
	Truck 10-20 Tonne	876-1071	608-726	539-618
	Truck > 20 tonne	1174-1566	839-1078	724-885
	Truck trailer	1023-1661	694-1082	558-819
	Longer heavier vehicle	1381-2243	937-1461	754-1106

As the 5 vehicles used from Milton Point were 12 Tonne lorries, the average between 608 gram/km and 726 gram/km for Non-urban travel will be used (667 gram/km).

The scenario was then run through Logix (the process is described in 3.3.1) and then the modelled times and other key performance indicators (CO_2 and kg collected per km travelled) of each route were observed. It was necessary to create this base case, so that further scenarios could be fairly tested and compared against a model that reflected the real-world, but that used the same parameters, such as vehicle speed.

The base case models the 10 current routes used by Milton Point drivers (Table 27). In most cases, with the exception of Oxford, the routes are repeated during the week to ensure that sites are visited as frequently as needed, although these routes can have slight variations between each day.

Table 27. Milton Point routes

Day	**Routes**				
Monday	Cambridge	Reading	Bishops Stortford	Watford	Berkhamsted
Tuesday	March	Peterborough	Northampton	Beaconsfield	
Wednesday	Cambridge	Reading	Bishops Stortford	Watford	
Thursday	March	Peterborough	Northampton	Berkhamsted	Oxford
Friday	Cambridge	Reading	Bishops Stortford	Watford	Beaconsfield

A breakdown of the base case modelled routes over the week period is shown in Appendix 7. Five different lorries as currently used by Milton Point are needed to undertake these routes. Table 28 shows the key statistics of the base case scenario.

Table 28. Base case model statistics

Vehicles required	5 (12 Tonne lorries)
Total distance (km)	5588
Total time spent	220 hours 44 minutes
Total collected (bags, kg)	8902, 66764
Collected from shops (kg)	41175
Collected from donation banks (kg)	25589
Total CO_2 (kg)	3727
Kg/km	11.95
Km/bag	0.63
CO_2 (kg)/bag	0.42

Table 29 shows the case study week actual route times against the Logix modelled route times. In 14 cases out of the 23, the case study route time for the round was greater than the Logix modelled route times. The route distances modelled by Logix replicated those recorded in the case study week. Care was taken to calibrate the modelled times to match the case study week actual route times. This was achieved through adjusting vehicle speeds and route traversal times. It was difficult to make the two sets of data match, this was because the real world nature of the collection routes and the many variables that can affect total route time (such as traffic, shop and bank dwell times, restrictions and trouble accessing sites). The route distances of the actual case study week were replicated in Logix by adhering to identical routing.

Table 29. Logix modelled route times against the case study week actual route times

Route	Day	Route distance (km)	Case study week actual route time (hh:mm)	Logix modelled route time (hh:mm)	Calls	Route time difference (hh:mm)
March	Tue	334	08:55	12:29	9	03:34
Peterborough	Tue	372	10:31	13:05	11	02:34
Bishops Stortford	Mon	299	09:40	12:00	13	02:20
Berkhamsted	Thu	128	06:20	07:57	8	01:37
Reading	Mon	347	08:20	09:50	6	01:30
Bishops Stortford	Fri	265	10:20	11:40	13	01:20
Reading	Wed	354	09:00	09:52	5	00:52
Northampton	Tue	251	10:40	11:08	15	00:28
Watford	Wed	165	07:40	07:47	10	00:07
March	Thu	367	11:48	11:44	12	00:04
Beaconsfield	Tue	214	09:50	09:42	10	00:08

Bishops Stortford	Wed	392	12:35	12:17	12	00:18
Reading	Fri	349	11:29	10:46	8	00:43
Northampton	Thu	201	08:25	07:40	11	00:45
Peterborough	Thu	281	10:45	09:41	10	01:04
Cambridge	Wed	242	09:10	07:56	6	01:14
Berkhamsted	Mon	245	11:15	09:52	13	01:23
Cambridge	Mon	276	12:25	10:58	12	01:27
Beaconsfield	Fri	193	11:00	09:31	10	01:29
Cambridge	Fri	259	09:45	07:03	11	02:42
Oxford	Thu	171	09:00	06:07	10	02:53
Watford	Fri	157	10:45	06:38	10	04:07
Watford	Mon	164	12:30	05:01	10	07:29

The actual round times are generally longer than the modelled times due to factors such as:

- Traffic – Although Milton Point drivers start their rounds at 04:30 to avoid congestion, they invariably face road congestion during their rounds. Routes can follow busy roads and must enter congested towns to service the Oxfam shops.
- Restrictions (shop, road and parking) – Many shops can be visited at any time by Milton Point drivers as they have the shop's keys. A few shops must be visited during open hours. Due to the town centre nature of most of the shops, some of the sites face parking restrictions which mean that these sites have to be visited at a certain time. Some parking restrictions mean that the drivers have to park further away from the shop, resulting in longer dwell times.
- When visiting shops out of open hours, sometimes the driver will have his own key to access the shop. In some cases, shop managers have not allowed the driver to have their own key and in this circumstance, the driver will need to wait until the shop is open. This can drastically increase route times.
- Other circumstances – Some sites may take longer than normal to service. For example, donation bank visits can take longer than expected if the driver has to force a stiff padlock or deal with large amounts of waste. Shop visits can take longer if the driver takes a break on-site.
- Particular drivers may take longer to complete their rounds than other drivers. Some may have reduced capability to service shops or empty donation banks as quickly as other drivers.

An initial analysis of the data suggested that the timings on the Watford rounds did not represent the actual round activity and due to a suspected error in the data capture system, which only affected the two Watford rounds, therefore they were omitted from the analysis. The route data showed that the departure times for these routes had not been recorded correctly. For example, during the Watford Monday route a shop visit took 1 hour and 30 minutes to collect 517 kg of textiles. Using the formula for dwell times (0.07kg per kg collected), a collection of 517.1 kg should take just over 36 minutes. A bank visit took 45 minutes to collect 90 kg of stock which should have taken just over 6 minutes. This route showed high dwell times throughout the day. This was due to an error in the semi-automated process of the PODFather data capture service. It was not possible to investigate these errors in more detail. This analysis only considers the remaining rounds.

Some of the modelled route times were longer than the case study week actual route time, such as the March Tuesday route. During this route a collection of 135 kg from a bank took 5 minutes to collect. Using the formula for dwell times, this visit should have taken 9 and a half minutes. This theme continued throughout the route when a collection of 540 kg from a bank took 25 minutes. Using the dwell time formula, this visit would take nearly 38 minutes. Visits that were recorded as quicker than the modelled route times could be because the driver had an assistant. This would affect the dwell times considerably, however there was not the capacity to model this from the data available. Future study could aim to calculate how route times and dwell times are affected by driver assistance.

4.4 Donation bank theft

4.4.1 Introduction

Donation bank theft has been identified as a major problem to charities and it has not been possible to estimate the actual quantities being lost. The theft and onward sale of even used textiles can be extremely profitable. In order to tackle this, the extent of the problem must be realised.

Oxfam employed Smartbin (2010b) to enable the monitoring of selected donation bank fill levels using infra red sensor technology. With the use of an electronic key fob (by the Oxfam driver) to record solicited bank servicing it is possible to ascertain which emptying events are by a third party (ie. theft).

By extrapolating the data and looking at the fill level at the time the bank was emptied, it was possible to determine how many kg of textiles are stolen at each theft event. By matching these with the Oxfam bank servicing events, it is possible to tell the total donations received to the bank and the proportion actually received by Oxfam collectors and thus the amount stolen.

4.4.2 Results

December 2011

Table 30 shows that 25% of Smartbin donation banks showed recorded 'service events' for every collection that took place during December. 51% of donation banks showed some of the collections were recorded by scanning the key upon collection. 15% of donation banks did not have any of their collections recorded as a 'service event'. 'Service events' might not be recorded due to: 1) Drivers forgetting or failing to scan their key. 2) Drivers failing to scan the key correctly. 3) Smartbin sensor not functioning correctly. The data was ignored in 9% of cases due to sensor errors.

Table 30. Key scanned upon collection? Out of 95 Smartbin donation banks

Yes	24 (25%)
Sometimes	48 (51%)
No	14 (15%)
Data ignored	9 (9%)

In some cases, Smartbin 'service events' were recorded but did not correlate perfectly with Oxfam collection records. 52% of donation banks showed 'service events' to match well with the corresponding Oxfam collection record data (Table 31). However in 14% of cases only some collections from each donation bank correlated well between datasets. In 11% of cases Smartbin 'service events' did not correlate with Oxfam records (ie. Collections shown a day or two either side of the other dataset

Table 31. Do Smartbin 'service events' correlate with Oxfam collection records?

Yes	49 (51.5%)
Sometimes	13 (14%)
No	10 (10.5%)
Data ignored or no 'service events' logged	23 (24%)

Table 32 shows a list of donation banks where Smartbin ‘service events’ in December did not correlate perfectly with Oxfam collection records. In many of these cases Oxfam records show collections were made a day or two before or after they appeared on Smartbin records. The difference in days between these two datasets could be attributed to collections being recorded on the wrong day.

Table 32. List of donation banks where 'service events' did not correlate with Oxfam collection records (December 2011)

Smartbin code	Location	Servicer
P-0619	Sainsburys Altrincham	Manchester man-with-van
P-0621	Tesco St Helens	Wastesaver
P-0623	Tesco Haydock	Wastesaver
P-0628	Tesco Dingle	Wastesaver
P-0633	Tesco Formby	Southport
P-0642	Tesco Newton Le Willows	Wastesaver
P-0682	Sainsburys Hazel Grove	Wastesaver
P-0692	Dun Elm Clifton Moore Centre	Thirsk
P-0695	Barnard Court Car Park	Wastesaver
P-0713	Tesco Old Swan	Wastesaver
P-0719	Tesco Burscoe Bridge	Wastesaver
P-0735	Tesco Handforth	Wastesaver

Suspected theft

Taking un-recorded ‘service events’ and mismatching collection dates into account, Table 33 shows a rank (top 10) of suspected donation bank theft for Smartbin donation banks in December 2011. Figure 57 shows the estimated amounts of textiles stolen from each of the Smartbin banks in December 2011. Also plotted (shown with grey squares) is the percentage of stock estimated stolen from each bank. 13 donation banks (out of the 95) showed zero levels of theft, shown on the left hand side of the graph. 4 banks showed an estimated 100% of textile stock stolen, although 3 of these banks only received around 200 kg of textiles in that month. The other bank with 100% estimated stolen was located at Sainsburys Northwich which features in Table 33. Top 10 suspected theft from Smartbin donation banks (December 2011) with 826 kg in total estimated stolen. Tesco Bury showed a smaller percentage of stock estimated stolen (74.4%), but with 1250 kg estimated stolen in total.

Table 33. Top 10 suspected theft from Smartbin donation banks (December 2011)

Site code	Location	Approx. kg estimated stolen	Approx value of stock estimated stolen (£)	Percentage of stock estimated stolen
P-0669	Tesco Bury	1250.1	875.07	74.4%
P-0654	Tesco Wigan	1201.5	841.05	91.8%
P-0672	Tesco Prescot-2	1171.8	820.26	92.3%
P-0617	Tesco Didsbury	1155.6	808.92	87.2%
P-0648	Tesco Prescot-1	1144.8	801.36	86.2%
P-0729	Asda Hunts Cross	1063.8	744.66	81.9%
P-0732	Sainsburys Upton	1058.4	740.88	60.4%
P-0634	Tesco Burnley	1004.4	703.08	67.9%
P-0678	Tesco Gorton Cross	834.3	584.01	59.9%
P-0641	Sainsburys Northwich	826.2	578.34	100%

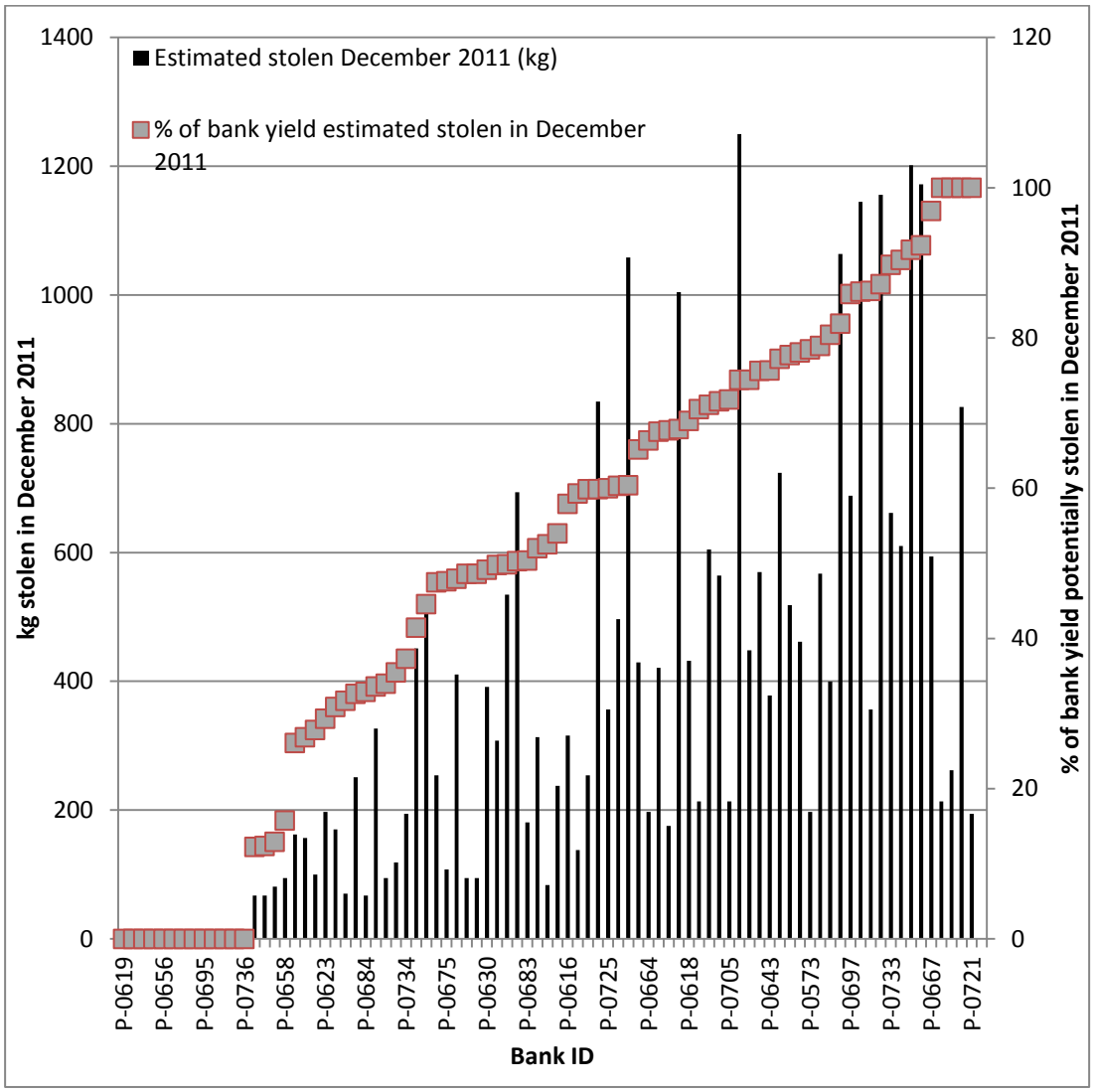


Figure 57. Percentage of donation bank yield estimated stolen against the total amount (kg) estimated stolen

Shown in Figure 58 are the locations of Smartbin donation banks with accompanying percentages for the level of stock assumed stolen in December. Most of the donation banks with the highest proportion of stock assumed stolen were located in the Liverpool and Manchester areas. Donation banks located in Woodhall Spa (100%), Harrogate (86%), Birstall (near Bradford) (86%), Blackburn (77%), York (74%) and Louth (72%) also showed high proportions of suspected donation bank theft in December.

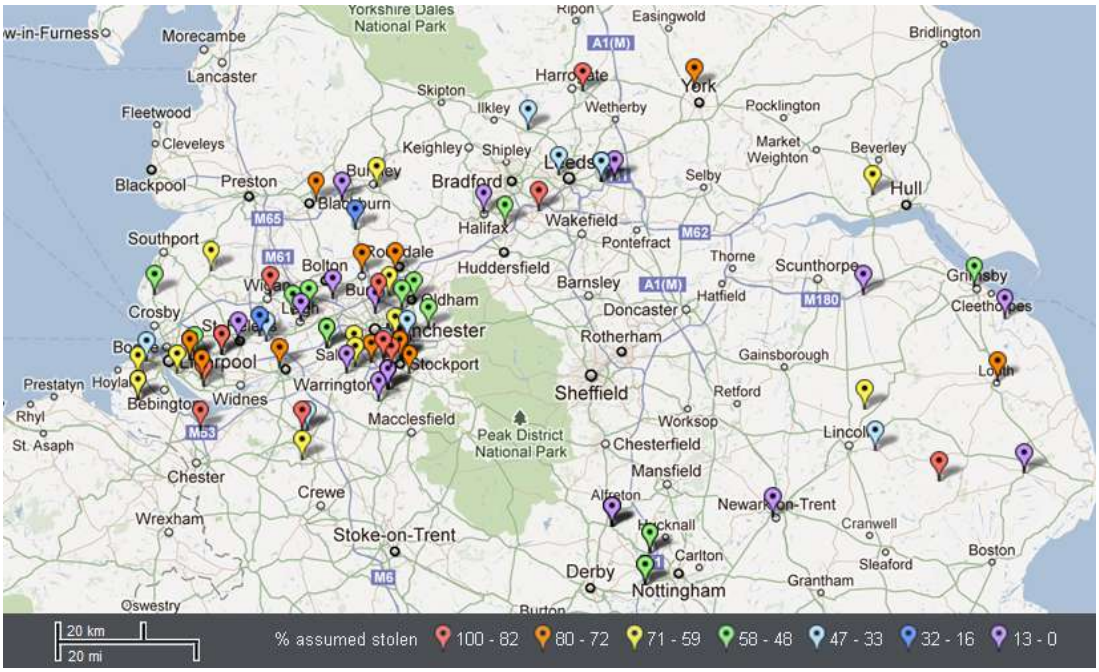


Figure 58. Percentage of stock assumed stolen December 2011 (Google Maps, 2012)

February 2012

After studying the top 'hit' donation banks in December it is possible to look at any continuing trends by studying these donation banks again. Table 34 shows the amount of stock assumed collected and stolen from these donation banks as found from Smartbin data correlated with Oxfam collection records in February 2012. The sensor located at Tesco Bury is assumed faulty and the sensor located at Tesco Burnley was destroyed by fire during this month. Suspected theft levels in these donation banks remain high, ranging from between 31.8% to 77.3% of donated stock suspected stolen.

Table 34. Stock suspected stolen in February from Decembers top 10 'hit' donation banks

Site code	Location	Approx. kg suspected stolen	Approx. kg collected	Approx value of stock suspected stolen (£)	% stock suspected stolen	Notes
P-0669	Tesco Bury	0	0	0	N/A	Possible battery problem
P-0654	Tesco Wigan	1247.4	367.2	257.04	77.3%	
P-0672	Tesco Prescot-2	556.2	299.7	209.79	65.0%	
P-0617	Tesco Didsbury	1112.4	442.8	309.96	71.5%	
P-0648	Tesco Prescot-1	1096.2	396.9	277.83	73.4%	
P-0729	Asda Hunts Cross	477.9	556.2	389.34	46.2%	
P-0732	Sainsburys Upton	534.6	1144.8	801.36	31.8%	
P-0634	Tesco Burnley	0	0	0	N/A	Sensor destroyed by fire
P-0678	Tesco Gorton Cross	453.6	513	359.1	46.9%	
P-0641	Sainsburys Northwich	318.6	410.4	287.28	43.7%	

Table 35 shows the approximate levels of theft for donation banks in February 2012 alongside the levels for the same donation banks in December (ranked by the donation banks theft levels in December). Three of these donation banks are still showing high levels of theft, although the amount stolen from five of these donation banks dropped by around 50% between these months (Figure 59). Oxfam confirmed that the banks that were identified as being heavily targeted for theft were emptied on a more regular occurrence, which resulted in lower amounts being stolen.

Table 35. Approximate kg of textile stock suspected stolen from Smartbin donation banks in December 2011 and February 2012

Site code	Location	Approx. kg suspected stolen (December 11)	Approx. kg suspected stolen (February 12)	Total Approx value of stock suspected stolen (£)	Percentage change
P-0669	Tesco Bury	1250.1	0	875.07	N/A
P-0654	Tesco Wigan	1201.5	1247.4	1714.23	3.8%
P-0672	Tesco Prescot-2	1171.8	556.2	1209.6	-52.5%
P-0617	Tesco Didsbury	1155.6	1112.4	1587.6	-3.7%
P-0648	Tesco Prescot-1	1144.8	1096.2	1568.7	-4.2%
P-0729	Asda Hunts Cross	1063.8	477.9	1079.19	-55.1%
P-0732	Sainsburys Upton	1058.4	534.6	1115.1	-49.5%
P-0634	Tesco Burnley	1004.4	0	703.08	N/A
P-0678	Tesco Gorton Cross	834.3	453.6	901.53	-45.6%
P-0641	Sainsburys Northwich	826.2	318.6	801.36	-61.4%

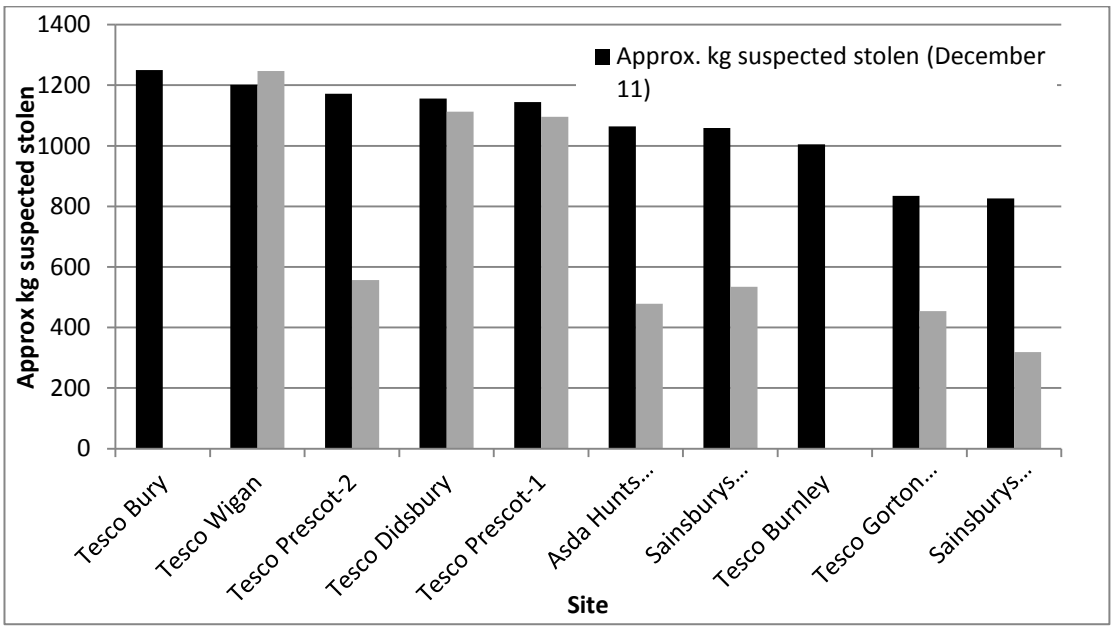


Figure 59. Approximate kg of textile stock suspected stolen from Smartbin donation banks in December 2011 and February 2012

4.4.3 Summary

Textile theft from charity collection donation banks has been identified as an increasing problem within recent years (MRW, 2009). Indeed, as at mid 2013, unsorted donated clothes were fetching around £1,000 per tonne. This was three times the price of seven years before (Charity Bags, 2013).

The British Heart Foundation reported losses of around £3million during the 2010 financial year resulting from the theft of doorstep donations and clothing donation banks (British Heart Foundation, 2010) and this is expected to rise. Theft of textiles and bogus collections are important to consider because they directly affect the profits of charities. They also affect public perception of textile collection, and so can deter the public from supporting door to-door collections, textile donation banks and they can jeopardise the viability of other legal collection schemes. Textile theft also directly affects the profits of charities.

Remote donation bank monitoring technology has allowed donation bank theft to be quantified for the first time in history. Even to this day, charities remain in the dark about the scale of the problem of donation bank theft. Through the trial of Smartbin with Oxfam, estimations of donation bank theft have been realised, with up to 77% of donations been stolen in some cases. The severity of donation bank theft varies across the country with larger amounts expected to be stolen in areas such as Manchester and the gateway to Europe, between London and the English Channel crossing, where donations that are stolen can quickly be transported to the continent. During the Smartbin trial, a total approximate value of stock potentially stolen from the top 10 hit banks in December 2011 and February 2012 was £10114.

Through realising the problem of donation bank theft, if using remote monitoring technology, charities can understand the scale of the problem and devise measures to reduce donation bank theft. This can be realised in a number of ways. Charities should use donation banks that are better designed to be more resistant to theft, such as by incorporating locks that are more secure. Locations such as supermarkets that have the donation banks in their car parks could increase their security, if the scale of the problem was conveyed to them. Charities could modify the timings of donation bank servicing to plan visits before expected theft events. This could be realised through identifying when donation banks are routinely ‘hit’ and ensure that the donation bank has been emptied before they arrive. Another

measure could be to increase security measures in areas that are likely to be subjected to higher levels of donation bank theft.

During the Smartbin trial, banks that were identified as being heavily targeted by theft were visited more often and Oxfam found that the amount of textiles being stolen decreased. This shows that a more effective collection strategy can be realised, mitigating the effects of theft, by visiting banks more frequently. Using remote bank monitoring technology, it is also possible to reschedule bank emptying to occur before the predicted event, thus reducing the amount possible to be stolen.

Chapter 5: Optimising donation bank placement strategy

Donation banks play a key role in the collection infrastructure of many of the major charities (such as Oxfam, The Salvation Army and British Heart Foundation). Often, the location of banks depends on the relationship the charity has with local landlords such as supermarkets, county councils and private landowners who allow them to site their banks on their property for a rental fee.

The site is then effectively trialled over a period and an assessment made of the stock generated from donors. In essence, a lot of banks sites are chosen, not through a detailed analysis of the local population and their potential as valued recyclers but via a trial and error basis.

A more scientific approach would be to investigate the relationships between donation weights by commodity and various demographic characteristics such as population density, level of affluence and proximity to amenities and services. This chapter investigates these potential relationships using a significant data set of bank weight data and makes inferences about the yield quantity of different population groups.

5.1 Hypotheses

The following hypotheses have been drawn based upon the various literature based around attitudes and behaviours linked with textile donation and disposal (found in section 2.5). The hypotheses were also of direct interest to Oxfam derived through dialogue over the period of the project.

Hypothesis 1: The weight of textile donations to charity donation banks is affected by the population density in the vicinity. The higher the population density, greater collection yields are expected.

Hypothesis 2: The weight of textile donations to charity donation banks is affected by the locations convenience. Donation banks placed near convenient locations such as supermarkets and school, that can enable trip chaining, are expected to receive greater yields.

Hypothesis 3: The weight of textile donations to charity donation banks is linked to affluence within the area. The wealthier an area is, greater collection yields are expected.

Hypothesis 4: The quality of textile donations to charity donation banks is linked to affluence within the area. The wealthier an area is, greater quality yields are expected.

5.2 Introduction

Oxfam utilise a 'donation pyramid' (Henderson, 2010) for textile donations (see Figure 6) which shows the proportions of each origin of donation that are typically suitable for sale. The percentages given are for stock that is suitable for sale through Oxfam's online store which has been promoted in recent years.

Corporate stock comes in the form of donations from clothing companies, and normally results in around 50% of stock suitable for online sale. For example, a company may donate their out of stock goods direct to Oxfam. 'Oxfam Collects' is the first 'permanent workplace charity donation programme' (Jeffrey, 2010) and involves collections by Oxfam from locations such as offices and schools that wish to take part in the scheme. Around 25% of the textiles received from 'Oxfam Collects' are suitable for sale online, with an additional 25% suitable for high street retail. Marks & Spencer donations are received through their alliance with Oxfam; where independent donors give their clothes to Oxfam via M&S in return for Marks & Spencer's vouchers in-store. Around 20% of this type of stock is typically suitable for sale online. House-to-house collections can expect to yield around 12% of stock saleable online. Over-the-desk donations within Oxfam shops and school collections result in around 5-10% online saleable stock. Donations made via clothing donation banks and black sack donations result in the lowest percentages of good quality stock.

According to the CRA 2013 Stock Survey, 80% of donations received by charities are given directly to shops. While the majority of donations come via direct to shop donations, donation banks located at strategic sites such as supermarkets and public car parks across the country play a vital role in the collection of used textiles, books, CDs and other goods (Figure 60). While such textile and book donation banks might also yield a lower proportion of quality stock than direct to shop donations, the revenue from these is very important for maintaining shop profitability.

Figure 60. Oxfam textile donation bank locations in England (and typical Oxfam textile donation bank)

The collection of donations from widespread donation banks contributes a significant cost to the logistics process which detracts from the potential revenue generated. It is therefore key to understand where to best locate the donation banks (both national spread and in relation to local situations) to achieve maximum revenue for minimum logistics costs. Of real interest is the impact the local situation and underlying local population characteristics have on the yield volume at the site, and whether a better understanding of this relationship can be gained using historic fill levels over time. If a relationship exists and different postcodes can be shown to yield significantly different weights of stock then donation banks can be targeted to certain areas, and the logistics optimised accordingly.

This study therefore aims to use historical Oxfam donation bank collection data to develop an analytical framework to explore the variability in charity collection donation bank weights countrywide and provide recommendations on future donation bank placement based upon projected stock quantity yields.

5.3 Donation bank weight data

Donation bank weight data was collected from Oxfam for the period April 2010 to March 2011. The data was studied to find patterns and trends in donations to Oxfam collection banks. Figure 61 shows the range of monthly collection yields for the 488

Oxfam textile donation bank sites in England, with a mean monthly yield for all donation bank sites of 684.5 kg.

