ED50254 Issue 7

The Validity of Food Miles as an Indicator of Sustainable Development

Final Report produced for DEFRA

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Executive Summary

Study Objectives

Over the last fifty years, there have been dramatic changes in the food production and supply chain in the UK. The most striking changes have been:

- Globalisation of the food industry, with an increase in food trade (imports and exports) and wider sourcing of food within the UK and overseas;
- Concentration of the food supply base into fewer, larger suppliers, partly to meet demand for bulk year-round supply of uniform produce;
- Major changes in delivery patterns with most goods now routed through supermarket regional distribution centres, and a trend towards use of larger Heavy Goods Vehicles (HGVs);
- Centralisation and concentration of sales in supermarkets, with a switch from frequent food shopping (on foot) at small local shops to weekly shopping by car at large out of town supermarkets.

These trends have led to a large increase in the distance food travels from the farm to consumer, known as "food miles". Indeed, since 1978, the annual amount of food moved in the UK by HGVs has increased by 23%, and the average distance for each trip has increased by over 50%.

The rise in food miles has led to increases in the environmental, social and economic burdens associated with transport. These include carbon dioxide emissions, air pollution, congestion, accidents and noise. There is a clear cause and effect relationship for food miles for these burdens – and in general higher levels of vehicle activity lead to larger impacts. Growing concern over these impacts has led to a debate on whether to try to measure and reduce food miles.

Against this background, DEFRA have commissioned this study to assess whether a practical and reliable indicator based on food miles can be developed, and whether this would be a valid indicator of progress towards the objectives of the government's Sustainable Farming and Food Strategy and the proposed Food Industry Sustainability Strategy. The study has undertaken four key tasks:

1. To compile a **food miles dataset** covering the supply chain from farmer (both UK and overseas) to consumer for 1992, 1997 and 2002.
2. To assess the **main trends** leading to increases in food miles around the UK and overseas.
3. To identify and quantify the **economic, environmental and social impacts** of food miles.
4. To develop a **set of key indicators** which relate food miles to their main impacts on sustainability.

The main criteria for the validity of a progress indicator based on food transport include:

- It should be based on easily available statistics which are updated annually;
- Any data gaps can be filled with reasonable estimates;

- It should be possible to structure a food miles indicator so that the indicator is directly correlated with food transport (and the associated negative externalities) and any exceptions can be dealt with;

- The indicator should have strong links to the aims and outcomes of the proposed Food Industry Sustainability strategy, such that progress towards the aims of the strategy will have a noticeable effect on food transport km (and levels of negative externalities);

- The indicator will have a reasonably quick response to policy measures;

- It will be accepted as a valid indicator by all stakeholders;

- It is consistent with the other indicators for the Food Industry Sustainability strategy.

Study Findings

The four key findings of the study are summarised below.

1. **A single indicator based on total food kilometres is an inadequate indicator of sustainability**. The impacts of food transport are complex, and involve many trade-offs between different factors. A single indicator based on total food kilometres travelled would not be a valid indicator of sustainability. To capture the complexities of the issue, we recommend **a suite of indicators** which reflect the key adverse impacts of food transport (see below).

2. **Data is available to provide and update a meaningful set of indicators on an annual basis**. A spreadsheet system for collating the data and calculating the indicators accompanies the report. The key transport stages (HGV and LGV transport in the UK, car shopping trips for food and international sea and air freight) are covered by good quality DfT and HM Customs and Excise statistics gathered annually. Areas where the data quality is poor are either of less policy interest to DEFRA (road transport overseas), or currently have a negligible role in UK food transport (rail, inland waterway). A summary of the data sources and quality is provided in Table E2.

3. **Food transport has significant and growing impacts.** Food transport accounted for an estimated 30 billion vehicle kilometres in 2002, of which 82% are in the UK. Road transport accounts for most of the vehicle kilometres, split between cars, HGVs and LGVs (see figure E1).

    - Food transport accounts for **25% of all HGV vehicle kilometres in the UK**.

    - Food transport produced **19 million tonnes of carbon dioxide** in 2002, of which 10 million tonnes were emitted in the UK (almost all from road transport), representing 1.8% of the total annual UK CO_2 emissions, and 8.7% of the total emissions of the UK road sector.

    - **Transport of food by air has the highest CO_2 emissions per tonne, and is the fastest growing mode.** Although air freight of food accounts for only 1% of food tonne kilometres and 0.1% of vehicle kilometres, it produces 11% of the food transport CO_2 equivalent emissions (see figure E2).

4. **The direct environmental, social and economic costs of food transport are over £9 billion each year, and are dominated by congestion.** Using standard government methodology, the social cost of congestion, associated with

food transport is estimated at £5 billion. This is over 50% of the social costs associated with food transport, and arises from the use of HGVs, LGVs, and cars are associated with food transport in the UK. Accidents lead to social costs of £2 billion per year (Table E1). Greenhouse gas emissions, air pollution, noise, and infrastructure cost a further £2 billion. The total costs are very significant compared with the gross value added of the agriculture sector (£6.4 billion), and the food and drink manufacturing sector (£19.8 billion) in 2002. It should be noted that these cost estimates depend on the assumptions and methodology used. For example, the congestion costs are marginal costs, as the impact of an extra kilometre travelled depends on the existing level of traffic. The use of average costs, although not recommended, would give lower values. Also, the costs reflect only immediate impacts. For congestion, these impacts are short term and reversible, whereas climate change impacts are long term and irreversible. It should be stressed that not all impacts are included in this assessment (for example noise, infrastructure and congestion costs from air transport are not quantified).

Figure E1. UK food vehicle-kilometres by transport mode (2002)

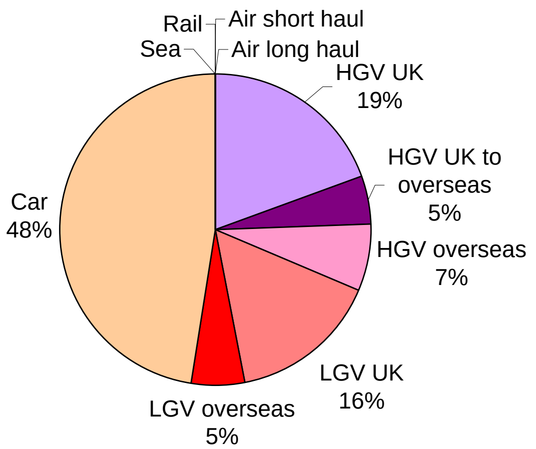

Figure E2. CO_2 emissions associated with UK food transport (2002)

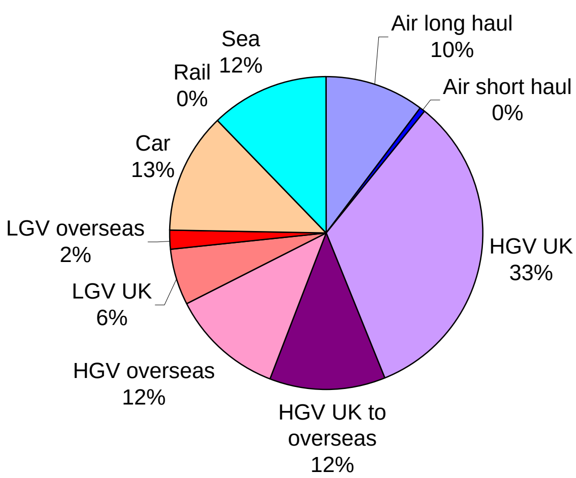

Table E1: Social cost estimates for UK-generated food transport (2002)

£M	CO_2	Air quality	Noise	Congestion	Accidents	Infrastructure	Total costs
UK HGV	120	165	123	1359	327	387	2480
UK LGV	21	48	27	1056	148	4	1303
UK car	46	24	42	2576	965	9	3662
UK to overseas road	43	54	39	52	115	141	443
Overseas HGV	42	58	43	90	304	272	809
Overseas LGV	7	18	9	54	147	3	239
Rail	0	15	0	0	0	0	16
Deep sea	43	32	0	0	26	nq	106
Short sea	3	22	0	0	3	nq	32
Air long haul	38	1	nq	nq	nq	nq	39
Air short haul	2	0	nq	nq	nq	nq	2
Total	**364**	**439**	**283**	**5187**	**2036**	**815**	**9123**

nq=not quantified

Table E2: Summary of data sources, assumptions and data quality for food transport dataset components

Data component	Data sources and assumptions	Data quality	Estimated % of CO_2 emissions	Estimated % of vehicle km	Timing of data
UK HGV	Annual Continuing Survey of Road Goods Transport (CSRGT) from DfT – data compiled from monthly surveys of thousands of transport operators.	Good. Can disaggregate food types but not imports and exports.	33%	19%	May
UK LGV	DfT survey of private and company van use (2004).	Good.	6%	16%	August
UK car	Annual DfT survey of personal travel. Car travel for food shopping is identified separately.	Vehicle km well defined. Urban/rural split for food shopping not available – the split for all car travel purposes is used.	13%	48%	September
UK sea, rail, inland waterway, air	DfT statistics available for total UK sea and rail freight, but not split out by food transport.	Little data which separates out food from other freight, but insignificant	Very low	Very low	N/a
International air	HM C&E database for non-EU countries. Assumed insignificant for EU countries – expert opinion is that most food commodities from the EU travel by road or ship (cheaper and just as fast).	Good for non-EU countries. Not available for EU countries but thought to be insignificant.	11%	0.1%	March
International HGV	HM C&E database gives total tonne km for road and sea. Split between road and sea depends on assumptions.	Good for total tonne-km. Assumptions for split between road and sea are reasonably well informed.	12%	5%	March
International sea	HM C&E database gives total tonne km for road and sea. Split between road and sea depends on assumptions.	Good for total tonne-km. Assumptions for split between road and sea are reasonably well informed.	12%	0.04%	March
International rail, inland waterway	Not available.	Not available but thought to be insignificant.	Low?	Low?	N/a
Overseas HGV	Estimate based on country size and handling factor	Poor. May be an underestimate, but of less policy interest to DEFRA.	12%	7%	N/a
Overseas LGV	Estimate based on overseas HGV estimate and ratio of HGV to LGV food transport in the UK.	Poor, but of less policy interest to DEFRA.	2%	5%	N/a
Overseas rail, air, inland waterway	Not available.	Not thought to be very significant.	Very low?	Very low?	N/a

How to measure food miles: complexities and trade-offs

The relationship of food transport to overall sustainability is complex. We have established that the transport of food has significant direct environmental, economic and social impacts. Therefore, in like for like systems, where food supply chains are identical except for transport distance, reducing food transport will improve sustainability. However, differences between food supply systems often involve trade-offs between various environmental, social and economic effects. These must be taken into account when designing an indicator to measure the impacts of food transport, and when formulating associated policies. Some of the main issues are summarised below.

1. **Transport mode.** The impacts of food transport are highly dependent on the transport mode. Air transport has a very high climate change impact per tonne carried, whereas sea transport is relatively efficient. Transport by HGV accounts for most of the infrastructure (road maintenance), noise and air pollution costs, yet shopping for food by car accounts for a high proportion of the congestion and accident impacts. For this reason, we propose a set of key indicators which focus on the main direct impacts of food transport, taking account of transport mode, rather than a single aggregate indicator of total food miles (see below).

2. **Transport efficiency.** There is a trade-off between transport distance, vehicle size and transport efficiency. The current dominant system of food supply in the UK involves large HGVs travelling long distances between suppliers and shops via centralised distribution centres. However, this system enables very efficient loading of vehicles, which reduces the impacts per tonne of food. More local sourcing can greatly reduce the distance travelled by food, but the reduction in transport impacts may be offset to some extent by the use of smaller vehicles or lower load factors. We recommend further research into this issue.

3. **Differences in food production systems**. The impact of food transport can be offset to some extent if food imported to an area has been produced more sustainably than the food available locally. For example, a case study showed that it can be more sustainable (at least in energy efficiency terms) to import tomatoes from Spain than to produce them in heated greenhouses in the UK outside the summer months. Another case study showed that it can be more sustainable to import organic food into the UK than to grow non-organic food in the UK. However, this was only true if the food was imported by sea, or for very short distances by road. Finally we considered whether there could be a net energy saving from centralised mass-production of food (ready meals) compared to home cooking. On the whole, we found that any exceptions related to food production systems did not relate to a significant proportion of food transport, and were also often covered by other indicators and policies (e.g. the DEFRA targets for increasing UK supply of organic produce, and government policies to increase the energy efficiency of UK food production).

