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SID 5 Research Project Final Report

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Project identification

1. Defra Project code: SFFSD0705

2. Project title:
   Evidence on the role of supplier-retailer trading relationships and practices in waste generation in the food chain.

3. Contractor organisation(s):
   Cranfield University
   Cranfield, Bedfordshire
   MK43 0AL
   UK

4. Total Defra project costs (agreed fixed price): £ 80000

5. Project: start date ..... 01 July 2008
   end date ..... 01 July 2009

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Executive Summary

7. The executive summary must not exceed 2 sides in total of A4 and should be understandable to the intelligent non-scientist. It should cover the main objectives, methods and findings of the research, together with any other significant events and options for new work.

Waste is a significant problem for the UK food and drinks supply chain. It has been estimated that the industry produces about a third of all industrial and commercial waste in the UK and volume figures range between 18 – 20 million tonnes of waste per annum. In 2006, the Food Industry Sustainability Strategy (FISS) decided to address the waste problem and presented the industry with a major challenge: "to reduce the amount of food and packaging waste that is produced each year… and to recycle or otherwise gain value from the waste that does arise" (Defra, 2006: 37). The FISS also suggested a target of reducing waste by 15-20% by 2010. Furthermore, a recent consultation by (BBSRC, 2009) has highlighted waste reduction as a major challenge for food security.

The government has made significant investments in best practice programmes such as WRAP and Envirowise to help industry reduce waste. These programmes have made good progress, however, an area that has so far been neglected is the waste generated in the interface between retailers and their suppliers. Waste generated at this stage has important financial and environmental implications because products have already gone through most of their value adding activities, accumulating costs and embedded energy.

This project aimed to address the problem of waste at the supplier – retailer interface in the UK food chain. More specifically the objectives of the project were:

1. To assess the prevalence and magnitude of food and packaging waste in the supplier / retailer interface.
2. To identify the main root causes of waste
3. To identify good practices and examine the enablers and inhibitors to their implementation
4. To provide recommendations for policy and practice that will help the food and retail industries to jointly address the root causes of waste.

To achieve these objectives a case study methodology was used, looking at a range of products with different characteristics of temperature regime (ambient, chilled and frozen) and shelf-life (short, medium and long). Initially we agreed to conduct 16 case studies, although this was expanded to 20 in order to explore in more detail issues related to chilled products. The cases were divided into two waves; the first wave of 10 cases focused on estimating the magnitude of the problem and identifying the root causes of waste. The second wave focused on identifying good practices in waste management.

The research indicates that average waste generated between suppliers and retailers ranges between 0.1% and 10%. Out of the 20 cases, ten had waste figures below 3% and only one had figures exceeding

7%. However we found that in extreme cases, during short periods, waste for some products could be as high as 30%. Nevertheless it is possible to conclude that waste levels between food manufacturers and retailers are considerably lower to those reported by Wrap (2008) on household waste which amount to one third of all purchases.

The majority of products with high and very-high waste are products with short shelf-lives (less than two weeks) such as meat, fruits and vegetables. Similarly the majority of products with long shelf-lives (more than two months), such as ice cream, pasta sauces and beverages tend to have very low levels of waste. However, it is important to note that not all products with short shelf-lives have high levels of waste, several products such as milk, cooked poultry and potatoes have levels of waste lower than 3%. These products however, have relatively stable demand patterns throughout the year, as they are not substantially affected by factors, like seasonality, weather and promotions. This is an important finding because it shows that the causes are dependent. This is, it is not the short shelf-life of the product or the demand variability that cause the waste, but the combination of the two. This makes it impossible to attribute specific figures of waste to either of these causes.

The analysis of root-causes led to the identification of the groups of issues affecting waste:

1. Mega-trends: these are consumer and industry trends that affect the problem of waste such as increasing demand for fresh products and products out of seasons, as well as a move away from products with preservatives. These are important factors affecting the waste problem, but the impact that company strategies and processes have on them is limited.
2. Natural constraints: these are factors associated with the nature of the products and processes that can affect waste. Issues like short shelf-lives of fresh products, seasonality of supply and demand, weather fluctuations and longer lead-times for imported products are among these factors. Similarly to the megatrends, the impact of business practices on these issues is limited.
3. Management root-causes: these are factors affecting waste on which management practices have a direct impact. We believe these are the root-causes that are worth exploring in detail, since it is by changing these issues that organisations will be able to reduce waste. The nine causes identified are: Waste management responsibilities, information sharing, promotions management, forecasting, performance measurement, packaging, cold chain management, quality management and training.

Not all companies deal with the management root-causes in the same way and through the case studies it was possible to identify good practices to deal with each of the causes. These good practices can then be translated into recommendations for industry. Ten specific recommendations for food producers and retailers were identified in the research and are discussed in detail in the scientific report. These are:

- To ensure there is accountability for waste
- To promote a culture of waste reduction
- To embark in collaborative activities to improve information flows and decrease waste
- To analyse promotions more closely and consider their impact on waste
- To have an analytic approach to forecasting
- To manage process efficiently and effectively to reduce waste at all stages
- To maintain the cold chain management
- To consider the natural characteristics of the product
- To use packaging effectively and responsibly to protect the product and extend its life
- To follow the “Reduce, Reuse, Recycle” logic to prevent waste to landfill

Waste reduction should be a priority for organisations in the food industry, not only because waste represents an economic loss for the companies involved, but also because of its environmental implications. Nevertheless, there are some areas for further research and dissemination . These are:

- Continual and systematic data collection on waste, particularly figures on waste to landfill, which will support benchmarking and allow trend analysis.
- Dissemination to make industry more aware of the scale and impact of the problem, by conducting research and disseminate good practices
- To support research and technology transfer in areas such as cold chain technologies, packaging technologies, shelf life extension, and anaerobic digestion
- To investigate approaches to incentivise alternatives to landfill such as the use charities or the generation of energy from waste

8. As a guide this report should be no longer than 20 sides of A4. This report is to provide Defra with details of the outputs of the research project for internal purposes; to meet the terms of the contract; and to allow Defra to publish details of the outputs to meet Environmental Information Regulation or Freedom of Information obligations. This short report to Defra does not preclude contractors from also seeking to publish a full, formal scientific report/paper in an appropriate scientific or other journal/publication. Indeed, Defra actively encourages such publications as part of the contract terms. The report to Defra should include:
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1. Introduction

Waste is recognised as a major issue by the retail, food and packaging industries in the UK. In 2005, major retailers and producers signed a voluntary agreement with Defra and WRAP aimed at reducing packaging and food waste. This agreement, known as the Courtauld Commitment, covers 39 major retailers, brands and suppliers, and represents 92% of grocery supermarkets (WRAP, 2008; 2009). A year later, the Food Industry Sustainability Strategy (FISS) presented the industry with the challenge of *"reducing the amount of food and packaging waste that is produced each year… without compromising food safety; and to recycle or otherwise gain value from the waste that does arise"* (Defra, 2006).
The UK government has made significant investment in best practice programmes, such as the Waste Resources Action Programme (WRAP) and Envirowise to help the industry reduce waste and meet the targets set by FISS. These programmes have made good progress in various areas of waste minimisation, such as packaging, manufacturing and home waste. However, an area that has received limited attention is waste generated between producers and retailers. Waste at this stage has important financial and environmental implications because products have already gone through most of their value adding activities, accumulating costs and embedded energy. Therefore, reducing waste at this stage would not only cut costs but also reduce emissions. This project addressed this gap by analysing waste generated in the interface between retailers and suppliers. Furthermore, in 2009 WRAP commissioned a series of projects focussing on food waste across the supply chain for specific product groups, in an effort to continue addressing this issue.