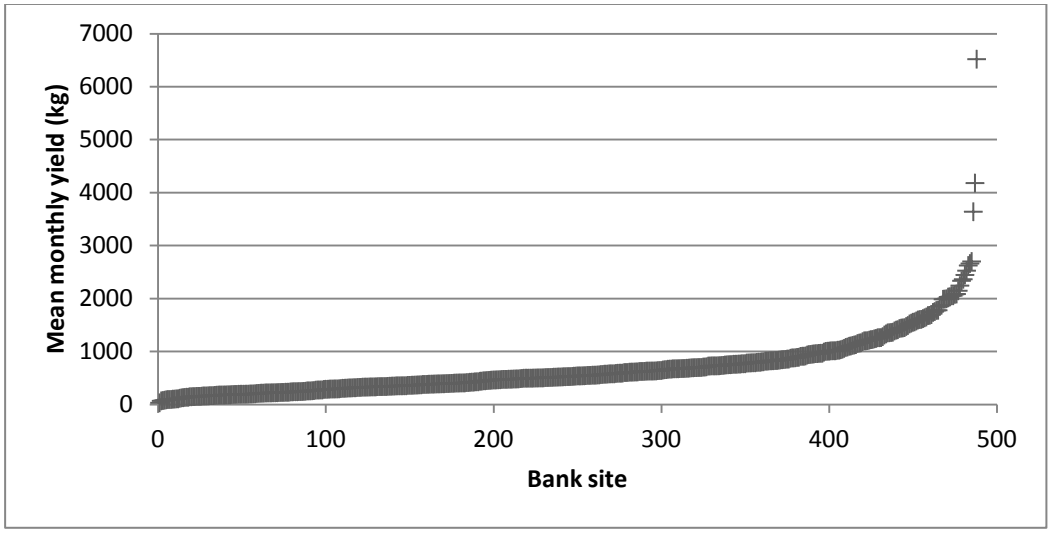


Figure 61. Mean monthly yield of textile donation banks (2010-2011)

Most donation bank sites recorded average yields of between 0 and 1000 kg per month (397 donation banks); 88 donation banks recording average yields of between 1000 kg and 2000 kg per month. Only 3 donation banks recorded average monthly yields greater than 3000 kg: A major supermarket in Balham (3638 kg average monthly yield), Park Royal WTS, Brent, London (4178 kg) and Regis Road Recycling Centre, Camden, London (6517 kg). Park Royal and Regis Road donation bank sites are located at busy inner-city Household Waste & Recycling Centres (HWRCs) and this may have some effect on overall average donation bank yields for the area. The donation bank site located at Park Royal also features a large roll-on roll-off (RORO) donation bank that allows for far greater amounts of donations per full load (around 1500 kg) than a standard donation bank (bank sizes are shown Section 4.1.3). Other HWRC sites are very variable in terms of yield, ranging from between 91.9 kg per month (Ilkley HWRC, Yorkshire) and 2051.9 kg per month (Milners Rd HWRC, Yorkshire).

In terms of regional differences in the amount of textile donations received to the charity through their donation banks, Figure 62 shows that the banks in the south generally received more donated textiles than banks in the north.

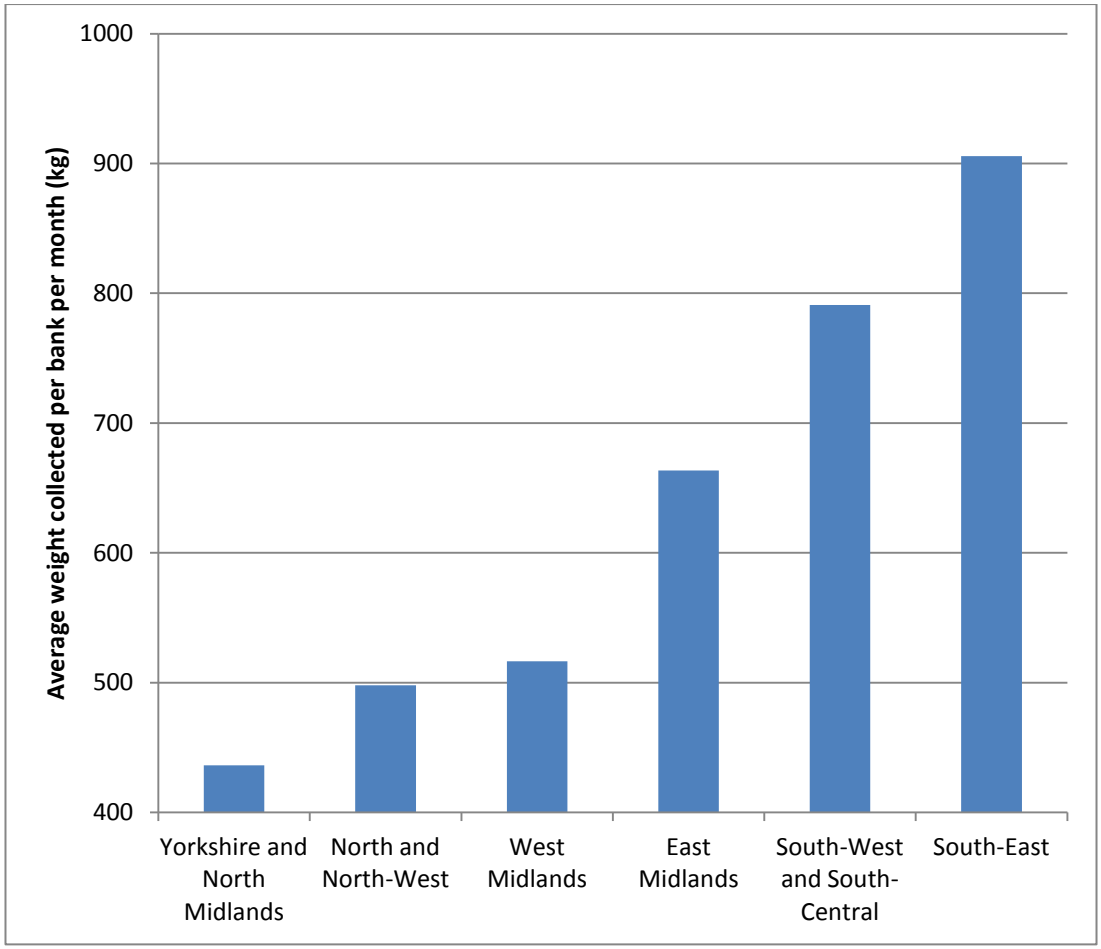


Figure 62. Regional differences in textile donation bank average yields

As with any real dataset, there are a number of important considerations necessary to fully understand the context of the values:

- Donation banks can be emptied at different times of the month (for example, a donation that is made to a donation bank in late October may not be recorded until a collection is made in November) and donation banks are not emptied at fixed intervals (for example, a donation bank might be emptied twice in one month, but only once (if at all) the next).
- Some donation banks entered or went out of commission during the April 2010 to March 2011 period. Donation bank sites showing more than 3 or more consecutive months of a zero reading for donation bank weight (82 donation bank-sites overall) were removed from the analysis.
- Donation bank theft. Some donation banks may have experienced high levels of theft due to the rising value of textiles on international markets (British Heart Foundation, 2010), and this will have an effect on textile donation bank yields. This issue is discussed in detail in Section 4.4.

Collection weights were calculated by recording the number of bags/boxes of goods collected from donation banks and multiplying this by the standard value for bag weight derived by Oxfam (bags of textiles equalling 7.5 kg). At each donation bank the driver uses a 90 litre hessian sack and empties the contents of the bank (bags of clothes, loose clothes and other textiles) until it reaches around 7.5 kg. As different drivers will load textiles into bags differently, this will potentially have an effect on the weights recorded for donation bank collections, however 7.5 kg is used as the mean bag weight.

5.3.1 W14 Region stock quality audit

Initial study regarding stock quality was undertaken in the Oxfam W14 region audit assessment in 2011 (described in Section 4.2.1). Based from the Winton Distribution centre the man-with-van visits a variety of shops and banks in order to collect stock for online sale, and cascade items between shops. The stock quality audit was undertaken over the course of a week, enabling all routes to be evaluated and the contents from each bank weighed and valued.

This study looked into the proportion of saleable stock taken from donation banks in the area, and many donation banks showed encouraging levels of good quality stock (Figure 63). The blue bars correlate with the proportion of saleable stock and the red bars indicate the total yield of each bank between April and October 2010. This shows that the contents of 19 donation banks provided over 30% saleable stock. Within the W14 region, most of the donation banks surveyed were book donation banks.

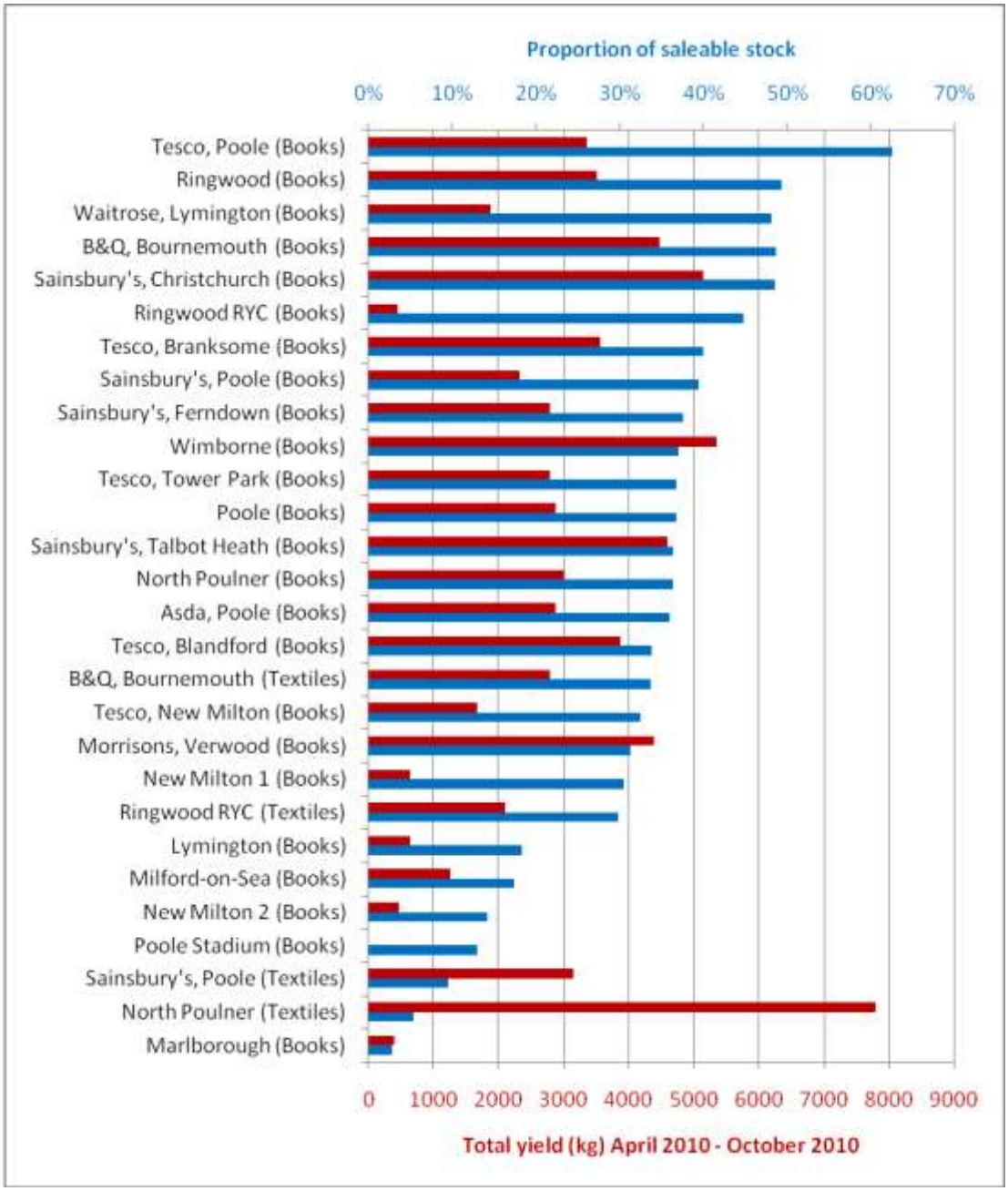


Figure 63. Proportions of saleable stock

The ‘donation pyramid’ (Figure 6) suggests that textile donation banks will only produce around 10% of saleable stock (2% through online outlets and 8% in shops). However, from the textile donation banks in the Winton area, only 2 recorded these sorts of values (North Poulner = 5.8% saleable stock and Sainsbury's, Poole = 9.5% saleable stock). The other textile donation banks showed much higher values (Ringwood RYC = 29.8% saleable stock and B&Q, Bournemouth = 33.6% saleable stock). Most of the donation banks recorded proportions of saleable stock during the trial week of between 30-50%, which was above average according to the Winton manager.

Although the textile donation bank at North Poulner produced a low proportion of saleable stock during the audit week, 7785 kg were generated from the donation bank between April and October in 2010. At this site, two textile donation banks are in place to deal with the large amounts of stock generated. This area showed a low Deprivation Index of 25937 (provided by the Office for National Statistics. All of the neighbourhoods in England are ranked from 1 (most deprived) to 32,482 (least deprived). The Index is the result of combining a number of indicators including income, health, employment, education deprivation, barriers to housing and services, levels of crime and living environment deprivation into a single deprivation score) and average house values of £410,000, showed this to be an area of great affluence. This would suggest that affluence does not have a positive effect on quality yields here. Further audits would be necessary to see whether this bank consistently shows low proportions of saleable stock.

The audit showed that in general, book and music donation banks produced higher proportions of saleable stock than textile banks with the top 12 performing donation banks coming from this category. During the audit week it was observed that many of the textile donation banks were filled with bulky unsaleable items such as bed linen and curtains.

Six out of the 24 book banks returned over 40% saleable stock, which is encouraging considering Oxfam expects only 10% of donation bank stock to be saleable. Particularly notable was the donation bank located at Tesco, Waterloo Road, Poole (Figure 64), giving 62.5% saleable stock (80.2 kg from 128.3 kg). This area showed a deprivation index of 14622 (out of 32482), with an average house value of £202,000.

Figure 64. Donation bank at Tesco, Waterloo Road, Poole

Most of the book donation banks recorded proportions of saleable stock during the trial week of between 30-50%, which was above average according to the Winton manager. One should remember that the percentage of saleable stock was an estimate made by the Winton Manager and does not reflect the actual sales values that would be returned from the items.

The Marlborough book bank returned a saleable stock value of 2.8%, due to the large volume of video tapes donated (Figure 65). The Oxfam data suggested that the total stock yield for this donation bank was 388.3 kg between April and October in 2010 perhaps calling into question its profitability long term, especially considering the large distances involved in servicing the donation bank.

Figure 65. Marlborough Books & Music donation bank

In order to gain a better picture of donation bank performance, it is necessary to monitor the quality of stock taken from donation banks over a longer period of time. Repeat audits would be needed and this is an action that is recommended. A future audit tracking donated items to the point of sale could ascertain the actual value of donations from each location. In the future, banks that have shown low amounts of yield and low quality stock should also be monitored for profitability. Banks that continue to show low quality and quantity yields should be recommended for moving to an alternative site.

5.3.2 Value of stock

During the audit week, estimates were made (undertaken by the Winton Manager) of the value of the accepted stock taken from one day's donation bank collections. Table 36 shows an example of the raw data collected from the quality audit. Each bag was numbered individually and weighed upon return to the Winton depot. The Winton manager then processed the stock picking out items suitable for online sale, and therefore a proportion of saleable stock could be taken. On one day of the week's audit, the accepted stock was valued by the Winton manager.

Table 36. Example of the W14 donation bank stock quality audit

Tesco, Tower Park, Poole (Books & Music bank)

Origin (bank ID)	**Bag number**	**Bag weight (kg)**
p3	3	7.8
p3	13	9.4
p3	15	9
p3	16	5.1
p3	14	10.2
p3	2	9.5
p3	7	10.6
p3	11	9.9
p3	12	8.5
p3	1	9.2
p3	5	10.1
p3	10	8.5
p3	4	7.6
p3	9	8.5
p3	8	9.9
	Total	133.8

Accepted stock	49.3 kg
Proportion saleable stock	**36.80%**

Estimates can be made on the total value of stock taken from the week by extrapolating the value of stock taken from the one day's stock that was valued. Rejected stock can be valued in-line with Oxfam's valuations, where unseen (black bag) stock can be sold for £700 per tonne.

Table 37 shows the weight of accepted stock taken from donation banks alongside an estimate of its value. Taking this valuation and dividing it by the total weight of collected stock enables an estimate of value per kg collected by donation bank.

Table 37. Donation bank stock value

Donation bank	Accepted stock (kg) and estimated value (£)	Rejected stock (kg) and value (£)	Total stock (kg)	Total stock estimated value	Value of accepted stock per kg (£/kg)	Total value of all stock per kg (£/kg)
Barfields, Lymington	24 (£90)	107.3 (£75.11)	131.3	**£165.11**	**£3.75**	**£1.26**
Waitrose, Lymington	21.9 (£100)	23.6 (£16.52)	45.5	**£116.52**	**£4.75**	**£2.56**
Recycling Centre, Milford-on-Sea	28.7 (£130)	136.4 (£95.48)	165.1	**£225.58**	**£4.53**	**£1.37**
Tesco, New Milton	23.2 (£105)	48.3 (£33.81)	71.5	**£138.81**	**£4.53**	**£1.94**
Spencer Road, New Milton	13.7 (£90)	31.3 (£21.91)	45	**£111.91**	**£6.60**	**£2.49**
Elm Avenue, New Milton	2.7 (£5)	16.3 (£11.41)	19	**£16.41**	**£1.85**	**£0.86**
Totals	**114.2 (£520)**	**363.2 (£254.24)**	**477.4**	**£774.34**		

Table 38 shows the different values that can be assigned to stock acceptable for sale online and the remaining stock that is bagged and sent to Wastesaver.

Table 38. Average stock values

Average value of accepted donation bank stock per kg	£4.55 (£520 / 114.2 kg)
Value of rejected donation bank stock per kg	£0.70 (£254.24 / 363.2 kg)
Average value of Wednesday's donation bank collected stock per kg	£1.62 (£774.34 / 477.4 kg)

It is worth noting that the numbers used for stock value are based purely on the opinion of one person. The stock could sell for more or less than the estimated value.

Value of online saleable stock

Table 39 shows the average value of accepted donation bank stock, taken from the estimated value of stock from the six donation banks emptied on the Wednesday of

the audit. These values have been used in conjunction with the total amounts of stock collected over the week (where 694.7 kg is the total weight of accepted stock from the week). The calculations show the approximate value of goods for online sale taken from donation banks over the course of the week could be in the region of £3000. This does not include the value of the rejected stock.

Table 39. Value of accepted stock acquired

Average value of accepted donation bank stock per kg	£4.55
Approximate value of accepted stock from donation banks over the week	**£3161** (£4.55 x 694.7 kg)

Value of rejected stock

The rejected stock can be assigned a total value by using the value of unseen stock that Oxfam can get from traders. Unseen (black bag) stock can be sold unseen to traders for £700 per tonne. Table 40 shows the approximate value of the rejected Winton stock.

Table 40. Value of rejected stock acquired

Oxfam value for unseen (black bag) stock per kg	£0.70
Total weight of rejected stock	1400 kg
Approximate value of the rejected stock collected from donation banks over the week	**£980**

Total value of stock taken

The total value of the stock taken for the week can be estimated at £4140.

To more accurately measure the value of goods taken from the donation banks, the stock would need to be tracked from where it originated to its point of sale.

Operational costs versus yields

Operational costs shown against yields are calculated on a weekly basis. Table 41 suggests that the value of the stock collected outweighs the cost involved in its collection. These calculations do not take into account the value of other activities to the organisation such as cascading stock and refuse disposal. This also assumes that the weekly yields will remain similar, however the results are encouraging. Van costs are derived in Section 4.2.4.

Table 41. Weekly costs against yields

Costs (per week)	Value
Van fuel, tyres and maintenance	£94
Van lease cost	£92
Drivers wages	£307
Assistant's expenses	£15
Equipment	£5
Total	**£513**
Yields	
Accepted Donation bank stock per week	**£3161**
Rejected donation bank stock value per week	**£980**
Total	**£4141**

5.3.3 Average bag weights

The average bag weight value used allows the amount of stock collected (tonnage) from donation banks throughout the country to be estimated. Table 42 and Table 43 show that the bag weights found from the Winton audit are generally around 1.5 kg less than the average values currently used by Oxfam.

Table 42. Textile bag weights

Average bag weight used by Oxfam	7.5 kg
Number of bags sampled	31
Average bag weight from audit	5.79 kg
Percentage error	29.53%
Standard deviation	0.312

Table 43. Books and music bag weights

Average bag weight used by Oxfam	10 kg
Number of bags sampled	226
Average bag weight from audit	8.58 kg
Percentage error	16.55%
Standard deviation	0.095

Findings from this audit would suggest that current values used for average bag weight may be inaccurate. Different areas will use different sizes and strengths of sack to collect goods from donation banks and 226 bags of books were collected during the audit week providing a good representative sample.

5.4 Factors affecting donation bank quantity and quality yields

Following on from the W14 stock quality audit, this subsequent study took place to identify the main factors affecting donation stock quality and quantity through Oxfam textile donation banks. Research into the factors affecting the quantity and quality of donations received through textile donation banks enables the importance of bank locating to be considered, where improving performance would lead to increased profits

In order to understand the factors influencing the value of donated textile stock to charity donation banks it was important to break this down into two separate approaches:

- The factors affecting the quantity of textiles donated
- The factors affecting the quality of textiles donated

These two approaches can then be combined to give an overall idea of the factors influencing donation values.

This study has been approached with the hypothesis that the demographics of an area can have an effect on the quantity and quality of textiles donated to local donation banks.

Firstly, the study aimed to identify the key factors influencing the quantity of textiles donated to charity donation banks. This was achieved through using historic donation bank collection data (2010-2011) from Oxfam for 488 donation bank sites to develop an analytical framework to explore the variability in charity collection donation bank weights countrywide.

5.4.1 Predictive Model Development

Traditional analysis of variance approaches to identifying which explanatory variables should be included in a predictive model are unsuitable as the volume of data leads to even the smallest random effects appearing highly significant. Instead, an approach has been used based on sequentially identifying the explanatory

variable (and its 2-way interactions with other variables already in the model) which contributes to the greatest increase in R^2, an approach used by Maynard, Cherrett and Waterson (2009). The approach is described in section 3.2.1 with a description of each of the variables.

Single Variable Models

Table 44 shows that Regional Group is by far the most beneficial single explanatory variable, producing an R^2 value of 0.068, substantially above the other variables; showing that Regional Group explains 6.8% of the variability in observed mean weights. Although not a significant result, explaining only a very low proportion of the total variability, this does show some effect given the real-world nature of the dataset.

Table 44. R^2 values created by single explanatory variable models

Physical Factors	**R^2**
Regional Group	0.068
Supermarket Group	0.015
Nearest Upper School	0.005
Nearest First/Middle School	0.005
Population Density	0.004
Alternative Recycling	0.002

Socio-economic Factors	**R^2**
Property Values	0.021
Population Age	0.009
Job Seekers Allowance	0.001
Deprivation	0.000
Temporal Factor	
Month	0.016

Dual Variable Models

Following identifying the most beneficial single explanatory variable, the model was then developed by identifying the most beneficial model that combines two of the explanatory variables.

Combining Regional Group with Supermarket Group into a dual variable model produces an R^2 value of 0.093 (which is still not a significant result, but does show a greater explanation of the variability in bank weights than the single factor model) Figure 66 shows the relationship between Regional Group and Supermarket Group.

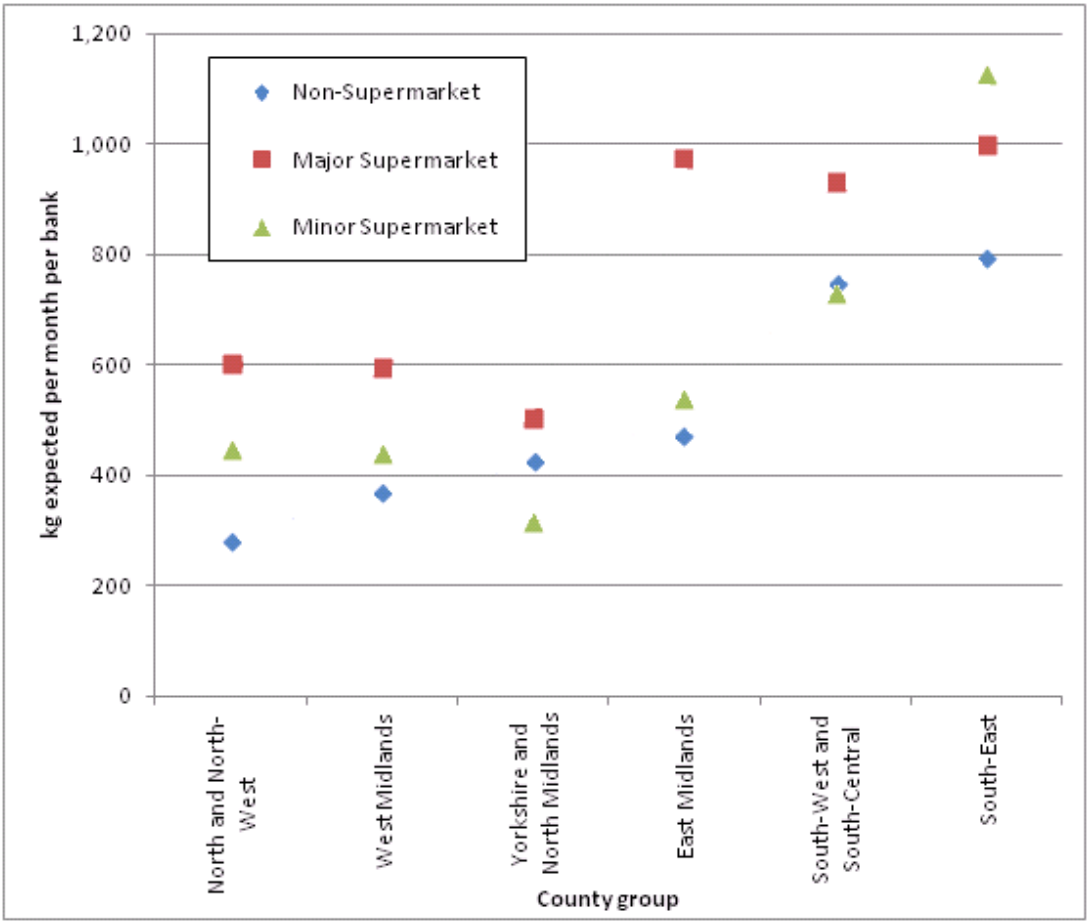


Figure 66. Effect of supermarket on textile donation bank weights

Donation banks located at the Major Supermarkets generally performed better than donation banks located elsewhere. Also, donation banks located at Minor Supermarkets or Non-Supermarket donation banks seem to have performed similarly (apart from in the south-east, where Minor Supermarket donation banks were the top performers). Of the 488 Oxfam textile banks, 291 were located at supermarkets (197 located at other locations). 245 donation banks were located at one of the major supermarkets, with 46 located at other brands of supermarket Figure 67 shows the locations of Non-Supermarket, Major and Minor Supermarket banks.

Figure 67. Location of Non-Supermarket and Supermarket banks

Multi Variable Models

Table 45 and Figure 68 show the highest R^2 values achievable at each stage when increasing the number of explanatory variables in the model (comprising all main effects and all significant 2-way variable interaction terms). All factors above a factor are included to give the R^2 value in the right hand column for that factor. For example, the most beneficial model with three variables combines Regional Group, Supermarket Group and Month to give a R^2 value of 0.109. Deprivation index was not included as it was found to have no effect on the variability of observed weights.

Table 45. R^2 values created by multiple explanatory variable models

Factor	**Number of Factors**	**R^2**
+ Regional Group	1	0.068
+ Supermarket Group	2	0.093
+ Month	3	0.109
+ Nearest First/Middle School	4	0.133
+ Alternative Recycling	5	0.146
+ Population Age	6	0.153
+ Property Values	7	0.163
+ Job Seekers Allowance	8	0.181
+ Nearest Upper School	9	0.186
+ Population Density	10	0.192

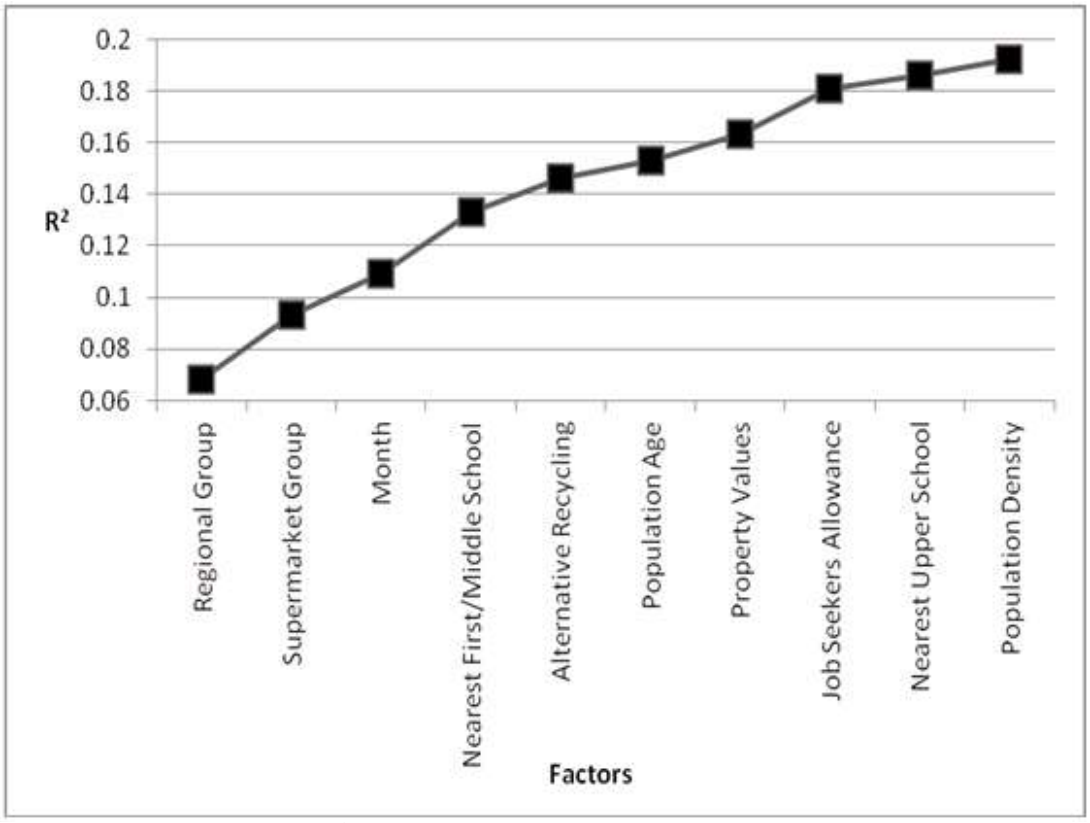


Figure 68. Progressive R^2 values created by multiple explanatory variable models

Because of the size and nature of the dataset, even the last variables added into the model (Nearest Upper School and Population Density) do provide significant increases in model fit. It is noticeable however that the physical factors dominate the model building process, with socio-economic factors only being added towards the end of the analysis. However, the increases are not significant in terms of improving the model.