4. **Wider economic and social costs and benefits.** The term “food miles” has come to signify more than the transport of food and the direct physical impacts of this transport. A number of other economic and social issues are bound up in the food miles debate. Firstly, issues surrounding the international trade of food are part of the debate on globalisation. It is clear that transport and trade of food has the potential to lead to economic and social benefits, for example through economic gains for both developed and developing nations, reduced prices for consumers and increased consumer choice. However, the realisation of these benefits depends on a number of complex political, social and economic factors, such as global trade rules and trends in commodity markets. At the individual

level, food trade and the consolidation of food supply chains can lead to both winners and losers. Secondly, there are issues related to UK agriculture and rural communities. Food miles are often discussed in the context of decreasing farm gate prices, the disappearance of local shops and detrimental effects on rural economies and farming communities in the UK.

Our analysis indicates that the wider environmental, social and economic effects associated with different food supply chains are complex and very system specific. Consideration of these effects does not lead to a clear case for a move to either higher or lower food miles systems. What is clear is that the complex trade-offs between different social, environmental and economic costs and benefits cannot be evaluated, and policies cannot be formulated, unless food miles and their impacts are monitored and measured. It is also clear that policies directed at reducing food transport should consider these wider effects, and be integrated with policies and initiatives in other key areas, such as rural development, trade, international development, agriculture, transport and environment. A correctly structured food miles indicator would allow continuous analysis of the trade-off between different environmental, social and economic factors.

Key Indicators and Trends

Based on an analysis of the key impacts of food transport, the most important trends, and the complexities and trade-offs involved, we propose a set of four "key indicators" (Table E3). These indicators focus on the direct impacts of food transport, such as congestion, accidents and pollution. Wider economic and social issues such as local sourcing of food are not addressed directly by this indicator set.

Table E3. Key indicators.

Indicator	Notes
Urban food km in the UK, split by car, LGV, HGV.	Urban food km account for most of the accident and congestion costs. The impact of air pollution is also much higher in urban areas. At present, this indicator relies on the assumption that the urban/rural travel ratio is the same for food transport as for all other transport. An alternative proxy for congestion and accident costs would be car food km.
HGV food km	This covers HGV transport both in the UK and overseas. HGV transport is responsible for the majority of infrastructure, noise and air pollution costs.
Air food km	Air freight of food is rapidly growing and has a higher environmental impact than any other transport mode.
Total CO_2 emissions from food transport	Emissions of CO_2 from the transport sector are highly significant and are growing. This indicator includes estimated CO_2 from transport fuel use both in the UK and other countries. Currently excludes CO_2 and other greenhouse gas emissions from refrigeration during transport, although it would be desirable to include this in future.

In addition to the four headline indicators above, we also identified other areas where supplementary indicators are desirable, to capture some of the complexities and trade-offs discussed above. However, for most of these areas, related indicators or policies already exist as part of other government strategies. For example, the UK share of the organic food market is covered in DEFRA's action plan for organic food and farming, live animal transport is covered by the animal health and welfare strategy, and ethical trading is an indicator in the food industry sustainability strategy.

Table E4 compares the four key indicators and some supplementary indicators (including exports) for 1992, 1997 and 2002. The data shows that:

- **Urban food vehicle km** are estimated to have increased by 27% since 1992, due largely an increase in shopping for food by car. This has been driven by an increase in car ownership together with changes in shopping patterns (from frequent visits to local shops towards weekly visits to large out-of-town supermarkets).

- **HGV food tonne km have increased dramatically in the UK, but this has not been accompanied by an increase in HGV food vehicle km because of efficiency improvements.** HGV tonne kms have increased by 36% since 1991 and by over 100% since 1974. This is due to concentration of food sales in supermarkets, concentration of the food supply base, and associated changes in food delivery patterns. However, this rise in tonne kilometres has been partially offset by a switch to larger vehicles and improvement in load factors, resulting in a proportionally lower increase in vehicle km. HGV food vehicle km increased by 8% between 1992 and 1998, but then declined by 7% to 2002, giving a net increase of only 1% from 1992 to 2002. It is not clear how long this trend can be sustained. When opportunities for further improvements in load factor are fully exploited, HGV food vehicle km could begin to rise again if there are continuing increases in food movements.

- **Overseas HGV transport associated with UK food supply has declined slightly since 1992**. This is due to a recent trend to increase food trade with nearer EU countries (France, the Netherlands and Ireland) at the expense of Spain, Italy and Greece, which has decreased HGV vehicle km for the international stage of transport. However, as the overall level of food imports have increased, the road transport associated with food production *within* overseas countries has increased steadily (although there is a high uncertainty in these estimates), partially offsetting this trend. We estimate that overseas HGV transport associated with UK food supply has decreased by 8% overall since 1992. Future changes in food sourcing, perhaps due to EU enlargement for example, could reverse this trend.

- **Air freight has increased by 140% since 1992,** although it still accounts for only 0.1% of total vehicle km. However, it now accounts for 11% of CO_2 –equivalent emissions. The increase in air freight is largely due to increased globalisation of food supply, together with a relative decrease in the real cost of air freight compared to other transport modes.

- **CO_2 emissions from food transport increased by 12% from 1992 to 2002**. In contrast, air pollutant emissions (e.g. PM_{10}, NO_X) have decreased over this period, despite the increase in overall vehicle kilometres, because of the introduction of European emission standards for road vehicles.

Use of the indicator set

It is envisaged that the indicator set would be updated yearly, following publication of the key underlying datasets (HM Customs and Excise data and the DfT CSRGT surveys for HGVs and LGVs).

Because of the complex relationship between food transport and sustainability, great care must be exercised in interpreting any changes observed in the indicators or in the setting of any associated targets. It will be important to establish the underlying causes and statistical significance of such changes and to consider all the economic, social and environmental implications before drawing conclusions or formulating policy responses.

Again we emphasise that this indicator set focuses on the direct adverse impacts of food transport: congestion, pollution and accidents. It is not designed to directly measure wider economic and social impacts, or to detect trends such as changes in food sourcing and food retailing, although policy initiatives in these areas may well have detectable impacts on the indicators.

Study Conclusions and Research Priorities

Food transport has been increasing steadily over the last few decades. This has direct negative impacts on sustainability (congestion, accidents, road maintenance costs, greenhouse gas emissions, noise and air pollution), and these impacts are significant at a national level. Many of these impacts are not included in existing indicator sets (e.g. international air and shipping).

Food miles have a complex relationship to sustainability, and there can be trade-offs between environmental, social and economic factors. For this reason, a single indicator based on total food miles is not appropriate. A correctly structured indicator will enable the key impacts of food transport to be targeted, and allow appropriate policies to be formulated to ensure that a balance is maintained between economic, social and environmental sustainability.

Adequate data exists to compile an annual food transport indicator. The proposed indicator suite is consistent with the approach and objectives of DEFRA's Sustainable Farming and Food Strategy and the proposed Food Industry Sustainability Strategy.

Several recommendations for further work have been identified:

Dataset improvements

1. Improvement of the estimates of urban food transport (currently food transport cannot be distinguished from other transport on urban / rural roads);
2. Improved estimates of load factors for international air and sea transport;
3. Improved estimates of the burden arising from SO_2 and NO_x emissions from shipping;
4. Improvement of estimates of overseas transport using national datasets from other countries if available;
5. Inclusion of estimated CO_2 and other emissions associated with refrigeration during transport;
6. Possible identification of indicators on a regional basis.

Validity of indicator

7. Further assessment of the statistical validity of the indicator (e.g. confidence limits for the four main headline indicators);
8. Further investigation of the wider social and economic impacts of a reduction in food transport;
9. Research into the change in transport efficiency or energy efficiency which might result from a switch towards more locally produced food, (including the investigation of the potential for increases in local delivery traffic), and measures to improve this efficiency.

Policies

10. A study of potential policies to reduce the impacts of food transport.

Table E4: Trends in Key Indicators 1992-2002 (Headline indicators in bold)

Including exports		**Total**			**In UK**			**Overseas**		
		1992	**1997**	**2002**	**1992**	**1997**	**2002**	**1992**	**1997**	**2002**
Total tonne kilometres	billion tonne km	203	222	234	39	49	50	164	173	183
Total vehicle kilometres	billion vehicle km	27	29	30	21	23	25	5.7	5.5	5.3
Urban road food km	million vehicle km				9,847	11,015	11,778			
Car	*million vehicle km*				*5,178*	*6,108*	*6,975*			
LGV	*million vehicle km*				*2,974*	*2,974*	*2,974*			
HGV	*million vehicle km*				*1,696*	*1,932*	*1,828*			
HGV food km	million vehicle km	9,325	10,026	9,425	5,391	6,145	5,812	3,933	3,881	3,613
	million tonne km	*62,745*	*75,270*	*76,871*	*36,278*	*46,131*	*47,400*	*26,467*	*29,139*	*29,471*
Air food km	million vehicle km	11	22	27	0	0	0	11	22	27
Total CO_2 emissions	million tonnes	16.9	18.7	19.1	8.9	9.9	9.7	7.9	8.7	9.2
Total PM_{10} emissions	thousand tonnes	9.5	7.3	5.3	5.6	4.1	2.5	3.8	3.1	2.8
Total NO_x emissions	thousand tonnes	206	201	158	105	102	72	101	98	85
Total SO_2 emissions	thousand tonnes	51	42	41	8.81	2.51	0.25	43	40	41
Live animal food km	million tonne km				870	884	764	NK	NK	NK
Imports of indigenous foods	million tonnes				13.55	14.20	16.15			
Retail sales of ethically traded foods	million £				0	13	63			
% of indigenous organic food grown in the UK	%				NK	NK	62%			

NK=Not known

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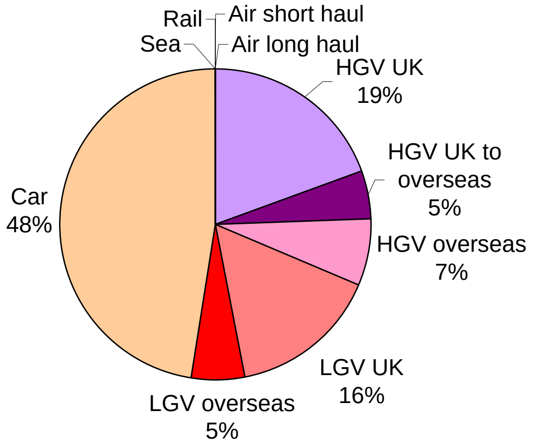

Figure E2. CO_2 emissions associated with UK food transport (2002)

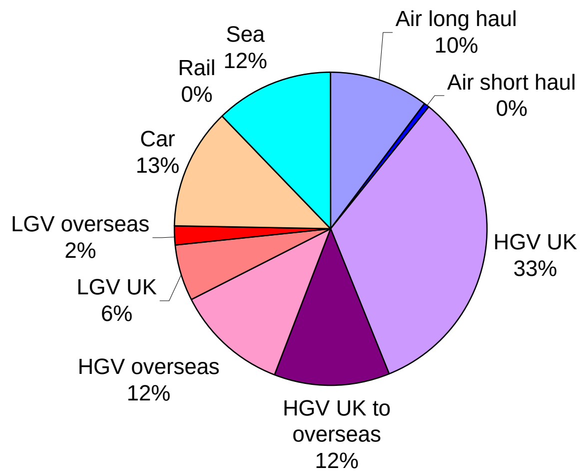

Table E1: Social cost estimates for UK-generated food transport (2002)

£M	CO_2	Air quality	Noise	Congestion	Accidents	Infrastructure	Total costs
UK HGV	120	165	123	1359	327	387	2480
UK LGV	21	48	27	1056	148	4	1303
UK car	46	24	42	2576	965	9	3662
UK to overseas road	43	54	39	52	115	141	443
Overseas HGV	42	58	43	90	304	272	809
Overseas LGV	7	18	9	54	147	3	239
Rail	0	15	0	0	0	0	16
Deep sea	43	32	0	0	26	nq	106
Short sea	3	22	0	0	3	nq	32
Air long haul	38	1	nq	nq	nq	nq	39
Air short haul	2	0	nq	nq	nq	nq	2
Total	**364**	**439**	**283**	**5187**	**2036**	**815**	**9123**

nq=not quantified

Table E2: Summary of data sources, assumptions and data quality for food transport dataset components