1.1 Scope and Objectives

The project was conducted between July 2008 and June 2009. Its overall aim was to provide a qualitative analysis of the food and packaging waste arising from the link between food manufacturers and retailers in the UK. The specific objectives of the project were:

- To identify the root causes of waste between suppliers and retailers in the UK
- To assess the magnitude of each root cause
- To identify good practices and examine the enablers and inhibitors of their implementation
- To provide recommendations at a company and government level that will help the food and retail industries to jointly address the root causes of waste

The study had a UK perspective and it focused on the relationship between food retailers and their suppliers, and how their business processes and practices affect waste. Waste of finished products, discarded by producers, wholesalers, hauliers or retailers was the primary focus, and waste arising during production and agricultural processes was excluded from the study. However, during the project we collected additional information concerning other stages of the chain and other countries, which we have used for comparative purposes.

2. Food and packaging waste: Framing the problem

Waste can be defined in a number of ways. For instance the OECD/Eurostat (2005) uses the following definition: "*Waste refers to materials that are not prime products (i.e. products produced for the market) for which the generator has no further use for his own purpose of production, transformation or consumption, and which he discards, or intends or is required to discard. Waste may be generated during the extraction of raw materials, during the processing of raw materials to intermediate and final products, during the consumption of final products, and during any other human activity*."

For this project we decided to follow the more concise definition from the EU Council Directive, which defines waste as *"any substance or object the holder discards, intends to discard or is required to discard"* (EU, 1991). This will include all facets of physical waste including produce and packaging. Not included in this project will be the study of wasted time, energy and resources. This compares with other definitions of waste that often include products that are under sold, recycled back into production or waste arising from process inefficiencies.
It has been estimated that the food and retail industries produce about a third of all industrial and commercial waste in the UK and volume figures range between 18–22 Mt per annum. Waste is generated at various stages in the chain. UK homes alone are responsible for 6.7 Mt of food waste and an additional 5.2 Mt of food-related packaging (Hogg et al., 2007; WRAP, 2008). It is estimated that this would generate at least 15 Mt of CO_2, mostly embedded energy and methane emissions from landfill (Hogg et al., 2007). For the retail sector there is a wide range of figures; the Cabinet Office (2008) recently reported 0.4 Mt of waste per year, while WRAP reported 1.5 Mt (WRAP, 2007) and Envirowise (2002) 12 mt. Reported figures for food manufacturers also present a wide range going from 3.5 Mt (WRAP, 2007) to 6.6 Mt (Cabinet Office, 2008). These ranges appear to indicate that waste data for food manufacturing and retail is based on rough estimates and are likely to have a high degree of error.
The waste problem is not exclusive to the UK; it has been acknowledged that the European food system produces an enormous amount of waste from both packaging and food (Ethical Corporation, 2006) and it has been estimated that approximately 25% of material that is introduced into the supply chain is wasted (C-Tech Innovation, 2004; Green and Johnston, 2004). Charities such as FareShare have estimated that up to 25% of the food sent to landfill by the food manufacturing and retail industries is either edible or could be turned into compost or energy (Green and Johnston, 2004). It is thought that this could feed more than 250,000 people which has provided a raison d'être and growth for these charities.
Waste can be divided into avoidable and unavoidable streams when items of food cannot be processed further into by-products or co-products. Unavoidable waste mostly comprises inedible parts of raw food, for example, fruit and vegetable produce with inedible skin/peel will cause waste if it is to be prepared into a 'ready to eat fresh-cut product'. There is scope for further study into the causes, limitations and usage of the unavoidable waste created by production and manufacture of certain foodstuffs. For example, the UK poultry industry produces 150,000 tonnes of feathers every year, which costs the industry around £3 million in landfill charges per annum (C-Tech Innovation, 2004).
The overall cost of waste is often undervalued (Binyon, 2007) since many of the costs associated to dealing with waste are "hidden costs". It follows that an item wasted at a later stage in the supply chain has had more production, transportation, energy use and additional costs attributed to it, therefore the higher the embedded waste value of that item. Raising awareness of these hidden costs could be a catalyst for resolving the problem as business will start to realise the scale of the problem and its impact on the bottom line.

2.1 Consumer trends and their impact on waste

The UK food and drink supply chain is a complex network of organisations that is continuously adapting to satisfy changing customer demands. This involves identifying new trends in customer demands, such as increasing emphasis on healthy eating or concern for ethical issues and then introducing new products or adapting existing products to satisfy customers. In this way consumers play a key role in shaping the structure of the food supply chain.
Table I presents consumption data on the main food and drink categories between 2004 and 2008. It shows that the largest categories in terms of expenditure are meat, bread and cereals and vegetables. However, the fastest growing categories are oils and fats (62%), fish (52%) and fruits (40%), while the two largest categories, meat (21%) and cereals (27%), are growing at below average (31%) rates. This has implications for the supply chain since two of the fastest growing categories tend to have short shelf-life and require temperature-controlled supply chains; factors which could be affecting overall levels of waste, both at the household and across the supply chain.
There are a number of economic, demographic and social trends that affect the consumer and as a result, the industry as a whole. Some of these trends are briefly described below:

- **Economic trends:** After a decade of favourable economic climate the situation started to deteriorate in 2006. On the supply side, prices for many agricultural commodities have increased substantially since 2006 as a result of increasing demand from Asian countries, higher energy costs, poor harvests and certain policies, such as support for the use of bio-fuels (Cabinet Office, 2008). This has led to an increase of 6.9% in the basket of food in the Retail Price Index (RPI) between April 2007 and April 2008 (Defra, 2008). On the demand side other economic factors are being experienced, such as the credit crisis, a reduction in consumer confidence and a general economic slowdown which could lead to a recession.

  The food industry is comparatively less sensitive to variations in income, and the share of food in total spending tends to increase during times of economic slowdown. However, it is possible that consumers will trade-down to cheaper alternatives. This has been popularised by the "Aldi effect", referring to the German discount retailer which has seen its sales increase by 21% in recent months, whilst other retailers have reacted by expanding their range of own brand products (Lyons 2008). Another possible consequence of the economic downturn could be that customers try to throw less food away and shop smarter by avoiding unnecessary purchases.

Table I: UK Consumer Expenditure on Food by Sector at Current Prices (£M at rsp) 2004-2008

	2004	2005	2006	2007	2008	Change 04-08
Bread and cereals	9480	9815	10124	10571	12081	27%
Meat	13597	13622	13867	14859	16459	21%
Fish	2290	2488	2726	3260	3471	52%
Milk, cheese & eggs	8006	8415	8675	9280	10455	31%
Oils and Fats	1216	1256	1333	1563	1969	62%
Fruits	4824	5311	5703	6416	6769	40%
Vegetables	8413	8824	9143	10344	11280	34%
Sugar & Sweet products	7245	7349	7434	8945	10104	39%
Food products n.e.c.	1596	1610	1622	1887	2202	38%
Non-alcoholic beverages	8163	8497	8783	10019	10203	25%
Total food and non-alcoholic beverages	**64830**	**67187**	**69410**	**77144**	**84993**	**31%**

rsp — retail selling prices
Source: Consumer Trends Q4 2008, National Statistics website
NB. tobacco and alcoholic beverages are excluded from the study