It is also clear that even utilising all ten of the factors proposed above only allows just under 20% of the overall variability to be explained. Given the high variability in donation bank weights, achieving this proportion is still an important result. While the analysis could have been undertaken based on yearly rather than monthly totals to reduce this impact, it has been shown that monthly variability is an important issue (entering the model at an early stage), with clear implications towards the need for flexibility in collection logistics practices.

Due to the large number of variables and inclusion of all significant 2-way interactions it would be impractical to include the formula of donation bank weight predictions for all permutations. The inclusion of multi-level factors means that providing a simple, single formula to predict donation bank weights was not

possible. However, an example formula [2] is given to predict weights for donation banks located at a Major Supermarket, in the Midlands for the month of March.

Tonne/month = -422.370 – 2.756 * (JSA * Age) – 14.038 * (Recycling * Age) – 0.001 * (House price * JSA) + 0.001 * (House price * Upper school) – 5.499*10-6 * (House price * Population Density) – 0.001 * (House price * Upper school) – 81.545 * (Recycling * First school) – 76.390 * (Recycling * Upper school) +256.139 * Recycling + 18.196 * Age + 0.792 * Population Density + 91.831 * First school + 0.003 * House price + 156.211 * JSA + 259.538 * Upper school [2]

While there were 139 parameters (variables and significant 2-way interactions) in total, by choosing levels of each factor (a specific supermarket group, region and month) this enabled the number of parameters within the formula to be reduced to 16. The formula is different for each combination of supermarket group, region and month. With 6 regions, 3 supermarket groups and 12 months this results in 216 different permutations of the formula for predicting donation bank weights.5.4.2 Model Application

The observed and predicted weights for every month's donation bank collection were plotted for each site and provided an indication of comparative site performance in terms of relative donation bank weights. Figure 69 shows a hypothetical set of data.

- Taking into account all of the site characteristics, the observed weights should equate to the predicted weights and would cluster around the 45 degree axis (cluster A in Figure 69).
- If the observed weights were lower than the predicted weights for a particular textile donation bank, this would indicate that the site was under performing in relation to its neighbours as one would expect the weight per donation bank to be higher (cluster B in Figure 69).
- If the observed weights were higher than those predicted by the model, the site could be deemed to be performing better than expected, producing consistently heavier donation bank loads compared to equivalent donation banks (cluster C in Figure 69).

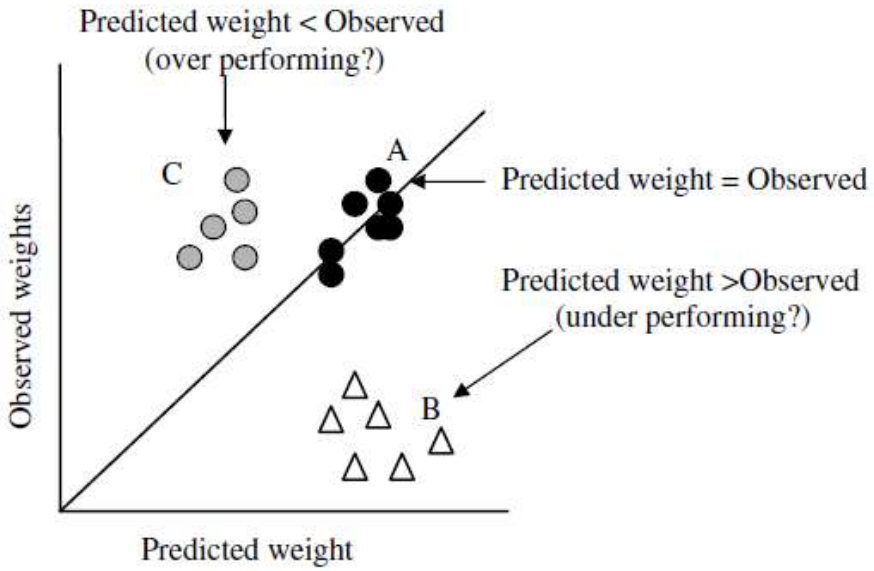


Figure 69. Use of model predictions for identifying comparative site performance

Due to the high variability of donation bank weights within London (Figure 70), initial prediction of donation bank weights in this area showed most of the donation banks over and underperforming to be from this location. Most of the donation banks in London produced under 1000 kg of textiles each month. There were were 5 locations which produced over 2000 kg of textiles ('super' sites located at HWRC's).

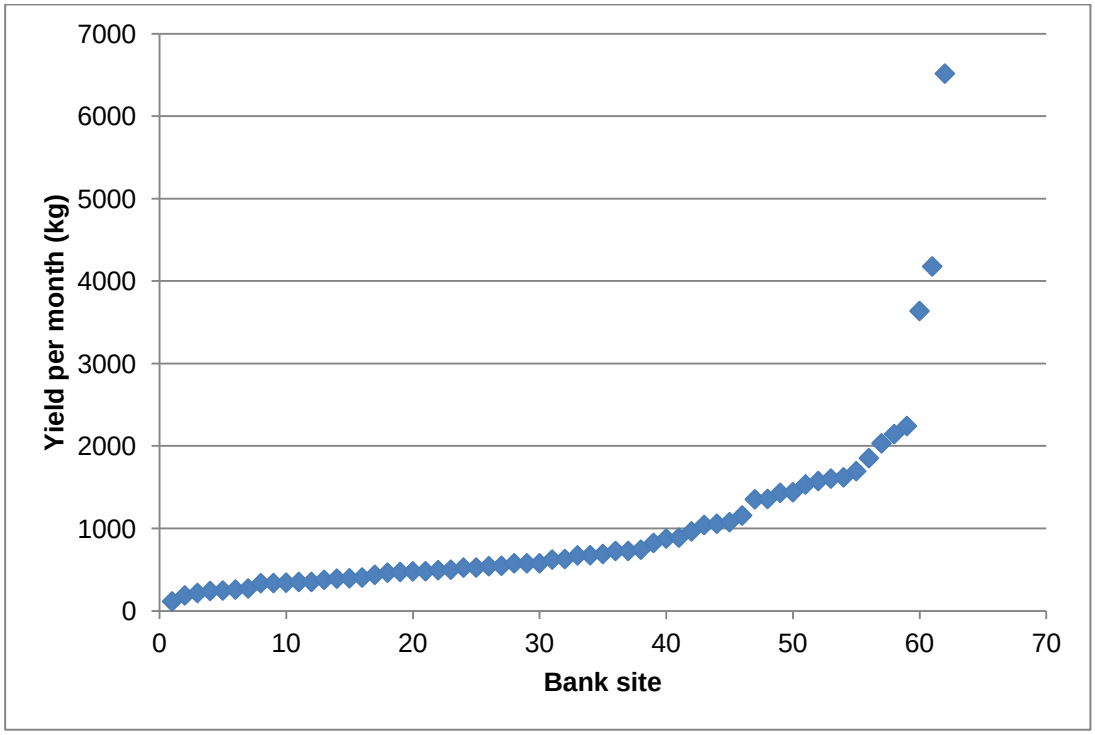


Figure 70. Yield per month (kg) of Central London donation banks

For the use of this analysis all donation banks with a Central London post code (Prefix NW, N, E, WC, EC, W, SW and SE) were removed from this part of the analysis. Figure 71 shows the model predicting donation bank weights for all sites and for each month and plots it against the actual observed weights for each month. The graph shows bank sites that are overperforming, underperforming and those performing as expected as in Figure 69.

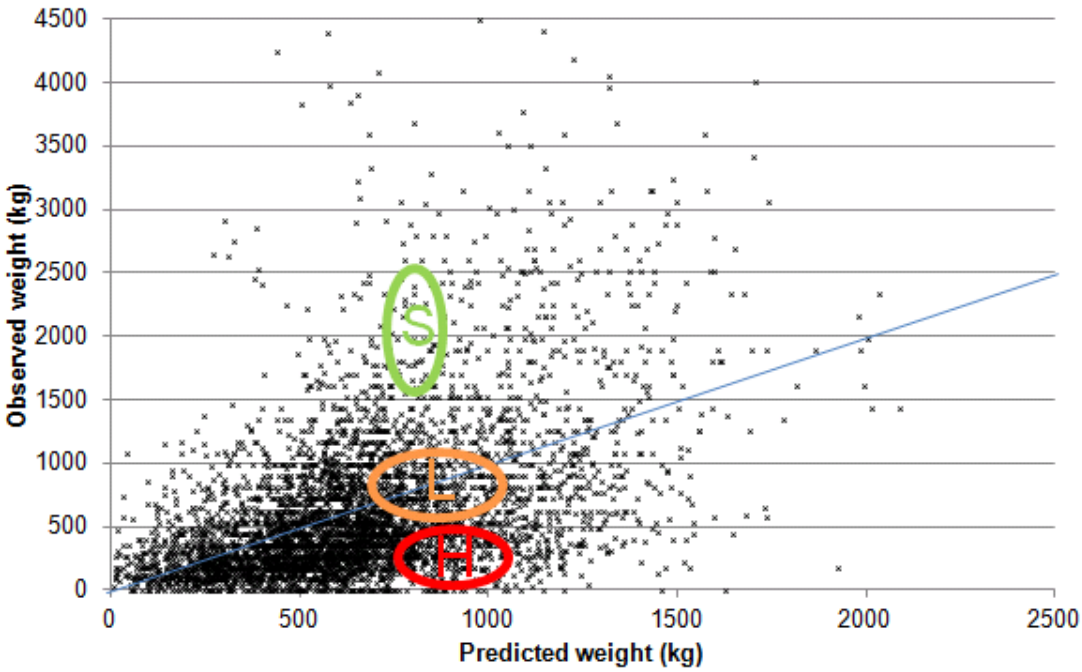


Figure 71. Observed and predicted textile donation bank weights

Using the model, 3 sites were subsequently highlighted for further analysis, which all had similar characteristics, but still returned significantly different mean donation bank weights after the effects of the physical, socio-economic and temporal factors had been taken into account. These 3 sites were selected to enable us to compare one site overperforming, one underperforming and one performing as expected. To reduce the number of variables between each site, all 3 sites were located at the same brand of supermarket: Green (S) = Shrewsbury, Orange (L) = (Fosse Park) Leicester and Red (H) = Harlow.

The model suggested that the donation bank located at the supermarket in Shrewsbury had produced consistently heavy donation bank weights, with observed weights greater than predicted. At Harlow the predicted donation bank weights were consistently greater than those observed; suggesting that for some reason not explained by the 10 factors, the site was producing consistently lower donation bank weights. At Fosse Park in Leicester, the predicted weights matched the observed

weights, indicating that the site was producing donation bank loads matching the average weight across all of the sites in the area.

5.4.3 Investigating differences in mean donation bank weights between sites

The 3 sites identified for this part of the analysis, are all located within the car park of the same brand of supermarket. Similar weights were predicted for these donation banks however a wide range in observed weights was noted. Car parks, and the locations of donation banks within these car parks, would be designed with the same guidelines in place, so other factors must be influencing donation bank weights in these situations. Table 46 shows the range in observed and predicted weights between these sites. Despite having the highest predicted weights (1034 kg per month), Harlow showed the lowest observed weights (226 kg per month). As with any real dataset, some variability is to be expected. However, other local factors will be considered in this section of the study as to why such a large variability was found between donation bank weights.

Table 46. Observed and predicted weights at the case study sites

Site	Average observed (kg)	Average predicted (kg)	Average Observed – Predicted (kg)
Shrewsbury	2524	802	+ 1722
Fosse Park	783	719	+ 64
Harlow	226	1034	-808

Harlow recorded the lowest donation bank weights and also had the fewest car parking spaces (400, with 18 disabled spaces) while Shrewsbury (recording the highest donation bank weights of the three sites) had 450 car parking spaces (with 30 disabled spaces), with Leicester having a much higher number (725, with 32 disabled spaces), but not producing proportionately higher weights. Shrewsbury was situated within a car park that also served other large chain stores and restaurants. The car park at Leicester served one restaurant as well as the supermarket while the car park in Harlow solely served the Supermarket. The number of services within the vicinity of the textile donation bank could have some effect on the visibility and convenience of the facility within the community.

Further discussions with the charity suggested that the number of donation banks physically located at the site may have had an impact in some circumstances because of the enhanced service visibility to members of the public. All three sites had a book donation bank located alongside the textile donation bank, but

Shrewsbury also had two other textile donation banks due to the high level of donations (the combined weight of the three donation banks is the value used in this analysis).

An Oxfam man-with-van driver commented that on occasions some Oxfam donation banks have had their access or view blocked by other donation or recycling (e.g. Glass and paper) banks leading to a potential reverse effect due to a 'lower than anticipated' local knowledge. This could result in some donation banks under performing. Donation banks for other charities on the same site will also reduce the potential for collection for each individual charity, as donations are divided between the charities. In order to get a full understanding of the factors affecting quantity yields of donation banks, it would be necessary to amalgamate the collections from all donation banks on that site. Other factors not previously considered within the analysis might contribute to the wide range of observed weights such as the level of crime, where areas recording higher levels might be expected to show higher levels of textile donation bank theft. To further understand this effect, a greater understanding of theft patterns would be needed alongside other factors such as ethnic diversity and level of education, addressed in Section 4.4.

5.4.4 Linking stock quality to bank placement strategy

The Milton Point donation stock quality audit was designed with the purpose of trying to understand the factors affecting the quality of donated stock received into Oxfam textile donation banks. From the 9 sites surveyed a range of findings were observed (Table 47).

Table 47. Stock quality audit findings

Site Name	Town	Site No	Number and size of textile banks	Total amount collected (25/6-11/7) (kg)	For retail (kg)	For wholesale (kg)	Value of retail stock (£)	% for retail	£/kg (for retail)	£/tonne (for retail)	Value of wholesale stock (£)	Total value (£)
Gerrards Cross	Gerrards Cross	E-3534-A	1 (standard)	12.5	0.5	12	2.25	4.00%	4.50	4500	8.40	10.65
RC Elsworth	Elsworth	C-0310-A	1 (standard)	35	0.5	34.5	1.25	1.43%	2.50	2500	24.15	25.40
Caledon Community Centre	St Albans	C-5669-A	1 (standard)	121.2	9.5	111.7	13.75	7.84%	1.45	1450	78.19	91.94
Northampton 2	Northampton	C-3069-A	1 (standard)	188.5	5	183.5	10	2.65%	2.00	2000	128.45	138.45
Dome Roundabout	Watford	E-3602-A	1 (standard)	224	11	213	25	4.91%	2.27	2270	149.10	174.10
Kettering	Kettering	C-5715-A	1 (standard)	241.5	14	227.5	36.25	5.80%	2.59	2590	159.25	195.50
Beaconsfield	Beaconsfield	E-3606-A	1 (standard)	302	18	284	31.75	5.96%	1.76	1760	198.80	230.55
Amersham	Amersham	E-0619-A	1 (standard)	457.5	25	432.5	84	5.46%	3.36	3360	302.75	386.75
Northampton 1	Northampton	C-5713-A	1 (standard)	481	33	448	187	6.86%	5.67	5670	313.60	500.60

Nb. Shaded banks are removed from the analysis due to the low amount of stock collected (<100kg) during the audit period

Unsorted stock valued at £0.70 per kg

From the sites at RC Elsworth and Gerrards Cross a small amount of stock was collected within the audit period. The Oxfam Donation bank Manager indicated that the RC Elsworth site received a small amount of stock because of its rural location. It was also indicated that the Gerrards Cross donation bank is located at a

Supermarket chain petrol station (the original adjoining supermarket has closed), and this would affect its donation levels. In both of these cases, the donation bank should be monitored for their profitability. Not enough stock was taken from these donation banks to produce representative findings for the area and therefore were not included within this study.

The other donation banks showed donation levels of between 121 kg and 458 kg during the 2 and a half week period of stock collection. From valuing the stock, the Northampton 1 site was found to produce the best quality retail stock during the audit (£5.67/kg). If donation banks such as this consistently produced high quality retail stock, then it would make sense to sort through this stock rather than selling it wholesale. The lowest quality retail stock was found from Caledon Community Centre with a value of £1.45/kg.

The Northampton 1 donation bank produced the highest total value of stock (£500.60) due to the high value of its retail stock and because this was the donation bank that produced the most stock (481 kg) during the audit period. The Amersham site produced about the same amount of stock (458 kg) during the audit period, and produced the second highest total value of stock £386.75.

It would appear that local value of property sale has no effect on donation stock quality levels due to the Northampton 1 donation bank being placed in an area with property value averaging £110,000. The donation bank that showed the highest proportion of retail (saleable) stock was the Caledon Community Centre donation bank which is located in an area with an ACORN rating of 50. These areas are typified by consisting of “council flats with hard-pressed and burdened singles” (Postcode Anywhere, 2012). This furthers the belief that local property value has little effect on donation stock quality levels.

It is believed that people would travel to a donation bank from a nearby radius (within around 2 miles) and within this radius property value can be hugely variable. The type of people that visit the area to donate would be likely to have an effect on donation stock quality levels.

The Northampton 1 site received a large amount of good quality stock during the audit period. The Northampton 1 donation bank is located at a large supermarket in Northampton. Also within the vicinity, and served by the same car park, is a range of attractions that would encourage the public to visit the area, such as shops, restaurants, a bowling centre and cinema. The local football stadium is also located

in the vicinity. These services would most likely attract the public and donations could be made by combining trips to these locations.

5.4.5 Analysis of donation value

This section of the paper aims to identify the key factors affecting donated textile quality by taking a similar predictive model approach to that of the donation stock quantity analysis. The much smaller number of data points for the quality data enables more traditional analysis of variance approaches to be used, but restricted to only the main effects of the possible explanatory variables. Using a backward variable selection approach (with significance level of 0.05) produced a model [1] containing three explanatory variables and achieving an R^2 value of 0.778. The approach is described in Section 3.2.3.

£/tonne = 544.502 + 23.906 * Age – 73.401 * JSA – 0.024 * Deprivation [1]

Age of population

The range of average ages of the population at the 9 sites was between 34.6 and 47.7. The model shows that areas with a higher average age of population are expected to produce higher quality donations for local textile donation banks. Discussions have identified two possible explanations for this effect, firstly that as people get older, they are thought to buy (and therefore donate) more expensive (perhaps designer) clothing and secondly, that younger (mid 30s) donors, with young children are giving more children's clothing to charity (children's clothing is considered to be of lower value to charities). CAF (2013) stated that over-60s are more than twice as likely to give to charity as the under-30s and more than half of all donations given in the UK now come from those aged 60 or over.

Percentage of Local Population on Job Seekers Allowance

The percentage of the population on JSA varies between 1% and 7% at the stock quality audit sites and as JSA percentage increases, the stock quality was found to decrease. Areas with a higher proportion of the population on JSA are expected to donate less high quality goods to donation banks, due to lower expected levels of disposable income. This contrasts with wealthy areas where there are generally lower levels of the population on JSA.

Local Postcode Deprivation Index

Local Postcode Deprivation Index was found to have a slight negative effect on the value of donation quality. Middle class families (ranked around 10,000-20,000) were found to produce the best quality donations, with donation value decreasing as affluence increases. It is possible this is because more affluent communities are less likely to take their good quality used textiles to donation banks and would prefer to donate their potentially designer goods direct to charity shops because of their high value. The public are advised to donate valuable items direct to shop rather than through donation banks because it is of far greater benefit to the charity (Charity Bags, 2014). More affluent areas may also be more likely to donate to charity through monetary standing orders than through donation of used goods. The most deprived neighbourhoods (ranked 1-10,000) showed increasing donated textile value as deprivation decreased, showing a link with JSA as these are the neighbourhoods with higher proportions of the population on JSA.

Overall, the donation bank that recorded the highest observed and predicted values for £/tonne was located in Northampton. This site ('Site 1') received a large amount of good quality stock during the audit period and whilst located at a large supermarket, was also in the vicinity of a range of trip attractors such as shops, restaurants, a bowling centre and cinema. From the audit locations, the donation bank with the lowest predicted textile value per tonne was also located in Northampton ('Site 2'). Compared to Site 1, this location had a lower average age of population (34.62 compared to 41.45), a higher proportion of the population on JSA (7% compared to 3%), and showed a much higher level of deprivation (ranked 7751 compared to 15825).

5.5 Predicting overall donation value

Combining the two models that have predicted the stock quantity (tonne/month) and the stock quality (£/tonne) from donation banks allowed a model to be created that predicted stock value yield (£/month) for all of the charities textile donation banks in the country.

The predicted value for £/month was derived by multiplying the predicted tonne/month by the predicted £/tonne. For example, a bank predicted to yield 0.5 tonnes of textiles each month (from the stock quantity predictive model) combined with a predicted value of £2000 per tonne (from the stock quality predictive model),

would result in a predicted overall stock yield of £1000 per month (0.5 tonne x £2000). This method was replicated across all banks to provide a database of predicted values for £/month across all sites.

This model allowed the donation banks that were of greatest potential benefit to the charity to be identified, and could help further the understanding of optimal donation bank placement.

Rather than show actual predicted textile values from donation banks, it was more beneficial to show the relative worth (as a %) of the textile stock compared to the predicted average from all textile donation banks used within the analysis. The predicted values for relative worth helped identify which sites were expected to perform comparatively well or poorly (Figure 72). Donation banks performing above the 100% mark are expected to perform better than the overall average across all donation banks. Donation banks performing below the 100% mark are expected to perform worse than the overall average across all donation banks.

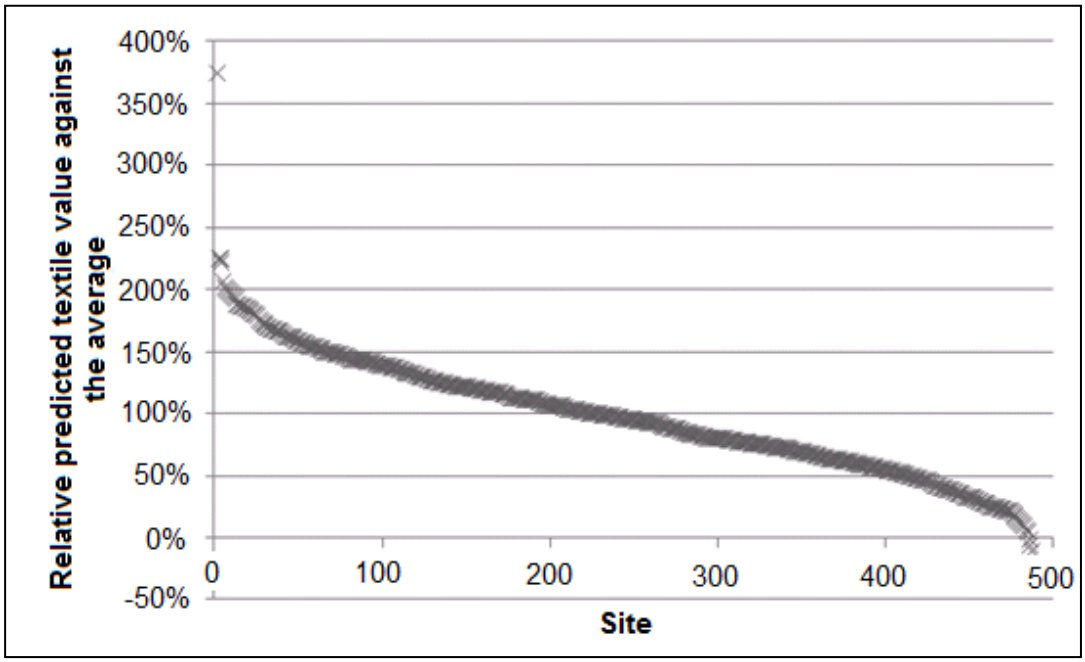


Figure 72. Relative predicted textile value against the average

There was a wide deviation in the predicted relative worth of textile donations across the country. In order to understand how effective this model is, it is necessary to look into a range of sites and examine how the model has predicted the potential textile value from each site. Figure 73 shows the locations of the five potentially most profitable (red) and least profitable (blue) sites for predicted donated textile

value which highlights the division in donated stock quality and quantity yield between the north and south of the country.

Figure 73. Potentially most profitable (red) and least profitable (blue) textile donation bank sites in terms of predicted donated textile value

In order to show a high predicted relative worth compared to the mean, sites must be predicted high levels of yield (tonne/month) as well as a high expected level of textile quality based on the demographics of each of these sites (although as the variation in quantity between sites is much greater than variations in quality, it is the quantity that tends to dominate the overall impact). The top performing site (in Cornwall) was predicted to produce 1933 kg of textile stock each month as well as being predicted to produce high quality stock, resulting in the relative worth of 377% over the average. Throughout the year 2010-2011, this site produced 19.8 tonnes of stock, confirming that this donation bank performed well.

Three of the worst performing sites have been predicted to produce effectively no value at all (once logistics collections costs are taken into account). The expected

worst performing site (in Warwickshire) was predicted by the model to produce a small negative weight of textile stock each month as all factors in the model count against the site (and quality is also predicted to be low due to poor levels of the socio-demographic factors). Although clearly negative values are not possible, throughout the year 2010-2011 this donation bank only produced 360 kg of textile stock in total, confirming that this donation bank was a low performer as expected.

5.6 Summary

Hypothesis 1 suggested that the weight of textile donations to charity donation banks is affected by the population density in the vicinity. The higher the population density, greater collection yields are expected. However, there was not found to be a correlation between population density and the weight of textile donations received to charity donation banks, therefore Hypothesis 1 is not supported.

Hypothesis 2 predicted that the weight of textile donations to charity donation banks is affected by the locations convenience. Donation banks placed near convenient locations such as supermarkets and school, that can enable trip chaining, are expected to receive greater yields. Supermarket sites are expected to have a high throughput of people combined with the factor of convenience (as donating can be combined with shopping trips) and expected good visibility of the donation bank sites in these locations, thus supporting the previous research on recycling facility locations by Stantec (2009). These findings are also in line with Joung and Park-Poaps (2011) research that stated recycling drop-off points should be located close to services such as supermarkets. Therefore, Hypothesis 2 is supported.

Hypothesis 3 suggested that the weight of textile donations to charity donation banks is linked to affluence within the area. The wealthier an area is, greater collection yields are expected. Property values as a measure of affluence showed some effect on weight yields in a single factor model but showed a far smaller effect when combined with other factors. Also as a measure of affluence, the percentage of the population on Job Seekers Allowance and local postcode Deprivation Index showed no effect on weight yields, therefore Hypothesis 3 is not supported.

Hypothesis 4 predicted that the quality of textile donations to charity donation banks is linked to affluence within the area and that the wealthier an area is, greater quality yields are expected. A lower percentage of the local population on Job Seekers Allowance was found to have a positive effect on quality yields. The age of population was found to have an effect on quality yields, where areas with an

average age of late 40's were found to provide the best quality textile donations, which could also be linked to affluence. However, relating to Postcode Deprivation Index, middle class families (ranked around 10,000-20,000 are expected to produce the best quality textiles, with decreasing quality expected towards both ends of the Deprivation Index scale. Therefore Hypothesis 4 is not supported. Although areas with high proportions of JSA and high levels of deprivation are expected to produce low quality textile donations, the least deprived areas are also expected to produce low quality of donated textiles compared to mid-range Postcode Deprivation Index areas.

Chapter 6: Assessing the merits of alternative localised and centralised collection strategies

6.1 Hypotheses

The following hypotheses were of direct interest to Oxfam derived through dialogue over the period of the project.

Hypothesis 5: Optimised donation bank collection strategy can result in cost and environmental savings.

Hypothesis 6: Improved understanding of bank fill levels can improve the efficiency of charity collection and delivery routes.

Hypothesis 7: More localised, shop-adopted donation bank collections could find potential mileage savings over more centralised donation bank collections.

6.2 Alternative collection strategies for localised collections

DPS Logix route optimisation software was used to determine more efficient collection and delivery schedules for the man-with-van operation based at Winton, comparing against the original base case scenario modelled in Section 3.3.2. Alternative collections scenarios were considered as they could enable a reduction in operating and environmental costs.

6.2.1 Scenario A: Same day collection / delivery route optimisation

In Scenario A, Logix was given all the current delivery and collection points to be visited during the day, but was allowed to decide what the optimal servicing order would be within that day and to optimise routing.

Table 48 shows the mileages given by Logix for Scenario A against the actual recorded miles during the audit week. Savings of 41 miles (10.68%) can be found from optimising routing while still visiting the same locations on the same days as before.

Table 48. Scenario A mileages against the base case

Day	Base case mileage	Scenario A

Monday	79	65
Tuesday	64	52
Wednesday	41	38
Thursday	158	150
Friday	42	38
Total	384	343

The optimised routes are shown for each day in figures 72 to 76. Here we can see a representation of where savings in mileage are found. On each map, the blue line indicates the route that was taken during the audit week. The orange line indicates the route given by Logix related to scenario A.

Monday

The route optimised by Logix shows a saving of 14 miles over the course of the day (Figure 74). The recorded mileage includes a house collection and one Marks and Spencer collection, which accounts for some extra mileage.