Data component	Data sources and assumptions	Data quality	Estimated % of CO_2 emissions	Estimated % of vehicle km	Timing of data
UK HGV	Annual Continuing Survey of Road Goods Transport (CSRGT) from DfT – data compiled from monthly surveys of thousands of transport operators.	Good. Can disaggregate food types but not imports and exports.	33%	19%	May
UK LGV	DfT survey of private and company van use (2004).	Good.	6%	16%	August
UK car	Annual DfT survey of personal travel. Car travel for food shopping is identified separately.	Vehicle km well defined. Urban/rural split for food shopping not available – the split for all car travel purposes is used.	13%	48%	September
UK sea, rail, inland waterway, air	DfT statistics available for total UK sea and rail freight, but not split out by food transport.	Little data which separates out food from other freight, but insignificant	Very low	Very low	N/a
International air	HM C&E database for non-EU countries. Assumed insignificant for EU countries – expert opinion is that most food commodities from the EU travel by road or ship (cheaper and just as fast).	Good for non-EU countries. Not available for EU countries but thought to be insignificant.	11%	0.1%	March
International HGV	HM C&E database gives total tonne km for road and sea. Split between road and sea depends on assumptions.	Good for total tonne-km. Assumptions for split between road and sea are reasonably well informed.	12%	5%	March
International sea	HM C&E database gives total tonne km for road and sea. Split between road and sea depends on assumptions.	Good for total tonne-km. Assumptions for split between road and sea are reasonably well informed.	12%	0.04%	March
International rail, inland waterway	Not available.	Not available but thought to be insignificant.	Low?	Low?	N/a
Overseas HGV	Estimate based on country size and handling factor	Poor. May be an underestimate, but of less policy interest to DEFRA.	12%	7%	N/a
Overseas LGV	Estimate based on overseas HGV estimate and ratio of HGV to LGV food transport in the UK.	Poor, but of less policy interest to DEFRA.	2%	5%	N/a
Overseas rail, air, inland waterway	Not available.	Not thought to be very significant.	Very low?	Very low?	N/a

How to measure food miles: complexities and trade-offs

The relationship of food transport to overall sustainability is complex. We have established that the transport of food has significant direct environmental, economic and social impacts. Therefore, in like for like systems, where food supply chains are identical except for transport distance, reducing food transport will improve sustainability. However, differences between food supply systems often involve trade-offs between various environmental, social and economic effects. These must be taken into account when designing an indicator to measure the impacts of food transport, and when formulating associated policies. Some of the main issues are summarised below.

1. **Transport mode.** The impacts of food transport are highly dependent on the transport mode. Air transport has a very high climate change impact per tonne carried, whereas sea transport is relatively efficient. Transport by HGV accounts for most of the infrastructure (road maintenance), noise and air pollution costs, yet shopping for food by car accounts for a high proportion of the congestion and accident impacts. For this reason, we propose a set of key indicators which focus on the main direct impacts of food transport, taking account of transport mode, rather than a single aggregate indicator of total food miles (see below).

2. **Transport efficiency.** There is a trade-off between transport distance, vehicle size and transport efficiency. The current dominant system of food supply in the UK involves large HGVs travelling long distances between suppliers and shops via centralised distribution centres. However, this system enables very efficient loading of vehicles, which reduces the impacts per tonne of food. More local sourcing can greatly reduce the distance travelled by food, but the reduction in transport impacts may be offset to some extent by the use of smaller vehicles or lower load factors. We recommend further research into this issue.

3. **Differences in food production systems**. The impact of food transport can be offset to some extent if food imported to an area has been produced more sustainably than the food available locally. For example, a case study showed that it can be more sustainable (at least in energy efficiency terms) to import tomatoes from Spain than to produce them in heated greenhouses in the UK outside the summer months. Another case study showed that it can be more sustainable to import organic food into the UK than to grow non-organic food in the UK. However, this was only true if the food was imported by sea, or for very short distances by road. Finally we considered whether there could be a net energy saving from centralised mass-production of food (ready meals) compared to home cooking. On the whole, we found that any exceptions related to food production systems did not relate to a significant proportion of food transport, and were also often covered by other indicators and policies (e.g. the DEFRA targets for increasing UK supply of organic produce, and government policies to increase the energy efficiency of UK food production).

4. **Wider economic and social costs and benefits.** The term “food miles” has come to signify more than the transport of food and the direct physical impacts of this transport. A number of other economic and social issues are bound up in the food miles debate. Firstly, issues surrounding the international trade of food are part of the debate on globalisation. It is clear that transport and trade of food has the potential to lead to economic and social benefits, for example through economic gains for both developed and developing nations, reduced prices for consumers and increased consumer choice. However, the realisation of these benefits depends on a number of complex political, social and economic factors, such as global trade rules and trends in commodity markets. At the individual

level, food trade and the consolidation of food supply chains can lead to both winners and losers. Secondly, there are issues related to UK agriculture and rural communities. Food miles are often discussed in the context of decreasing farm gate prices, the disappearance of local shops and detrimental effects on rural economies and farming communities in the UK.

Our analysis indicates that the wider environmental, social and economic effects associated with different food supply chains are complex and very system specific. Consideration of these effects does not lead to a clear case for a move to either higher or lower food miles systems. What is clear is that the complex trade-offs between different social, environmental and economic costs and benefits cannot be evaluated, and policies cannot be formulated, unless food miles and their impacts are monitored and measured. It is also clear that policies directed at reducing food transport should consider these wider effects, and be integrated with policies and initiatives in other key areas, such as rural development, trade, international development, agriculture, transport and environment. A correctly structured food miles indicator would allow continuous analysis of the trade-off between different environmental, social and economic factors.

Key Indicators and Trends

Based on an analysis of the key impacts of food transport, the most important trends, and the complexities and trade-offs involved, we propose a set of four "key indicators" (Table E3). These indicators focus on the direct impacts of food transport, such as congestion, accidents and pollution. Wider economic and social issues such as local sourcing of food are not addressed directly by this indicator set.

Table E3. Key indicators.

Indicator	Notes
Urban food km in the UK, split by car, LGV, HGV.	Urban food km account for most of the accident and congestion costs. The impact of air pollution is also much higher in urban areas. At present, this indicator relies on the assumption that the urban/rural travel ratio is the same for food transport as for all other transport. An alternative proxy for congestion and accident costs would be car food km.
HGV food km	This covers HGV transport both in the UK and overseas. HGV transport is responsible for the majority of infrastructure, noise and air pollution costs.
Air food km	Air freight of food is rapidly growing and has a higher environmental impact than any other transport mode.
Total CO_2 emissions from food transport	Emissions of CO_2 from the transport sector are highly significant and are growing. This indicator includes estimated CO_2 from transport fuel use both in the UK and other countries. Currently excludes CO_2 and other greenhouse gas emissions from refrigeration during transport, although it would be desirable to include this in future.

In addition to the four headline indicators above, we also identified other areas where supplementary indicators are desirable, to capture some of the complexities and trade-offs discussed above. However, for most of these areas, related indicators or policies already exist as part of other government strategies. For example, the UK share of the organic food market is covered in DEFRA's action plan for organic food and farming, live animal transport is covered by the animal health and welfare strategy, and ethical trading is an indicator in the food industry sustainability strategy.

Table E4 compares the four key indicators and some supplementary indicators (including exports) for 1992, 1997 and 2002. The data shows that:

- **Urban food vehicle km** are estimated to have increased by 27% since 1992, due largely an increase in shopping for food by car. This has been driven by an increase in car ownership together with changes in shopping patterns (from frequent visits to local shops towards weekly visits to large out-of-town supermarkets).

- **HGV food tonne km have increased dramatically in the UK, but this has not been accompanied by an increase in HGV food vehicle km because of efficiency improvements.** HGV tonne kms have increased by 36% since 1991 and by over 100% since 1974. This is due to concentration of food sales in supermarkets, concentration of the food supply base, and associated changes in food delivery patterns. However, this rise in tonne kilometres has been partially offset by a switch to larger vehicles and improvement in load factors, resulting in a proportionally lower increase in vehicle km. HGV food vehicle km increased by 8% between 1992 and 1998, but then declined by 7% to 2002, giving a net increase of only 1% from 1992 to 2002. It is not clear how long this trend can be sustained. When opportunities for further improvements in load factor are fully exploited, HGV food vehicle km could begin to rise again if there are continuing increases in food movements.

- **Overseas HGV transport associated with UK food supply has declined slightly since 1992**. This is due to a recent trend to increase food trade with nearer EU countries (France, the Netherlands and Ireland) at the expense of Spain, Italy and Greece, which has decreased HGV vehicle km for the international stage of transport. However, as the overall level of food imports have increased, the road transport associated with food production *within* overseas countries has increased steadily (although there is a high uncertainty in these estimates), partially offsetting this trend. We estimate that overseas HGV transport associated with UK food supply has decreased by 8% overall since 1992. Future changes in food sourcing, perhaps due to EU enlargement for example, could reverse this trend.

- **Air freight has increased by 140% since 1992,** although it still accounts for only 0.1% of total vehicle km. However, it now accounts for 11% of CO_2 –equivalent emissions. The increase in air freight is largely due to increased globalisation of food supply, together with a relative decrease in the real cost of air freight compared to other transport modes.

- **CO_2 emissions from food transport increased by 12% from 1992 to 2002**. In contrast, air pollutant emissions (e.g. PM_{10}, NO_X) have decreased over this period, despite the increase in overall vehicle kilometres, because of the introduction of European emission standards for road vehicles.

Use of the indicator set

It is envisaged that the indicator set would be updated yearly, following publication of the key underlying datasets (HM Customs and Excise data and the DfT CSRGT surveys for HGVs and LGVs).

Because of the complex relationship between food transport and sustainability, great care must be exercised in interpreting any changes observed in the indicators or in the setting of any associated targets. It will be important to establish the underlying causes and statistical significance of such changes and to consider all the economic, social and environmental implications before drawing conclusions or formulating policy responses.

Again we emphasise that this indicator set focuses on the direct adverse impacts of food transport: congestion, pollution and accidents. It is not designed to directly measure wider economic and social impacts, or to detect trends such as changes in food sourcing and food retailing, although policy initiatives in these areas may well have detectable impacts on the indicators.

Study Conclusions and Research Priorities

Food transport has been increasing steadily over the last few decades. This has direct negative impacts on sustainability (congestion, accidents, road maintenance costs, greenhouse gas emissions, noise and air pollution), and these impacts are significant at a national level. Many of these impacts are not included in existing indicator sets (e.g. international air and shipping).

Food miles have a complex relationship to sustainability, and there can be trade-offs between environmental, social and economic factors. For this reason, a single indicator based on total food miles is not appropriate. A correctly structured indicator will enable the key impacts of food transport to be targeted, and allow appropriate policies to be formulated to ensure that a balance is maintained between economic, social and environmental sustainability.

Adequate data exists to compile an annual food transport indicator. The proposed indicator suite is consistent with the approach and objectives of DEFRA's Sustainable Farming and Food Strategy and the proposed Food Industry Sustainability Strategy.

Several recommendations for further work have been identified:

Dataset improvements

1. Improvement of the estimates of urban food transport (currently food transport cannot be distinguished from other transport on urban / rural roads);
2. Improved estimates of load factors for international air and sea transport;
3. Improved estimates of the burden arising from SO_2 and NO_x emissions from shipping;
4. Improvement of estimates of overseas transport using national datasets from other countries if available;
5. Inclusion of estimated CO_2 and other emissions associated with refrigeration during transport;
6. Possible identification of indicators on a regional basis.

Validity of indicator

7. Further assessment of the statistical validity of the indicator (e.g. confidence limits for the four main headline indicators);
8. Further investigation of the wider social and economic impacts of a reduction in food transport;
9. Research into the change in transport efficiency or energy efficiency which might result from a switch towards more locally produced food, (including the investigation of the potential for increases in local delivery traffic), and measures to improve this efficiency.