- **Population structure**: The UK population is growing slowly and it is expected that between 2007 and 2012 it will increase by about 1 million (Mintel, 2007). However, the structure of the population will continue to change. Some of the most significant changes are the decrease in the number of children, the increase in the group between 15-24 and rapid increases for the groups of over-45 and over-65 (Mintel, 2007). Associated with these trends are the reduction in household size and the increasing number of people living alone (Mintel, 2007). These trends are likely to affect demand patterns for food products, such as an increase demand for fresh, local and premium products and a decrease in large packs sizes (Mintel, 2007).
- **Changes in lifestyle**: Other social trends are affecting the demand for food and drink and we have identified two that are particularly relevant to this project.
  - Healthy eating: Consumers are becoming more health conscious increasing the demand for products with lower fat, calories or salt, as well organic produce. This has been reflected in the increasing demand for fruit and vegetables (Cabinet Office, 2008). This trend affects the entire supply chain and companies have to address these issues in order to remain competitive. Similarly it could have an impact on waste, as fruit and vegetables tend to have a shorter shelf-life. There has, however, been a reduction in demand for organic produce in recent months owing to the current economic climate.
  - The ethical consumer: consumers are increasingly concerned about ethical issues, such as fair trade, animal welfare, support for local farmers and impact on the environment which encompasses a number of issues, such as climate change, waste, pollution, pesticides and "food miles" (Cabinet Office, 2008; Mintel, 2007). A recent survey on attitudes towards grocery shopping indicates that waste related issues, such as packaging waste, carrier bags, recycling are considered important by consumers. However, there appears to be a gap between what people do and what they say (Cabinet Office, 2008).

3. Methodology

The food supply chain covers a wide range of products with different characteristics, such as shelf-life, temperature regime and demand variability and the research methodology selected should be able to cater for this diversity. Furthermore, the project required the analysis of quantitative data, to estimate the magnitude of the problem, and qualitative data to understand the causes and potential solutions. This context calls for a research methodology that can study contemporary events from different perspectives and is adaptable to many different situations.

Based on the objectives of the project and on the characteristics of the food sector, it was decided to use a multiple case-study research design. In this instance the unit of analysis is a product or product category flowing between a manufacturer and a retailer. This focus allows an understanding of the issues emerging between the two parties and, more importantly, can lead to solutions that are acceptable to both.

In the original research design we aimed to conduct 16 cases covering a range of product types across different temperature regimes: frozen (3), chilled (5), ambient short shelf-life (5), ambient long shelf-life (3). This approach allowed the research team to understand the factors affecting different types of food chains. The actual number of cases conducted was 20 although the balance of cases shifted slightly during the process. As the cases were conducted it became apparent that the biggest issues in terms of waste appear in products that have short shelf-life and are often chilled. For this reason it was decided to increase the number of cases in chilled from 5 to 10 and decrease the number of cases in frozen from 3 to 2. The number of cases for ambient products was

conducted as planned. Table II presents the comparison of actual and planned cases by product category. For confidentiality reasons it was decided to maintain the names of companies and products anonymous.

Table II: Case Studies (Planned vs. Actual)

	Cold Chain		Ambient	
	Frozen	**Chilled**	**Short shelf-life**	**Long shelf-life**
Planned	3	5	5	3
Actual	2	10	5	3
Examples	Ice-cream, frozen veg.	Meats, dairy, drinks, sandwiches	Fruit and vegetables	Confectionery, canned & bottled product, oil

3.1 Data collection

The case studies involved three forms of data collection: (1) semi-structured interviews, to understand the issues and causes of waste; (2) company records, to estimate the amount of waste; and (3) process observation, to understand the physical and information processes in the chain. The interviews and observations aimed to collect quantitative and qualitative data which would help to define the magnitude of the problem and identify its causes. It must be noted that it was not possible to conduct all three forms of data collection for all cases. In 17 of the cases it was possible to use at least two of these methods. Data for the remaining three cases was collected through a workshop in which three producers of fruits and vegetables discussed the issues collectively and completed a questionnaire based on the same questionnaire used for the semi-structured interviews. The data was validated via e-mail and publicly available information about these companies was sourced from the internet.

The main data collection method was semi-structured interviews; each interview lasted around 1 hour and was conducted by two members of the research team. One member of the team was responsible for asking the questions while the other one would take notes. These notes would be agreed by both members of the team and then sent to the interviewee for validation. Most of the interviews were conducted face to face, although on two occasions it was necessary to conduct them over the phone due to the long distances involved.

Interviews were conducted with managers responsible for waste in their respective organisation. In some organisations there was no specific waste management role and in these cases we interviewed managers with supply chain responsibilities.

The interview protocol was developed in three stages. A first draft was prepared by one of the researchers; this draft was reviewed by all members of the team and adapted based on their feedback. The second draft was piloted in the first two cases, after which it was decided to include only one additional question (the final interview protocol is included in the appendices). The interview questionnaire covered four key areas:

- Contact details and demographic: covering details about the company and the product under review.
- Quantitative waste data: specific data concerning waste volumes and percentages
- Causes of waste and good practices: discussion on the main areas of waste
- Destination of waste: discussion of how waste is managed

From the beginning of the project it became evident that waste information was considered as sensitive by many organisations. For this reason a confidentiality agreement was offered to all participating companies. Many of them decided to sign this agreement, but some were satisfied with a verbal agreement that data would be treated confidentially. Likewise, some of the companies participating in the study were willing to provide us with quantitative data about the levels of waste in their organisations, while others preferred to focus on the qualitative elements of the research (causes of waste and good practices) without revealing specific waste figures.

To ensure the data collected were an accurate reflection of what was discussed during the interview, a case study report would be sent to the companies involved a few days after the interview. The companies then verified the accuracy of the data and often included additional data that were missing during the interview process.

Observations and company records were used as secondary methods of data collection and were applied selectively according to the situation. In some companies it was difficult to have a complete observation of the process since this was distributed across different sites. Waste records were requested during the interview, however, some companies did not have waste records or were unwilling to provide them.

3.2 Data analysis

The focus of the project was on the causes and best practices around waste management which are best suited to qualitative data analysis approaches. Initially case studies were analysed independently; data for each of them were coded and put into a standard case-study template. Following the single case analysis, key information ware extracted to produce tables to facilitate cross-case comparison. Then these data ware analysed in three ways:

- Analysis of waste by product types: products were grouped by temperature control in order to analyse the key issues for each product grouping.
- Analysis of root causes: a method using current reality trees (CRTs) was used to analyse the complex set of causal connections leading to waste.
- Analysis of good practices: this was done by focusing on the promising practices documented in each of the cases and trying to identify patterns across the cases.

The aim of the project was not to produce a statistical analysis of waste in the sector and for this reason statistical tools were not applied.

4. Analysis

4.1 Case Studies

Initially the case studies were analysed independently looking at causes of waste and best practices. For brevity, it was decided to omit the individual case studies from this report and to focus on the cross-case analysis, which was used to investigate the similarities and differences across cases, highlighting key information extracted from the individual case reports and presented in tables for ease of comparison. Products were classified by temperature regimes: frozen (table III), chilled (tables IV and V) and ambient (tables VI and VII). For ease of reference, the case studies have also been numbered and coded according to temperature regime, using F for frozen products, C for chilled and A for ambient.