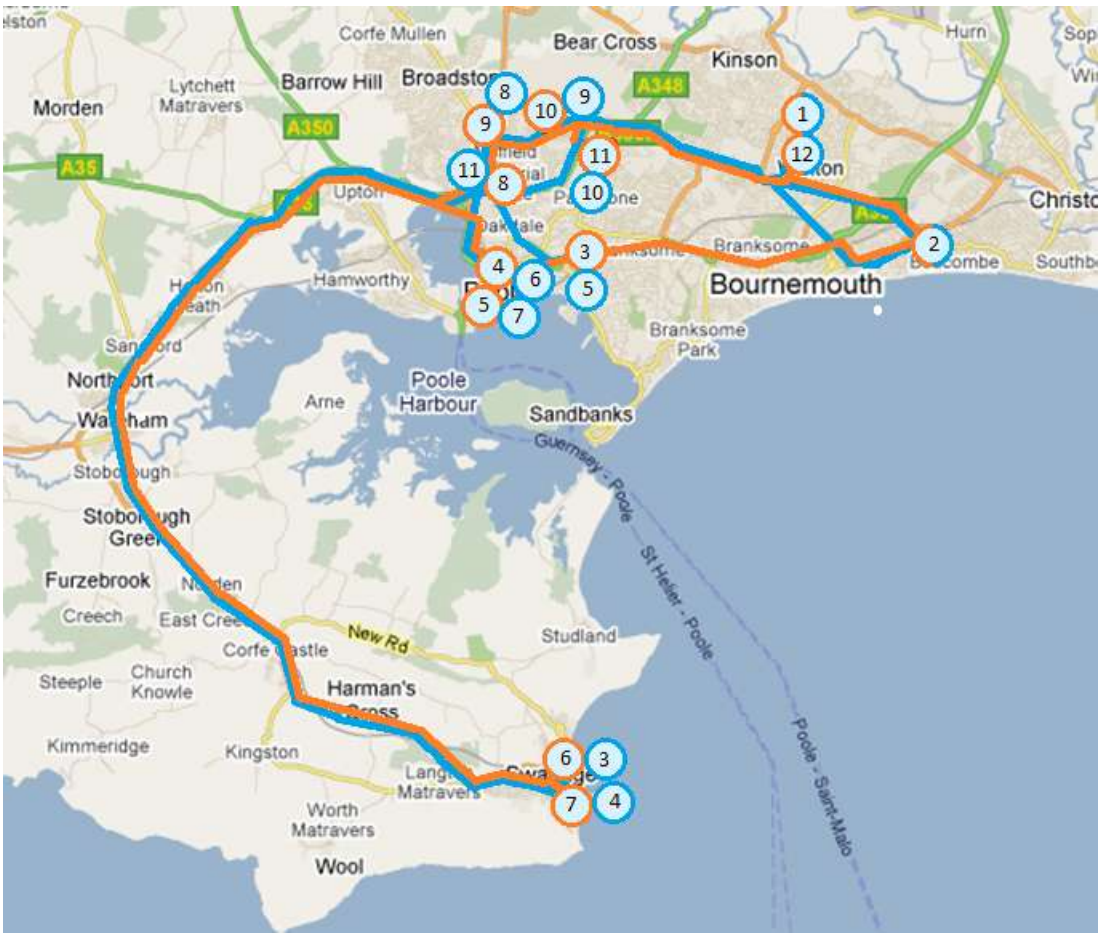


Figure 74. Scenario A Monday route

As a way of further reducing mileage for the Monday route there is the possibility of using the Sandbanks ferry. This would drastically reduce travel time and fuel costs; however the cost of using the ferry should be taken into account. Perhaps contact could be made with the ferry company requesting a discount on the ticket cost for the Oxfam van.

Tuesday

Savings of 12 miles are found when using Logix to optimise the route for Tuesday (Figure 75). The recorded mileage includes one Marks and Spencer collection which accounts for some extra mileage.

Figure 75. Scenario A Tuesday route

Logix identified some savings in mileage due to planning the route to visit the westernmost donation banks in Poole before heading east and finishing the day at Winton. During the audit week following the collection at Wimborne, the next visit was to Marks and Spencer's in Bournemouth before heading west for donation bank collections and then east again back to Winton.

Wednesday

Although the total recorded mileage for Wednesday was taken as 49 miles, for the purpose of route optimisation, the 8-mile round trip visit to Millham's Recycling Centre has been removed from consideration. This trip for recycling can be considered separately.

Logix shows savings of 3 miles for the Wednesday route against the route taken during the audit week (Figure 76).

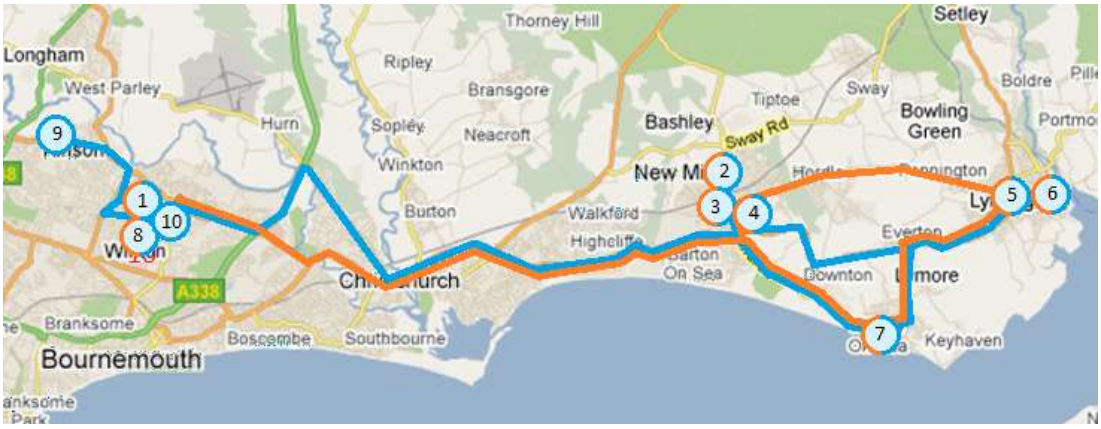


Figure 76. Scenario A Wednesday route

Thursday

Thursday was the day with the largest mileage travelled (158). Therefore the 8 miles saved by Logix is fairly insignificant (Figure 77).

Figure 77. Scenario A Thursday route

Logix identified the optimal route for the first leg of the journey as using the A31/M27/A3057 going via Romsey, rather than the A338/A30 via Salisbury (as currently used). However savings in mileage are negligible. Due to part of the route being motorway it would be interesting to see if any time savings were found using this alternative route.

5 miles can also be saved from using the A342 between Andover and Marlborough. The rest of the route is already running the optimised standards.

Friday

Savings of 4 miles were found from using Logix on Friday's route. The routes that were taken by the driver and shown by Logix are remarkably similar, and the extra 4 miles can be attributed to using a few different roads to avoid traffic and searching for suitable location for breaks (Figure 78).

Figure 78. Scenario A Friday route

6.2.2 Scenario B: Logix optimised delivery / collection schedule

Scenario B gave Logix the freedom to decide which locations should be visited on each day (across the whole schedule, with the exception of sites that had to be visited on a specific day) along with its own order of collection. This was with the exception of the Parkstone and Poole shops which must be visited on Monday and Friday, due to the need to cascade stock between these shops on those days. Other necessities were considered, such as the donation bank at Swanage needing to be visited before the Swanage shop, as stock from this donation bank is delivered to the shop.

Table 49 shows the base case mileage against the scenario B mileages. Scenario B found weekly savings of 72 miles over the base case (Table 49).

Table 49. Scenario B mileages against the base case

Day	Base case mileage	Scenario B
Monday	79	66
Tuesday	64	41
Wednesday	41	38
Thursday	158	149
Friday	42	18
Total	384	312

When collections and deliveries were optimised using the same days as used in the audit week, the total mileage found for the week was 343 miles. Scenario B found weekly mileage savings of 31 miles over scenario A.

Monday

The optimised route identified by Logix (Figure 79), creating its preferred delivery/collection schedule shows visits to Swanage combined with visits to the donation bank and shop in Blandford. It made sense to combine these visits due to their location as both required travelling west of Poole.

Figure 79. Scenario B Monday route

Tuesday

Figure 80 shows the route given by Logix for Tuesday. This route combines visits within Bournemouth/Poole with sites further north such as Ferndown, Verwood and Ringwood.

Figure 80. Scenario B Tuesday route

Wednesday

The route shown for Wednesday incorporates visits to New Milton, Lymington and Milford-on-Sea, as currently carried out by the Winton driver (Figure 81). In addition to these visits collections are also made from a donation bank in east Bournemouth and Christchurch.

Figure 81. Scenario B Wednesday route

Thursday

Thursday's route given by Logix is almost identical to the route currently undertaken by the Winton driver (Figure 82). The difference between the two routes is travelling east from Ringwood on the A31/M27 rather than going north on the A338 via Salisbury. This difference in route does not show significant savings in mileage, but the section travelled via motorway may result in some time savings.

Figure 82. Scenario B Thursday route

Friday

Friday's route identified by Logix shows a shorter day than the other days in terms of mileage. The visits on this day focus around servicing the shops as Parkstone and Poole, and collecting from the remaining donation banks in Poole (Figure 83). The advantage of having Friday as the day with only a few local collections is that there is time available for additional ad-hoc collections/deliveries.

Figure 83. Scenario B Friday route

6.2.3 Summary

Table 50 shows a comparison of the mileages from the base case compared with scenarios A and B.

Table 50. Scenario A and B mileages against the base case

Day	Base case mileage	Scenario A	Scenario B
Monday	79	65	66
Tuesday	64	52	41
Wednesday	41	38	38
Thursday	158	150	149
Friday	42	38	18
Total	384	343	312

Where Logix was given all the current delivery and collection points to be visited during the day, but was allowed to decide what the optimal servicing order would be within that day (Scenario A) savings of 41 miles over the base case.

Scenario B showed optimised routes where Logix decided upon which days to make visits, apart from a selection of visits which had to be made on certain days. The

total mileage for the Logix optimised routes was 312 miles, showing a saving of 72 miles over base case. However, this does not include house visits or Marks & Spencer collections which took place during the base case. Visits to these locations occur on an ad-hoc basis and therefore, cannot be modelled or scheduled for.

Only visits to donation banks and shops were entered into Logix. Other visits were made during the audit week that will have added to the recorded mileages. Two Marks and Spencer collections and one house collection was made during the audit week. It was not suitable to add these into the route optimisation because these locations are not visited on a scheduled basis.

Donation banks within the Poole and Bournemouth vicinity generated good amounts of quality stock for collection. The vicinity to Winton means that they are cheap to service and the amount of stock generated justifies their existence. Donation banks in areas such as Marlborough should be monitored for their performance over a longer period of time as given the service costs relative to the volume of saleable stock generated they may not prove profitable in the long term.

6.2.3 Limitations of the audit

With regards to looking into donation bank performance, a major limitation is that the audit was only carried out over the course of one week. A donation bank that gave low proportions of saleable stock in the audit week may not always give similar results. This works conversely in that a donation bank that gave a high proportion of valuable stock may not always be so reliable. In order to gain a better insight into donation bank performance it would be necessary to monitor the quality of stock taken over time, and this would enable seasonal trends to be identified and highlight particularly profitable postcode areas for donation bank deployment.

A further limitation could have been that the auditor’s presence on the round which may have affected the time span of tasks. For example, tagging bags during donation bank collections may have added additional time to the job to reduce total productivity over the course of the day.

When looking into the accuracy of average bag weights currently used by Oxfam, it is believed that 226 bags of books provides a good representative value for bag weights. However, over the week only 31 bags of textiles were collected and tagged and this is not enough to provide a good representative sample for textiles.

This report has briefly looked into the value of stock found from one days' worth of collections from donation banks. Estimates were made of the total value of stock taken that week, and this should only be taken as a rough estimate due to the nature of the calculations, made by one experienced person.

6.3 Modelling impacts of a minimum fill level collection strategy

With the use of the developed Smartphone App, this part of the study modelled the impacts of visiting donations banks only when needed (50%-80% full). By taking donation bank fill levels into account (which were recorded by the driver through the Smartphone App upon each donation bank collection), Scenario C shows whether visiting low performing donation banks less frequently could aid in increasing routing efficiency. This is achieved by studying the average donation bank fill levels. Bank fill levels were estimated given fill level history to determine which banks could be visited less often. For example, a bank that usually showed weekly fill levels of 25% was modelled for visiting every 3 weeks. A bank that usually showed weekly fill levels of 75% was modelled for visiting every week.

Table 51 shows the donation banks with average fill levels of under 50% between 3/5/13 and 22/7/13 that were considered for visiting less frequently within Scenario C.

Table 51. Low performing W14 donation banks (3/5/13-22/7/13)

Site name	Collection (#bags)	Average fill (%)
Sainsbury's Melksham	33	38.3
Ringwood RYC (textile)	49	37.0
Barfields Public Car Park	42	34.3
Milford on Sea Recycling Centre	41	32.2
Sainsbury's Poole (textile)	84	26.8
Ringwood RYC (book)	54	23.8
North Beach CP	25	23.5
Spencer Rd	29	22.2
Poole Stadium	19	19.6
Wootton Hall Tiptoe	15	17.8
Bath Rd CP	14	17.3

The following considerations were taken into account when considering Scenario C. Although Sainsbury's Poole (textile) donation bank showed low average fill levels (26.8%) it was placed next to a high performing book donation bank (56.3% average

fill). Both donation banks were emptied at the same time, therefore this donation bank was not considered for visiting less frequently in the alternative collection scenario. Although Ringwood RYC (book) only showed an average fill of 23.8% and should be considered for visiting a third as often as during the trial period, it was placed next to a textile donation bank showing 37% average fill which is recommended for visiting half as often as during the trial week. Therefore both donation banks shall be visited at the same time and visited half as often as during the base case.

This part of the study replicated the method used in Section 6.2 to provide an updated base case to compare with scenario C (visiting donation banks at 50%-80% fill level). Scenario A and B were updated to reflect the routes in the updated base case, but still followed the same rules as in the original scenarios. Scenario A ran the same day and frequency of visits made in the case study 4-week period (3/6/13-28/6/13) with optimised routing. Scenario B modelled the same frequency of visits, but allowed the optimising software to decide collection days. Scenario C modelled collecting from donation banks when collections were needed (at 50-80% fill levels). Tables 52-54 compare the findings from the updated scenario A, scenario B and scenario C.

Scenario A - Same day collection / delivery route optimisation

Table 52. Scenario A route statistics

Week	Route	Day	Kms	Calls	Time	Kg delivered	Kg collected	Total kg moved	Cost to run	Cost per kg moved	CO_2 emissions (kg)
1	3/6/13	Mon	143	11	03:57	481	548	1029	£105.31	£0.10	34.32
	4/6/13	Tue	237	6	05:23	435	526	961	£119.41	£0.12	56.88
	5/6/13	Wed	252	5	05:15	210	405	615	£121.66	£0.20	60.48
	6/6/13	Thu	85	13	02:46	68	797	865	£96.61	£0.11	20.4
	7/7/13	Fri	223	9	05:19	421	631	1052	£117.31	£0.11	53.52
2	10/6/13	Mon	140	10	03:32	406	331	737	£104.86	£0.14	33.6
	11/6/13	Tue	70	9	02:33	0	541	541	£94.36	£0.17	16.8
	12/6/13	Wed	254	6	05:09	270	256	526	£121.96	£0.23	60.96
	13/6/13	Thu	72	15	02:59	105	1142	1247	£94.66	£0.08	17.28
	14/6/13	Fri	246	6	05:17	15	736	751	£120.76	£0.16	59.04
3	17/6/13	Mon	140	10	03:28	421	248	669	£104.86	£0.16	33.6
	18/6/13	Tue	237	7	05:54	315	1090	1405	£119.41	£0.08	56.88
	19/6/13	Wed	104	10	04:38	1500	428	1928	£99.46	£0.05	24.96
	20/6/13	Thu	49	12	02:00	120	767	887	£91.21	£0.10	11.76
	21/6/13	Fri	224	8	05:32	458	773	1231	£117.46	£0.10	53.76
4	24/6/13	Mon	140	11	03:42	473	399	872	£104.86	£0.12	33.6
	25/6/13	Tue	104	14	03:35	0	987	987	£99.46	£0.10	24.96
	26/6/13	Wed	252	5	05:02	23	405	428	£121.66	£0.28	60.48
	27/6/13	Thu	246	4	05:03	0	563	563	£120.76	£0.21	59.04
	28/6/13	Fri	72	12	04:15	120	2177	2297	£94.66	£0.04	17.28
			3290	183	85:19	5841	13750	19591	£2,170.70	£0.11	789.6

Scenario B - Logix optimised delivery/collection schedule

Table 53. Scenario B route statistics

Week	Route	Day	Kms	Calls	Time	Kg delivered	Kg collected	Total kg moved	Cost to run	Cost per kg moved	CO_2 emissions (kg)
1	3/6/13	Mon	143	11	03:57	481	548	1029	£104.56	£0.10	34.32
	4/6/13	Tue	237	6	05:23	435	526	961	£121.51	£0.12	56.88
	5/6/13	Wed	252	5	05:15	210	405	615	£120.76	£0.20	60.48
	6/6/13	Thu	85	13	02:46	68	797	865	£86.71	£0.11	20.4
	7/7/13	Fri	223	9	05:19	421	631	1052	£118.96	£0.11	53.52
2	10/6/13	Mon	140	10	03:32	406	331	737	£101.41	£0.14	33.6
	11/6/13	Tue	70	9	02:33	0	541	541	£96.61	£0.17	16.8
	12/6/13	Wed	254	6	05:09	270	256	526	£122.41	£0.23	60.96
	13/6/13	Thu	72	15	02:59	105	1142	1247	£87.31	£0.08	17.28
	14/6/13	Fri	246	6	05:17	15	736	751	£123.31	£0.16	59.04
3	17/6/13	Mon	140	10	03:28	421	248	669	£101.26	£0.16	33.6
	18/6/13	Tue	237	7	05:54	315	1090	1405	£121.51	£0.08	56.88
	19/6/13	Wed	104	10	04:38	1500	428	1928	£95.11	£0.05	24.96
	20/6/13	Thu	49	12	02:00	120	767	887	£90.46	£0.10	11.76
	21/6/13	Fri	224	8	05:32	458	773	1231	£117.46	£0.10	53.76
4	24/6/13	Mon	140	11	03:42	473	399	872	£101.26	£0.12	33.6
	25/6/13	Tue	104	14	03:35	0	987	987	£121.36	£0.10	24.96
	26/6/13	Wed	252	5	05:02	23	405	428	£123.16	£0.28	60.48
	27/6/13	Thu	246	4	05:03	0	563	563	£93.61	£0.21	59.04
	28/6/13	Fri	72	12	04:15	120	2177	2297	£100.81	£0.04	17.28
			3149	183	82:10	5841	13750	19591	£2,149.55	£0.11	755.76

Scenario C – Visiting donation banks at approximately 50%-80% full

Table 54. Scenario C route statistics

Week	Route	Day	Kms	Calls	Time	Kg delivered	Kg collected	Total kg moved	Cost to run	Cost per kg moved	CO_2 emissions (kg)
1	3/6/13	Mon	138	12	03:53	481	541	1022	104.56	£0.10	33.12
	4/6/13	Tue	251	9	06:09	435	849	1284	121.51	£0.09	60.24
	5/6/13	Wed	246	6	05:05	210	345	555	120.76	£0.22	59.04
	6/6/13	Thu	19	5	00:46	68	248	316	86.71	£0.27	4.56
	7/7/13	Fri	234	12	05:57	421	924	1345	118.96	£0.09	56.16
2	10/6/13	Mon	117	10	03:11	406	376	782	101.41	£0.13	28.08
	11/6/13	Tue	81	5	01:54	0	345	345	96.01	£0.28	19.44
	12/6/13	Wed	257	9	05:44	270	549	819	122.41	£0.15	61.68
	13/6/13	Thu	23	6	00:59	105	376	481	87.31	£0.18	5.52
	14/6/13	Fri	255	9	05:52	15	998	1013	122.11	£0.12	61.2
3	17/6/13	Mon	118	13	03:20	421	555	976	101.56	£0.10	28.32
	18/6/13	Tue	251	8	06:23	315	1180	1495	121.51	£0.08	60.24
	19/6/13	Wed	74	5	02:00	0	360	360	94.96	£0.26	17.76
	20/6/13	Thu	22	4	00:41	120	129	249	87.16	£0.35	5.28
	21/6/13	Fri	228	11	07:56	1958	1073	3031	118.06	£0.04	54.72
4	24/6/13	Mon	116	13	05:05	473	2013	2486	101.26	£0.04	27.84
	25/6/13	Tue	117	12	03:27	0	1329	1329	101.41	£0.08	28.08
	26/6/13	Wed	250	6	05:01	23	428	451	121.36	£0.27	60
	27/6/13	Thu	247	7	06:00	0	698	698	120.91	£0.17	59.28
	28/6/13	Fri	65	7	01:52	120	444	564	93.61	£0.17	15.6
			3109	169	81:15	5841	13750	19591	2143.55	£0.11	746.16

6.3.1 Comparison of scenarios

Table 55 shows a comparison of the findings between the base case and the 3 alternative scenarios over the 4-week modelled period. Allowing Logix the freedom to choose which day to carry out donation bank visits (Scenario B) resulted in potential savings of 168 km per month (equating to £25.20 cost savings and 40.32 kg CO_2). Visiting low performing donation banks less frequently (aiming for all donation banks to be approximately 50%-80% full), while visiting shops on the same day as the current schedules (Scenario C), shows cost savings of £31 per month on the existing routes. Monthly distance savings of 208 km could be realised by visiting select donation banks less frequently.

Table 55. Route statistics comparison between scenarios A-C

Schedule	Km	Calls	Time (hh:mm)	Kg delivered	Kg collected	Cost to run	Cost per kg moved	CO_2 emissions (kg)
Base case	3317	183	87:32	5841	13750	£2,174.75	£0.11	796.08
Scenario A	3290	183	85:19	5841	13750	£2,170.70	£0.11	789.60
Scenario B	3149	183	82:10	5841	13750	£2,149.55	£0.11	755.76
Scenario C	3109	169	81:15	5841	13750	£2,143.55	£0.11	746.16

Table 56 shows the potential savings of the 3 alternative scenarios over the base case scenario per week. Greater percentage savings are found relating to distance, time and CO_2 emissions rather than monetary savings. This is because a great proportion of the total cost is taken by the cost of the driver and the van itself, rather than the differences in distance.

Table 56. Potential savings of the alternative scenarios over the base case

Schedule	Km saved	% saving	Time saved (hh:mm)	% saving	Cost savings	% saving	CO_2 emissions saved (kg)	% saving
Scenario A	27	0.82	02:13	2.59	£4.05	0.18	6.48	0.82
Scenario B	168	5.33	05:22	6.53	£25.20	1.17	40.32	5.33
Scenario C	208	6.69	06:17	7.73	£31.20	1.46	49.92	6.69

The difference between the existing routes used by the W14 man-with-van (base case) and scenario A is minimal in terms of mileage and cost savings (27 km over a 4 week period). The routes used in the base case may also take local knowledge into account, such as routes that avoid traffic.

Cost savings of up to around £30 per week could be found by visiting banks at a minimum fill level (Scenario C), however this would require extra monitoring of bank performance. The cost of monitoring bank performance may outweigh the potential cost savings found from reduced mileages. When taking these additional costs into account, the savings are not significant.

While the results here are not significant, reviewing the strategy for shop visits, such as visiting shops with low stock movement on a less regular basis could result in more substantial cost savings. Oxfam have begun to look into dynamic shop servicing based on a minimum stock level within each shop (used as the servicing trigger) and this is now being investigated in trials across the south-east of England.

6.3.2 Discussion

On the W14 routes, donation banks such as RYC Butlers Lane and Allenview CP Wimborne regularly produce high amounts of donated stock.

Sites such as Wootton Hall Tiptoe and Bath Road CP have shown extremely low yields over the trial period. If these sites are in close proximity of sites that are high performers (or not straying far from routes) then they may result in much additional travel costs. If these sites are remote and require extra mileage then they may not be profitable for the charity.

Despite Scenario C potentially saving the charity 208 km distance travelled every month, by visiting low performing donation banks less frequently, the total estimated costs savings of this method only equate to £31 every month. Therefore in this situation, visiting low performing donation banks would not greatly affect profits.

Unless using remote monitoring technology the charity will have no knowledge of donation bank fill level or state of the donation bank. Donation bank fill rates can be extremely unpredictable and also vary throughout the year. Sometimes donation banks can fill extremely slowly, and sometimes a single large donation can fill a donation bank. This is something that is not taken into account by aiming to visit

donation banks less frequently, where collection amounts have been averaged to inform on visit frequency. Although we can plan to visit donation banks less often based on low average fill rates, this does not take into account unpredictable large donations.

The manager of the Oxfam Distribution Centre in Bournemouth said that corporate donations yield around 50% saleable stock, compared to around 30% from house collections and 20% from donation banks. The manager also stated that house collections vary in size and are only visited if there is enough donated to warrant a collection. These collections are planned so that they tie in with scheduled donation bank or shop collections collecting around 5 boxes or bags on average at a time. These collections are difficult to value because the quality differs vastly as they are so individual.

6.4 Alternative centralised collection strategy

This part of the study identified the impact of alternative centralised collection strategies. The different scenarios involved the utilisation of shop adopted banks in different ways. The objective of this part of the study was to understand whether significant savings could be realised by the charity through the adoption of alternative collection strategy, principally through the utilisation of shop adopted banks.

6.4.1 Scenario 1 - Shop adopted donation bank collections

Scenario 1 modelled the adoption of shop adopted banks, whereby the banks in the Milton Point area were serviced by the nearest shop. This scenario involved shop volunteers using their own private vehicles to service their local donation bank donation bank and return the stock to the shop instead of a centralised service emanating from the Milton Point Depot. Excess stock was assumed as being passed on at the back door to rag merchants.

Throughout the week, 53 separate routes have been modelled (utilising 24 medium sized cars) (14 shop vehicles used twice a week, 7 shop vehicles used three times a week). It is possible, that shops that are nearby to each other could share transport. This would have an effect on the mileage of the routes, but could find cost savings through reduced transport needs.

A breakdown of a weeks' worth of modelled activity for shop adopted donation bank collections is shown in Appendix 8. Table 57 shows the key statistics for Scenario 1.

Table 57. Shop adopted donation bank model statistics

Vehicles required	24 (medium sized cars)
Total distance (km)	587
Total time spent	73 hours 23 minutes
Total collected (bags, kg)	3093, 23194
Collected from shops (kg)	0
Collected from donation banks (kg)	23194
Total CO_2 (kg)	110
Kg/km	39.51
Km/bag	0.19
CO_2 (kg)/bag	0.04

Using this method, 6 donation bank sites were not planned for servicing, due to their remote location. As only 23194 kg were modelled to be collected using this method, this shows that the majority of stock collected by Milton Point drivers is excess stock from shops (66764 - 23194 = 43570 kg). This shows that this scenario alone will not satisfy the current demand for stock movement in the Milton Point area. If however, the only requirement was for donation bank collections to be made and there was access to vehicles at each of the shops (e.g. Volunteers vehicles), this method of collection could be viable. Despite the increased number of vehicles needed, total drive time, distance and CO_2 emissions for Scenario 1 are vastly reduced over the Logix modelled Milton Point routes (Table 58).

Table 58. Key statistics for the base case against Scenario 1

	Base case	**Scenario 1**
Vehicles required	5 (12 Tonne lorries)	24 (medium sized cars)
Total distance (km)	5588	587
Total time spent	220 hours 44 minutes	73 hours 23 minutes
Total collected (bags, kg)	8902, 66764	3093, 23194
Collected from shops (kg)	41175	0
Collected from donation banks (kg)	25589	23194
Total CO_2 (kg)	3727	110
Kg/km	11.95	39.51

Km/bag	0.63	0.19
CO_2 (kg)/bag	0.42	0.04

Other issues to consider with the use of volunteers and their vehicles with donation bank collections would be the associated private mileage costs as well as insurance issues.

6.4.2 Scenario 2 - Shop adopted donation bank collections with centralised shop and remote donation bank collections

Scenario 2 involved the utilisation of shop adopted banks, but included centralised visits to shops and remotely located donation banks. The shops currently serviced by Milton Point have a need to deal with culled and waste stock and this scenario takes that into account. With the majority of donation banks being visited by shops, there is still the requirement to deal with the more remote donation bank locations. This scenario does assume however, that the shop deals with all of the stock that is brought in from the donation banks that they have adopted, through shop sales or selling to rag merchants at the back door. This scenario also assumes that the shop is large enough and has the workforce to deal with up to 3 full donation banks worth of stock per week (~630 kg).

A breakdown of a weeks' worth of Milton Point based shop collections and remote donation bank collections is shown in Appendix 9. Using the 5 vehicles as currently run by Milton Point drivers, the total km to visit all shops and remote donation banks are shown in Table 59.

Table 59. Milton Point shop and remote donation bank collection statistics

Vehicles required	5 (12 Tonne lorries)
Total distance (km)	4957
Total time spent	186 hours 17 minutes
Total collected (bags, kg)	5793, 43445
Collected from shops (kg)	41175
Collected from donation banks (kg)	2270
Total CO_2 (kg)	3306
Kg/km	8.76
Km/bag	0.86
CO_2 (kg)/bag	0.57

These collections would need to run in conjunction with the shop adopted donation bank collections (Scenario 1). Table 60 shows the key statistics for the combination of shop adopted donation bank collections alongside the centralised take-back service.

Table 60. Shop adopted donation banks model with Milton Point shop and remote donation bank collection statistics

Vehicles required	5 (12 Tonne lorries) + 24 (medium sized cars)
Total distance (km)	5544
Total time spent	259 hours 40 minutes
Total collected (bags, kg)	8885, 66639
Collected from shops (kg)	41175
Collected from donation banks (kg)	25464
Total CO_2 (kg)	3416
Kg/km	12.02
Km/bag	0.62
CO_2 (kg)/bag	0.38

By comparing this to the base case, we can see that although the total distance for the shop adopted method sees minor savings of around 44 km over the week, it would take approximately an extra 25 hours cumulatively to undertake the routes in this way. This method also requires the use of a large number of staff and vehicles (29 vehicles in total with associated staff). By using the smaller vehicles to collect from donation banks and limiting the larger vehicles to collections from shops and the remote donation banks, there are potential savings of 311 kg of CO_2 each week.

6.4.3 Scenario 3 - Shop adopted donation bank collections with centralised shop and remote donation bank collections (with centralised collection of donation bank stock from shops)

Scenario 3 is similar to scenario 2; however, all donation bank stock that was collected from donation banks that are shop adopted was then to be collected by centralised routes at the shop and returned to the sortation centre. The stock that is collected on each day will have been stored in the shop from the previous donation bank collection (from Scenario 1). The shop acts as a consolidation point to forward

donation bank stock to Milton Point. A breakdown of a weeks' worth of shop adopted donation bank collections with centralised shop and remote donation bank collections (with centralised collection of donation bank stock from shops) is shown in Appendix 10. This scenario assumes that no stock taken from donation banks is used by the shop before being taken to Milton Point, however it is possible that the shop could used some of the stock if desired. The scenario assumes that all stock is taken back to Milton Point, in order to model the situation to its limits. Table 61 shows the key statistics for the centralised take-back service in Scenario 3 that collects donation bank stock from shops as well as culled and waste shop stock.

Table 61. Milton Point shop and remote donation bank collection statistics (MP collects all donation bank stock from shops)

Vehicles required	5 (12 Tonne lorries)
Total distance (km)	4957
Total time spent	213 hours 40 minutes
Total collected (bags, kg)	8840, 66299
Collected from shops (kg)	64018
Collected from donation banks (kg)	2281
Total CO_2 (kg)	3306
Kg/km	13.44
Km/bag	0.56
CO_2 (kg)/bag	0.37

Table 62 shows the combination of the centralised take-back service with the shop adopted donation bank collections.