Policies

10. A study of potential policies to reduce the impacts of food transport.

Table E4: Trends in Key Indicators 1992-2002 (Headline indicators in bold)

Including exports		**Total**			**In UK**			**Overseas**		
		1992	**1997**	**2002**	**1992**	**1997**	**2002**	**1992**	**1997**	**2002**
Total tonne kilometres	billion tonne km	203	222	234	39	49	50	164	173	183
Total vehicle kilometres	billion vehicle km	27	29	30	21	23	25	5.7	5.5	5.3
Urban road food km	million vehicle km				9,847	11,015	11,778			
Car	*million vehicle km*				*5,178*	*6,108*	*6,975*			
LGV	*million vehicle km*				*2,974*	*2,974*	*2,974*			
HGV	*million vehicle km*				*1,696*	*1,932*	*1,828*			
HGV food km	million vehicle km	9,325	10,026	9,425	5,391	6,145	5,812	3,933	3,881	3,613
	million tonne km	*62,745*	*75,270*	*76,871*	*36,278*	*46,131*	*47,400*	*26,467*	*29,139*	*29,471*
Air food km	million vehicle km	11	22	27	0	0	0	11	22	27
Total CO_2 emissions	million tonnes	16.9	18.7	19.1	8.9	9.9	9.7	7.9	8.7	9.2
Total PM_{10} emissions	thousand tonnes	9.5	7.3	5.3	5.6	4.1	2.5	3.8	3.1	2.8
Total NO_x emissions	thousand tonnes	206	201	158	105	102	72	101	98	85
Total SO_2 emissions	thousand tonnes	51	42	41	8.81	2.51	0.25	43	40	41
Live animal food km	million tonne km				870	884	764	NK	NK	NK
Imports of indigenous foods	million tonnes				13.55	14.20	16.15			
Retail sales of ethically traded foods	million £				0	13	63			
% of indigenous organic food grown in the UK	%				NK	NK	62%			

NK=Not known

Contents

Annexes

1 Introduction

1.1 WHAT ARE FOOD MILES?

Over the last fifty years, there have been dramatic changes in the way food is produced, sourced, processed, packaged, delivered and marketed in the UK. The most striking changes have been:

1. Globalisation of the food industry and increase in food trade. In the UK there has been a steady increase in imports and exports of food, especially imports of fresh fruit and vegetables, with more produce sourced from further afield (Africa, Far East, New Zealand).

2. Concentration of sales in supermarkets, accompanied by loss of small shops, markets and wholesalers. Parallel concentration of supply base into fewer, larger suppliers, partly to meet supermarket preferences for bulk year-round supply of uniform produce.

3. Switch from frequent food shopping on foot at small local shops to weekly shopping by car at large out of town supermarkets.

4. Intensification of agriculture and increase in processing and packaging of food.

5. Dramatic changes in transport logistics, with most goods now delivered to the supermarket's own regional distribution centres and taken from there to the shops in large HGVs, replacing local deliveries direct to the store in smaller vehicles.

These changes have contributed to a significant increase in the transport of food within the UK and to, from and within our food trading partners overseas (Figure 1).

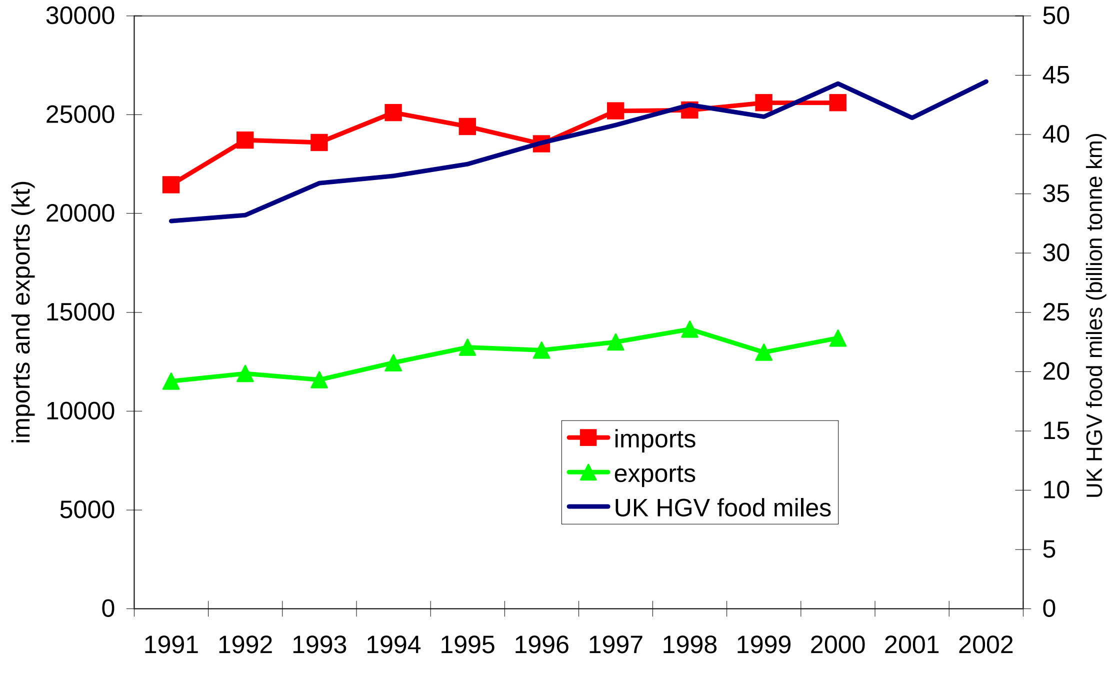

Figure 1: Trends in food trade and HGV food transport in the UK, 1991-2002

Since 1978, the annual amount of food moved in the UK by HGVs has increased by 23%, and the average distance for each trip has increased by over 50%[1]. Food transport accounts for 30% of all road freight transport tonne kilometres within the UK. Food shopping trips by car have also increased in frequency and length, due largely to the replacement of local shops by out of town supermarkets. This increase in the distance travelled by food is associated with environmental, social and economic impacts.

The term "Food Miles" was first coined almost ten years ago in a report by the SAFE Alliance, now Sustain, which highlighted concerns over the negative environmental and socio-economic impacts of increasing transport of food[2]. Food miles are simply the distances travelled by foodstuffs from farm gate to consumer. They are generally measured as tonne-kilometres, i.e. the distance travelled in kilometres multiplied by the weight in tonnes for each foodstuff. However, to measure the environmental impact of food miles it is necessary to convert them into vehicle kilometres, i.e. the sum of the distances travelled by each vehicle carrying food.

One might ask why food is considered separately to other goods in this context. Why worry about "food miles" but not "other product miles"? Transport of all goods obviously causes the same direct environmental impacts, and some of the issues discussed in this paper do apply equally to other goods. The reason why food miles have attracted so much concern is because transport and trade of food is connected to several wider issues: the issues discussed in Section 5 (Wider social and economic effects) in this report.

1.2 BACKGROUND TO THE PROJECT

The rise in food miles has led to increases in the environmental, social and economic burdens associated with transport. These include carbon dioxide emissions, air pollution, congestion, accidents and noise. There is a clear cause and effect relationship for these burdens, and in general, higher vehicle activity leads to larger impacts[i]. Growing concern over these impacts has led to a debate on whether to try to measure and reduce food miles.

This debate has been part of a discussion on the wider environmental, social and economic effects associated with the trends in the food supply chain identified in the previous section. For example:

- Studies by NGOs such as Sustain and IEED[2,3,8,11,34] have argued that the trends in the food supply chain listed in the previous section have led to social and economic impacts in the UK, through downward pressure on farm gate prices, the disappearance of local shops and detrimental effects on rural economies and farming communities. These studies have argued the need to increase the demand for food produced closer to the point of sale, and strengthen the position of local suppliers and retailers. It is argued that this would reduce food miles, as well as leading to other potential sustainability benefits (economic benefits for UK farmers, local shops and suppliers). This would be consistent with government objectives to strengthen rural communities and assist small and medium sized enterprises.

- Others argue that the current food supply system is well tailored to meeting the needs of today's consumer, with the convenience of a weekly supermarket shopping trip. They argue that centralisation and consolidation of food production and retailing operations, along with global sourcing, have led to lower prices and also

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[i] Though the nature and level of the environmental and social costs associated with food transport vary widely depending on the mode, technology, time and load efficiencies.

meet consumer expectations for a year-round supply of a wide range of produce from around the world. Although most food in the UK is transported long distances in large HGVs, improved transport logistics have largely offset the rise in vehicle kilometres. They argue that current logistics operations are highly optimised and there are practical constraints on some options for reducing food miles (e.g. supermarkets are no longer equipped to handle large numbers of direct or small-scale deliveries, and local suppliers using greater numbers of smaller vehicles with lower load factors could actually increase congestion). Furthermore, they argue that local food production may not be the most efficient approach for strengthening rural communities and assisting small and medium sized enterprises, and it might cut across other policy aims, such as the need for higher levels of productivity and a more liberal international trading system. It is also argued that policies to reduce food miles through a move towards local production could lead higher costs for consumers, or reduced choice of produce at certain times of year, and that there could be economic disadvantages for developing countries which currently export to the UK.

The wider issues above can be considered in relation to a food miles data set. The impacts will depend on the policies used to reduce food miles and on the response of consumers and industry to these policies. There is no direct correlation between food miles and, for example, food prices or the strength of rural economies. However, food miles are a potential indicator for the trends above (e.g. the move towards more global sourcing is reflected in increasing food miles, just as a move towards more local sourcing would show through decreasing food miles). Similarly, policies which can reduce food miles can also have a wider social and economic impact in the areas listed above.

What is clear is that food miles are a complex issue, and must be considered in the context of a host of other indicators of sustainability. In like for like systems (i.e. where the only differences in the food supply chain are with transport distance), reducing food miles will have a beneficial effect on sustainability, by reducing the environmental and social burdens of transport. However, when all activities across the food supply chain are considered, there are often differences that involve trade-offs between various environmental, social and economic effects. For example, can there be benefits for sustainability when importing organic food, or importing crops which require less energy to produce in more favourable climates overseas?

Thus, whilst food miles have impacts in all three areas of sustainability: economic, environmental and social, it is not always clear whether a decrease in food transport would necessarily lead to an increase in sustainability, and there may be some cases where the reverse is true. DEFRA therefore commissioned this study to assess whether a practical and reliable indicator based on food miles can be developed, and whether this would be a valid indicator of progress towards the objectives of the government's Sustainable Farming and Food Strategy[4]. and the proposed Food Industry Sustainability Strategy.

The main criteria for validity of food miles as a progress indicator include[5]:

- The indicator should be based on easily available statistics which are updated on an annual basis;
- Any data gaps can be filled with reasonable estimates;
- It should be possible to structure a food miles indicator so that the indicator is directly correlated with sustainability and any exceptions can be dealt with;

- The indicator should have strong links to the aims and outcomes of the proposed Food Industry Sustainability strategy, such that progress towards the aims of the strategy will have a noticeable effect on food miles;

- The indicator will have a reasonably quick response to policy measures;

- It will be accepted as a valid indicator by all stakeholders;

- It is consistent with the other indicators for the Food Industry Sustainability strategy.

1.3 TASKS

The study addressed the following tasks.

1. **Food miles dataset.** Compile a dataset covering the supply chain from farmer (both UK and overseas) to consumer, including the retail to home stage, for 1992, 1997 and 2002. Assess the validity of the data and the practicality of compiling the dataset on an annual basis.

2. **Factors driving food miles**. Assess the main trends, including the increase in imports and exports of food, changes in logistical systems and retail structure leading to increased movement of food around the UK, and the increase in car use for food shopping.

3. **Impacts of food miles.** Identify and quantify (where possible) the positive and negative economic, environmental and social impacts of food miles. These include both direct transport impacts, including congestion, pollution, greenhouse gas emissions, accidents and infrastructure costs, and also wider social and economic effects including the impact on rural communities, and links between food miles, food prices and consumer choice. Determine to what extent social costs are already internalised through road user charges. Consider the ways in which the economic impacts of reductions in food miles might be distributed across different sectors of the food and farming industry.

4. **The validity of food miles as an indicator of sustainable development.** Summarise the arguments for and against using food miles as an indicator of sustainable development, using case studies to illustrate key issues

5. **Develop key indicators**. Develop a set of indicators that allow food miles to be expressed in ways related to their main negative impacts on sustainability, ensuring that the validity of the indicator is not compromised by those cases where a reduction in food miles would not lead to increased sustainability. Calculate the indicators for 1992, 1997 and 2002 and analyse trends. Set these indicators in the context of the proposed Food Industry Sustainability Strategy, reflecting economic, environmental and social impacts in a balanced way.

1.4 STRUCTURE OF THE REPORT

Section 2 presents an assessment of the **factors driving food miles**, including increased trade, consumer demand, and changes in logistical systems and food retail structure within the UK.

Section 3 describes the derivation of a **database of food miles**, and presents and discusses the results for the years 1992, 1997 and 2002.

Section 4 gives an assessment of the **direct economic, environmental and social impacts** arising from UK-generated food miles both in the UK and in other countries, including pollution, congestion, accidents and greenhouse gas emissions.

Section 5 assesses the **wider social and economic effects** of food supply systems, including the implications of a food miles indicator for rural communities and developing countries, food prices, consumer choice and nutrition, and the distribution of economic benefits between different sectors of the food and farming industry.

Section 6 addresses key issues through a set of case studies which explore the question "when might a reduction in food miles ***not*** result in enhanced sustainability?"

Section 7 develops a set of Key Indicators which reflect the major impacts of food miles and account for some potential exceptions to the link between food miles and sustainability, and sets these indicators in the context of the Food Industry Sustainability Strategy.