Table III: Frozen Product case studies

	F1	F2
Product category	Vegetables	Ice cream
Temperature regime	Frozen	Frozen
Focus	Retail	Retailer – supplier
Shelf-life	6 months +	18 months
Lead-time	Day 1 for day 3	Day 1 for day 3 in RDC, day 4 in store
Demand variability	Stable with some seasonality	Highly seasonal / Weather dependent
Stock	7 days depot 7 days store	7 days in store Stockless depot
Waste	0.12% Very Low	Very low
Main causes of waste	- Damage (packaging) - Failure in refrigeration (rare but high impact)	- Inaccurate promotional forecast - Human error (inventory) - Failure in refrigeration equipment (rare but high impact) - Recalls (rare but high impact)
Good practices	- Clarity of responsibilities - Performance measurement - Forecasting and replenishment software - Orders place automatically by adjusted re-order point system - Sales visibility to all suppliers - Reducing waste to landfill	- Clear responsibilities for waste management - Clear promotional planning process (not always followed) - Clear process for shelf management (not always followed) - Continuous replenishment related to till sales. - Product with short shelf-life left sold through other channels
Destination of waste	Landfill (aim to reduce to zero)	- Landfill - Retailer has trial with Fareshare

Table IV: Chilled products case studies

	C1	C2	C3	C4	C5
Product category	Milk	Vegetables (bagged salad)	Red meat	Margarine	Sandwiches (pre-packed)
Temperature regime	Chilled	Chilled	Chilled	Chilled	Chilled
Focus	Retail	Supplier – Retail	Retail – producer	Retailer – supplier	Retailer
Shelf-life	3 days (average in retail)	3 days	7 days	8 weeks	2 days
Lead-time	Day 1 for day 3	Variable (seasonality)	Day 1 for day 2 in store	D1 for D3 in RDC, D4 in store	Day 1 for day 3 (store)
Demand variability	Stable / predictable	Seasonal (summer uplift)	Irregular	Stable	Irregular (seasonal and weather a)
Stock	1.5 days at depot 1.5 days at store		1 day	7 days in store - stockless depot 3 days at supplier	1 day
Waste	0.1 % (Very Low)	High – Very high	Low	Low	7% (Very high)
Main causes of waste	- Damage (poor handling)	- Unpredictable demand - Inaccurate forecasting - Retailers service level requirements (over stock) - Promotions - Rejected deliveries (quality) - Packaging design changes - Seasonality of supply (longer transport in winter)	- Product out of shelf-life	- Inaccurate promotional forecasts - Poor stock rotation (shelf) - Failure in refrigeration equipment (rare but high impact) - Recalls (rare but high impact)	- Irregular demand - Inflated orders to make shelves look full - Poor stock rotation (shelf) - Failure in refrigeration equipment
Good practices	- Clarity of responsibilities - Performance measurement - Forecasting and replenishment software - Orders place automatically by adjusted re-order point system - Sales visibility to all suppliers - Reducing waste to landfill		- Butcher in store helps to preserve the product for longer - Shorten lead times (vertical integration) - Visibility of promotions (vertical integration) - Availability sacrificed in promotions - Forecasting influenced by historic data, seasonal events and weather. - Ordering managed centrally but store managers can flex - Culture of waste reduction	- Product with short shelf-life left sold through other channels - Clear responsibilities for waste management - Clear promotional planning process (not always followed) - Clear process for shelf management (not always followed) - Continuous replenishment related to till sales. - Product with short shelf-life sold through other channels that mainstream retailers	- Forecasts are manually adjusted to account for regional variations - Promotions run constantly so don't affect waste - Change packaging from plastic to cardboard to increase recycling (although cardboard is less durable) - Clear responsibility for waste
Destination of waste	Landfill (aim to reduce to zero)	Landfill	- Landfill - Trials on anaerobic digestion	- Recycle secondary packaging - Landfill - Retailer has trial with Fareshare	- Local arrangements with charities to collect unsold product - Mainly goes to landfill

Table V: Chilled products case studies (continued)

	C6	C7	C8	C9	C10
Product category	Cooked poultry (organic)	Cooked poultry	Fruit drinks	Milk (own brand)	Fresh meat
Temperature regime	Chilled	Chilled	Chilled	Chilled	Chilled
Focus	Producer	Producer	Producer	Producer (single retailer)	Producer
Shelf-life	10 days	26 days	20-40 days	12 days	8-9 days
Lead-time	Same day for orders before 2.00; else day 1 for day 2	Same day for orders before 2.00; else day 1 for day 2	12 to 36 hrs	2 days from farm to depot 2 days to store	Day 1 for delivery to store on day 2
Demand variability	Irregular (low volume; weather)	Irregular (Promotion; weather)	High	Stable (some seasonality)	Variable (seasonal and weather)
Stock	1.5 days	2.5 days	8-10 days	0.5 days	1.5 days
Waste	1.85 % (producer) Very low	0.38% (producer) Very low	3% in store; 1% in manufacture Intermediate	0.02% Very low	6-10% main retailers; 15-30% in convenience (High – Very High)
Main causes of waste	- Combination of poor forecast accuracy and short shelf-life - Low volume - Packaging changes and price changes can cause waste	- Combination of poor forecast accuracy and short shelf-life - Promotions planning with retailers (base demand is stable but promotions cause variability) - Packaging changes and price changes can cause waste	- Forecasting error - Promotional forecasting - Cannibalisation during promotions - Product damage	- Rejected deliveries - Poor stock rotation - Wrong date coding - Planning errors - Cannibalization (brand promotions slow down demand, but not major impact)	- Bad weather - Achieving a balance between OSA and waste - Differences in appearance (customer pick) - Volatility in small retailers - Occasional damage
Good practices	- Collaborative forecasting delivers more accurate forecast but is resource intensive (particularly for seasonal products) - Use of alternative routes to market, such as discounters and pet food producers for product with short remaining shelf-life	- Collaborative forecasting delivers more accurate forecast but is resource intensive (particularly for seasonal products) - Use of alternative routes to market, such as discounters and pet food producers for product with short remaining shelf-life	- Sharing of data and close collaboration with retailers - Pasteurisation technologies to increase product life. - Use of packaging to increase shelf-life. - Developing new forecasting model to reduce forecast error.	- No waste to landfill - Effective system leading to very low levels of waste.	- Clear responsibilities for waste - Partnership with retailers - Regular meetings with retailers - Use of implants with large retailers to reduce forecast error - Some promotions create less unpredictability (e.g. link deals) - Some retailers treat product better (e.g. handling, ergonomics, lighting, stock , temperature) - Looking at approaches to extend shelf-life
Destination of waste	- Packaging waste is recycled - General waste goes to landfill. - Products can be stripped to separate waste.	- Packaging waste is recycled - General waste goes to landfill. - Products can be stripped to separate waste.	- Damaged product goes to landfill - Planning to give away product with short shelf-life left.	- Animal feed, bio-gas and composting - Milk cannot be sent to landfill - Packaging is recycled - Durable tertiary packaging	