Table 62. Shop adopted donation banks model with Milton Point shop and remote donation bank collection statistics (MP collects all donation bank stock from shops)

Vehicles required	5 (12 Tonne lorries) + 24 (medium sized cars)
Total distance (km)	5544
Total time spent	287 hours 03 minutes
Total collected (bags, kg)	11932, 89493 (includes movement of donation bank stock twice)
Collected from shops (kg)	64018
Collected from donation	25475

banks (kg)	
Total CO_2 (kg)	3416
Kg/km	16.14
Km/bag	0.46
CO_2 (kg)/bag	0.29

Vehicles used: 5 Milton Point 12 Tonne lorries and 24 shop vehicles (medium sized cars) (14 shop vehicles used twice a week, 7 shop vehicles used three times a week).

This model of stock collection shows by far the longest total time spent on the road (over 235 hours), with the same requirement for vehicles as Scenario 2, compared to the base case (over 183 hours). The distance travelled is the same as for Scenario 2; however the time spent is greater due to the larger amount of stock being collected. This scenario still shows CO_2 savings over the base case of 311 kg per week.

6.4.4 Comparison of scenarios

This part of the study looked at alternative ways of collecting bank donations and waste shop stock using a centralised collection strategy, based from Milton Point. Table 63 shows a comparison of the statistics from each of the scenarios against the Logix modelled base case. Scenario 1 involves the shop adoptions of donation banks within the Milton Point region; however this scenario does not account for any centralised collection from shops or collection from remote donation banks. This scenario would require shops to deal with their own waste stock at the back door. Scenario 2 models collections from shop adopted banks along with centralised collection of culled shop stock and from remote donation banks. Scenario 3 is similar to scenario 2; however all of the shop adopted donation bank collections are then collected for centralised processing.

Table 63. Comparisons between scenarios

Scenario	**Vehicles required**	**Total distance (km)**	**Total time spent**	**Total collected bags (and weight in kg)**	**Total CO_2 (kg)**	**Kg/ km**	**Km/ bag**	**CO_2 (kg/bag)**
Base Case	5	5588	220:44	8902 (66764)	3727	11.95	0.63	0.42
Scenario 1	24	587	73:23	3093 (23194)	110	39.51	0.19	0.04
Scenario 2	29	5544	259:40	8885 (66639)	3416	12.02	0.62	0.38
Scenario 3	29	5544	287:03	11932 (89493)	3416	16.14	0.46	0.29

With the sites located as they are, and with the same needs for stock collection (from all donation banks and shops) it appears more economical to run the centralised collections which service shops and donation banks, rather than the extensive use of shop adopted donation banks. This is because only 5 vehicles are needed to collect from all sites over the space of a week, rather than the extra need of 24 smaller shop vehicles. This method also results in the lowest amount of cumulative time spent compared to the other options.

The base case does show higher CO_2 emissions over Scenarios 2 and 3 because the 12 Tonne lorries are used to visit all sites rather than just shops, but the difference is negligible. This also results in the base case showing the longest distances travelled over the space of a week. The shop adopted donation bank scenarios cut the need for the Milton Point vehicles to visit these sites, thus reducing the mileage in these scenarios. However, these scenarios do require each shop to provide transport to collect from their adopted donation bank sites.

Currently, given that the excess stock is not sold to rag merchants at the shop back door, the base case appears to be the most effective way of collecting stock. If the charity's policy allowed stock to be sold at the back door to rag merchants for onwards recycling, then Scenarios 1 and 2 would be more viable. This could then result in possible mileage and transport cost savings to the charity.

Without a change in policy on dealing with excess stock, Scenario 3 is the most realistic alternative to the base case, whereby all donations are collected by shop adopted collections before being forwarded on for processing at a central location, because all excess stock and donation bank yield is taken into account. Using this method, shops can choose to process some of the donated stock and sell in store before forwarding the rest of central processing.

To increase their efficiency, Scenarios 2 and 3 could be adjusted to visit different sites, or routes could be amalgamated considering that there would be less of a workload without the donation bank collections. Also, if donation bank sites were moved to different locations, then this may also change the outlook.

6.5 Visiting donation banks at particular fill levels

Benefits relating to stock volumes and quality could be gained from visiting donation banks at particular fill levels. In some cases this would require donation banks to be visited on a regular basis to ensure that they do not overfill.

Textile donation banks in particular are at great risk from theft (textile values are at their highest in years). In previous studies, it was estimated that up to 75% of donated stock was missing from some donation banks. If donation banks were visited at lower fill levels, then there is less potential for this stock to be stolen. Also, ensuring that donation banks are kept at lower fill levels provides less incentive for textile thieves.

Currently, Oxfam aim to visit donation banks when they are around 80% full. Visiting donation banks on a weekly basis results in most donation banks being around this level, with some deviation (on occasions, some donation banks are visited when they are over-full). For alternative scenarios, donation banks could be planned for visits when around 20% or 50% full. This would require donation banks to be visited more often and routes would have to be adjusted accordingly to allow for this.

Research carried out by Oxfam showed that through carrying out donation bank collections more often, donation banks showed higher yields (Appendix 11). During a trial in the North-West of England, over a 6 month period with 1 collection being made a week, the mean weekly stock value was £833. Through trialling and increasing the number of donation bank collections to 2 or 3 times a week over a 4 week period, a mean weekly yield of £2222 was found. Although there are additional costs associated with carrying out collections more often, it appears that there are

benefits to be found from collecting from donation banks when at lower fill levels. This would certainly prove effective in areas that experience high levels of donation bank theft.

Chapter 7: The use of technology to improve charity logistics

A Smartphone Application (App) was developed and trialled with Oxfam drivers in a range of locations. The goal of the App was to give the area managers, shop managers, paid and volunteer drivers a tool which enabled them to visualise stock profiles in banks, stock demand from shops and live collection/delivery activity being undertaken by drivers to aid business decision making.

The Smartphone App (described in Section 3.4) was designed to increase visibility of stock movement and collaboration within the supply chain. During and following the trials of the App, the main users were interviewed to show how the App was used, how useful it was and the potential for its use in the future.

7.1 Effect of community engagement on collection strategy

Increasing visibility within the supply chain can benefit the charity, because they can have a greater understanding of how stock is moved around the system. This understanding can help them to increase efficiency within the system and ensure that shops receive stock that is right for them.

Increasing levels of collaboration within the charity logistics chain can also be of benefit to the charity. Communication made possible through the App can help shops to work together, with the assistance of the driver to maximising profit for the charity. For example, profit can be maximised by ensuring that donations are sold in the optimal location. Collaboration can also assist in managing stock levels, where some shops can be inundated with stock, while others struggle to muster enough good quality stock. The App can help to highlight these issues to the driver and managers and encourage these issues to be managed effectively and efficiently.

A key benefit is that this technology is used through commercial grade phone. This provides a benefit to the charity whereby this tool is available to those throughout the system through managers and volunteers own personal devices, which comes at no extra cost to the charity.

7.1.1 Shop managers

Pre-trial and post-trial interviews identified the following findings relating to how the App could change Oxfam shop managers work schedules, stock management and collection/delivery routes.

Appendix 12 shows the findings from the Cambridge area shop manager interviews relating to the usage and functionality of the App using the Likert scale (ranging between 1 = strongly disagree, 5 = strongly agree).

Viewing other shop delivery/collection patterns

Some shops liked seeing how other shops were operating. However, some were not interested in seeing what other shops were getting up to. A manager was quoted as saying that you should “work with what you have”, meaning that it does not matter to them what others are doing, and that they just have to do the best that they can with the resources available.

Collaboration

Shops agreed that more collaboration between shops would be of benefit to the charity and that gaining an integrated view could benefit their own shop and others. Five out of the six managers who participated in the post-trial interviews agreed that the App had improved communications with, and maintained the relationships between shops they already collaborated with (mean = 3.7). In terms of engaging in more collaboration with shops over the trial period using the App, 4 out of the 6 managers agreed that they had (mean = 3.3) and a similar number felt that their relationships had improved as a result (mean = 3.3) and they had developed new relationships with shops in terms of stock collaboration (mean = 3.3).

Using the Smartphone App, shop managers agreed that they were more likely to offer and ask for stock increasing collaboration.

Shop managers agreed that the App would be really useful if there was a cultural change in the way the charity operated. They currently felt that the way the charity is run that collaboration is not promoted as much as it could be. Initiatives such as the Smartphone App could help to bring around cultural change. Shop managers felt that in order for there to be more collaboration, that area targets should be used rather than shop targets. Shop managers face a difficulty here, because although they would like to maximise the amount that a shop receives from donations, they

may sell an item in their own shop rather than give to another shop to sell at a higher price.

Driver activity

The three shop managers, depot manager and area manager disagreed with the statement that the App did not provide them with any extra visibility of the driver's activity over what they had before (mean = 1.8) and their understanding of the drivers daily activities had improved as a result (mean = 3.8). They felt that their ability to communicate with the driver had improved (mean = 3.6) and that decision making had been better informed with the data presented through the App (mean = 3.6) although all recognised that it was still early days in the trial. Understanding of donation bank performance (mean = 3.6) and shop delivery/cascade patterns (mean = 3.4) also showed improvement but this was primarily by the depot and area manager who need this information more than the shop managers. In terms of understanding how time is used in the business, all managers felt that the App had had a positive affect (mean = 4.2).

Previously, shop managers and their staff didn't appreciate the long distances that the man-with-van covers. The App helped the shop managers to appreciate the work that the driver does. In previous times they may have felt that they could call on the driver at their convenience and ask him to undertake jobs on their behalf. The App assisted in their understanding of the driver's availability and his schedule.

Although able to provide a likely arrival time of the driver based on historic records, some shop managers weren't interested in this Apps functionality because they are aware of the time that the driver usually arrives. However some shops liked knowing when the driver was arriving so helped with decision making/planning. If the driver was not running to his usual schedule, then the App could pinpoint his location to anticipate the driver's arrival.

Donation bank performance

The App gives functionality to view how a donation bank was performing over time. Shops that received stock from donation banks liked to have proof of how the banks were performing. This was because if they felt a bank was underperforming, they could prove it to their manager in order to make a business case for moving the bank to another location.

Shops that did not receive stock from donation banks were not interested in this functionality. However, they could appreciate why the functionality would be useful to shops that did receive stock from donation banks.

Stock levels on van

Some shop managers didn't think the functionality of knowing van stock levels was relevant to them as they did not tend to receive cascaded stock.

One shop thought the knowledge of van stock levels was important so that they could plan how much room to make available for deliveries. However, given the van fill level, shops would still need to know how many bags would actually be delivered. Some shops also liked being able to tell what type of stock was on board the van so that they could request a certain stock type for cascade.

All shops agreed that it was important for the driver only to cascade stock that is actually wanted by the receiving shop. Some shop managers felt that the stock being cascaded should actually have been sent to Wastesaver or even directly to landfill. Ensuring that unsaleable stock is sent for recycling or to landfill direct rather than being cascaded could save the charity time, money and effort.

Messaging

Shops liked being able to message through the system as it provides a written reminder of action required. However, shops found communicating with the driver, difficult through the App. This could either be due to how the App actually functions, which could be developed to increase usability, or by a lack of response by the driver. Shops felt that unless the driver replied to their message directly, there was no way of knowing that their request had been understood. 43% of (collection, cascade, enquiry, request) messages did not have a confirmation that the action was completed. 57 % of messages did have confirmation that an action was completed.

All of the managers agreed that they could get across what they needed to say using the short message system in the App (mean = 4) but it was not universally preferred to discussing issues on the phone (mean = 3.2) despite all agreeing that it saved time over calls to other shops (mean = 4.0). One manager was quoted as saying, "The instant side of the messaging to the community is really great. It's so much better than email when you have to log in and someone's got to think about it'. Another manager agreed stating, "It is much easier just to send a quick message

and get a response than to have to have a long winded phone call or email that might even not be picked up for 3 days, yes it is good".

Some shops felt frustrated that cascades were not always being offered and that they didn't feel part of the community.

To increase usability, shops liked the idea of the functionality being available on computer, so that it didn't have to be used via Smartphone.

7.1.2 Drivers

Drivers were also interviewed to understand how the App changed their collection schedules, their change of communication with shop managers and how the App could affect their routes in the future. Pre and post trial interviews with drivers revealed a range of findings.

One driver felt that if the App showed that a few banks did not need emptying then they would be short of work to do. In order to find mileage savings using knowledge of bank fill levels, drivers would have to know what other tasks could be undertaken in the mean time when banks are found to be at low fill level. The drivers felt that the functionality of informing on bank fill levels served to confirm their predictions of how a bank was performing.

One driver agreed that being able to tell the fill level of a bank was useful information to have, but also felt that understanding bank fill levels became second nature to them. They felt that they were able to predict how full a bank would be before arrival.

All drivers felt that using the App to record collections and deliveries was useful because it could allow them to stop having to fill paperwork. Currently drivers have to fill in multiple pieces of paperwork to show to managers and shops.

The drivers felt the donation bank fill level graph was useful, but that you would need to empty the bank on the same day every week to get a good representation of bank performance over time.

The drivers felt that knowledge of the stock levels in their van was not relevant to them as they empty the van at the end of each day and that shops did not phone him to ask for specific stock types. In the future, shops could potentially ask the driver for specific types of stock that he may be able to deliver at short notice, if they were in desperate need.

7.2 Problems using the App

Users did find some problems using the App. Drivers found that data entry could be quite difficult and that recording collection data on paper was easier. The ability of entering data into the App is something that is likely to improve over time as drivers get used to how Smartphones function.

Drivers found that 3G signal was often non-existent while out on their rounds at certain locations and that data sometimes had to be entered into the App retrospectively.

Drivers and managers found some frustration with regards to the messaging system, whereby they found that a lot of their messages were being ignored. The culture of checking the messaging system regularly is something that would need to be encouraged to improve this. In the past, drivers have had a pre-determined understanding of what tasks he needs to perform on a certain day. In order for routes to become more dynamic and flexible the managers and drivers will have to become accustomed to carrying out tasks such as checking their messaging system and giving requests to other people in the system. However, this could provide an additional challenge whereby the driver could become inundated with requests for stock collection or delivery.

7.3 Summary

Drivers and managers found the App to be an extremely useful tool in increasing visibility and collaboration in the supply chain. Overall, it appears that managers preferred using the App over the drivers, because they liked the functionality of knowing the location of assets, whereas drivers did not like the idea of being tracked or told what they were required to do.

To date, drivers' routes have been developed over years of experience and driver preference so may be unwilling to change their schedules based on the output of the App. However, if the App can prove that its use results in better use of the drivers' time by prioritising locations and increasing profit from the charity, then its use should be encouraged.

Managers agreed that there is currently not much collaboration between shops. A shift in the way that charities measure shop performance could push a cultural change. Currently, shop performance is measured on a by-site basis, if area

performance was used instead, then it would encourage the charity to find the best shop for a particular item and maximise profit. A shop with a potentially high value item could contact the driver for collection using the App, and the item could be transported to the most suitable shop location.

Some problems relating to the Apps use were found, such as the entry of data and communication between users. These problems are likely to decrease in significance over time as users become more accustomed to their use and adopt the technology as part of their daily routine. The problem of 3G reception is also something that is likely to reduce over time as coverage becomes more widespread. Dead spots in signal may always be present due to geographical features such as valleys, however a future design change to the App could allow data to be entered that would then go into the system automatically when signal becomes available.

Chapter 8: Conclusions

8.1 Understanding current charity logistics operations – a case study on Oxfam

8.1.1 Oxfam – the case study charity

The case study charity, Oxfam, runs one of the largest charity shop operations in the UK, servicing 1456 donations banks (987 sites; 919 Clothing and 537 Book), 670 shops and 7 online hubs, along with the Winton Distribution Centre and the festivals team Oxfam's logistical layers are mainly split into two main areas: Localised and centralised (Wastesaver) collection/delivery. Both of these logistical layers serve the network of Oxfam shops, donation banks and distribution centres in different ways. These collection strategies have been studied using different case studies. Oxfam was chosen as the case study charity because of this range of collection and delivery strategies. The majority of charities run only localised collection and distribution of stock collected from donation banks. Studying Oxfam allows us to compare and contrast the different logistical techniques used and provide recommendations on best practice in charity logistics, improving performance and increasing efficiency through reducing costs, fuel and time.

8.1.2 Investigating localised collection strategies

Localised collection of donation banks is the most common method used by charities to collect from donation banks. This is because most charities do not have the infrastructure in place to run a nationalised network of donation collections. For Oxfam, although around 540 textile donation banks stock is centrally processed through Wastesaver, the remaining 379 textile donation banks are collected from and processed locally.

Each of the Oxfam regions has a driver which will collect from their adopted donation banks before returning to a location within the region. For example, in the Dorset region (W14), the local driver collects from 32 donation banks around the area. Most of the textile donation banks in the area are serviced by Oxfam subcontractors, however the Dorset driver collects from 4 textile donation banks, where the contents are processed and sold locally. The remaining donation banks in the driver's route (28 book and music donation banks) constitute the main focus of their collection rounds and the stock is sorted and processed for sale at the Winton

Distribution Centre, Bournemouth through Oxfam's online retail streams or distributed to local shops. This region was used as a case study for localised collection strategy. The research was primarily informed by field work carried out at Oxfam's distribution centre at Winton, Bournemouth. This field work allowed us to gain an understanding of how localised collection works, understanding the tasks undertaken by Oxfam localised logistics and to quantify the efforts of a man-with-van driver.

An audit of the man-with-van's working week was undertaken, recording the mileages undertaken and the amount of stock collected and delivered at each site. Analysing the data resulted in a range of findings. Study of this week ascertained that for localised collections the most efficient way of collecting stock is to visit as many locations as possible within the day over a short range of distance. Days involving travelling larger distances intrinsically involved fewer collections, showing reduced levels of efficiency. In the case of W14, the ideal situation would be to carry out very local deliveries and collections (around the Bournemouth area), however due to the lack of a driver in Wiltshire it is currently necessary for Winton to service these shops and donation banks. Re-evaluating the areas of jurisdiction for shop and bank collections could find potential mileage savings from more efficient collection schedules and could be an area for potential study.

To compare against alternative collection scenarios (Chapter 6) a base case of a 4-week period in the W14 region was undertaken, recording weights collected and delivered, time taken, costs and CO_2 emissions. Options for optimising localised collection strategies are shown in 8.3.1.

8.1.3 Investigating centralised collection strategy

Centralised charity logistics involves collections of textiles to a central location for sortation and onward processing (selling/recycling). Oxfam centralised routes visit shops to collect culled stock and also service donation banks.

Due to the nature of centralised collections, routes cover large distances and service a high number of locations. Because of this, centralised routes utilise larger vehicles than localised collections.

The routes from the Southern Logistics Centre at Milton Point were used as the case study for centralised collection strategy.

From this a range of alternative scenarios were studied (Chapter 6). Options for optimising centralised collection strategies are shown in Section 8.3.2.

8.1.4 Donation bank theft

Textile theft from charity collection donation banks has been identified as an increasing problem within recent years (MRW, 2009). Indeed, as at mid 2013, unsorted donated clothes were fetching around £1,000 per tonne. This was three times the price of seven years before (Charity Bags, 2013). There has been a rise in theft in recent years because of the growing price of textiles and the emergence of companies who take in bulk textiles and buy for cash.

The British Heart Foundation reported losses of around £3million during the 2010 financial year resulting from the theft of doorstep donations and clothing donation banks (British Heart Foundation, 2010) and this is expected to rise. Theft of textiles and bogus collections are important to consider because they directly affect the profits of charities. They also affect public perception of textile collection, and so can deter the public from supporting door to-door collections, textile donation banks and they can jeopardise the viability of other legal collection schemes. Textile theft also directly affects the profits of charities.

Remote donation bank monitoring technology has allowed donation bank theft to be quantified for the first time in history. Even to this day, charities remain in the dark about the scale of the problem of donation bank theft. Through the trial of Smartbin with Oxfam, estimations of donation bank theft have been realised, with up to 77% of donations been stolen in some cases. The severity of donation bank theft varies across the country with larger amounts expected to be stolen in areas such as Manchester and the gateway to Europe, between London and the English Channel crossing, where donations that are stolen can quickly be transported to the continent.

Through realising the problem of donation bank theft, if using remote monitoring technology, charities can understand the scale of the problem and devise measures to reduce donation bank theft. This can be realised in a number of ways. Charities should use donation banks that are better designed to be more resistant to theft, such as by incorporating locks that are more secure. Locations such as supermarkets that have the donation banks in their car parks could increase their security, if the scale of the problem was conveyed to them. Charities could modify the timings of donation bank servicing to plan visits before expected theft events.

This could be realised through identifying when donation banks are routinely ‘hit’ and ensure that the donation bank has been emptied before they arrive. Another measure could be to increase security measures in areas that are likely to be subjected to higher levels of donation bank theft.

During the Smartbin trial, banks that were identified as being heavily targeted by theft were visited more often and Oxfam found that the amount of textiles being stolen decreased. This shows that a more effective collection strategy can be realised, mitigating the effects of theft, by visiting banks more frequently.

8.2 Optimising donation bank placement strategy

8.2.1 Donation stock quantity

A study of donated textile stock from across England was undertaken, using Oxfam donation bank collection records.

Hypothesis 1 predicted a positive relationship between charity textile donation bank weights and population density within an area. However, population density did not appear to have any effect on donation bank weights so Hypothesis 1 is not supported. It would appear that physical factors such as regional group and supermarket have the greatest effect on weight yields as well as the temporal factor. Hypothesis 2 predicted a positive correlation between charity textile donation bank weights and areas with a high ‘convenience’ factor. Supermarket sites are expected to have a high throughput of people combined with the factor of convenience (as donating can be combined with shopping trips) and expected good visibility of the donation bank sites in these locations, thus supporting the previous research on recycling facility locations by Stantec (2009). These findings are also in line with Joung and Park-Poaps (2011) research that stated recycling drop-off points should be located close to services such as supermarkets. Therefore, Hypothesis 2 is supported.

Property values as a measure of affluence showed some effect on weight yields in a single factor model but showed a far smaller effect when combined with other factors. Also as a measure of affluence, the percentage of the population on Job Seekers Allowance and local postcode Deprivation Index showed no effect on weight yields. Perrin and Barton (2001) stated that the more affluent were more likely to recycle, therefore Hypothesis 3 predicted a positive relationship between the weight of textile donations and the affluence within an area. However, Hypothesis 3 is not supported.

Donation banks have been shown to yield higher volumes throughout the summer months, and placement strategy should take this into consideration. There is also a noticeable peak in January, reflecting the need for flexibility in logistics collection scheduling throughout the year. Donation banks located at major supermarkets generally perform better than those located elsewhere (and donation banks in southern England are expected to perform better than those in the north). Proximity to schools (especially the nearest first/middle school) leads to higher expected volumes, but this effect may actually be representative of a donation bank location in

close proximity to a range of public services and residential areas rather than a specific impact of the school itself.

8.2.2 Donation stock quality

An audit of donated textiles from Milton Point collection routes was undertaken to understand the key factors affecting donated stock quality. Textiles were collected from banks chosen because of their range of demographic characteristics.

Hypothesis 4 predicted a positive relationship between the quality of donated textiles and the affluence within an area as Oakdene Hollins (2006) stated that less affluent areas were expected to donate lower value materials. A lower percentage of the local population on Job Seekers Allowance was found to have a positive effect on quality yields. The age of population was found to have an effect on quality yields, where areas with an average age of late 40's were found to provide the best quality textile donations, which could also be linked to affluence. However, relating to Postcode Deprivation Index, middle class families (ranked around 10,000-20,000) are expected to produce the best quality textiles, with decreasing quality expected towards both ends of the Deprivation Index scale. Therefore Hypothesis 4 is not supported. Although areas with high proportions of JSA and high levels of deprivation are expected to produce low quality textile donations, the least deprived areas are also expected to produce low quality of donated textiles compared to mid-range Postcode Deprivation Index areas.

Donation banks in areas recording a higher average age of population are expected to yield greater quality textiles. Also, donation banks in areas with low levels of the population on Job Seekers Allowance are expected to yield greater quality textiles. Interestingly, donation banks in middle class areas (ranked around 10,000-20,000 on the Postcode Deprivation Index) are expected to yield greater quality textiles.

While charities are now able to actively target donation banks in locations that are expected to yield greater textile amounts and greater quality, it is also possible to use this information to assist in optimising their logistics strategy. Collections from donation banks could be prioritised to banks that give higher quality yields or quantity yields more frequently.

Timlett and Williams (2011) identified the culture of regular donation behaviour to certain locations based upon good infrastructure and servicing behaviour. Charities must understand that it may take some time for this regular donation behaviour to

occur, however ensuring good quality infrastructure in trusted and safe environments with regular servicing is vital.

8.2.3 Recommendations on donation bank placement

Previous literature largely discusses attitudes and behaviours towards general recycling of used household goods, rather than donations to charity. Based on historical collection records and audits of donated stock, study has found some of the key factors affecting charity donations. Many of the factors positively affecting the levels of recycling also apply to charity donations, such as access to services, convenience and socio-demographic factors. This study has also introduced predictive models for textile donation bank performance. By combining the two separate predictive models, a model has been created which can predict overall textile donation bank performance, based on both stock quantity and quality. By understanding the impact of physical and socio-economic variables on the volumes and monetary value of the donations, charities can better target the locations of their collection donation banks to achieve maximum yields and hence maximise benefit for their charitable work.

Based on the analysis undertaken, it appears that physical and temporal factors are the most important with relation to donation bank yields (stock quantity), with the socio-economic characteristics of the local population providing a greater explanatory indicator of stock quality. Physical factors (and the month) show the most important relationships with the donation bank yields, with the socio-economic characteristics of the local population providing a comparatively smaller (but still significant) explanatory effect.

Donation banks in southern England are expected to perform better than donation banks in the north, with donation banks located at Major Supermarkets generally performing better than those located elsewhere. While logistics costs could be minimised by concentrating exclusively in southern England, these donation banks may also perform a substantial ‘advertising’ function for the work of Oxfam and as such it may not be sensible to focus placement that exclusively.

Donation banks have been shown to yield higher volumes throughout the summer months, and it is advised that donation banks are placed in time for collections to be made in these months where possible. There is also a noticeable peak in January, reflecting the need for flexibility in logistics collection scheduling throughout the year. It may be possible for charities to adopt a temporal strategy for donation bank

placement, moving donation banks throughout the year in order to target particular types or quantities of textiles. For example, charities could move donation banks into areas that are shown to yield greater weights during winter, before moving the donation banks into areas that are expected to perform well in the summer months.

Proximity to Schools (especially the nearest first/middle school) leads to higher expected quantity yields, although this may actually be representative of a location in close proximity to a range of public services and residential areas rather than a specific impact of the school itself.

Donation banks that have been identified as poor performers could be investigated more closely, to ascertain whether it would be more beneficial to move these donation banks to different sites or dispense with them altogether. Based upon this research, banks are recommended to be moved to sites with a higher average of population, in middle class areas to garner higher quality textiles. To gain greater quantities of textiles banks should be placed in areas of high convenience, such as supermarket car parks or near schools. Finding sites in areas that show these characteristics should result in donation banks that provide good yields of textiles both in quality and quantity.

8.3 Assessing the merits of alternative localised and centralised collection strategies

Charities run a range of logistical models within the UK. Many of the smaller charity shop operations within the UK run by supporting themselves through locally sourced donations, and deal with unsaleable donations locally as well. While Oxfam shops can support themselves locally, they also run a centralised system of donation collection and processing. The scale of the operation means that optimising their logistical systems could result in significant cost savings, benefitting the charity and their good cause.

8.3.1 Optimising localised collection strategy

Oxfam run localised, man-with-van, routes across the country to collect from donation banks and to provide a reliable transport service to move stock between shops, known as cascading. This is necessary because some shops have an excess of good quality stock, whereas shops lower in the chain struggle to receive enough good quality stock.

Using the W14 region as case study over a 4-week period, the potential benefits of using different collection methods and schedules were identified. Before investigating the potential cost savings from introducing initiatives such as dynamic routing it was important to study possible mileage and cost savings by using route optimisation software alone. The study found that savings of 2 hours 13 minutes could be saved over the 87 hours 32 minutes base case purely by optimising routing.

Through allowing the optimisation software to decide on which day to undertake donation bank collections potential savings of 5 hours 22 minutes were found over the base case. Visiting banks when 50-80% full and found possible savings of 6 hours 17 minutes over the base case. Hypothesis 5 predicted that through informed routing and visiting banks when collections are needed that cost, fuel and time savings could be found, therefore Hypothesis 5 is supported.

The Smartphone App enabled the charity to keep an historical record of the fill levels of each donation bank. Looking at these over a period of time it was possible to draw some conclusions on how quickly each donation bank generally filled. This allowed a collection strategy to be dictated by donation bank fill levels, only visiting each donation bank when necessary (around 75-80% full). Using the App data to

track a month's worth of collections and deliveries, Logix was then used to calculate the benefits of visiting donation banks less often rather than on a weekly basis. Hypothesis 6 predicted an understanding of bank fill levels could assist in finding cost and time savings of collection and delivery routes. Within this scenario, minimal savings were found. Potential savings of 208 km were identified over the modelled 4-week period. However, due to the majority of cost of the vehicle being due to van lease and drivers wages, this only resulted in potential cost savings of around £30 over the 4 week period. Time savings of around 6 hours were found over the 4-week period. Therefore, Hypothesis 6 is supported to some degree as distance and CO_2 savings could be found even though costs were not reduced greatly. Further savings could be found by reducing the number of days worked within the week which could be possible if banks were visited less frequently.

More significant distance savings could be found in routes that service donation banks in remote locations. If these banks were found to have low fill levels then this could save on wasted journeys of great distance. Within the studied scenario, many banks are located in close proximity of other banks and shops, so the effect of not skipping visits along the route is minimal.

8.3.2 Optimising centralised collection strategy

Centralised collections provide an effective method of collecting donations and waste and returning them to a centralised processing facility. A range of different scenarios were combined with centralised collections or used as an alternative to centralised collection to identify potential mileage savings. Shop adopted donation bank collections were modelled (with or without centralised shop and remote donation bank collections) as a potential alternative. A further scenario modelling additional centralised collection of all donation bank stock from shops was modelled.

Study found that with the sites located as they are, and with the same needs for stock collection (from all donation banks and shops) it appears more economical to run the centralised collections which service shops and donation banks, rather than the extensive use of shop adopted donation banks. This is because only 5 vehicles were needed to collect from all sites over the space of a week, rather than the additional need of 24 smaller shop run vehicles. This method also results in the lowest amount of cumulative time spent compared to the other options.

The base case did show higher CO_2 emissions over the shop adopted bank collection scenarios because the 12 Tonne lorries are used to visit all sites rather

than just shops, but the difference was negligible. The base case showed the longest distances travelled over the space of a week. The shop adopted donation bank scenarios cut the need for the Milton Point vehicles to visit these sites, thus reducing the mileage in these scenarios. However, these scenarios required each shop to be able to provide transport to collect from their adopted donation bank sites.