Section 8 summarises the **conclusions** of the study.

Further technical details of the derivation of the dataset, analysis of factors driving food miles and assessment of impacts are to be found in the Annexes.

2 Factors driving food miles

The rising trend in food transport can be attributed to changes in three major areas:

1. **Increase in food trade**: large increase in exports, steady increase in imports. Retailers, particularly supermarket chains, now source their supplies from more distant locations (both in the UK and overseas).

2. **Trends in transport logistics and retail operations** have acted to increase the distance travelled by food freight within the UK,

3. **The use of cars for food shopping**, and distances driven, have increased.

Counteracting this there have been various attempts to reduce food miles and stimulate demand for local food. These areas are addressed in turn below.

2.1 INCREASE IN FOOD TRADE

Exports of food from the UK have increased greatly since 1961, from 2 million tonnes to 15 million tonnes in 2000 (Figure 2). Total exports in 2002 for food and drink came to £8.9bn of which 62.6% went to EU members. Around 62% of the UK's consumption of food and drink (and 75% of indigenous food) is met by domestic production[6]. Imports are valued at £18.9 billion. Although the UK has been a net importer of food for a long time, imports are currently growing significantly. DEFRA statistics show that imports in tonnes increased by 38% from 1988 to 2002 (35% for indigenous foods, 43% for non-indigenous foods)[7].

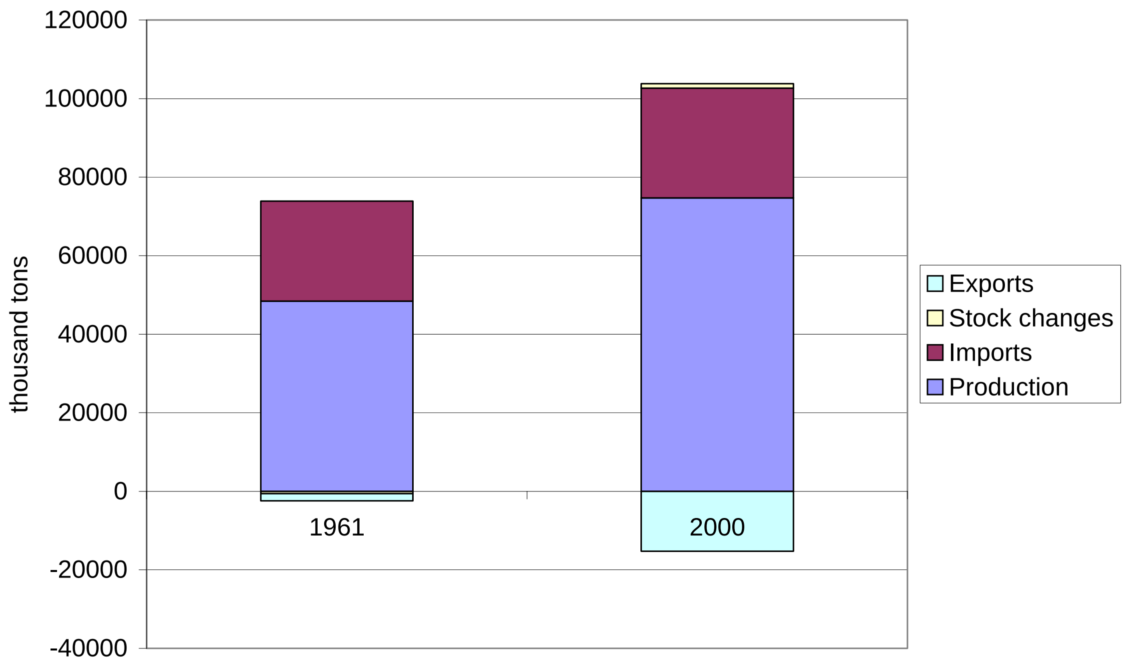

Figure 2 Changes in food trade since 1961

Source: FAO[35]

Overall imports of food have increased by 10% since 1961 (from 25 million tonnes to 28 million tonnes in 2000), but for some food types the increase has been more dramatic. Imports of fruit have doubled and imports of vegetables have tripled. Half of all vegetables and 95% of all fruit consumed in the UK now come from overseas. This has been counterbalanced by a large decrease in imports of cereal[35].

These changes have been driven by a number of factors:

Long distance transport and trade is cheaper and easier…
- Reduction in international trade barriers[i];
- Availability of cheaper (in real terms), faster national and international road, sea and air transport (sea freight unit costs have fallen by 70% during the past 20 years, while air freight costs have decreased by 3-4% per year)[8];
- Availability of more efficient packaging and mobile refrigeration technologies to allow longer transport of fresh produce;
- Advances in IT have increased the 'visibility' of long supply chains and made them easier to manage[ii];
- Development of e-commerce, including e-marketplaces for food products such as Transora, has enabled companies to extend geographically their search for suitable suppliers.

Overseas produce is more in demand…
- Some overseas produce may be cheaper and / or better quality than UK produce, and the season of availability can be extended;
- Increased demand from consumers for imported food not generally available in the UK (e.g. exotic fruit, out-of-season produce, wine, rice and pasta). This diversification of consumer demand has been influenced to some extent by cookery programmes, foreign travel and restaurants specialising in foreign cuisine.

Globalisation and concentration of supply and retail structures…
- Greater regional specialisation in agriculture at both national and international scales, meaning that retailers need to source produce from further afield (e.g. English orchard fruit production is now concentrated in Kent; onions and carrots in East Anglia etc.);
- Opportunity for wider sourcing from smaller suppliers created by the development of retailers' distribution centres (see section 2.5 in Annex 2);
- Large food manufacturers and retailers have adopted global procurement strategies.

Consumer demand or supermarket demand?
Although one of the drivers for increasing imports is consumer demand for non-indigenous or out of season foods, over half of the food imported in 2002 was indigenous produce, i.e. at the time when it was imported, it could have been sourced from the UK[7] (though this does not take into account price issues) Sometimes this is partly attributed to consumer preference for certain varieties (e.g. it is claimed that consumers today prefer sweeter varieties of apple such as Braeburns which are not grown in the UK). However, other things being equal, consumers do not specifically demand to buy onions or apples from New Zealand in preference to UK produce – in fact many would prefer to buy British food[9]. In these cases, an important driver is the supermarket chains' own preference for dealing with suppliers who can supply large quantities of produce of a uniform quality and appearance year-round[10]. Often these suppliers are located

[i] Although agricultural tariffs still remain high – see later section.
[ii] Supply chain visibility software enables suppliers, retailers and distributors to access certain information on sales forecasts, warehouse stock levels, stock in transit and so on to enable better management of the supply chain.

overseas, where more favourable climatic conditions and lower labour costs allow a year round supply of produce at low prices to be produced more easily[11].

2.2 TRENDS IN TRANSPORT LOGISTICS AND RETAILING

A full analysis of the trends in food transport logistics and retailing which have contributed to the growth in food miles is presented in Annex 2. Below we summarise the key trends.

1. ***Restructuring of logistical systems***: changes to the number, location and capacity of factories, warehouses and terminals:

    1.1 Spatial concentration of production:
        a) reduction in production locations
        b) increased specialisation at production location ('focused production')

    1.2 Spatial concentration of inventory (warehouses and in-store storage)

    1.3 Development of local break-bulk operations

    1.4 Creation of hub-satellite networks

    1.5 Primary consolidation

Food processing companies have been concentrating their production capacity in fewer locations to take advantage of economies of scale. Others have adopted a 'focused production' strategy, retaining the same number of plants but concentrating the manufacture of particular items in particular locations. Agricultural specialisation has also been taking place. There has been a parallel concentration of warehouse capacity. By reducing the number of stockholding points in their production and distribution systems companies exploit the so-called 'square root law' of inventory, cutting the amount of safety stock required to maintain a given level of customer service. The associated transport cost penalty is usually quite small relative to the savings in inventory and storage costs (Figure 3).

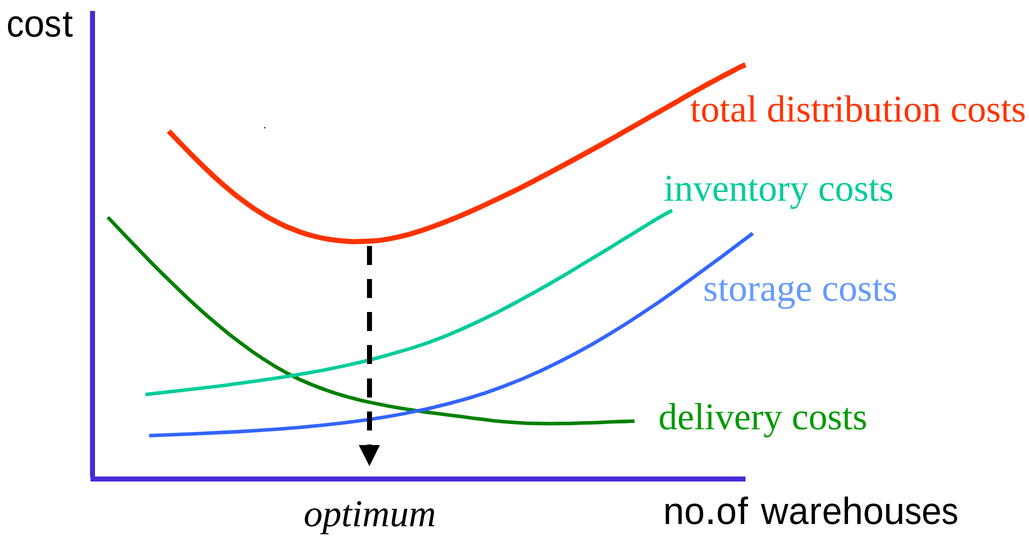

Figure 3: Logistical Cost Trade-offs in the Inventory Centralisation Decision

By increasing the average distance between the point of production and the final consumer, centralisation generates additional tonne-kms. It can result in a less than proportional increase in vehicle-kms, however, where centralisation is accompanied by an increase in vehicle load factors.

New distribution systems such as local break-bulk operations, hub-satellite networks and primary consolidation (Annex 2) also have the effect of increasing tonne kms through more circuitous routing of products. In hub-satellite networks, pallets of food products are collected from several suppliers and aggregated at local 'satellite' depots. They are then trunked to a central hub, in most cases located in the Midlands, where they are sorted for onward trunking to the local depot closest to their destination (Figure 4). The operator of this local depot arranges final delivery. The main advantages of this system lie in the speed and efficiency of centralised sorting at the hub and the high vehicle load factors achieved on the radial, trunk movements to and from the hub. The effect on vehicle kms is less pronounced than the increase in tonne kms.

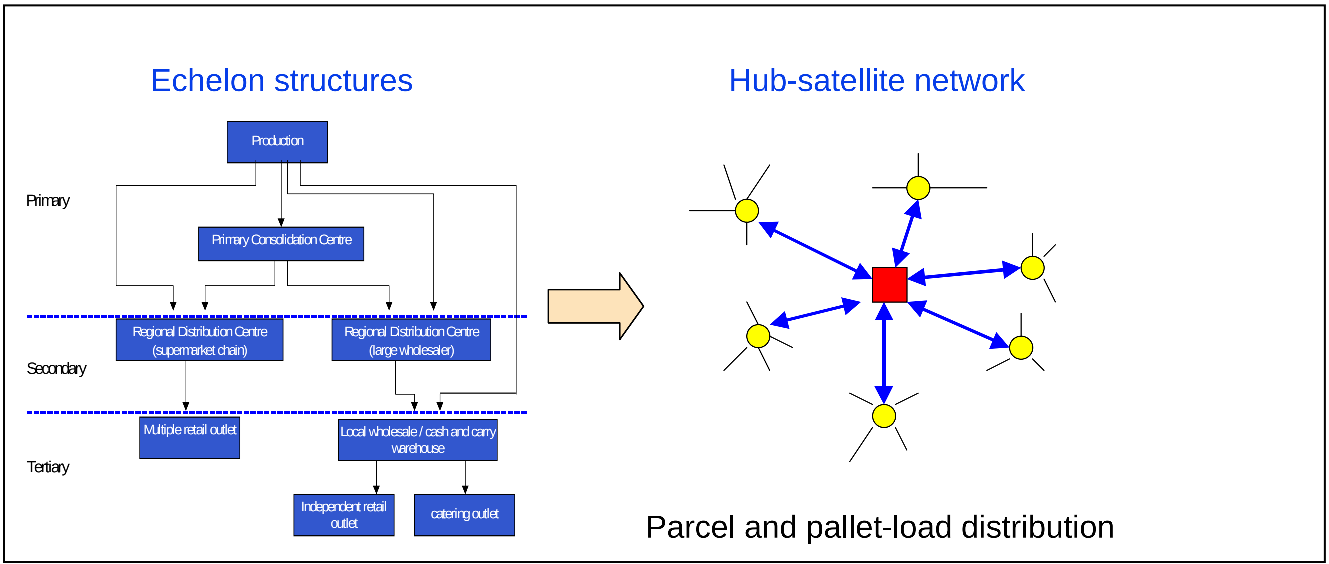

Figure 4: Shift from Echelon to Hub-Satellite Networks

2. ***Realignment of supply chains***: affected by commercial decisions on sourcing, sub-contracting and distribution channels. These decisions determine the pattern of freight flow between a company's premises and those of its trading partners.