Table VI: Ambient product case studies

	A1	A2	A3	A4
Product category	Fruits and Vegetables (potatoes)	Fruits and Vegetables (raspberries)	Fruit and vegetables (general)	Pasta sauce
Temperature regime	Ambient	Ambient	Ambient	Ambient
Focus	Retail	Supplier – Retailer	Retail - producer	Retailer – supplier
Shelf-life	3-5 days	3 day	Product dependent (short)	9 months
Lead-time	Day 1 for day 2 in RDC day 3 in store	N/A	Day 1 for day 2 in store	Day 1 for day 3 in RDC, day 4 in store
Demand variability	Seasonal (winter uplift)	Seasonal supply and demand (summer uplift)	Irregular	Stable Seasonal variations
Stock	1.5 days in depot 1.5 days in store	N/A	1 day in store (average)	7 days in store 4-7 days in dept 14-28 days at supplier
Waste	Low	High – Very High	Low	Low
Main causes of waste	- Inaccurate forecasting - Insufficient shelf space available - Exceptionally poor handling	- Quality expectations (reject) - Weather effects on demand - Difficult to predict demand - Poor store handling	- Product damage - Difficulties in predicting demand accurately	- Inaccurate promotional forecast - Damage - Product handling - Recalls (rare but high impact)
Good practices	- Efficient handling (reduce order – delivery time) - Clarity of responsibilities - Performance measurement - forecasting and replenishment software - Orders place automatically by adjusted re-order point system - Sales visibility to all suppliers	- Train packers to select appropriate fruit. - Promotions used to manage waste (cope with seasonal fluctuations)	- Shorten lead times (through vertical integration) - Visibility of promotions (vertical integration) - Availability sacrificed in promotions - Forecasting influenced by historical data, seasonal events and weather. - Ordering managed centrally but store managers can flex - Experimenting with packaging to protect products - Culture of waste reduction	- Product with short shelf-life left sold through other channels - Clear responsibilities for waste management - Clear promotional planning process (not always followed) - Clear process for shelf management (not always followed) - Continuous replenishment related to till sales. - Product with short shelf-life sold through other channels that mainstream retailers
Destination of waste	Landfill (aim to reduce to zero)	Landfill	- Recycling or landfill - Trials on anaerobic digestion	- Landfill - Retailer has trial with Fareshare

Table VII: Ambient product case studies (Continued)

	A5	A6	A7	A8
Product category	Oils	Drinks	Fruits and Vegetables (peppers)	Fruits and Vegetables (citrus)
Temperature regime	Ambient	Ambient	Ambient	Ambient
Focus	Producer	Producer	Supplier - Retailer	Supplier
Shelf-life	12-18 months	75 days – 24 months	2 weeks	10 days (more dependent on cold chain)
Lead-time	3-4 days	From 1 to 3 days depending on customer	N/A	Same day
Demand variability	Stable (some seasonality and weather impacts)	Moderately stable (seasonality, marketing initiatives and weather)	Seasonal and weather dependent	Stable with 3 fold increase in Christmas
Stock	17 – 21 days	11 days	N/A	10 days southern hemisphere; 2 -3 days northern hemisphere
Waste	5-10%:-High – Very high	Very Low (most waste is packaging)	Intermediate	Around 5% Moderate - High
Main causes of waste	- Forecasting error; out of shelf-life - Damage (broken glass) - Quality issues (rejects)	- Some promotions can cause waste - Product can get damaged but not very significant	- Depot rejections: low quality product - Damage: handling and in-store damage by customer - Waste occurs when weather is poor and there is over availability of the product.	- Product quality issues like mould and disease - Incorrect temperature / humidity storage - Packaging / labelling errors
Good practices	- Visibility of retailer information (POS) and forecast, but need to pay for POS data! - Storage and in store displays can impact waste - Product with short shelf-life left can be sold to discounters, but not for own brand product. - The threat of penalties for not delivering on-time-in-full (OTIF) motivates to reduce forecast error.	- Product with short life left is discounted - Seasonality and weather fluctuations don't affect waste due to long shelf-life	- Use of forecasting software; use forecast from retailer - Demand management approach to reduce gaps in supply chain and inconsistencies in stock levels	- Promotions agreed with retailer help to reduce waste
Destination of waste	- Can be destroyed or reworked - Some returnable packaging	- Mainly recycle - 4.5% of all waste goes to landfill	- Landfill	28 % is land-filled Packaging is recycled

4.2 Causes of waste

A summary of all the products analysed in the case studies is presented in table VIII. The table indicates the main characteristics of each product, the level of waste and main causes of waste. Products are classified according to their level of waste, ranging from very-high (> 7%), high (5-7%), Medium (3-5%), Low (1-3%) and Very Low (< 1%).

Only one product, pre-packed red meat, was classified in the very high category and the main causes for waste include a variety of causes including short shelf-life, weather, availability and damage. Four products were categorised in the range between high - very high. These products tend to suffer from similar issues, such as forecasting, promotions, weather effects and damage. The products with high and medium levels of waste have a mix of chilled and ambient products, all of them with short shelf-lives. The products with low and very low levels of waste include a mix of products, several have medium to long shelf-lives, however others, such as milk and cooked poultry have short shelf lives and require chilling.

Table VIII shows that although a variety of reasons are mentioned as main causes of waste, there are many commonalities across the different products, with reasons, such as short shelf-life, unpredictable demand, poor forecasting and weather effects appearing in many of the products. This appears to indicate that many of the root causes might be common across products.

Table VIII: Main causes of waste

Products	Product Characteristics	Waste	Main Causes of Waste
Fresh red meat (pre-packed)	Chilled, Short shelf-life	V High	Bad weather, shelf-life, balance between availability and waste, differences in appearance, volatility in small retailers, occasional damage
Sandwiches	Chilled; very short shelf-life	High – V High	Planning and forecasting, variability of demand and shelf-life
Vegetables (bagged salads)	Chilled, very short shelf-life	High – V High	Unpredictable demand / forecasting, shelf-life, service level requirements, promotions, rejected deliveries (quality), packaging design changes, seasonality of supply (longer transport in winter)
Fresh fruit (raspberries)	Chilled + Ambient; short shelf-life	High – V high	Quality expectations (reject), weather effects on demand, demand predictability, handling
Oils	Ambient, long shelf-life	High – V high	Forecasting error, damage (broken glass), poor quality i
Fresh fruits (citrus)	Ambient, short shelf-life	High	Poor quality, incorrect storage, packaging and labelling issues
Fresh veg (peppers)	Ambient, short shelf-life	Med	Poor quality, handling and storage, weather fluctuations
Fruit drinks	Chilled; short-long shelf-life	Med	Forecasting, promotions (cannibalization) shelf-life, product damage
Fresh Veg. (general)	Ambient; short-medium shelf-life	Low	Product damage, difficulties in predicting demand accurately
Potatoes	Ambient; short shelf-life, seasonality	Low	Handling, shelf-life, inaccurate forecasting
Margarine	Chilled; medium shelf-life	Low	Temperature control, shelf-life, promotions, stock rotation
Cooked poultry	Chilled; short shelf-life; promotional, low volume	Low	Promotions planning, temperature control, shelf-life, demand variability
Cooked poultry (organic)	Chilled; short shelf-life, high value	V Low	Promotions planning, temperature control, shelf-life,
Milk	Chilled; short shelf live; low demand variability	V Low	Temperature abuse
Milk (own brand)	Chilled; short shelf live; low demand variability	V Low	Poor stock rotation, wrong date coding, planning errors, promo cannibalization
Beverages	Ambient; long shelf-life	V Low	Poor inventory management, promotions
Past Sauce	Long life; fragile packaging	V. Low	Handling
Ice Cream	Frozen; long life, variable demand	V Low	Temperature control, handling
Frozen vegetable	Frozen; long shelf-life	V Low	Temperature control, handling
Fresh Veg. (general)	Ambient; short-medium shelf-life	Low	Product damage, difficulties in predicting demand accurately

Figure 1 presents a diagram comparing the waste ranges against the shelf-life of the products in the study. It is clear that the majority of products with high and very-high waste are products with short shelf-lives. Similarly the majority of products with long shelf-lives, such as ice cream, pasta sauces and beverages tend to have very low levels of waste. The only exception is the case of oils, which indicate a high level of waste despite their long shelf-life. This case study reveals other causes of waste, such as poor handling, poor inventory management and the effects of storage conditions on the appearance of the product.