Currently, given that the excess stock is not sold to rag merchants at the shop back door, the base case appears to be the most effective way of collecting stock. If the charity's policy allowed stock to be sold at the back door to rag merchants for onwards recycling, then shop adopted bank collections would be more viable and possible mileage and transport cost savings to the charity could be found. Hypothesis 7 predicted that more localised, shop-adopted donation bank collections could find potential mileage savings over more centralised donation bank collections. Therefore, Hypothesis 7 is supported.

Without a change in policy on dealing with excess stock, Scenario 3 (involving shop adopted bank collections, with centralised collections from remote donation banks and take-back of donation bank stock) is the most realistic alternative to the base case, as the excess stock and donation bank yield is taken for processing at a central location. Within this scenario, the shop also has a chance to use whatever stock they may require for sale on site

To increase their efficiency, Scenarios 2 and 3 could be adjusted to visit different sites, or routes could be amalgamated considering that there would be less of a workload without the donation bank collections. Also, if donation bank sites were moved to different locations, then this may also change the outlook.

Shop-adopted donation banks can result in mileage savings over centralised and localised collections; however this provides a need for a larger fleet of vehicles (e.g. Each shop would need their own vehicle, rather than one vehicle that serves the whole operating region). This may prove possible as the amounts collected from donation banks could generally be achieved using a vehicle of a shop volunteer or manager. As shops adopt their own donation banks this helps individual shops to become more self sufficient as they do not rely on area drivers and other outside influences.

The possibility of using shop-adopted donation banks does depend on location. Many shops find it possible to run profitably solely through donations received

through the front door. Conversely, some shops in less affluent areas cannot rely on donations received in this manner and require stock to be brought in from further afield. Shops in less affluent areas that struggle to receive quality goods may also find problems with receiving enough quality goods from their own adopted donation banks, therefore stock cascaded from other shops can be necessary.

8.3.3 Modelling impacts of a minimum fill level collection strategy

An Oxfam trial found that visiting banks more regularly showed higher bank yields. This could be down to reduced effect of theft. Another possible reason for this could be that banks that are emptied more regular appear tidier and thus have a higher appeal for attracting donations. In some cases, when not emptied regularly, banks can fill above capacity and therefore cannot receive further donations.

Knowledge of bank fill levels can prove useful in avoid wasted journeys. However, altering donation bank collection routes to visit banks at 50%-80% fill level was found to show minimal cost savings. This is because collection routes are chained to visit a number of different locations on a route. Avoiding visiting remotely located donation banks with low fill levels could provide better cost savings. It is important to consider that waiting for banks to reach a certain fill level can result in the degradation of bank stock over time and encourage theft. Banks should be visited regularly to ensure that donated stock is collected in a timely fashion reducing the effect of theft.

8.3.4 Recommendations on optimal collection and delivery routing strategies

It is effective for charities to run a combination of the different logistical strategies of centralised, localised and shop-adopted collections where feasible and possible. Oxfam finds great profit from running centralised collections and processing their stock through centralised processing facilities and in doing so, process a vast amount of used textiles, that would prove too much of a task for shops alone to process.

Localised collections provide a useful tool for providing a community of stock movement and collaboration within an operating region. The man-with-van provides an invaluable tool for charity shops ensuring that each shop receives as much donated stock as is necessary to be profitable. This is extremely valuable to shops that struggle to find enough quality donations through the front door or from local sources (such as shop adopted donation banks).

It is important that a strong line of communication is held between shop managers and the man-with-van to ensure that that the shop receives stock that is required and suitable. If the shop does not require a certain type of cascade, the charity could find time and cost savings from notifying the driver, saving a wasted journey.

Despite increases to running costs, charities can find increased bank yields through visiting donation banks more frequently. Banks shown to have high levels of textile theft resulted in lower amounts stolen when visited more frequently.

8.4 The use of technology to improve logistics

The recent development in ICT techniques allows for new technologies to be employed in the charity field that were not possible before. More traditional ICT techniques such as route optimisation software can be used to identify alternative options for donation bank collections. Route optimisation combined with the more recent advent of remote monitoring allows for a more transparent, dynamic and reactive donation bank strategy. Transport schedules advised by these systems can then be enhanced by more on-the-go decision making tools such as the recently developed Smartphone App.

8.4.1 Smartphone App

A Smartphone App was developed to provide an affordable way of increasing visibility within the supply chain, promote dynamism and collaboration in collection/delivery strategy. Trials with the Smartphone App were held across a range of areas that utilised different collection techniques. Before the trials commenced, Smartphones were disseminated to shop managers within each trial area and also to the driver. Each user was trained in the use of the App before the trial started. Pre and post trial interviews with drivers and managers were undertaken in order to identify ways in which the App affected collaboration and collection/donation strategy. Holding interviews before and after the trial made it possible to understand how attitudes towards the App changed following its implementation.

Managers

Within each trial, shop managers were given a Smartphone allowing them to track and communicate with the local driver, communicate with other managers and view

stock levels within the system. The App also allowed shop managers to monitor donation bank performance.

Area and shop managers alike found the Smartphone App to be a useful tool in increasing flexibility and visibility relating to the drivers routes. Interviews found that generally, managers did not appreciate the magnitude of the work undertaken by the driver and using this tool allowed them to increase their understanding of the range of tasks undertaken.

Managers agreed that using the system had increased the possibility of collaboration between shops. However, the consensus between managers that was for real collaboration to take place, there would have to be a cultural change in the way that profits are viewed within the charity. Currently performance is viewed on a shop by shop basis, so if a valuable item is received by a shop they are more likely to try and sell themselves rather than collaborating and giving it to a shop that could sell the item for potentially more. There is no incentive to the shop to pass the item on to the other shop to try and achieve a greater sale price for the charity. In order to increase collaboration, the charity could consider measuring performance on a more regional basis, thus promoting collaboration. However, this could result in underperforming shops going undetected. A system could be implemented whereby when an item is transferred to another shop, the potential future sale price is identified. This price would have to be agreed between the shops involved.

A key aim of the App was to help promote collaboration between managers and driver. While the App did help to improve communications between managers and drivers, it was agreed in interviews that for real collaboration to happen there would have to be a cultural change in the way that the charity operates. If there was a shared goal for profit within an area, rather than by shop, this could help to promote collaboration further.

Drivers

Within each trial, the driver was given a Smartphone to record their collections and deliveries and communicate with managers, as the link between shops allowing greater levels of collaboration.

Study found that drivers tended to find the App to be of less use to themselves than it was to the managers; however they could understand why the App was useful.

Drivers found that the functionality of being able to remotely identify the fill level of banks of limited use. They described that over time, they could often predict the fill level of banks based upon experience. They also stated that if the system identified that if a bank might be empty, that it would result in them being short of work to undertake. This is where the concept of dynamic scheduling could be of benefit to the charity. In situations where the driver could avoid visiting locations where there is limited stock to collect, the App could enable the driver to find alternative collections or deliveries through communication with shop managers.

Chapter 9: Key findings

9.1 Understanding current charity logistics operations

- Charities use a range of logistical methods to transport donations between donation banks, shops and distribution centres.
- Oxfam and The Salvation Army are the only UK charities that use a centrally located processing facility for their textile donations.
- The majority of charities run only localised collection and distribution of stock collected from donation banks.
- The most efficient way of collecting stock is to visit as many locations as possible within the day over a short range of distance.
- Days involving travelling larger distances intrinsically involved fewer collections, showing reduced levels of efficiency.
- Donation bank theft has been identified as an increasing problem for charity donation banks.
- Donation bank theft can be mitigated by servicing donation banks at a more regular interval. Banks that are visited more often showed lower levels of theft.
- Donation bank theft can also be mitigated by increasing security and utilising more secure donation banks and locks.

9.2 Optimising donation bank strategy

Donation stock quantity

- Just under 20% of the variability in 2010-2011 textile donation bank weights was explained using a range of 10 factors. Given the nature of the dataset, this high a proportion is an important result.
- Donation banks in southern England are expected to perform better than donation banks in the north, with donation banks located at Major Supermarkets generally performing better than those elsewhere.
- Donation banks have been shown to yield higher volumes throughout the summer months.
- Proximity to schools (especially the nearest first/middle school) leads to higher expected yields, although this may actually be representative of a location in close proximity to a range of public services and residential areas.

- Population density did not appear to have any effect on donation bank weights.
- Physical factors such as regional group and supermarket have the greatest effect on weight yields as well as the temporal factor.
- Property values as a measure of affluence showed some effect on weight yields in a single factor model but showed a far smaller effect when combined with other factors. Also as a measure of affluence, the percentage of the population on Job Seekers Allowance and local postcode Deprivation Index showed no effect on weight yields.

Donation stock quality

- Through initial trials, it appears that local social-demographic factors do not have a significant effect on the quality of donated donation bank stock.
- Those donating stock are expected to be willing to travel within a radius of a few miles to find a location to donate textiles.
- Supermarket car parks serving a range of other public attractions, such as shops, restaurants, cinema and bowling are expected to yield better quality stock than donation banks in supermarket only car parks.
- A lower percentage of the local population on Job Seekers Allowance was found to have a positive effect on quality yields.
- Middle class areas showing a deprivation index of between 10,000 and 20,000 were found to yield greater quality textiles in donation banks.
- The age of population was found to have an effect on quality yields, where areas with an average age of late 40s were found to provide the best quality textile donations, which could also be linked to affluence.

9.3 Alternative collection strategies

- Through informed routing and visiting banks when collections are needed that considerable cost, fuel and time savings can be found.
- Cascading is necessary where some shops have an excess of good quality stock, whereas shops lower in the chain struggle to receive enough good quality stock.
- Shop-adopted donation banks can result in mileage savings over centralised and localised collections; however this provides a need for a larger fleet of vehicles.

- It is effective for charities to run a combination of the different logistical strategies of centralised, localised and shop-adopted collections where feasible and possible.
- There cannot be a one-size-fits-all approach to donation collection within the charity, due to the range of locations and their associated characteristics. Many shops find it possible to run profitably solely through donations received through the front door. Conversely, some shops in less affluent areas cannot rely on donations received in this manner and require stock to be brought in from further afield.
- Localised collections provide a useful tool for providing a community of stock movement and collaboration within an operating region.
- Donation banks can find increased yields through more frequent visits. This can be explained through reduced levels of theft and reduced bank overspill.

9.4 The use of technology to improve logistics

- The developed Smartphone Application can be used to provide on-the-go assistance for drivers and managers.
- Area and shop managers alike found the Smartphone App to be a useful tool in increasing flexibility and visibility relating to the drivers routes.
- Drivers found that the functionality of being able to remotely identify the fill level of banks of limited use. They described that over time, they could often predict the fill level of banks based upon experience.
- Managers agreed that using the system had increased the possibility of collaboration between shops. However, the consensus between managers that was for real collaboration to take place, there would have to be a cultural change in the way that profits are viewed within the charity.

Chapter 10: Recommendations for Oxfam

10.1 Logistics operations

Ensure that driver's visit as many locations as possible during each day to maximise efficiency. If possible, reduce schedules to 4 day weeks to realise cost savings.

It is recommended that collection routes minimise the distance travelled. This will result in cost savings and reduce CO2 emissions.

Donation banks that show high theft levels should be provided better security (utilising more secure designs or using better locks) or visited more often to reduce the amount possible to be stolen.

10.2 Donation bank strategy

Textile donation banks are recommended to be placed in areas of high convenience such as supermarket car parks or near schools to yield greater quantity yields.

Donation banks are recommended to be placed in time for the summer months when higher quantity yields are expected.

Textile banks are recommended to be placed in supermarket car parks that also serve a range of other public attractions to yield greater quality textiles.

Textile donation banks are recommended to be placed in higher average age, middle class areas, with a lower percentage of the population on Job Seekers Allowance to yield greater quality yields.

Finding sites that show a combination of these factors should provide donation banks that yield good quality and high quantity yields.

10.3 Alternative collection strategies

Where possible, it is recommended that shops adopt their own donation banks. These supply the shops with stock, maximise value of the stock collected (as it is all sorted through and valued rather than sold unseen) and save the need for centralised collection.

It is recommended that for shops that cannot sufficient good quality stock, that cascading is an effective method of stock replenishment.

There cannot be a one-size fits all approach to donation bank collections. It is effective for charities to run a combination of centralised, localised and shop-adopted bank collections. Smaller charities may be limited to localised, shop-adopted bank or through the door donations.

Donation banks are recommended for more regular collections, to limit stock degradation and donation bank theft.

10.4 The use of technology

Newly developed technology can help charities to promote dynamic routing and increase collaboration. It is recommended for the charity to continue trialling the App to realise its potential.

With the proliferation of ‘smart’ mobile phones, it is recommended that future technologies used in the sector be available through volunteer and staff-owned mobile phones to reduce potential costs to the charity.

Chapter 11: Opportunities for future research

A range of options for future research opportunities are shown in this section of the thesis. These options could be studied with a view to further optimising the efficiency of charity donation bank collections. With a recent increase of available technologies, this increases the potential for cost savings and profit maximisation.

10.1 Donation collection strategy

Oxfam local collections are carried out within the boundaries of each region. Re-evaluating the areas of jurisdiction for shop and bank collections could find potential mileage savings. There is no overlap in collections between regions, however it may prove beneficial for regions to share banks in order to provide more efficient routing. This method would require collaboration between regions, and this would require the charity to rethink the way that they rate region performance.

Current studies on donation bank theft have been limited to focus on the areas in which the bank monitoring technology was trialled. Using the technology over a wider area can help to further highlight and quantify the problem.

10.2 Collaboration

Collaboration between charities may be possible, to help cut mileage and costs related to donation bank collections. Different charities often collect from donation banks on the same sites as other charity donation banks (such as in Waste Recycling Centres), it may be possible for each charity to take turns in collecting from the donation banks on each site. The feasibility of this approach has not yet been studied and provides a potential option for future study.

Appendices

Appendix 1: W14 Donation bank performance between 3/5/13 and 22/7/13

Appendix 2: Example of W14 Man-with-van audit spreadsheet

Appendix 3: W14 Donation bank names and codes

Appendix 4: W14 Shop performance between 3/5/13 and 22/7/13

Appendix 5: W14 June 2013 collection routes (Base case)

Appendix 6: Statistics for each case study week route (3/9/12-7/9/12) against the mean average (September-November 2012)

Appendix 7: Base case modelled routes

Appendix 8: Scenario 1 - Shop adopted donation bank collections

Appendix 9: Scenario 2 - Shop adopted donation bank collections with centralised shop and remote donation bank collections

Appendix 10: Scenario 3 - Shop adopted donation bank collections with centralised shop and remote donation bank collections (with centralised collection of donation bank stock from shops)

Appendix 11: Visiting donation banks at lower fill levels

Appendix 12: Pre and post Smartphone App trials

Appendix 1: W14 Donation bank performance between 3/5/13 and 22/7/13

Ban name	Type	Number on site	Postcode	Code	Collection (#bags)	Average fill (%)	#bags/fill level	Visits	Bags/visit (mean)	Weight collected (kg)	Average weight collected (kg)	Collection st dev
RYC Butlers Lane	Standard Textile	2	BH24 1UB	E-1918-A	231	51.1	4.52	7	33.0	1732.5	247.5	11.5
Allenview CP Wimborne	Book	1	BH21 1AS	D-0010-D	169	81.8	2.07	13	13.0	1267.5	97.5	5.2
RYC Butlers Lane	Book	1	BH24 1UB	E-1918-D	162	75.3	2.15	4	40.5	1215	303.8	13.7
Morrisons Bath	Standard Textile as book	1	BA1 6AE	D-2184-D	162	59.8	2.71	6	27.0	1215	202.5	6.9
Sainsbury's Poole	Book	1	BH15 1XU	D-0134-D	124	56.3	2.20	4	31.0	930	232.5	20.5
Waitrose Lymington	Book	1	SO41 9GF	E-1874-D	110	77.4	1.42	9	12.2	825	91.7	7.9
Morrisons Verwood	Book	1	BH31 6UQ	D-0012-D	107	74.6	1.43	10	10.7	802.5	80.3	3.9
Sainsbury's Ferndown	Book	1	BH22 9AL	D-0011-D	102	76.4	1.34	10	10.2	765	76.5	4.0
Asda Canford Heath	Book	1	BH17 9DW	D-4105-D	94	73.8	1.27	9	10.4	705	78.3	4.3
Tesco Branksome	Book	1	BH12 1AU	D-0651-D	86	64.7	1.33	11	7.8	645	58.6	3.6
Sainsbury's Poole	Standard textile	1	BH15 1XU	D-0134-A	84	26.8	3.13	5	16.8	630	126.0	4.6
Tesco Fleetsbridge Poole	Book	1	BH17 7EJ	D-0646-D	83	67.5	1.23	10	8.3	622.5	62.3	3.2
Tesco New Milton	Book	1	BH23 6BP	E-1879-D	81	66.8	1.21	9	9.0	607.5	67.5	4.3
Sainsbury's Christchurch	Book	1	BH23 4RY	D-0786-D	79	55.8	1.42	10	7.9	592.5	59.3	3.6
Tesco Blandford Forum	Book	1	DT11 9PU	D-1437-D	78	46.1	1.69	9	8.7	585	65.0	4.4
Furlong Car Park Ringwood	Book	1	BH23 1AT	E-1888-D	77	61.1	1.26	10	7.7	577.5	57.8	2.8
Tesco Tower Park	Book	1	BH12 4NX	D-0136-D	70	54.0	1.30	10	7.0	525	52.5	3.1
Sainsbury's Bradford-On-Avon	Book	1	BA15 2AZ	D-4175-D	57	91.8	0.62	4	14.3	427.5	106.9	4.3
Ringwood RYC	Book	1	BH24 1PX	E-1974-D	54	23.8	2.27	4	13.5	405	101.3	6.6
Ringwood RYC	Standard textile	1	BH24 1PX	E-1974-A	49	37.0	1.32	2	24.5	367.5	183.8	0.7
Barfields Public Car Park	Book	1	SO41 9GN	E-1873-D	42	34.3	1.22	9	4.7	315	35.0	2.4
Milford on Sea Recycling Centre	Book	1	SO41 0DA	E-1877-D	41	32.2	1.27	10	4.1	307.5	30.8	3.0
Sainsbury's Melksham	Book	1	SN12 6LL	D-4202-D	33	38.3	0.86	4	8.3	247.5	61.9	3.6
Spencer Rd	Book	1	BH25 6DL	E-1929-D	29	22.2	1.31	9	3.2	217.5	24.2	1.6
North Beach CP	Book	1	BH19 1NT	D-4152-D	25	23.5	1.06	8	3.1	187.5	23.4	2.0
Poole Stadium	Book	1	BH15 2BP	D-4180-D	19	19.6	0.97	7	2.7	142.5	20.4	1.7
Wootton Hall Tiptoe	Book	1	BH25 5SJ	E-1951-D	15	17.8	0.84	6	2.5	112.5	18.8	2.3

Appendix 2: Example of W14 Man-with-van audit spreadsheet

Start location (e.g. Shop/donation bank)	Start time	Start mileage	Van fill level at start of trip	Type of stock on board	Arrival location (e.g. Shop/donation bank)	Arrival mileage	Arrival time	Route	Collection or delivery?	Type of collection/delivery (e.g. Donation bank/cascading)
Winton	9.10	35461	<0.25	Books, textiles, CDs, bric-a-brac	BO shop	35466	9.28	A35	delivery and box collection	delivery of Winton sorted stock
BO shop	9.40	35466	<0.25	Books +1 bag kitchen waste	S donation bank	35494	10.46	A347, A3049, A35, A351, B3075, A351	book donation bank collection	to be delivered to SW
S donation bank	10.57	35494	<0.25	Books	SW shop	35495	11.01	in town	deliver books + collection	deliver donation bank + Winton stock
SW shop	11.21	35495	<0.25	Books	P shop	35516	12.03	back the same route + A350	collection of stock for PO shop	cascading
P shop	12.18	35516	0.25	books, textiles	PO shop	35518	12.26	town centre roads (A350)	delivery of P stock + boxes of Winton books + collect one bag and empties	cascading from P shop and Winton
Lunch					M&S Poole	35521	13.13	town centre roads	collection	M&S donation
M&S Poole	13.28	35521	0.33	books, textiles	house collection	35527	13.45	local roads	house collection	
House	13.49	35527	0.5	books, textiles, bric-a-brac	P8 donation bank	35529	13.57	local roads	collection	book donation banks
P8 donation bank	14.13	35529	0.5	books, textiles, bric-a-brac	P3 donation bank	35531	14.20	local roads	collection	book donation banks
P3 donation bank	14.34	35531	>0.5	books, textiles, bric-a-brac	P7 donation bank	35533	14.43	local roads	collection	book donation banks
P7 donation bank	14.55	35533	0.75	books, textiles, bric-a-brac	depot	35540	15.16	local roads		

Unusual circumstances? (e.g. Delays, house collections)	Donation bank fill level before collection	Donation bank fill level after collection	Number of bags of textiles collected	Boxes of bric-a-brac collected	Bags of books collected	Boxes of music/DVD collected	Bags of other items collected (note type of good)	Numbers of bags of textiles delivered	Boxes of bric-a-brac delivered	Bags of books delivered	Boxes of music/DVD delivered	Bags of other items delivered (note type of good)	Van fill level after collection/ delivery	Photos taken?
								16	7	3			<0.25	yes
fuel stop	half	empty			8		bag of videos to Winton						<0.25	yes
tea break					12 (culled stock)		1x box of records, empty's			8 bags (from S donation bank), 16 boxes			<0.25	yes
			5 for PO	3 for PO	4 (for depot), 2 for PO							1 bag kitchen waste	0.25	yes
							1 bag festival/bridal		3 from P	5 from P shop, 5 from Winton			<0.25	yes
			12										0.33	yes
				4 + 3 paintings									0.50	yes
	full	empty			10 + 1 rubbish								0.50	yes
	over full	empty			16 + 3 rubbish								>0.5	yes
	full	empty			13								0.75	yes
														yes

Continuation of Appendix 2

Appendix 3: W14 Donation bank names and codes

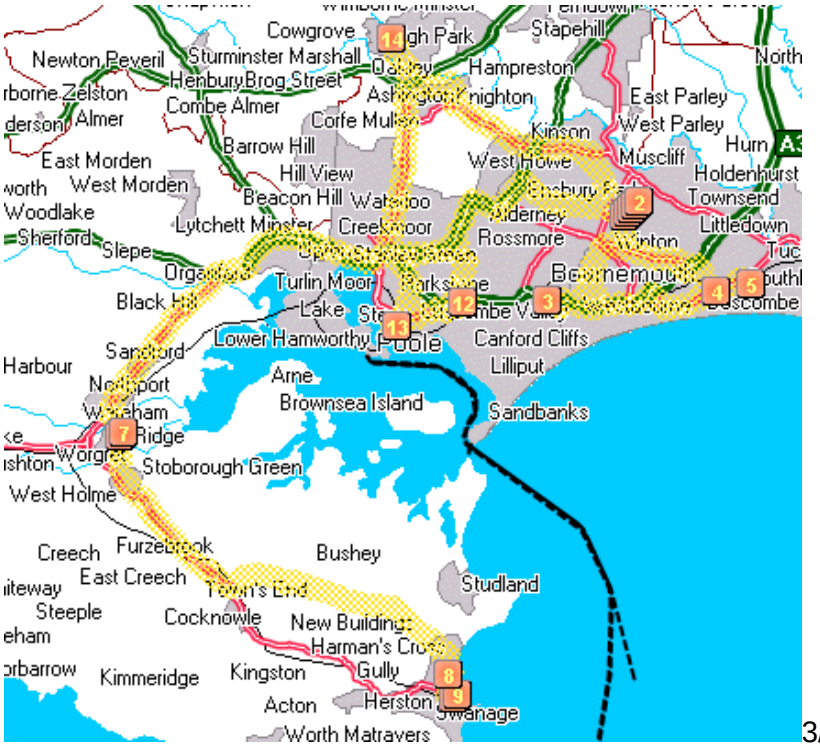
Donation bank type	Location	Address	Town	Postcode	Donation bank code
Books & Music	Tesco	Old Mills, Paulton	Midsommer Norton	BS39 7SW	M
Books & Music	Elms Cross Shops	Rowden Lane	Bradford-on-Avon	BA15 2AZ	BR
Books & Music	Morrison's	London Rd	Bath	BA1 6AE	BA
Clothing Donation bank	B&Q	Castle Point, Castle Lane	Bournemouth	BH8 9UB	BO1
Books & Music	B&Q	Castle Point, Castle Lane	Bournemouth	BH8 9UB	BO2
Books & Music	Allenview Centre	Allenview Rd	Wimborne	BH21 1AS	W
Books & Music	Tesco	Poole Rd Branksome	Poole	BH12 1AU	P1
Clothing Donation bank	Sainsbury's	4 Alder Park, Talbot Heath	Poole	BH12 4BA	P2
Books & Music	Tesco	Tower Park, Mannings Heath	Poole	BH12 4NX	P3
Books & Music	Commercial Rd Car Park	Commercial Rd, Lower Parkstone	Poole	BH14 0JD	P4
Books & Music	Sainsbury's	11 Pitwines Close	Poole	BH15 1XU	P5
Clothing Donation bank	Sainsbury's	11 Pitwines Close	Poole	BH15 1XU	P6
Books & Music	Tesco	Waterloo Rd	Poole	BH17 7EJ	P7
Books & Music	Asda	Culliford Crescent, Canford Heath	Poole	BH17 9DW	P8
Books & Music	Poole Stadium	Stadium Way	Poole	BH15 2BP	P9
Books & Music	North Beach CP	De Moulham Rd	Swanage	BH19 1NT	S
Books & Music	Sainsbury's	597 Ringwood Rd, Trickets Cross	Ferndown	BH22 9AL	F
Books & Music	Sainsbury's	1 Lyndhurst Rd	Christchurch	BH23 4RY	C
Books & Music	Furlong Car Park	The Furlong	Ringwood	BH24 1AT	R1
Clothing Donation bank	Ringwood RYC	Parsonage Barn Lane	Ringwood	BH24 1PX	R2
Books & Music	Ringwood RYC	Parsonage Barn Lane	Ringwood	BH24 1PX	R3
Clothing Donation bank	RYC Butlers Lane (nr Tescos)	Butlers Lane	North Poulner	BH24 1UB	NP1
Books & Music	RYC Butlers Lane (nr Tescos)	Butlers Lane	North Poulner	BH24 1UB	NP2
Books & Music	Tesco	Caird Avenue	New Milton	BH25 6BP	NM1
Books & Music	Spencer Rd (nr Somerfield)	Spencer Rd Stannington	New Milton	BH25 6DL	NM2
Books & Music	Elm Avenue Car Park	Elm Avenue	New Milton	BH25 6HE	NM3
Books & Music	Morrison's	Verwood District Shopping Centre	Verwood	BH31 6UQ	V
Books & Music	Tesco	Stour Rd	Blandford	DT11 9PU	B
Books & Music	Barfields	Car Park	Lymington	SO41 9GN	L1
Books & Music	Waitrose	Stanford Rd	Lymington	SO41 9GF	L2
Books & Music	Recycling Centre	Sea Rd	Milford-on-Sea	SO41 0DA	MS
Books & Music	George Lane Car Park	George Lane	Marlborough	SN8 1AA	MA

Appendix 4: W14 Shop performance between 3/5/13 and 22/7/13

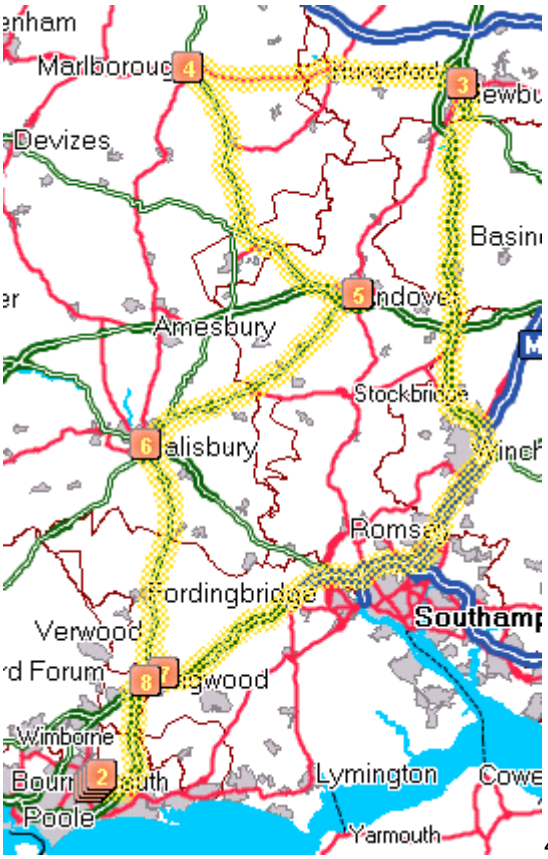
Name	Postcode	Code	Bags delivered	Bags cascaded	Bags moved (delivery + cascade)	Delivery/cascade	Visits	Bags delivered per visit	Bags cascaded per visit
Bournemouth, 6 Victoria Park Road, Winton	BH9 2RE	F4072	3820	1228	5048	3.1	96	39.8	12.8
Andover, 23 Chantry Way	SP10 1LS	F4040	366	3	369	122.0	6	61.0	0.5
Poole, 136 High Street	BH15 1DN	F3319	347	13	360	26.7	19	18.3	0.7
Marlborough, 29b High Street	SN8 1LW	F2935	0	317	317	0.0	10	0.0	31.7
Bath, 4/5 Lower Borough Walls	BA1 1QR	F2936	171	125	296	1.4	9	19.0	13.9
Swanage, 21/21a Institute Road	BH19 1BT	F3323	208	69	277	3.0	9	23.1	7.7
Bath, 12a George St/Gay St	BA1 2EH	F2802	162	88	250	1.8	11	14.7	8.0
Blandford Forum, 30b Salisbury Street	DT11 7AU	F4067	8	189	197	0.0	10	0.8	18.9
Shaftesbury, 19 High Street	SP7 8JS	F3324	0	108	108	0.0	6	0.0	18.0
Bournemouth, 681 Christchurch Rd, Boscombe	BH7 6AA	F3321	95	6	101	15.8	9	10.6	0.7
Bristol, 57 High Street, Keynsham	BS31 1DS	F2809	31	44	75	0.7	4	7.8	11.0
Bath, 12 Argyle Street	BA2 4QB	F2801	30	41	71	0.7	5	6.0	8.2
Devizes, 6/7 Maryport Street	SN10 1AH	F2933	0	66	66	0.0	4	0.0	16.5
Chippenham, 5 The Bridge	SN15 1HA	F2924	1	60	61	0.0	4	0.3	15.0
Salisbury, 10 Catherine Street	SP1 2DA	F2937	0	9	9	0.0	2	0.0	4.5
Salisbury, 12/14 Catherine Street	SP1 2DA	F2906	0	9	9	0.0	3	0.0	3.0
Frome, 7 Market Place	BA11 1AB	F3024	0	3	3	0.0	1	0.0	3.0