   2.1 Creation of more complex production networks (through greater processing and packaging of food)

   2.2 Vertical disintegration of production (contracting out ancillary functions which can be performed more cheaply and effectively by other companies)

   2.2 Increase in single sourcing

   2.3 Wider sourcing of supplies

   2.4 Increase in retailer's control over the supply chain

3.5 Concentration of international trade on hub ports. (Direct deep-sea container services have been withdrawn from regional ports, forcing longer overland transport of consignments to hub ports).

An increase in the processing and packaging of food has led to more links in the food supply chain. Contracting out of operations to other companies has a lesser effect as it is less pronounced in the food and drink industry.

Single sourcing is an important trend. Many food producers have been cutting the number of suppliers – for example, some supermarkets are now aiming to have no more than three suppliers for each produce line[8]. In the past, companies often preferred to buy the same materials from several suppliers to spread the risk of disruption and promote competition among vendors. The rationalisation of the supply base is closely associated with the adoption of just-in-time (JIT) and total quality management, techniques which require close supply chain integration.

Single sourcing can benefit the transport operation by consolidating inbound flows of supplies, allowing firms to achieve higher load factors and lower delivery costs per unit. This is particularly important where firms are operating within a JIT regime. Had JIT not been accompanied by a reduction in supplier numbers, its impact on the transport system would undoubtedly have been much greater. However, where single sourcing is adopted at a national level it has the effect of cutting out a large number of more local suppliers, thus increasing the tonne kms travelled significantly.

Wider sourcing of supplies is generally regarded as the main cause of the increase in ‘food miles’. Manufacturers, wholesalers and retailers are sourcing more of their supplies from further afield for many reasons, already discussed in Section 2.1. However, another crucial trend is the huge increase in multiple retailers’ control over the supply chain over the past 30 years. This is discussed in Box 1.

3. ***Rescheduling of product flow*****:** Over the past decade the scheduling of production and distribution operations has been transformed by the introduction of new management systems designed to minimise inventory levels.

   3.1 Adoption of just-in-time / quick response replenishment

   3.2 Growth of ‘nominated day’ deliveries

Firms operating on a just-in-time (JIT) basis minimise inventory by sourcing supplies in small quantities at frequent intervals. ‘Quick response’ (QR) can be regarded as the application of the JIT principle to retail distribution. As the ratio of total sales to inventory (ie. the ‘stock turn rate’) is critical to retail profitability, retailers have a strong incentive to minimise stock levels.

As JIT is associated with smaller, more frequent deliveries it would be expected to lead to a decrease in vehicle payloads, increasing the ratio of vehicle kms to tonne kms. However, payloads have in fact increased over the last two decades (by over 30% between 1982 and 1997)[12]. The fact that average payloads have risen suggests that the potentially adverse effects of JIT / QR on vehicle utilisation have been avoided as a result of structural changes in the grocery logistics system, in particular primary consolidation and the centralisation of distribution operations in RDCs. It is likely, however, that in the absence of JIT / QR pressures, the degree of load consolidation would have been even greater, permitting a larger reduction in vehicle-kms.

Box 1. How supermarket influence on supply chains affects food miles

Over the past 30 years there has been a huge increase in multiple retailers' influence over the food supply chain. While expanding their share of the retail market, they have been assuming greater responsibility for food distribution from the factory and farm. They initially moved into 'secondary distribution', channelling supplies through their own regional distribution centres (RDCs) and consolidating deliveries to shops. This centralisation of distribution was closely associated with the centralisation of purchasing. Shop managers ceased to have any responsibility for buying, sales representatives no longer visited shops and purchasing negotiations were thereafter confined to the retailer's head office. Any links that had previously existed between shop managers and local suppliers were severed and managers were unable to exert much influence on the product range available in their stores.

The transfer of responsibility for shop delivery from supplier to retailer diverted flows of food products from manufacturers' distribution depots (and wholesale warehouses) to retailers' RDCs. There are currently around 70 RDCs in the UK. As the RDCs were much more centralised and served wider hinterlands, this considerably lengthened the last link in the chain from warehouse to shop, and increased food tonne-kms, though the consolidation of retailer-controlled deliveries in much larger vehicles may well have reduced total vehicle-kms[13].

Any reduction in lorry traffic at the secondary distribution level must be set against increases in traffic volumes upstream of the RDC, including the centralised sourcing of food supplies from smaller producers. Prior to the development of retailers' distribution systems, small suppliers lacked the means of distributing their products to all the shops in a retail chain. This either prevented them from securing a contract with the retailer or confined their sales to branch stores in a particular region. By channelling their products through retailers' RDCs, smaller producers can gain access to national chains of shops, substantially expanding their market areas. For products sourced from small regional producers, the development of retailers' distribution systems has, therefore, greatly increased 'food miles' measured by both tonne-kms and vehicle-kms. The market dominance and centralised distribution systems of UK supermarket chains also make it easier for foreign food producers to penetrate the UK market. Bulk deliveries to a relatively small number of RDCs can give them wide exposure across major supermarket chains. In other countries with much more fragmented retail and wholesale sectors, importers face much greater logistical constraints.

Ironically, the large, highly centralised retail logistics system which enabled small producers to hugely extend their market areas made it virtually impossible for them to deliver directly to local chain stores. Over the past thirty years, supermarket chains have greatly increased the proportion of supplies channelled through their RDCs, leaving only a few lines of 'morning goods' (e.g. milk, bread and eggs) to be delivered directly to the shop by suppliers. Back store reception facilities and storerooms have been redesigned to handle the arrival of supplies in large consolidated loads palletised on articulated vehicles. Companies replenishment systems are based on centralised ordering and receipt of goods at the RDCs where they are checked and sorted for onward distribution. These systems make it impossible for all but a few product lines to penetrate the retailer's supply chain anywhere but the RDC. To the layman, this creates logistical anomalies. A sandwich company in Derbyshire, for example, supplies its products to a major supermarket chain and has a plant within a few hundred metres of one of its shops. The sandwiches arriving on this shop's shelves, however, have to be routed through one of the retailer's RDCs on a round-trip of approximately 160 kms. At an aggregate level, however, the centralised systems are more efficient and achieve higher levels of vehicle utilisation.

The ‘nominated day’ principle also improves vehicle payloads and thus reduces vehicle km. Customers are informed that a vehicle will be visiting their area on a ‘nominated’ day and that to receive a delivery on that day, they must submit their order a certain period in advance. By concentrating deliveries in particular areas on particular days, suppliers can achieve higher levels of load consolidation, drop density and vehicle utilisation. A significant proportion of food deliveries were subject to nominated day constraints during the 1970s and early 1980s when suppliers controlled much of the secondary distribution to shops. With the decline in small-scale grocery retailing and supplier-controlled delivery, this practice has declined in importance in the food sector, though continues to be widely used by food wholesalers and in the food service sector where catering outlets and hotels typically get deliveries on particular days of the week.

***Changes in the management of transport resources*:** Decisions made at the previous three levels dictate a company’s overall demand for freight transport. Operational decisions made by transport and distribution managers determine how much vehicle movement is required to meet this demand.

4.1 Modal shift

4.2 Outsourcing of the transport / logistics function

4.3 Changes in vehicle size, weight and type

4.4 Changes in handling systems

4.5 Increased use of computerised vehicle routing and scheduling (CVRS)

4.6 Increase in return loading

Several changes to the way in which food is transported, including the use of larger vehicles, and multi-compartment vehicles combining products moved at different temperature regimes, have contributed to a substantial increase in load factors. The use of computerised vehicle routing packages, now widely adopted, can cut transport costs and distance travelled by between 5 and 10%, depending on the quality of the previous manual load planning[14]. However, new roll (or cage) pallets designed to improve ease of handling take up around 40% more space than wooden pallets[15]. The volume of primary and secondary packaging has also been increasing, further augmenting vehicle space requirements.

Overall effect on food freight miles

The growth of freight traffic is the result of a complex interaction between decisions made at these different levels. Decisions at levels 1 and 2 determine the quantity of freight movement measured in tonne-kms while decisions at levels 3 and 4 translate this movement into vehicle traffic, measured in vehicle-kms

The logistical trends affect three key ratios that link the weight of food produced or consumed to vehicle traffic levels. These ratios are:

1. **Handling factor: *ratio of tonnes-lifted to product weight.***
Government surveys of freight tonnes lifted record the weight of goods loaded onto vehicles at the start of a journey. As the average product makes several discrete journeys between raw material source and final point of sale, the tonnes-lifted statistic substantially exceeds the total weight of goods produced or consumed in a given time period. The handling factor effectively measures the degree of multiple-counting and can be considered a crude indicator of the

number of separate links in the supply chain. Several studies in the UK have estimated that the average handling factor for food products is between four and five[18,16]. This suggests that the UK food supply chain comprises 4-5 links.

2. **Average length of haul: *ratio of road tonne-kms to tonnes-lifted.***
This ratio indicates the average length of each link in the supply chain.

3. **Average payload weight: *ratio of road tonne-kms to vehicle-kms.***
This ratio translates the volume of freight movement, measured in tonne-kms, into vehicular traffic by taking account of the average loading of the vehicles. A distinction can be made between the average **load factor** on laden trips (measured by the ratio of tonne-kms to laden-kms) and **empty running** (proportion of vehicle-kms run empty).

Table 1 shows the relationship between the key ratios and the list of eighteen logistical trends. Up and down arrows, bold or plain, have been used to indicate the direction and strength of the relationship.

Table 1 Effects of the Dominant Logistical Trends on Key Freight Transport Ratios (adapted from REDEFINE analysis[16])

Key Logistics Trends	Key Ratios			
	Handling factor	Avg. length of haul	Load factor	Empty running
1 Restructuring of logistics systems				
1.1 Spatial concentration of production; either through				
Reduction in no. of product locations or		**↑**	↑	
Increased specialisation ('focused production')		**↑**	↑	
1.2 Spatial concentration of inventory		**↑**		
1.3 Development of local break-bulk operations	↑	↓		
1.4 Creation of hub-satellite networks	↑	↓		
2 Realignment of supply chains				
2.1 Insertion of more production stages	**↑**			
2.2 Vertical disintegration of production	**↑**			
2.3 Increase in single sourcing			**↑**	
2.4 Wider sourcing of supplies		**↑**		
2.5 Increase in retailer's control over supply chain		**↑**	**↑**	
2.6 Concentration of international trade on hub ports		↑		
3 Rescheduling of product flows				
3.1 Adoption of JIT / quick response replenishment			↓	
3.2 Growth of 'nominated day' deliveries			↑	
4 Changes in management of transport resources				
4.1 Modal shift	↑			
4.2 Outsourcing of transport / logistics function			↑	
4.3 Changes in vehicle size, weight and type			↑	
4.4 Changes in handling systems / packaging			↓	
4.5 Use of computerised vehicle routing / scheduling			↓	↓
4.6 Increase in return loading				↓

↑ = strong positive impact **↓ = strong negative impact**
↑ = weak positive impact ↓ = weak negative impact

Sources: Three empirical studies (McKinnon and Woodburn, 1996[18], NEI et al, 1999[16] and Technical University of Berlin et al., 2002[17]), supplemented by expert judgement

The table shows that the trends combine to increase the number of handling stages in the supply chain, and also to increase the average length of haul. These trends will both act to increase food miles when expressed as tonne kilometres. However, the corresponding growth in food vehicle kilometres is offset by trends to increase the efficiency of food freight, which increase the load factor and decrease the amount of empty running (despite the growth in just-in-time logistics).

These trends are also revealed by an analysis of growth in UK food transport for 1983-1991, which showed that the average number of links in the food supply chain rose by around 13%, while their average length increased by 26%, resulting in a 39% increase in tonne-kms[18]. Vehicle-kms grew by a significantly smaller margin because average payload weight also increased by around 14%.