It is important to note that not all products with short shelf-lives have high levels of waste, several products such as milk, cooked poultry and potatoes have low to very low levels of waste. These products however, have relatively stable demand patterns throughout the year, as they are not substantially affected by factors, like seasonality, weather and promotions. This is an important finding because it shows that the causes are not independent.

It is not surprising that shelf-life appears as a dominant cause of waste, as it determines the window in which the products can be sold to the customer. However, it is important to point out that management practices have a limited impact on the shelf-life of products. Packaging technologies and cold chains can help to extend the shelf-life of products, but the main factor affecting shelf-live is the nature of the products.

Figure 1: Waste vs. shelf-life

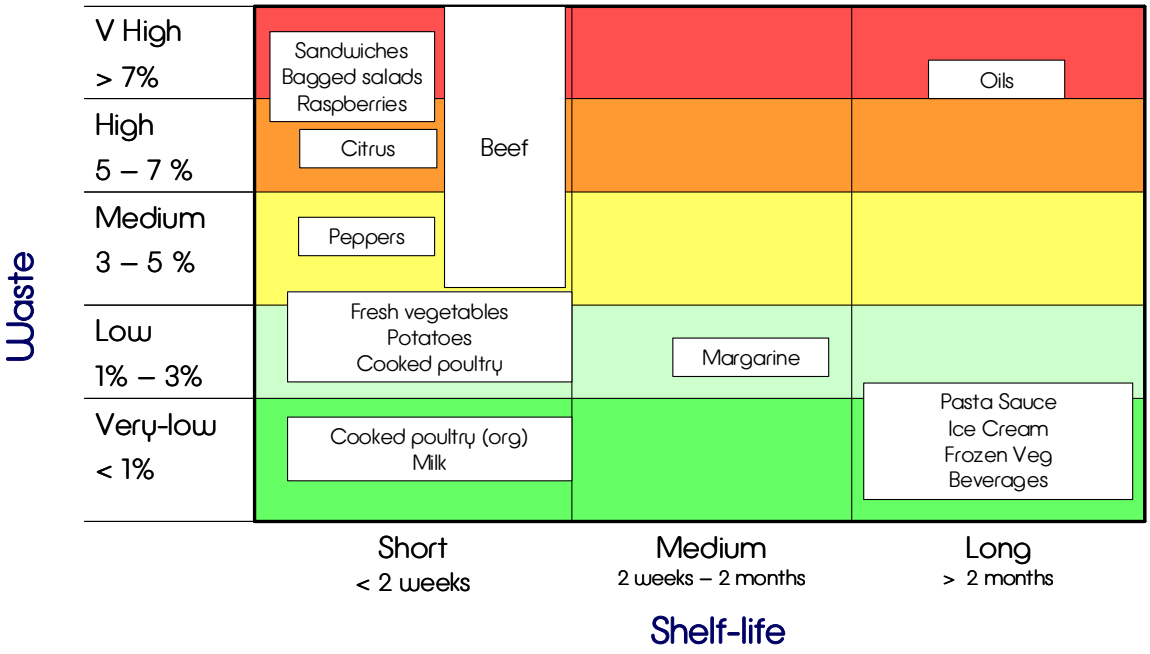
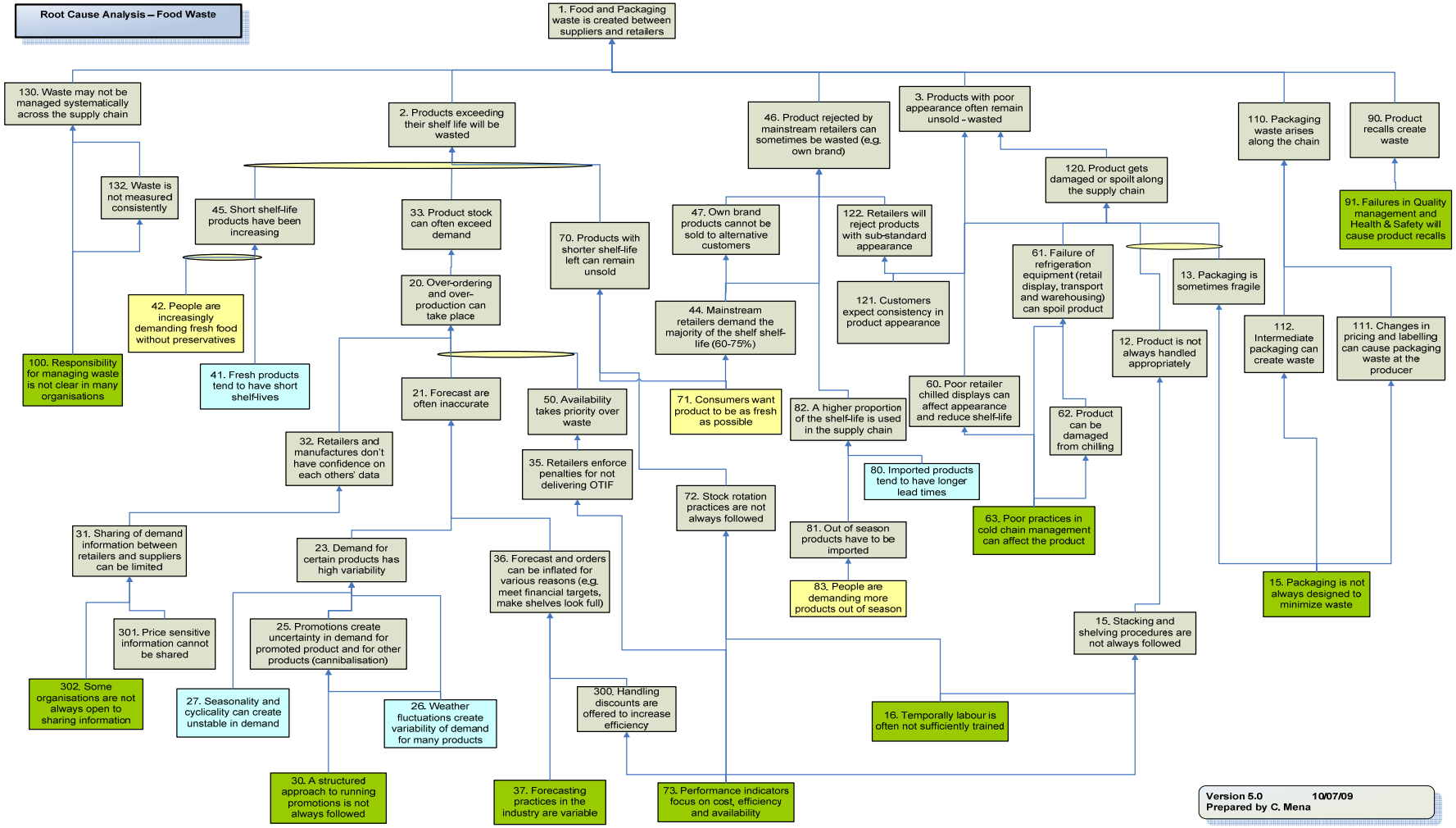


Figure 1 also shows a wide range of waste levels found for the two beef cases. This indicates that different practices in the management of the supply chain for different products can have a substantial impact on waste. In the case with the lower levels of waste, it was found that there was a high level of vertical integration in the chain and that the meat was butchered in the store. On the other hand, in the case with high levels of waste, it was found that large retailers were better at managing waste while small convenience stores had the highest levels of waste. These issues indicate management factors can also have a substantial impact.