Appendix 5: W14 June 2013 collection routes (Base case)

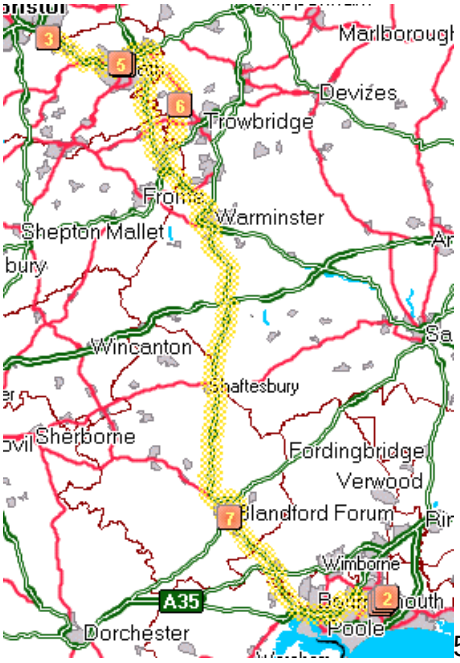
Week 1 (3/6/13-17/6/13) modelled using Logix



3/6/13



4/6/13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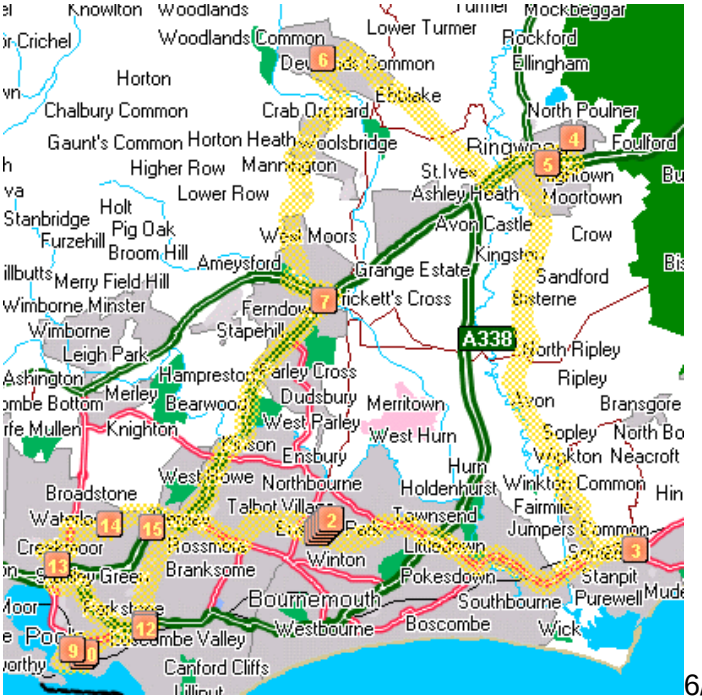
Devizes
Trowbridge
Warminster
Shepton Mallet
Wincanton
Shaftesbury
Sherborne
Fordingbridge
Verwood
Blandford Forum
Wimborne
A35
Dorchester
Poole

5/6/13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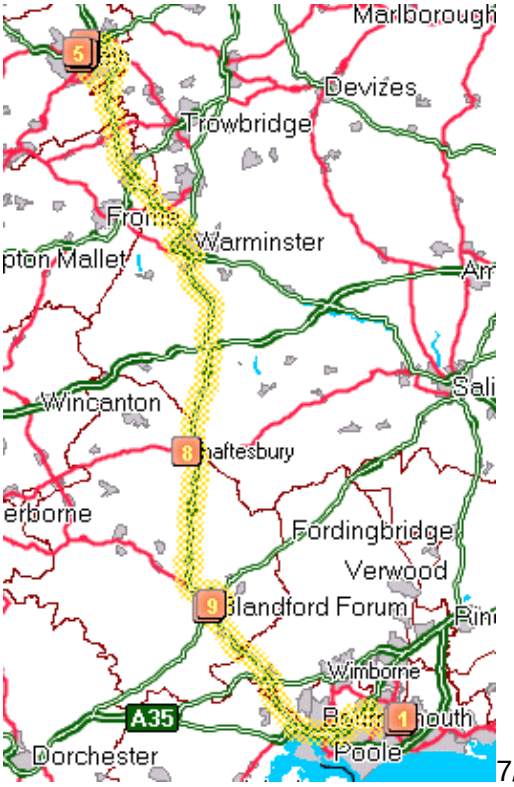
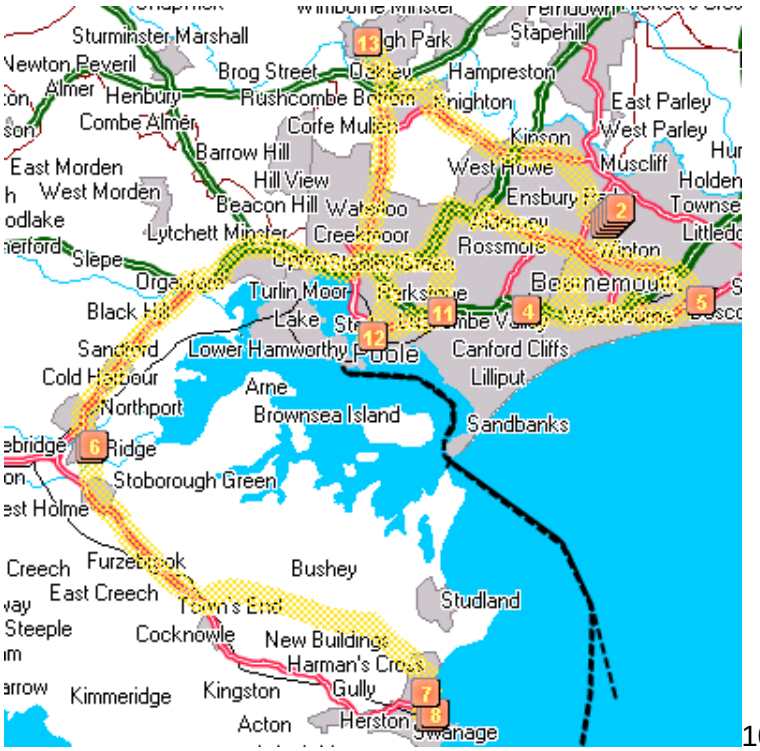
Woodlands
Woodlands Common
Lower Turmer
Rockford
Ellingham
Horton
Chalbury Common
Crab Orchard
North Poulner
Gaunt's Common
Horton Heath
Higher Row
Lower Row
St Ives
Ashley Heath
Moortown
Holt
Stanbridge
Furzehill
Pig Oak
Broom Hill
West Moors
Avon Castle
Crow
Ameysford
Grange Estate
Sandford
Merry Field Hill
Wimborne Minster
Wimborne
Stapehill
Leigh Park
A338
North Ripley
Ripley
Ashington
Merley
Bearwood
Dudsbury
Merritown
Bransgore
Knighton
West Parley
West Hurn
Sopley
Ensbury
Hurn
Neacroft
Broadstone
Northbourne
Holdenhurst
Winkton Common
Talbot Village
Townsend
Fairmile
Jumpers Common
Bossmore
Winton
Branksome
Pokesdown
Stanpit
Bournemouth
Southbourne
Purewell
Westbourne
Boscombe
Wick
Canford Cliffs

6/6/13

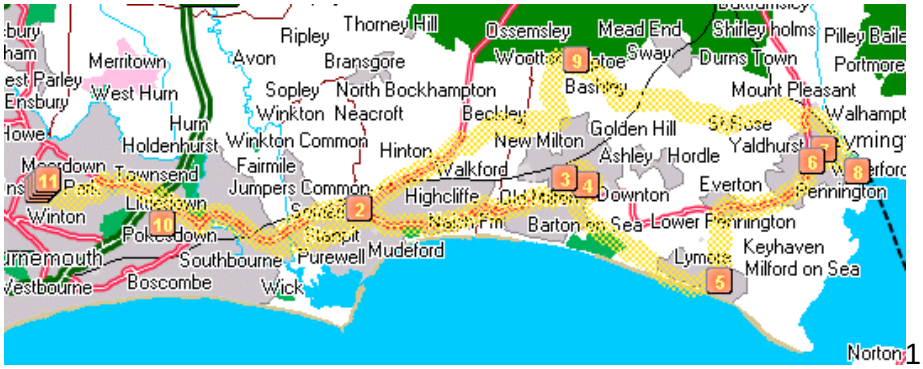


7/6/13

Week 2 (10/6/13-15/6/13) modelled using Logix



10/6/13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Sopley
North Bockhampton
Mount Pleasant
Winkton
Neacroft
Walhampt
Hurn
Golden Hill
Holdenhurst
Winkton Common
Hinton
New Milton
Yaldhurst
Fairmile
Walkford
Ashley
Hordle
Townsend
Jumpers Common
Highcliffe
Downton
Everton
Winton
Barton on Sea
Lower Pennington
Southbourne
Purewell
Mudeford
Keyhaven
Milford on Sea
Boscombe
Wick
Norton
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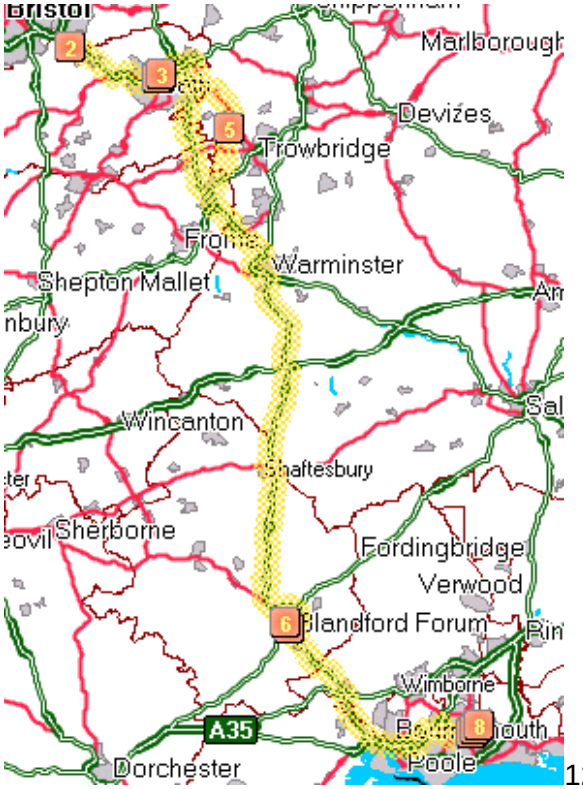
11/6/13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Verwood
Blandford Forum
Wimborne
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Dorchester
Poole
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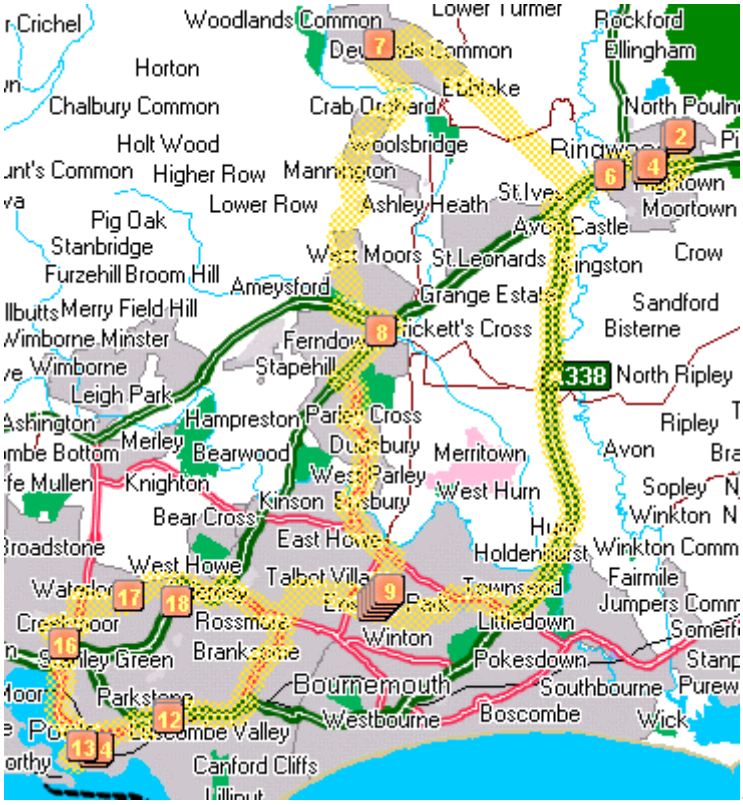
12/6/13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Leigh Park
Hampreston
Merley
Bearwood
Knighton
Bear Cross
West Howe
Rossmore
Winton
Bournemouth
Westbourne
Boscombe
Canford Cliffs
Pokesdown
Southbourne
Littledown
Merritown
West Hurn
Ashley Heath
St.Leonards
Ameysford
Stapehill
Ferndown
Rockford
Ellingham
North Poulner
Moortown
Crow
Sandford
Bisterne
North Ripley
Ripley
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Fairmile
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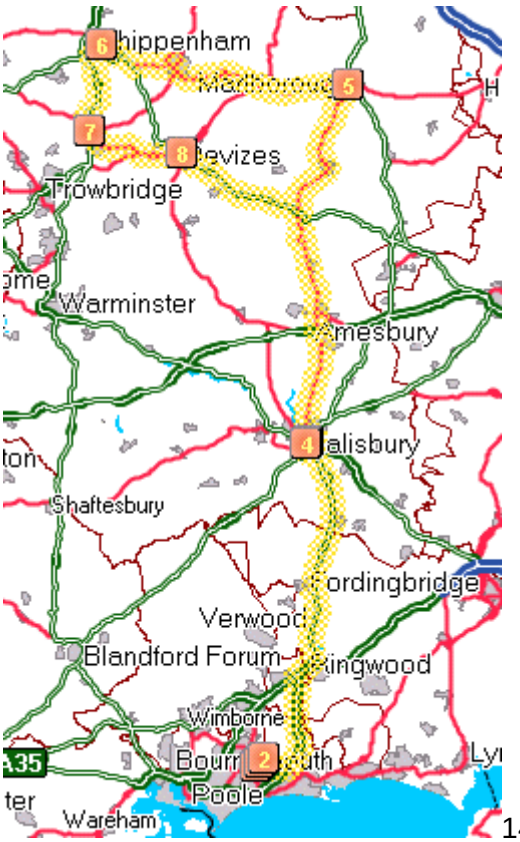
338
13/6/13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Poole
Wareham
Verwood
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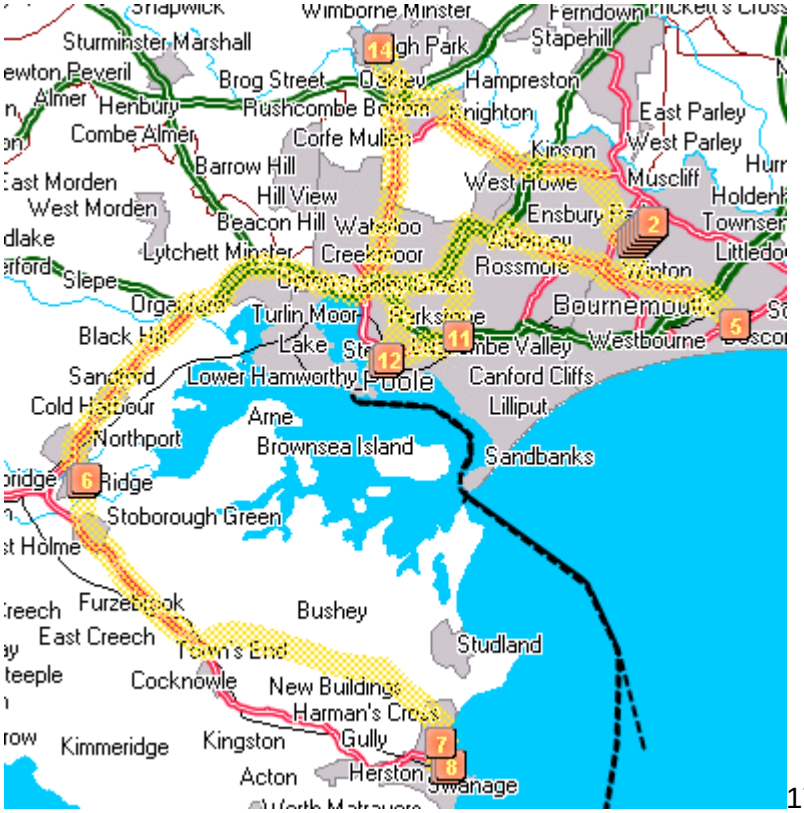
14/6/13

Week 3 (17/6/13-21/6/13) modelled using Logix



17/6/13

18/6/13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Custards
Goose Green
Clayhill
Bank
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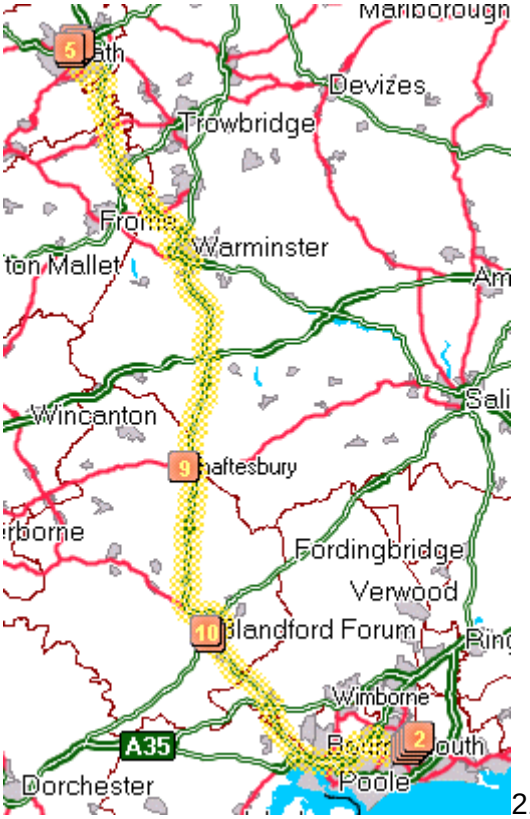
North Poulner
Ringwood
Crab Orchard
Woolsbridge
Ashley Heath
St.Ives
Hightown
Moortown
Burley Street
Burley Lawn
Burley
Avon Castle
Kingston
Crow
West Moors
St.Leonards
Grange Estate
Sandford
Bisterne
Bisterne Close
Brockenhurst
North Weirs
South Weirs
Setley
Battramsley
Hickett's Cross
A338
North Ripley
Thorney Hill
Ripley
Ossemsley
Mead End
Merritown
Avon
Bransgore
Wootton Tiptoe
Sway
West Hurn
Sopley
North Bockhampton
Winkton
Neacroft
Beckley
Bashley
Mount Pleasant
Hordle
St.Rose
Holdenhurst
Winkton Common
Hinton
New Milton
Ashley
Everton
Fairmile
Walkford
Townsend
Jumpers Common
Highcliffe
Downton
Winton
Pokesdown
Stanpit
Barton on Sea
Bournemouth
Southbourne
Purewell
Keyhaven
Westbourne
Boscombe
Wick

19/6/13

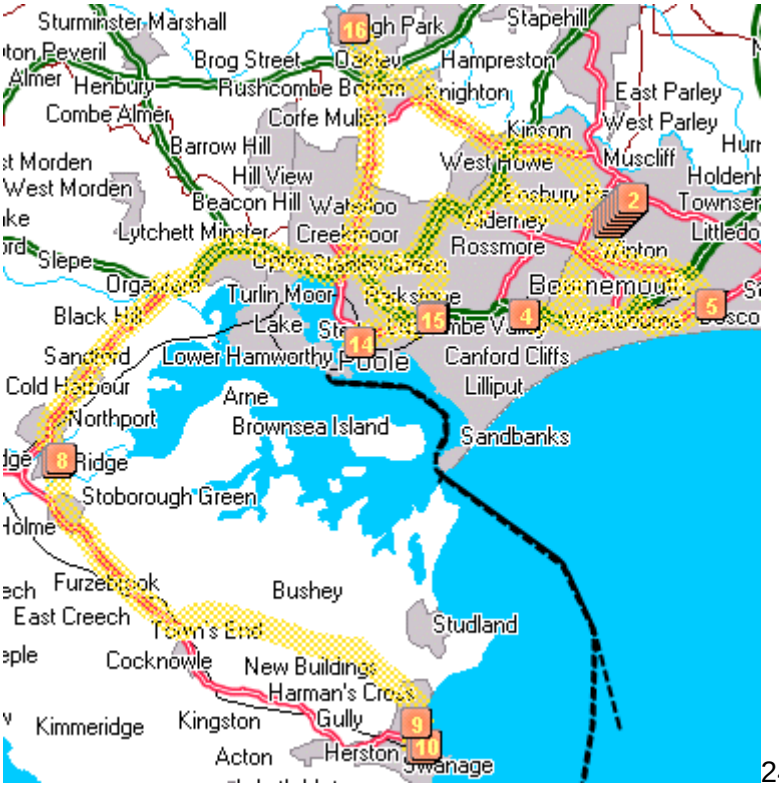

Wimborne Minster
Stapehill
Ferndown
Leigh
Leigh Park
Little Canford
Canford Magna
Longham
Parley Cross
Merley
Hampreston
Dudsbury
Ashington
Bottom
Bearwood
Knighton
West Parley
A349
Bear Cross
Kinson
Ensbury
Canford Heath
Northbourne
West Howe
East Howe
Darby's Corner
Waterloo
A3049
Wallisdown
Newtown
Rossmore
Oakdale
Branksome
Stanley Green
Longfleet
Bournemouth
Westbourne
Branksome Park
Luscombe Valley
Lower Hamworthy

20/6/13



21/6/13

Week 4 (24/6/13-28/6/13) modelled using Logix



24/6/13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Crow
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Avon Castle
Kingston
Sandford
Bisterne
Bisterne Close
Brockenhurst
North Weirs
South Weirs
Setley
Battramsley
Shirleyholms
Mead End
Sway
Durns Town
Mount Pleasant
Grange Estate
Rickett's Cross
A338
North Ripley
Thorney Hill
Ripley
Avon
Bransgore
Merritown
West Hurn
Sopley
North Bockhampton
Bashley
Winkton
Neacroft
Beckley
Hurn
Holdenhurst
Winkton Common
Hinton
New Milton
Golden Hill
Ashley
Hordle
Yaldhurst
Fairmile
Walkford
Townsend
Jumpers Common
Highcliffe
Downton
Everton
Winton
Pokesdown
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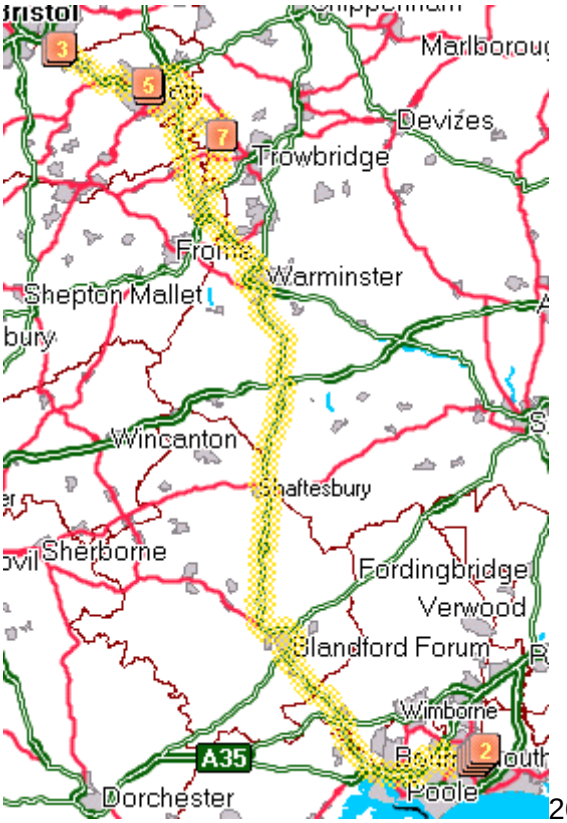
Keyhaven
Milford on Sea
Southbourne
Purewell
Mudeford
Westbourne
Boscombe
Wick

25/6/13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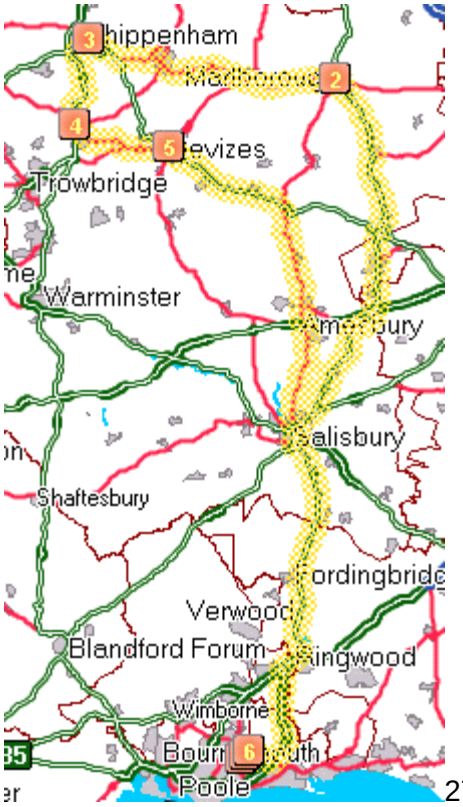
Wimborne
A35
Dorchester
Poole

26/6/13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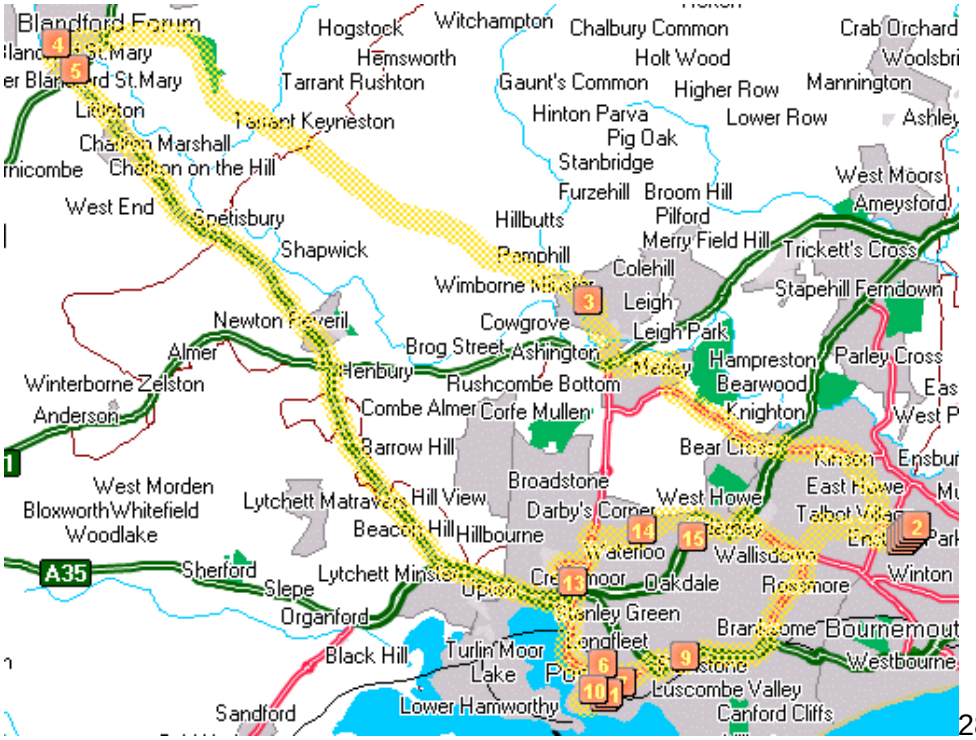
27/6/13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Pig Oak
Stanbridge
West Moors
Furzehill
Broom Hill
Ameysford
West End
Hillbutts
Pilford
Shapwick
Merry Field Hill
Trickett's Cross
Colehill
Stapehill
Ferndown
Leigh
Cowgrove
Leigh Park
Newton Peveril
Almer
Brog Street
Ashington
Hampreston
Parley Cross
Winterborne Zelston
Henbury
Rushcombe Bottom
Bearwood
Anderson
Combe Almer
Corfe Mullen
Knighton
Barrow Hill
Bear Cross
West Morden
Broadstone
East Howe
Bloxworth
Whitefield
Lytchett Matravers
Hill View
Darby's Corner
West Howe
Woodlake
Beacon Hill
Hillbourne
Waterloo
Wallisdown
Sherford
Lytchett Minster
Oakdale
Rossmore
Winton
Slepe
Organford
Ashley Green
Bournemouth
Black Hill
Turlin Moor
Lake
Westbourne
Lower Hamworthy
Luscombe Valley
Sandford
Canford Cliffs

28/6/13

Appendix 6: Statistics for each case study week route (3/9/12-7/9/12) against the mean average (September-November 2012)

Route	Number of shops on route	Number of donation bank-sites on route	Case study week kg collected from shops	Case study week kg collected from donation banks	Case study week km	Mean km (Sept)	Standard Deviation of mean km (Sept)	Case study week kg	Mean kg (Sept-Nov)	Standard Deviation of mean kg (Sept-Nov)
Watford Mon	4	6	912.1	258.5	164	168.3	11	1170.6	2688.1	1061
Reading Mon	5	1	1476.1	771.5	347	342.0	13	2247.6	2018.1	613
Cambridge Mon	7	5	1894.1	2220	276	254.8	18	4114.1	2865.5	823
Bishop Stortford Mon	6	7	1668.3	1544	299	290.5	23	3212.3	2666.6	907
Berkhamsted Mon	7	6	2085.8	2540.5	245	209.0	30	4626.3	3710.3	702
Peterborough Tues	7	4	2711.1	1486.5	372	331.3	50	4197.6	2670.7	929
Northampton Tues	9	4	2512.2	1533	251	215.5	51	4045.2	2433.6	1626
March Tues	3	6	867	2340	334	354.0	31	3207.0	1958.0	589
Beaconsfield Tues	6	4	2438.1	1080	214	214.3	5	3518.1	2793.4	317
Watford Wed	4	6	1796.4	1572	165	164.8	16	3368.4	2159.7	1024
Reading Wed	4	1	1780.3	739.5	354	346.3	10	2519.8	1774.1	298
Cambridge Wed	5	1	1456.7	90	242	226.8	10	1546.7	2139.3	386
Bishop Stortford Wed	6	6	2525	514.5	392	304.8	62	3039.5	2241.6	512
Peterborough Thurs	6	4	1345.1	598	281	283.5	12	1943.1	1430.8	269
Oxford Thurs	8	0	1998.4	0	171	197.8	43	1998.4	1364.8	400
Northampton Thurs	5	5	1313	1423	201	196.5	18	2736.0	1957.5	488
March Thurs	6	6	801.8	1006.5	367	336.3	24	1808.3	1319.0	227
Berkhamsted Thurs	5	3	1701.4	2074.5	128	172.0	63	3775.9	3137.8	556
Watford Fri	4	6	1467.1	1120	157	166.8	17	2587.1	2614.7	1101
Reading Fri	6	2	2248.1	801	349	336.3	14	3049.1	2222.8	530
Cambridge Fri	6	5	682	270	259	249.0	10	952.0	2190.2	603
Bishop Stortford Fri	9	4	2857.7	564	265	301.3	25	3421.7	3260.0	264
Beaconsfield Fri	6	4	2586.2	1042.5	193	193.3	12	3628.7	2510.2	456