In summary, the growth in food miles is not simply the result of retailers buying their supplies from further afield. It is caused by the complex interaction of numerous logistical and supply chain trends, some of which are mutually reinforcing and others counteracting. Over the last few decades the trend has been to transport food over longer distances and through a greater number of handling stages. This has been driven mainly by:

- the consolidation of food retailing into a few multiple retail chains, accompanied by central purchasing policies and routing of produce via regional distribution centres,
- greater processing and packaging of food
- growth in imports.

At the same time, the growth in just-in-time delivery has exerted a pressure to decrease load factors. However, the impact of this has been offset to some extent by an increase in transport efficiency. The use of larger vehicles, routing of produce via regional distribution centres to allow consolidation of loads and use of logistics software has allowed food freight operations to typically achieve load factors of around 70%, and empty running of only 23%. Therefore vehicle kilometres have not grown as fast as tonne kilometres.

2.3 GROWTH IN FOOD SHOPPING BY CAR

Over the last 10 years there has been a slight decrease in the number of shopping trips per person per year, from 227 in 1990 to 216 in 2000, despite the decrease in average household size which would tend to cause an increase in trips per person. In 2000, 55% of these trips were for food (data split into food and non-food shopping is only available from 2000). However, the average distance driven to shop increased from 3.3 miles to 4.2 miles, and the total distance travelled to shop increased from 747 miles per person per year to 898[19]. Trips for food are significantly shorter than trips for non-food shopping, with an average of 3 miles compared to 5.6 for non-food in 2000. Between 1985 and 1998 there was a 57% increase in the distance of shopping trips by car[8].

Over the same period there has been a huge increase in the number of out-of-town stores and decrease in the number of local shops. The construction of out-of-town superstores began in the 1970s, and their numbers increased from 20 in 1976 to 50 in 1986, 719 in 1992 and 960 in 2000. The number of independent grocers in the UK fell from 116,000 in 1961 to only 20,900 in 1997[20]. Villages and market towns lost half their small shops between 1991 and 1997, with more than 1,000 village shops closing down over the last decade[11]. The decline in local shops is directly linked to competition from supermarkets[20].

The construction of out-of-town superstores is currently less favoured by planning guidelines, due to problems such as the closure of many local shops, decline of town centres, loss of green space, reduction of shopping opportunities for the less mobile, creation of food “deserts” and an increase in traffic congestion on the outskirts of towns[20,21]. However, opinion is divided over whether the out-of-town location itself contributes to additional vehicle kilometres.

Ironically, the out-of-town superstore was originally seen partly as a solution to the increasing traffic problems of town centres. Some studies have assessed the traffic impacts of superstores compared to town centre shopping and have found an increase in the distance travelled and associated emissions for out-of-town shopping[22]. However, others have claimed that out-of-town superstores can reduce the total distance travelled through allowing less frequent trips[21]. Out of town superstores only became viable with the increase in car ownership and affluence during the 1960s. The popularity of "one-stop shopping" has been further driven by the increase in the number of women working outside the home, increase in working hours for employed people, and increased ownership of freezers and fridges permitting larger amounts of food to be purchased in one trip. Today, most shoppers with access to a car choose to drive to the shops regardless of location, simply because the car is the easiest means of transporting large quantities of shopping home.

As the infrastructure is already in place, out of town superstores are not going to go away. For affluent, mobile consumers the provision of easy car parking next to the store allows quick and convenient access to a wide variety of food products. However, alternative means of food supply can offer solutions to some of the disadvantages of out of town superstores listed above. Home delivery can reduce vehicle kilometres by 70%[23]. Local shops are also important to reduce car food miles for "top-up" shopping. If no local shop exists, consumers may be forced to drive several miles to a superstore to buy a pint of milk or a loaf of bread. Support for local shops can also stimulate the local economy (see Section 5.5.1) and give access to quality food for the less mobile, or those living in deprived areas where some studies argue the economic incentive for opening new supermarkets is low[11].

2.4 DEMAND FOR LOCAL FOOD

The growth of market share of the supermarkets with the associated decline in local shops and markets, and the increase in international food trade, have led to a move away from locally produced food in the UK.

To address this, there have been a variety of recent initiatives aimed at stimulating the market for local food. These have included:

- General national level campaigns aimed at the consumer, such the "Eat the View" campaign[24].
- Locally run farmers' markets, farm shops and vegetable box schemes, all increasingly popular in recent years and often offering organic products.
- Community-led initiatives such as community growing projects.
- Formation of producer co-operatives.

There are also an increasing number of networking and co-operative schemes such as East Anglia Food Link[26]. These link together local communities, farms, food producers, local shops, wholesalers, markets and box schemes to stimulate demand for a variety of local produce within a whole region. As well as marketing local food to the general public, these schemes can also encourage local schools, hospitals or businesses to adopt a policy of sourcing food more locally[27]. Local food organisations have adopted a definition of “local food” which goes beyond simple transport distance to cover other aspects of sustainability (see Box 2).

Box 2. Definitions of Local Food

The members of Food Links UK have the following vision for sustainable local food systems:

"*Systems of producing, processing and trading, foods from sustainable production systems including organic where the physical and economic activity is controlled within the locality or region where it was produced, which delivers health, economic, environmental and social benefits to the people in those areas”.*

The study categorises characteristics of sustainable local food sector as:

- Proximate – originating from the closest practicable source or the minimization of energy use
- Healthy as part of a balanced diet and not containing harmful biological or chemical contaminants
- Fairly or co-operatively traded between producers, processors, retailers and consumers
- Non-exploiting of employees in the food sector in terms of pay and conditions
- Environmentally beneficial in its production (e.g. organic)
- Not genetically modified
- Accessible both in terms of geographic access and affordability
- High animal welfare standards in both production and transport
- Socially inclusive of all people in society/building social capital
- Encouraging knowledge and understanding of food, food culture, and local distinctiveness.

However, these definitions do not address how far food can be transported before it ceases to be local. The Curry Commission Report recommended that an enforceable definition of “local” be developed once the sector had become more established. In response to this, the Food Standards Agency is considering the feasibility of producing guidelines on the use of the term “local” in marketing. It intends to consult on this initiative.

At present, although many local food initiatives have been successful in capturing niche markets, strong demand for local food has yet to penetrate the mass market. A 2002 IGD survey found that most consumers cite price, appearance and freshness of the produce as being their main buying criteria[28]. Nevertheless, there are signs that a wider demand for local food is beginning to emerge. The IGD survey showed that 59% of people said they were interested in local foods, 38% said they would usually look for local foods in their supermarkets and a further 35% would occasionally look.[29] In a recent IGD consumer tracker survey, when consumers were asked how shopping could be improved, “availability of locally produced food” was the most requested item after “prices should not increase” and “more special promotions”[30].

The proportion of food sold through supermarkets in the UK has steadily increased over the last few decades, to reach around 85%. Modern lifestyles make it likely that this high proportion of supermarket sales will continue in future – busy families where both parents work find it quicker and more convenient to do a weekly “one-stop-shop” with easy parking and long opening hours than to visit a number of different local shops within normal opening hours. Busy lifestyles also favour mass produced convenience food at the expense of fresh produce. Also, competition with supermarkets has led many local shops, wholesalers and markets to close, so there is less choice of independent outlets. The current move of multiple retailers into smaller town centre shops is further increasing the market share of the large retailers.

One way for local food to break out of its current niche market status would be for the multiples to increase their own local food offering. There are signs that they are doing this, in response to growing consumer demand for local food. However, as discussed in Box 1 (Section 2.2), the logistical and commercial systems of large supermarkets present barriers for local food sales. Although supermarkets have expressed an interest in local food sales, one of the largest retailers recently estimated that only 1% of their turnover was from local food, and another was aiming for a 2% turnover from local food items[88]. Local independent retailers, wholesalers and markets are the traditional outlets for local produce. It is estimated that 55% of local food is sold through local shops and markets[32].

There have been recent government-sponsored moves aimed at assisting small local producers to supply stores on a regional, or even an individual, basis. The Institute of Grocery Distribution (IGD), partly assisted by Defra, organised a series of workshops around the country in 2003 to bring together local producers with the large retailers and food service companies to discuss how to promote local sourcing and overcome barriers to it. Later that year Defra helped fund a Business in The Community (BiTC) and (IGD) guide for small businesses looking to work with large food retailers and foodservice companies. This guide, "*Local Sourcing – Opening the Door for Small Business*", includes instructions to help farmers and producers comply with supermarket requirements. Following on from this work, Food From Britain working with IGD produced a best practice guide to distribution, published in October 2004 and funded by Defra under their Regional Food Strategy. It aims to help address one of the main barriers to the encouragement of more local sourcing and highlights a number of successful initiatives some of which have been part-funded under the England Rural Development Programme.

In addition to this work, Food from Britain, funded by Defra under their Regional Food Strategy, has been facilitating meetings between a number of retailers and the Regional Food Groups aimed at getting more regional food on to supermarket shelves. A number of successful local sourcing initiatives have resulted from this work, which is continuing.

However, many of the schemes for promoting local food bypass the supermarkets completely (e.g. vegetable boxes, farmers markets etc). Indeed, promoters of local food often prefer not to deal with supermarkets, as sales through local retail outlets are seen as contributing to the local economy and fitting in better with the aims of the organisation. DEFRA recognise and support the benefits to producers of direct sales initiatives (see below).

To be successful, local food schemes have to fit in with modern lifestyles and consumer trends. Interest in local food (especially organic local food) has been fuelled by growing awareness of some of the potential negative impacts of mass produced food, such as animal welfare issues, pesticide residues, food safety scares such as salmonella, BSE and e-coli, and the enhanced spread of diseases such as the foot and mouth epidemic which can result from increased transport of food. Some consumers are now becoming more interested in tracing the origin of their food, and place increased confidence in local foods which can be traced to a specific farm. Some schemes tap into the demand for time-saving shopping, e.g. internet sales, or home delivery of vegetable boxes (although these do sacrifice some consumer convenience as there is little choice over the contents of the boxes). Others, e.g. some farm shops and pick-your-own outlets, tap into the trend for shopping as a family leisure activity by offering activities for children such as play areas and animals to feed.

In recognition of the benefits that direct sales outlets can bring to both producers and consumers, Defra has made funding available to support activities such as the establishment of farmers' markets, the development of regional and local branding of foodstuffs, the formation of collaborative groups to market quality products and to support public procurement initiatives.

Policy options and tools to stimulate the market for local food are also discussed in recent NGO reports such as "Feeding the Future"[34].

3 Food miles dataset

3.1 THE UK FOOD SUPPLY CHAIN

Figure 5 shows the balance between imported and exported food and food produced for consumption in the UK. Imports of food have been increasing over the last twenty years, and now account for 32% of the food consumed in the UK[i]. Imports are almost twice the level of exports.

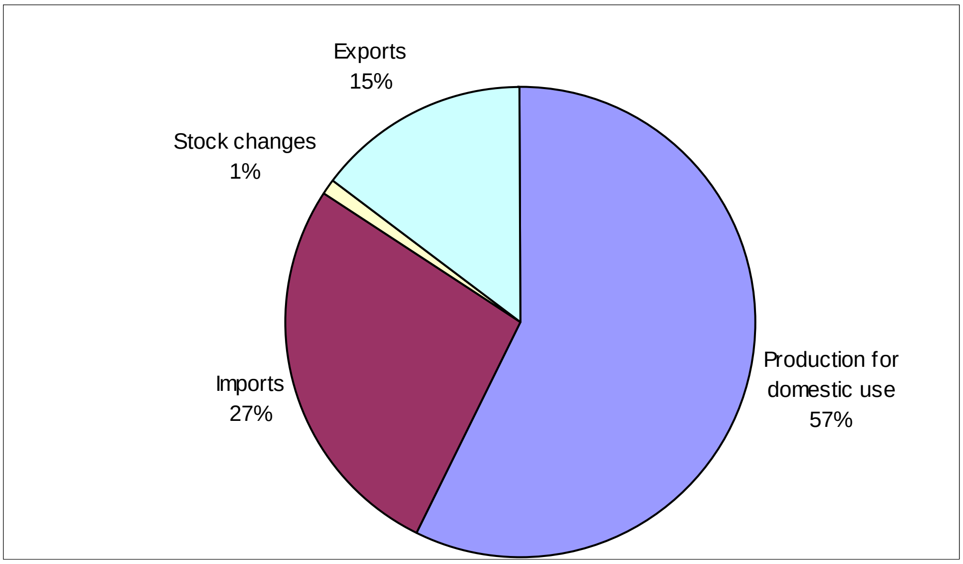

Figure 5 UK Food Balance in 2000 (by weight)

Source: FAO database[35]

The food miles dataset includes estimates of food miles associated with each of the following links of the supply chain:

Overseas produce

1. Overseas producer to overseas processor
2. Overseas processor to overseas distribution centre
3. Overseas distribution centre to overseas port or airport
4. Overseas port or airport to UK port or airport
5. UK port or airport to UK processor
6. UK processor to UK distribution centre

UK produce

7. UK producer to UK processor
8. UK processor to UK distribution centre

All produce

9. UK distribution centre to UK retailer or caterer
10. UK retailer to consumer

This is of course a simplistic representation of the supply chain. Depending on the product, some stages may be omitted (e.g. overseas produce may not go to an overseas processor, if it is processed in the UK). Some produce may have a more complex

[i] Note: Imports are 32% of food consumed in the UK. This differs from the 27% shown in Figure 2 because Figure 2 includes exports.

transport route (e.g. via more than one processor or distribution centre, perhaps through several countries).