4.2.1 Mapping the root-causes of waste

The initial analysis into the causes of waste revealed thee important issues: that many causes are common across products, that causes are interdependent and that some of the causes are not the result of management practices, such as short-shelf lives and weather fluctuations. These issues motivated us to perform further analysis which could help us understand the complexity of the problem and identify the root causes. For this reason, we decided to use a tool that maps the logic between causes and effects creating a tree where at the top you have the symptoms and at the bottom the root causes. Figure 2 presents the root causes map; at the top of the tree we find the creation of waste between retailers and suppliers and at the bottom we find the root causes of waste.

Figure 2: Root causes map



The root-cause map in figure 2 classifies root-causes of waste into three groups:

a) Mega-trends (yellow boxes): these are industry trends that affect the problem of waste, such as increasing demand for fresh products (71), and products out of season (83), as well as a move away from products with preservatives (42). These are important factors affecting the waste problem, but the impact that company strategies and processes have on them is limited.

b) Natural constraints (blue boxes): these are factors that influence waste, but that are associated with the nature of the products or process. Issues like short shelf-life of fresh products (41), seasonality of supply and demand (27), weather fluctuations (26) and longer lead-times for imported products (80) are among these factors.

c) Management root-causes (dark green boxes): these are factors affecting waste on which management practices have a direct impact. We believe these are the root-causes that are worth exploring in detail, since it is by changing these issues that organisations will be able to reduce waste. Each of these causes is discussed in more detail below:

- **Waste management responsibilities (100):** While some companies have very clear roles and responsibilities for managing waste, others do not have a specific role with in the company focusing on waste. This usually means that waste is not measured and managed systematically and this situation is likely to lead to increased waste.

- **Information sharing (302):** Accurate and timely information is essential for good planning and forecasting. When information is limited, variations between forecast and orders can increase and this could lead to waste. Furthermore, variations caused by poor information sharing can amplify across the supply chain. This amplification is a commonly known phenomenon known as the bullwhip effect (Lee, et al. 1997a,b)

  While some companies are effective at sharing information with their supply chain partners other are not. For instance, it was found that some retailers would charge for point of sale (POS) data, while others would give it away free. Poor practices in terms of information sharing can not only create waste but undermine the confidence in the information provided.

- **Promotions Management (30):** Promotions are an important strategy for driving footfall and sales, however, they can create more unpredictable demand patterns, not only for the products being promoted but also for other products due to cannibalisation. Higher unpredictability can in turn lead to over production and waste, particularly for products with short shelf-life. The research revealed that different promotion mechanics and practices can influence how much variability is created and that having clear processes for managing promotions and following them is critical.

  Promotions can also increase household waste as customers might buy unusually large quantities of product. This “forward buying” can lead to waste, particularly when product shelf-life is short.

- **Forecasting (37):** Poor forecasting was one of the most common issues identified during the interviews as a cause of waste. However, estimating the demand for a product is a complex and inherently inaccurate task which can be affected by many factors, such as weather, seasonality, marketing campaigns, product launches, promotions and special occasions like Christmas and Easter.

  The research showed that a variety of forecasting practices exist in the industry, with some companies using a scientific approach while others use more informal methods. Improving forecasting practices can reduce forecast error, however, it has to be recognised that uncertainty will continue to exist and that forecast error cannot be eliminated.

- **Performance measurement (73):** The emphasis in the industry appears to be on cost, efficiency and availability. Although waste has an impact on all of these factors, it is not usually a key performance measure and it can be sacrificed at the expense of other performance indicators. For instance most mainstream retailers have policies of only accepting product with a high proportion of shelf-life remaining (usually over 70%). This is particularly problematic for own label producers who are unable to sell the product through other channels, such as discount retailers.

- **Packaging (15):** Packaging can affect waste in two different ways. On the one hand, it has a positive impact on waste because it protects the products from damage and can help to extend the shelf-life of some products. On the other hand, packaging will at some point go to waste, either in the supply chain or at the point of consumption, so excessive packaging is to be avoided. From a waste point of view, the decisions of how much packaging and what kind of packaging to use are critical. Another related issue involves changes to packaging and labelling for marketing reasons which can cause packing waste, because packaging is usually bought in large quantities, well in advance of production.

- **Cold chain management (63):** Cold chains can help to maintaining certain products in good state and avoid spoilage. Cold chain abuse, cause by equipment failure or poor processes, will inevitably cause waste. The research revealed that failure in maintaining the cold chain can have a severe impact on waste, but these situations are relatively rare.

- **Training (16):** The research revealed that in some cases people do not follow procedures for stacking, shelving and stock rotation, all of which can lead to waste. This issue appears to be more prevalent during the Christmas period when temporary labour is hired to cope with high demand.
- **Quality management (91):** Quality issues can lead to rejections and even product recalls. Rejects in particular appear to be prevalent in the fruits and vegetables sector where product quality can be variable, particularly at the beginning and end of seasons. While quality issues can lead to waste, the loss of product quality appears to be more important to the companies than the waste created.

  Product recalls are relatively rare events. However, when they occur they are likely to generate large amounts of waste, particularly for products with long shelf-life since they are likely to have more stock in the pipeline.

4.3 Good practices

The research revealed that certain companies were better at dealing with the root causes of waste than others. Although it is not possible to claim we have identified best practices, we can highlight "good practices" which are currently being used to reduce waste in the food and retail industries. Each of the good practices identified are briefly described below.

- **Accountability and Culture:** It was found that having clear responsibilities for waste management at different levels (corporate, facility, process) is a starting point for creating a culture of waste reduction. Companies with clear responsibilities tend to have a robust performance measurement system for waste and this is usually linked to targets and in some cases incentives. Measuring waste performance helps to ensure that processes get managed from a waste perspective and supports other efforts such a training and investment aimed at reducing waste.
- **Collaborative Activities:** The research revealed that efforts such as Collaborative Planning Forecasting and Replenishment (CPFR), vendor managed or co-managed inventory (VMI/CMI), sharing of sales data and the use of "implants" working at the customer's facilities can have a significant impact in reducing forecasting error and consequently on waste. Nevertheless, some companies admitted that this kind of activities also require high investments in time and money.
- **Forecasting:** The use of forecasting techniques and software in the industry is variable; while some companies put great emphasis on using sophisticated statistical methods, others follow a relatively informal approach. Good practices in terms of forecasting, such as the use of dedicated software and the associated statistical techniques, can help reduce forecasting error, helping to reduce waste and improve availability**.**
- **Promotions:** It was found that promotions can cause more variability in demand leading to waste, particularly for products with short shelf-life, however some promotions can also prevent waste by moving product swiftly when there is a glut. While most companies have clear processes for managing promotions, it was found that some are much better at following these processes than others. Good practices in promotions management included clear processes that are followed rigorously, joint analysis of promotions throughout their lifecycle and good understanding of the impact of different promotions mechanics on waste and availability.
- **Process efficiency and effectiveness:** Efforts to reduce lead-times with approaches such as direct deliveries are cross-docking are examples of process management that can reduce waste and increase home life. Furthermore effective stock rotation and stock information management have also shown to reduce waste along the supply chain. Finally, it was found that poor product handling can have an impact on waste, although interviewers claimed most retailers have gradually improved handling of delicate products.
- **Cold chain management:** The case studies revealed that some organisations are better at maintaining the integrity of the cold chain, partly through better and more regular maintenance of refrigeration equipment and partly through technologies that allow them to monitor the temperature along the chain.
- **Packaging:** Packaging helps to protect the product and in some cases extend its shelf-life, reducing waste as a result. Good practices in primary packaging are around managing this trade-off between volume of packaging and protection to the product. In some cases it was found that the extension of shelf-life, made possible by packaging technologies, allowed companies to change their entire supply chain strategy. In terms of secondary and tertiary packaging, we found good practices in the use of trays and other re-usable units help to reduce waste.
- **Reduce, Reuse, Recycle:** The research revealed that good companies follow the hierarchy of waste approach to minimise waste. Firstly, they try to reduce waste levels by applying many of the approaches mentioned above. In order to avoid waste, many companies "reuse" the product with limited shelf-life left by using other routes to market, such as discounters or wholesalers, even charities. Some organisations also find alternative uses for the product, such as animal feed, composting and energy generation. Recycling, was also used by a number of organisations involved in the study, particularly for packaging materials, such as cardboard and some plastics. However, recycling requires product separation and only a few organisations in the study had the right equipment and personnel to separate the product.