Appendix 7: Base case modelled routes

Nb. Some routes do not have complete actual times due to the driver not recording the finishing times of their routes

Table 64. Monday routes

Route	Day	Start	Km	Calls	Modelled time	Actual time	Kg collected
Cambridge	Mon	04:30	218	12	10:58	12:25	4116
Reading	Mon	04:30	319	6	09:50	8:20	2250
Bishops Stortford	Mon	04:30	300	13	12:00	9:40	3215
Watford	Mon	04:30	155	10	05:01	12:30	1175
Berkhamsted	Mon	04:31	183	13	09:52	11:15	4629

Figure 84. Sites served by Milton Point routes on Monday

Table 65. Tuesday routes

Route	Day	Start	Km	Calls	Modelled time	Actual time	Kg collected
Beaconsfield	Tue	04:30	221	10	9:42	9:50	3520
March	Tue	04:30	322	9	12:29	8:55	3208
Peterborough	Tue	04:30	348	11	13:05	10:31	4202
Northampton	Tue	04:41	223	15	11:08	10:40	4049

Figure 85. Sites served by Milton Point routes on Tuesday

Table 66. Wednesday routes

Route	Day	Start	Km	Calls	Modelled time	Actual time	Kg collected
Reading	Wed	04:30	311	5	09:52	9:00	2521
Cambridge	Wed	04:30	224	6	07:56	9:10	1547
Bishops Stortford	Wed	04:30	342	12	12:17	12:35	3043
Watford	Wed	04:30	159	10	07:47	7:40	3371

Figure 86. Sites served by Milton Point routes on Wednesday

Table 67. Thursday routes

Route	Day	Start	Km	Calls	Modelled time	Actual time	Kg collected
March	Thu	04:30	361	12	11:44	11:48	1811
Oxford	Thu	04:30	148	10	06:07	9:00	2001
Peterborough	Thu	04:30	273	10	09:41	10:45	1945
Northampton	Thu	04:52	186	11	07:40	8:25	2738
Berkhamsted	Thu	04:30	140	8	06:20	6:20	3778

Figure 87. Sites served by Milton Point routes on Thursday

Table 68. Friday routes

Route	Day	Start	Km	Calls	Modelled time	Actual time	Kg collected
Cambridge	Fri	04:30	198	11	07:03	9:45	953
Reading	Fri	04:30	319	8	10:46	11:29	3049
Bishops Stortford	Fri	04:30	281	13	11:40	10:20	3424
Beaconsfield	Fri	04:30	202	10	09:31	11:00	3630
Watford	Fri	04:30	155	10	06:38	10:45	2589
Totals			**5588**		**220:44**		**66764**

Figure 88. Sites served by Milton Point routes on Friday

Appendix 8: Scenario 1 - Shop adopted donation bank collections

Monday routes

Table 69. Cambridge shop adopted routes (Monday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Cambridge 1	Mon	04:30	4	2	02:18	F2516	1350
Cambridge 2	Mon	04:30	3	1	01:22	F2505	600
Cambridge 3	Mon	04:30	2	2	00:56	F2504	270

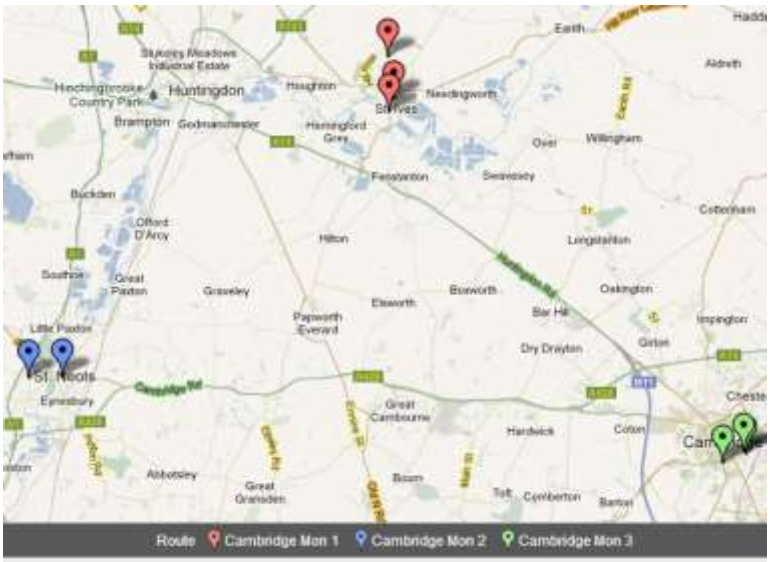

Figure 89. Cambridge shop adopted routes (Monday)

Table 70. Bishops Stortford shop adopted routes (Monday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Bishops Stortford 1	Mon	04:40	4	1	01:08	F4701	360
Bishops Stortford 2	Mon	04:31	22	1	01:29	F4737	225
Bishops Stortford 3	Mon	04:42	10	2	01:08	F3611	277

Figure 90. Bishops Stortford shop adopted routes (Monday)

Table 71. Watford shop adopted routes (Monday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Watford 1	Mon	04:34	16	3	01:16	F3621	68
Watford 2	Mon	04:42	1	1	00:42	F4704	90
Watford 3	Mon	04:38	11	2	01:01	F3608	103

Figure 91. Watford shop adopted routes (Monday)

Table 72. Reading shop adopted route (Monday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Reading 1	Mon	04:30	34	1	02:14	F3805	772

Figure 92. Reading shop adopted routes (Monday)

Table 73. Berkhamsted shop adopted routes (Monday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Berkhamsted 1	Mon	04:37	13	2	01:45	F3406	720
Berkhamsted 2	Mon	04:40	5	3	02:27	F3614	1417
Berkhamsted 3	Mon	04:37	17	1	01:20	F3627	405

Figure 93. Berkhamsted shop adopted routes (Monday)

Tuesday routes

Table 74. Peterborough shop adopted routes (Tuesday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Peterborough 1	Tue	04:30	41	3	02:58	F1816	1172
Peterborough 2	Tue	04:39	8	1	01:08	F2511	315

Figure 94. Peterborough shop adopted routes (Tuesday)

Table 75. Northampton shop adopted routes (Tuesday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Northampton 1	Tue	04:39	8	1	00:56	F1825	135
Northampton 2	Tue	04:41	3	1	01:38	F3402	798
Northampton 3	Tue	04:44	0	1	01:13	F3410	585

Figure 95. Northampton shop adopted routes (Tuesday)

Table 76. March shop adopted routes (Tuesday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
March 1	Tue	04:30	42	2	02:24	F2508	675
March 2	Tue	04:44	0	1	01:17	F2514	630

Figure 96. March shop adopted routes (Tuesday)

Table 77. Beaconsfield shop adopted routes (Tuesday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Beaconsfield 1	Tue	04:41	3	1	01:06	F3530	360
Beaconsfield 2	Tue	04:40	8	1	00:42	F3504	0
Beaconsfield 3	Tue	04:36	8	2	01:47	F3517	720

Figure 97. Beaconsfield shop adopted routes (Tuesday)

Wednesday routes

Table 78. Watford shop adopted routes (Wednesday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Watford 1	Wed	04:34	16	3	02:27	F3621	1080
Watford 2	Wed	04:42	1	1	01:06	F4704	425
Watford 3	Wed	04:38	11	2	00:58	F3608	68

Figure 98. Watford shop adopted routes (Wednesday)

Table 79. Reading shop adopted routes (Wednesday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Reading 1	Wed	04:30	34	1	02:12	F3805	740

Figure 99. Reading shop adopted route (Wednesday)

Table 80. Cambridge shop adopted routes (Wednesday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Cambridge 1	Wed	04:40	3	1	00:48	F2504	90

Figure 100. Cambridge shop adopted route (Wednesday)

Table 81. Bishops Stortford shop adopted routes (Wednesday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Bishops Stortford 1	Wed	04:40	4	1	00:56	F4701	180
Bishops Stortford 2	Wed	04:31	22	1	01:29	F4737	225

Figure 101. Bishops Stortford shop adopted routes (Wednesday)

Thursday routes

Table 82. Peterborough shop adopted routes (Thursday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Peterborough 1	Thu	04:30	41	3	02:09	F1816	463
Peterborough 2	Thu	04:32	24	1	01:19	F2511	135

Figure 102. Peterborough shop adopted routes (Thursday)

Table 83. Northampton shop adopted routes (Thursday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Northampton 1	Thu	04:39	8	1	00:47	F1825	15
Northampton 2	Thu	04:44	0	1	01:01	F3410	418
Northampton 3	Thu	04:42	5	2	01:33	F3407	765
Northampton 4	Thu	04:44	0	1	00:48	F3406	225

Figure 103. Northampton shop adopted routes (Thursday)

Table 84. March shop adopted routes (Thursday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
March 1	Thu	04:41	3	2	01:00	F3402	264
March 2	Thu	04:44	0	1	00:45	F2514	180

Figure 104. March shop adopted routes (Thursday)

Table 85. Berkhamsted shop adopted routes (Thursday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Berkhamsted 1	Thu	04:37	17	1	01:17	F3627	360
Berkhamsted 2	Thu	04:40	5	2	02:48	F3614	1715

Figure 105. Berkhamsted shop adopted routes (Thursday)

Friday routes

Table 86. Watford shop adopted routes (Friday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Watford 1	Fri	04:34	16	3	01:47	F3621	510
Watford 2	Fri	04:42	1	1	01:12	F4704	515
Watford 3	Fri	04:38	11	2	01:00	F3608	96

Figure 106. Watford shop adopted routes (Friday)

Table 87. Reading shop adopted route (Friday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Reading 1	Fri	04:30	34	2	02:16	F3805	801

Figure 107. Reading shop adopted route (Friday)

Table 88. Cambridge shop adopted routes (Friday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Cambridge 1	Fri	04:39	5	2	00:53	F2516	90
Cambridge 2	Fri	04:41	3	1	00:49	F2505	135
Cambridge 3	Fri	04:40	5	2	00:52	F2504	45

Figure 108. Cambridge shop adopted routes (Friday)

Table 89. Bishops Stortford shop adopted routes (Friday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Bishops Stortford 1	Fri	04:40	4	1	00:45	F4701	30
Bishops Stortford 2	Fri	04:31	22	1	01:19	F4737	90
Bishops Stortford 3	Fri	04:39	10	2	01:19	F3611	444

Figure 109 Bishops Stortford shop adopted routes (Friday)

Table 90. Beaconsfield shop adopted routes (Friday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Beaconsfield 1	Fri	04:41	3	1	00:56	F3530	225
Beaconsfield 2	Fri	04:40	8	1	00:43	F3504	8
Beaconsfield 3	Fri	04:36	8	2	01:54	F3517	810

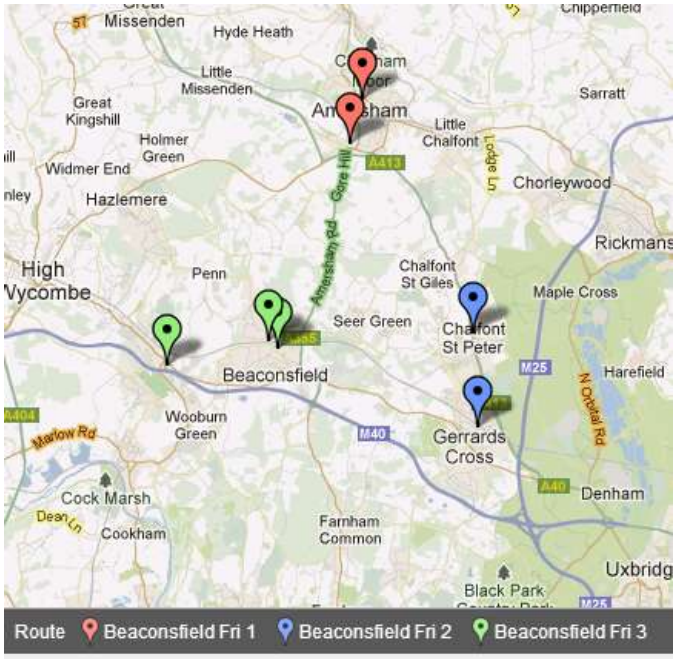

Figure 110. Beaconsfield shop adopted routes (Friday)

Appendix 9: Scenario 2 - Shop adopted donation bank collections with centralised shop and remote donation bank collections

Table 91. Shop and remote donation bank collections (Monday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Cambridge	Mon	04:30	211	7	08:19	MP	1896
Bishops	Mon	04:30	286	9	10:43	MP	2353
Watford	Mon	04:30	140	4	04:26	MP	914
Reading	Mon	04:30	259	5	08:28	MP	1478
Berkhamsted	Mon	04:30	135	7	06:05	MP	2087

Figure 111. Milton Point shop and remote donation bank collections (Monday)

Table 92. Shop and remote donation bank collections (Tuesday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
March	Tue	04:30	315	6	11:20	MP	1903
Peterborough	Tue	04:30	253	7	10:25	MP	2715
Northampton	Tue	04:38	190	11	08:45	MP	2516
Beaconsfield	Tue	04:30	203	6	08:21	MP	2440

Figure 112. Milton Point shop and remote donation bank collections (Tuesday)

Table 93. Shop and remote donation bank collections (Wednesday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Cambridge	Wed	04:30	223	5	08:08	MP	1457
Bishops	Wed	04:30	274	6	10:16	MP	2528
Reading	Wed	04:30	273	4	08:26	MP	1781
Watford	Wed	04:30	140	4	05:28	MP	1798

Figure 113. Milton Point shop and remote donation bank collections (Wednesday)

Table 94. Shop and remote donation bank collections (Thursday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
March	Thu	04:30	313	9	10:50	MP	1367
Oxford	Thu	04:30	141	10	06:09	MP	2001
Peterborough	Thu	04:30	227	6	08:11	MP	1347
Northampton	Thu	04:52	180	6	05:52	MP	1315
Berkhamsted	Thu	04:30	135	5	05:33	MP	1703

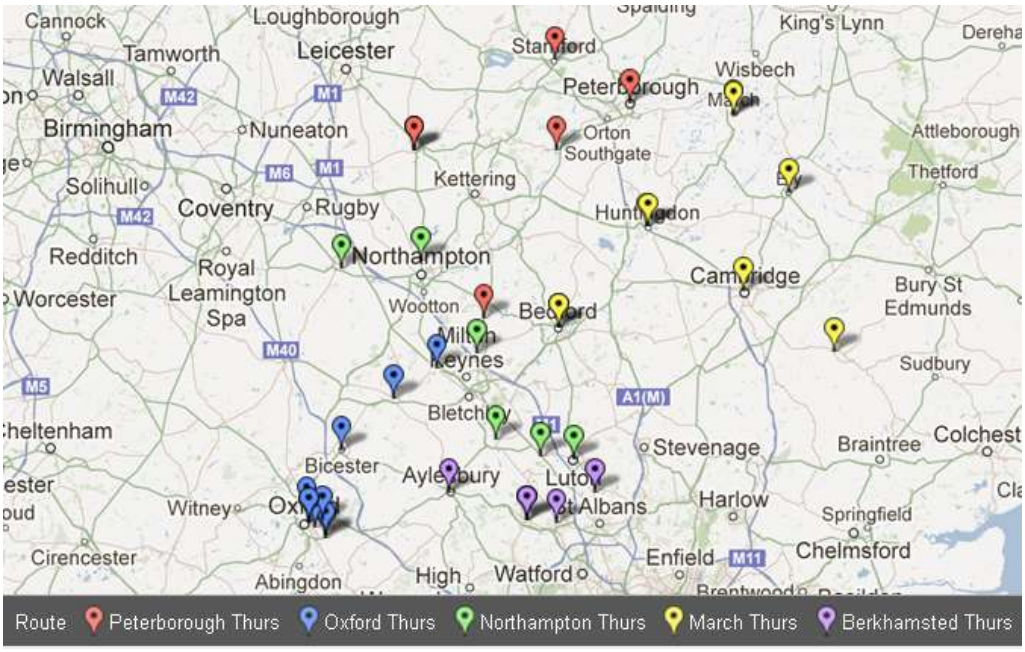

Figure 114. Milton Point shop and remote donation bank collections (Thursday)

Table 95. Shop and remote donation bank collections (Friday)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Cambridge	Fri	04:30	186	6	06:28	MP	683
Bishops	Fri	04:30	271	9	11:06	MP	2860
Reading	Fri	04:30	259	6	09:22	MP	2248
Beaconsfield	Fri	04:30	203	6	08:31	MP	2587
Watford	Fri	04:30	140	4	05:05	MP	1468

Figure 115. Milton Point shop and remote donation bank collections (Friday)

Appendix 10: Scenario 3 - Shop adopted donation bank collections with centralised shop and remote donation bank collections (with centralised collection of donation bank stock from shops)

Route	Day	Start	Km	Calls	Time	Route origin	Kg collected
Cambridge	Mon	04:30	211	7	10:55	MP	4116
Bishops	Mon	04:30	286	9	11:43	MP	3215
Reading	Mon	04:30	259	5	09:22	MP	2250
Berkhamsted	Mon	04:30	135	7	09:03	MP	4629
Watford	Mon	04:30	140	4	04:43	MP	1156
March	Tue	04:30	315	6	12:51	MP	3208
Peterborough	Tue	04:30	253	7	12:09	MP	4202
Northampton	Tue	04:38	190	11	10:31	MP	4034
Beaconsfield	Tue	04:30	203	6	09:37	MP	3520
Cambridge	Wed	04:30	223	5	08:15	MP	1547
Bishops	Wed	04:30	274	6	10:20	MP	2595
Reading	Wed	04:30	259	5	09:41	MP	2521
Watford	Wed	04:30	140	4	07:18	MP	3371
March	Thu	04:30	313	9	11:21	MP	1811
Oxford	Thu	04:30	141	10	06:09	MP	2001
Peterborough	Thu	04:30	241	7	09:13	MP	1945
Northampton	Thu	04:52	180	6	07:31	MP	2738
Berkhamsted	Thu	04:30	135	5	07:59	MP	3778
Reading	Fri	04:30	259	6	10:18	MP	3049
Bishops	Fri	04:30	271	9	11:46	MP	3441
Cambridge	Fri	04:30	186	6	06:47	MP	953
Beaconsfield	Fri	04:30	203	6	09:44	MP	3630
Watford	Fri	04:30	140	4	06:24	MP	2589
			4957		213:40		66299

Appendix 11: Visiting donation banks at lower fill levels

	Current collection values (weekly)						Trial collection values (weekly)					
Site Name	**Mean Weight Over 6 Months(kg)**	**Weekly Cost to Collect**	**Sales Value Tonne**	**Value Collected**	**Collections**	**Sales Value Minus Cost**	**Mean Weight Over 4 week trial(kg)**	**Weekly Cost to Collect**	**Sales Value Tonne**	**Value Collected**	**Collections**	**Sales Value Minus Cost**
Asda Trafford Park	16	20	£750.00	£12.27	1	-£7.73	115	£35	£750.00	£86.41	2	£52
Bridge Street CP Milnrow	23	20	£750.00	£17.08	1	-£2.92	115	£35	£750.00	£86.41	2	£52
Carr Lane CP Slaithwaite	73	20	£750.00	£54.54	1	£34.54	132	£52	£750.00	£98.78	3	£47
Morrisons Cheadle Heath	27	20	£750.00	£20.30	1	£0.30	132	£52	£750.00	£98.78	3	£47
Morrisons Hollinwood	67	20	£750.00	£50.14	1	£30.14	132	£52	£750.00	£98.78	3	£47
Sainsburys Cheadle	35	20	£750.00	£26.41	1	£6.41	132	£52	£750.00	£98.78	3	£47
Sainsbury's Denton	29	20	£750.00	£21.38	1	£1.38	132	£52	£750.00	£98.78	3	£47
Sainsburys Fallowfield	74	20	£750.00	£55.60	1	£35.60	115	£35	£750.00	£86.41	2	£52
Sainsbury's Hazel Grove	18	20	£750.00	£13.41	1	-£6.59	132	£52	£750.00	£98.78	3	£47
Sainsbury's Heaton Park (Maxi)	88	20	£750.00	£66.04	1	£46.04	115	£35	£750.00	£86.41	2	£52
Sainsburys Stockport	40	20	£750.00	£30.29	1	£10.29	132	£52	£750.00	£98.78	3	£47
Street Bring Site	51	20	£750.00	£38.29	1	£18.29	115	£35	£750.00	£86.41	2	£52
Tesco Atherton	48	20	£750.00	£35.78	1	£15.78	115	£35	£750.00	£86.41	2	£52
Tesco Blackley	46	20	£750.00	£34.79	1	£14.79	115	£35	£750.00	£86.41	2	£52
Tesco Cheetham Hill	76	20	£750.00	£57.29	1	£37.29	115	£35	£750.00	£86.41	2	£52
Tesco Didsbury	57	20	£750.00	£42.42	1	£22.42	132	£52	£750.00	£98.78	3	£47
Tesco Drolysden	14	20	£750.00	£10.76	1	-£9.24	132	£52	£750.00	£98.78	3	£47
Tesco Gorton Cross	68	20	£750.00	£51.36	1	£31.36	132	£52	£750.00	£98.78	3	£47
Tesco Middleton	33	20	£750.00	£24.38	1	£4.38	115	£35	£750.00	£86.41	2	£52
Tesco Northenden	38	20	£750.00	£28.69	1	£8.69	115	£35	£750.00	£86.41	2	£52
Tesco Rochdale	51	20	£750.00	£38.13	1	£18.13	115	£35	£750.00	£86.41	2	£52
Tesco Stalybridge	44	20	£750.00	£33.08	1	£13.08	132	£52	£750.00	£98.78	3	£47
Tesco Stockport	60	20	£750.00	£45.24	1	£25.24	132	£52	£750.00	£98.78	3	£47
Urmston Leisure Centre	35	20	£750.00	£26.25	1	£6.25	115	£35	£750.00	£86.41	2	£52
		£480		£833.91		£353.91		£1,039		£2,222		£1,183

Extra cost to service 2/3 times a week	£559
Gain in value of stock collected from increased collections	£1,388
Total gain per week	£829.32
If theft were beaten (Value of stock collected - weekly cost from 1 collection)	£1,742

Appendix 12: Pre and post Smartphone App trials

To what extent would you agree with the following statements:	**Shop 1**	**Shop 2**	**Shop 3**	**Shop 4**	**Shop 5**	**Shop 6**	**Total**	**Count**	**Mean**	**Median**
Over the trial period, I have engaged in more collaboration with other shops related to giving/receiving stock compared to before …… *(if 'agree' can they give 1 example)*	4	4	4	4	2	2	20	6	3.3	4.0
The App has helped improve the communication with shops I already deal with	4	4	4	4	2	4	22	6	3.7	4.0
The App has helped improve the relationships with shops I already deal with …. *(in what ways?)*	4	4	4	4	2	2	20	6	3.3	4.0
The App has helped maintain the relationships with shops I already deal with …. *(in what ways?)*	4	4	4	4	2	4	22	6	3.7	4.0
The App has helped develop new relationships with shops in terms of stock collaboration …. *(give details)*	4	4	4	4	2	2	20	6	3.3	4.0
	20	**20**	**20**	**20**	**10**	**14**				
I could get across what I needed to say adequately with the message system in the App *(if disagree ... discuss why not)*	4	4	4	4	4	4	24	6	4.0	4.0
I prefer to use short messaging rather than discuss on the phone	3	4	4	4	2	2	19	6	3.2	3.5
Messaging saves me time as opposed to making calls to other shops	3	4	4	5	4	4	24	6	4.0	4.0
I am happy to message other shops outside normal work hours *(what time periods are acceptable?)*	4	4	2	5	2	4	21	6	3.5	4.0
I am happy to receive and respond to messages received from other shops out of normal work hours	4	4	4	4	2	4	22	6	3.7	4.0
Messaging out of hours is more convenient then during the day …. *(what is the best time for you to deal with messages?)*	3	3	4	4	2	4	20	6	3.3	3.5
Other managers responded in a timely fashion to my messages …. *(what mediums were used?)*	4	4	1	4	4	3	20	6	3.3	4.0
The driver responded in a timely fashion to my messages	4	4	5	5	4	5	27	6	4.5	4.5
The ability to communicate with other managers via short text messages through the App has helped collaboration … *(examples)*	4	4	4	4	4	4	24	6	4.0	4.0
	33	**35**	**32**	**39**	**28**	**34**				

Please indicate your agreement with the following statements about the 6th Sense Transport App.	**Shop 1**	**Shop 2**	**Shop 3**	**Shop 4**	**Shop 5**	**Shop 6**	**Total**	**Count**	**Mean**	**Median**
I would find it easier to ask for help using the App rather than face-to-face or via the phone	2	4	2	4	2	3	17	6	2.8	2.5

I would use the App more if I knew that the whole area was using it	2	5	5	5	2	4	25	6	4.2	4.5
For me to use the App more I would need the first 'virtual' contact to be followed by face-to-face meeting, phone call prior to collaboration …. *(find out which secondary medium is preferred)*	4	2	4	3	4	4	21	6	3.5	4.0

8. There are various costs associated with helping others or being helped. Please rate your concerns about these items in relation to helping or being helped by others within your area.	**Shop 1**	**Shop 2**	**Shop 3**	**Shop 4**	**Shop 5**	**Shop 6**	**Total**	**Count**	**Mean**	**Median**
I might feel obligated to carry out a request for another shop *(describe ….)*	3	4	1	2	4	4	18	6	3.0	3.5
I do not want to make commitments in case I can't fulfil the request	4	2	2	2	2	2	14	6	2.3	2.0
It can be complicated to sort out arrangements …. *(give an example, organising staff to sort etc)*	4	2	2	1	2	2	13	6	2.2	2.0
I am concerned about privacy in terms of other shops knowing the operating status of my shop	2	1	1	1	2	2	9	6	1.5	1.5
managers might pursue unwanted friendships	3	2	2	1	2	3	13	6	2.2	2.0
I don't want to take responsibility for other managers stock issues	4	2	2	2	4	3	17	6	2.8	2.5
Dealing with cascade requests from other shops puts an additional burden on my staff	4	1	1	2	4	4	16	6	2.7	3.0
I don't want to be let down (in terms of requesting stock)	4	4	2	2	2		14	5	2.8	2.0
The task might demand too much of my time/my staffs time	4	2	1	2	4	4	17	6	2.8	3.0
	32	**20**	**14**	**15**	**26**	**24**				

15. Please indicate your agreement with the following statements about personal use of time:	**Shop 1**	**Shop 2**	**Shop 3**	**Shop 4**	**Shop 5**	**Shop 6**	**Total**	**Count**	**Mean**	**Median**
I prefer to do two or more activities at the same time	2	4	4	4	4	4	22	6	3.7	4.0
I typically do two or more activities at the same time	4	4	4	4	4	4	24	6	4.0	4.0
Doing two or more activities at the same time is the most efficient way to use my time	4	2	2	2	4	2	16	6	2.7	2.0
I am comfortable doing more than one activity at the same time	4	4	4	4	4	4	24	6	4.0	4.0
I like to juggle two or more activities at the same time	4	3	4	4	4	2	21	6	3.5	4.0

16. Please indicate your agreement with the following statements about the Smartphone App:	**Shop 1**	**Shop 2**	**Shop 3**	**Shop 4**	**Shop 5**	**Shop 6**	**Total**	**Count**	**Mean**	**Median**
The App does not provide you with any extra visibility of the driver's activity over what you had before	2	1	1	1	2	2	9	6	1.5	1.5
Your understanding of the driver's activity has improved as a result of data produced by the App *(example … how has it helped you?) … where he is and where he should be*	4	1	4	5	4	4	22	6	3.7	4.0
Your ability to communicate with the driver has improved with the addition of the App *(example … how has it helped you?)*	2	4	4	4	3	2	19	6	3.2	3.5
Your decision making/planning has been better informed with the data coming out of the App *(example – what type of decision making, in what circumstance?)*	4	4	4	4	4	2	22	6	3.7	4.0
Your ability to collaborate with other managers has improved with the addition of the App *(example … how has it helped you?)*	4	4	4	4	2	2	20	6	3.3	4.0
Your understanding of donation bank performance has improved *(example … how has it helped you?)*	4		4	4			12	3	4.0	4.0
Your understanding of shop delivery and cascade patterns have improved *(example … how has it helped you?)*	4	4	2	4			14	4	3.5	4.0
Your understanding of how time is used in the business has improved with the data provided by the App *(example – what type of decision making, in what circumstance?)*	4	4	5	4	4	2	23	6	3.8	4.0

16. Please indicate your agreement with the following statements about your use of your personal mobile phone:	**Shop 1**	**Shop 2**	**Shop 3**	**Shop 4**	**Shop 5**	**Shop 6**	**Total**	**Count**	**Mean**	**Median**
- I only use the phone for calls and texts	2	1	5	1	4	2	15	6	2.5	2.0
- I use the phone as my main camera	5	5	1	5	2	4	22	6	3.7	4.5
- I regularly check my email via the phone*	5	5	1	4	1	4	20	6	3.3	4.0
- I regularly surf the web on the phone*	5	5	1	5	1	2	19	6	3.2	3.5
- I use social media sites regularly from my phone*	1	5	1	5	1	1	14	6	2.3	1.0
- I regularly play games on the phone*	4	1	1	4	1	1	12	6	2.0	1.0
- I regularly check my phone even when enjoying a film, TV show, sporting event or night out	2	4	4	4	1	1	16	6	2.7	3.0
- I check my phone (email, messages etc) before bed and when I get up in the morning	4	4	4	4	1	3	20	6	3.3	4.0
- I will always look at messages straight away when my phone alerts me	4	5	2	4	4	2	21	6	3.5	4.0
- I use hands free in the car	1	5	1	1	4	4	16	6	2.7	2.5
- I don't go anywhere without my mobile	4	5	5	5	4	4	27	6	4.5	4.5

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