5. Conclusions and recommendations

The research indicates that average waste generated between suppliers and retailers ranges between 0.1% and 10%. Out of the 20 cases, ten had waste figures below 3% and only one had figures exceeding 7%. However, we found that in extreme cases, during short periods, waste for some products can be as high as 30%. Nevertheless, it is possible to conclude that waste levels between food manufacturers and retailers are considerably lower to those reported by WRAP (2008) on household waste which amount to about 30% of all purchases (although about 20% of avoidable food waste).

The majority of products with high and very-high waste have short shelf-life (less than two weeks), such as meat, fruits and vegetables. Similarly the majority of products with long shelf-lives (more than two months), such as ice cream, pasta sauces and beverages tend to have very-low levels of waste. However, it is important to note that not all products with short shelf-lives have high levels of waste, several products, such as milk, cooked poultry and potatoes have levels of waste lower than 3%. These products however, have relatively stable demand patterns throughout the year, as they are not substantially affected by factors like seasonality, weather and promotions. This is an important finding because it shows that the causes are dependent; it is not short shelf-life or the demand variability that cause the waste, but the combination of the two. This makes it impossible to attribute specific figures of waste to either of these causes.

The analysis of root-causes helped to identify three groups of issues affecting waste: (1) Mega-trends, which are consumer and industry factors that affect waste, for example increasing demand for fresh products; (2) Natural constraints, which are factors associated with the nature of the products that can affect waste such as shelf-life and (3) Management root-causes which are factors affecting waste on which management practices have a direct impact. Nine management root-causes were identified: waste management responsibilities, information sharing, promotions management, forecasting, performance measurement, packaging, cold chain management, quality management and training.

The identification of root-causes of waste and good practices in the industry was used to produce a series of recommendations which can help organisations improve the way they manage waste. These recommendations are outlined below:

- **Ensure there is accountability for waste**: Clear accountability is a prerequisite for managing waste. Organizations that have a person responsible for waste management tend to have a much better understanding of the scale and causes of the waste problem. This understanding is a first step for reducing waste.
- **Promote a culture of waste reduction:** The case studies revealed that some organisations promoted a culture of waste reduction and this culture was driving all other activities in the organisation, such as training, performance measurement and incentives.
- **Embark in collaborative activities:** Poor information sharing and lack of trust among supply chain partners can lead to waste. The case studies showed that some retailers are open to sharing information with their suppliers and in some cases they can even have employees form the supplier (implant) working on site, so that they can be in close communications. This kind of practices have proved to be effective in reducing forecasting error and hence waste, however, they can also expensive since they demand considerable resources from both suppliers and retailers.
- **Analyse promotions more closely and consider the impact on waste**: Poor promotional practices can create waste when sales do not achieve the expected demand, particularly in the case of products with short shelf-life. Understanding the impact of different promotion mechanics and working together using collaborative approaches can help to minimise the negative impact of promotions. In some cases, promotions can event help to reduce waste by helping to move product that otherwise would not reach the consumer.
- **Be more analytical about forecasting**: Although forecasts will never be perfectly accurate it is possible to reduce forecast error by using statistical techniques supported by information systems. From the case studies it appears that some retailers have an analytic approach to forecasting while others rely on more informal approaches. Given the impact that accurate forecasting can have on availability and waste, investing in forecasting methods appears to be a fruitful strategy.
- **Manage process efficiently and effectively**: The way processes are managed can affect waste at all stages in the chain, including the home. This involves efforts to reduce lead-times to increase product home life and discipline to ensure products are not damaged along the chain and that stock rotation is managed appropriately. Furthermore, it can also include efforts to extend shelf-life through improvements in technology and understanding of the microbiological, biochemical and physical changes that occur to a product through the supply chain and how these can be mitigated against or at least minimised/delayed.
- **Maintain the cold chain**: Interruptions to the cold chain can be caused by a failure in refrigeration equipment at any stage of the chain or by poor process management. Investments in both equipment

maintenance and process management to reduce cold chain abuse can be paid back through reductions in waste, although this needs to be quantified.

- **Consider the natural characteristics of the product:** Some products, particularly fresh fruits and vegetables, are subject to natural variability and retailers and producers should to make allowances for variations during the season in order to reduce waste. For example, the use of flexible data code management to reflect seasons and state of product would have a direct impact on waste.
- **Use packaging effectively:** Packaging plays a dual role in terms of waste; on the one hand it protects the product from damage and can help to extend its shelf-life, having a positive effect on waste. On the other, the amount of packaging on a product has a direct impact on household waste and to some degree on waste generated at other stages in the chain. Organisations need to look closely at packaging and decide what the right balance for each product is.
- **Reduce, Reuse, Recycle**: A number of alternatives exist to divert waste to landfill. Many organisations look for alternative markets, such as discounters, wholesalers, charities, animal feed, composting and energy generation. Recycling, particularly for packaging materials, is now a common practice for many. Using these alternatives not only compensates for some of the losses of not selling the product at full price, but also reduces waste to landfill.

Waste reduction should be a priority for organisations in the food industry, not only because waste represents an economic loss for the companies involved, but also because it has an environmental impact. Nevertheless, there are some areas where other organisations, such as universities, government and NGOs can support through further research and dissemination. These are:

- **To support data collection on waste:** many organisations do not collect waste data systematically and others are not willing to share this data openly. An alternative would be for an external organisation to establish a system for regular waste measurement across the UK. This would allow the analysis of national and regional trends as well as making possible the use of targets. At a company level, having national statistics on food waste could be used as a benchmark to promote continuous improvement. Current projects by WRAP on baseline data and resource maps could be a starting point for the continuous monitoring of food waste across the supply chain.
- **To promote discussion and dissemination:** organisations like WRAP and Envirowise are making great efforts raise awareness about waste and to identify and promote good practices in waste management. Nevertheless, this research shows that awareness about the impact of waste is still limited.
- **To support technology transfer:** As discussed in this report, many areas such as cold chain technologies, process management, packaging technologies and anaerobic digestion can be developed and improved. Technology transfer programmes, supported by research councils, government departments and universities are already in place, and our research suggest this kind of programmes should continue.
- **To support approaches to incentivise alternatives to landfill**: Sending food to landfill is costly from an economic and from an environmental perspective. Many alternatives to landfill exist, from the use charities such as Fareshare through the generation of energy from waste, however for many companies the incentives for using these alternatives are not sufficient. The impact of different approaches to disincentivise the use of landfill, such as the use of taxation and bans on landfill, should be research further.

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References to published material

9. This section should be used to record links (hypertext links where possible) or references to other published material generated by, or relating to this project.

No material has been published yet. However we intend to publish the results in academic journals such as the British Food Journal and the International Journal of Physical Distribution and Logistics Management. Furthermore, the results of the project will be disseminated through both Cranfield and IGD's websites.