Both imports and exports are included in the dataset, as they all have impacts (positive or negative) on sustainability. However, in order to reflect other government policy objectives we have also (in Section 6) provided estimates of food miles excluding exports.

For exports, stages 4, 5 and 6 above are reversed. However, for exports we do not assess the stages from the overseas port or airport onwards to the overseas shops and consumers. It could be that this transport would occur anyway, with substitute produce from a different country, even if UK exports were reduced. Alternatively domestic production could increase, thus reducing food miles. However, this is outside the influence of UK policy.

3.2 DERIVATION OF THE DATASET

We have aimed to base the food miles database on readily available, reliable national statistics, supplemented by simple assumptions. Some parts of the supply chain and some transport modes are reasonably well characterised (e.g. HGV and LGV transport in the UK), whereas others are based on very poor data supplemented by assumptions (overseas transport from producer to port or airport). We assess the quality of data for each part of the food chain in Section 3.4, and discuss the implications of this for the validity of food miles as an indicator.

Full details of the derivation of the data are contained in Annex 1 but the main data sources and assumptions are outlined below:

1. **UK HGV distances** are from the Department for Transport's Continuing Survey of Road Goods Transport (CSRGT)[1] – an annual survey of a sample of UK registered HGV owners which identifies tonne km and vehicle km split by type of goods carried. A separate estimate was made to cover transport by foreign registered lorries (which are not included in the survey).

2. **UK LGV distances** are now collected via a similar method to the CSRGT. Only data for the year 2003 is currently available, so this is used as an estimate for the year 2002 in the indicator dataset. Private vans and company vans are surveyed separately. Vehicle km are collected in the survey. This has been converted to tonne km using an assumption of a typical load of 0.7 tonnes. Total food-related vehicle km were estimated assuming empty running of 37%. In the absence of better data, the same value has also been used in the dataset for the years 1997 and 1992. It would have been possible to scale the 2003 estimate based on HGV km, but this is not necessarily a valid approach, as HGV transport may displace LGV transport to some extent.

3. **UK domestic air, sea and inland waterway transport** of food is assumed to be negligible. National statistics do not generally identify food as a separate category of freight for these transport modes.

4. **Transport from overseas to the UK** is based on HM Customs and Excise statistics for tonnages imported or exported by country, split into different food categories[37]. Supplementary data and assumptions were used to identify the transport mode. Distances by air are straight line distances between London and the capital city of each country, road distances are the distance on major roads, and shipping distances are used for sea transport.

5. **Transport overseas** is a very approximate estimate based on the typical distance travelled from the overseas producer to the port or airport – assumed to be approximately half the radius of the country. This was then multiplied by a handling factor of 2 for developed countries and 1.5 for developing countries, to reflect extra distance travelled related to processing, packing and transport logistics. This may be an underestimate, but the constraints of the study did not permit a more detailed assessment[i]. In the absence of other data, we assumed the same load factor as for the UK. This will also lead to an underestimate of vehicle kilometres for most countries as the UK has relatively efficient transport logistics. A corresponding LGV distance was based on the ratio of UK HGV to LGV tonne kilometres and was even more uncertain. There may well be some transport of food by rail or inland waterway overseas but it is unlikely to be significant. Although overseas transport is of less policy interest to the UK government, it is important that it is not neglected in the assessment as overseas transport displaces UK transport.

6. **Car transport** from shop to home is based on a DfT survey of shopping travel[38], which identifies the annual distance travelled for food shopping per UK inhabitant. This was multiplied by the UK population to give estimated vehicle kilometres, and combined with assumptions concerning the average weight of shopping carried in each car to give tonne kilometres[ii].

7. **CO_2 emissions** for road vehicles are derived from fleet-average emission factors in the NAEI database[39]. It should be noted that within the scale of this project we were unable to include an estimate of CO_2 emissions generated by fuel used for refrigeration in HGVs – this is an area for further work. Air, rail and sea freight CO_2 emissions are based on the updated 2002 DEFRA Company Guidelines for Environmental Reporting[40], supplemented by many other sources (see Annex 3).

This approach excludes international transport of food for manufacturing food products before they reach the country from which they are exported to the UK. For example, if jam made in France for export to the UK contains apricots from Greece and sugar from Mauritius, the transport of the apricots and sugar from Greece and Mauritius to France is excluded from our database (simply for lack of data). Also, the customs and excise data identifies only the country of dispatch, i.e. the last shipping point. Therefore for foodstuffs which are shipped in more than one stage, the earlier stages of transhipment are not included. International food miles are thus likely to be underestimated in our database. However, year by year trends should be fairly consistent.

Our estimates of food miles split by transport mode and location for 2002 are shown in Table 2. The different modes and locations are expressed as percentages of the total in Table 3. We also assessed two previous years, where possible, so that trends can be established. Data for the years 1997/98[iii] and 1992 are shown in Tables 4-7.

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[i] The study did not investigate in detail the data available from other countries for overseas food miles. Preliminary investigations indicated that, whilst some limited data was available (e.g. for France we found total tonnes of food moved by HGV, but not vehicle km), it was not possible to identify the proportion of food miles related to food destined for export to the UK. However, a more detailed study might be able to identify further data which could be used to improve our crude estimates.

[ii] Note: the accuracy of estimates of tonne kilometres for car transport are limited by the lack of data on the average weight of shopping carried per trip. However, vehicle kilometres are fairly well known and are of far more significance in estimating impacts.

[iii] We aimed to assess the years 1997 and 1992 in addition to 2002. However, UK HGV data was not available for 1997 due to an error in the DfT database. Therefore we used 1998 data for UK HGV transport, but 1997 data for all other transport.

We have presented the data in three formats: tonne kilometres, vehicle kilometres and carbon dioxide emissions. Of these:

- **tonne kilometres** are generally the most reliable measure, as the tonnages of food imported or exported are reasonably well known.

- **Vehicle kilometres** are well defined for UK LGVs, HGVs and cars, but for other transport modes they rely on assumptions for typical vehicle loads and are thus significantly less reliable than the estimate of tonne kilometres. Nevertheless it is necessary to have an estimate of vehicle kilometres in order to estimate environmental impacts.

- The estimation of **carbon dioxide emissions** for each transport mode is described in full in Section 4 of this report, but is presented here alongside the tonne km and vehicle km in order allow appreciation of the significant differences in energy efficiency between transport modes.

Table 2: Estimated total Food Transport split by transport mode (2002)

		Air		Road			Rail	Sea	Inland waterway	Total
		Long haul	*Short haul*	*HGV*	*LGV*	*Car*				
Tonne km (M)	*UK*		0	47,400	2,092	158	0	400	100	50,149
	UK to overseas	1,280	21	12,866			33	151,914		166,114
	Overseas		0	16,605	733					17,338
Total		**1,280**	**21**	**76,871**	**2,824**	**158**	**33**	**152,314**	**100**	**233,602**
Vehicle km (M)	*UK*		0	5,812	4,743	14,340	0	0	3	24,897
	UK to overseas	26	0.4	1,577			0.2	14		1,619
	Overseas		0	2,036	1,662					3,698
Total		**26**	**0**	**9,425**	**6,404**	**14,340**	**0**	**15**	**3**	**30,214**
CO_2 (kt)	*UK*		0	6,274	1,076	2,392	0	0	0	9,742
	UK to overseas	1,971	88	2,269			1	2,297		6,625
	Overseas		0	2,198	391		0		0	2,589
Total		**1,971**	**88**	**10,740**	**1,467**	**2,392**	**1**	**2,297**	**0**	**18,956**

Notes:

1. Figures in red are ***very*** approximate estimates.
2. Full details of data sources and assumptions are in Annex 1 (Annex 3 for CO_2).

Table 3: Estimated Food Transport split by transport mode as percentages of total (2002)

		Air		Road			Rail	Sea	Inland waterway	Total
		Long haul	Short haul	HGV	LGV	Car				
Tonne km (M)	*UK*		0.0%	20.3%	0.9%	0.1%	0.0%	0.2%	0.0%	21.5%
	UK to overseas	0.5%	0.0%	5.5%			0.0%	65.0%		71.1%
	Overseas		0.0%	7.1%	0.3%		0.0%		0.0%	7.4%
Total		**0.5%**	**0.0%**	**32.9%**	**1.2%**	**0.1%**	**0.0%**	**65.2%**	**0.0%**	**100.0%**
Vehicle km (M)	*UK*		0.0%	19.2%	15.7%	47.5%	0.0%	0.0%	0.0%	82.4%
	UK to overseas	0.1%	0.0%	5.2%			0.0%	0.05%		5.4%
	Overseas		0.0%	6.7%	5.5%		0.0%		0.0%	12.2%
Total		**0.1%**	**0.0%**	**31.2%**	**21.2%**	**47.5%**	**0.0%**	**0.05%**	**0.0%**	**100.0%**
CO_2 (kt)	*UK*		0.0%	33.1%	5.7%	12.6%	0.0%	0.0%	0.0%	51.4%
	UK to overseas	10.4%	0.5%	12.0%			0.0%	12.1%		35.0%
	Overseas		0.0%	11.6%	2.1%		0.0%		0.0%	13.7%
Total		**10.4%**	**0.5%**	**56.7%**	**7.7%**	**12.6%**	**0.0%**	**12.1%**	**0.0%**	**100.0%**

Table 4: Estimated total Food Transport split by transport mode (1997/98)

		Air		Road			Rail	Sea	Inland waterway	Total
		Long haul	*Short haul*	*HGV*	*LGV*	*Car*				
Tonne km (M)	*UK*		0	46,131	2,092	138	0	400	100	48,861
	UK to overseas	1,059	13	14,151			5	142,433		157,661
	Overseas		0	14,988	680					15,668
Total		**1,059**	**13**	**75,270**	**2,771**	**138**	**5**	**142,833**	**100**	**222,190**
Vehicle km (M)	*UK*		0	6,145	4,743	12,557	0	0	3	23,447
	UK to overseas	22	0.3	1,885			0.0	14		1,920
	Overseas		0	1,996	1,541					3,537
Total		**22**	**0**	**10,026**	**6,284**	**12,557**	**0**	**14**	**3**	**28,905**
CO_2 (kt)	*UK*		0	6,187	1,337	2,361	0	0	0	9,885
	UK to overseas	1,629	57	2,370			0	2,153		6,210
	Overseas		0	2,010	453		0		0	2,463
Total		**1,629**	**57**	**10,568**	**1,790**	**2,361**	**0**	**2,153**	**0**	**18,558**

Notes:

1. HGV UK data is for 1998, all other data for 1997 (1997 data was not available for UK HGVs).

Table 5: Estimated Food Transport split by transport mode as percentages of total (1997/98)

		Air		Road			Rail	Sea	Inland waterway	Total
		Long haul	*Short haul*	*HGV*	*LGV*	*Car*				
Tonne km (M)	*UK*		0.0%	20.8%	0.9%	0.1%	0.0%	0.2%	0.0%	22.0%
	UK to overseas	0.5%	0.0%	6.4%			0.0%	64.1%		71.0%
	Overseas		0.0%	6.7%	0.3%		0.0%		0.0%	7.1%
Total		**0.5%**	**0.0%**	**33.9%**	**1.2%**	**0.1%**	**0.0%**	**64.3%**	**0.0%**	**100.0%**
Vehicle km (M)	*UK*		0.0%	21.3%	16.4%	43.4%	0.0%	0.0%	0.0%	81.1%
	UK to overseas	0.1%	0.0%	6.5%			0.0%	0.05%		6.6%
	Overseas		0.0%	6.9%	5.3%		0.0%		0.0%	12.2%
Total		**0.1%**	**0.0%**	**34.7%**	**21.7%**	**43.4%**	**0.0%**	**0.05%**	**0.0%**	**100.0%**
CO_2 (kt)	*UK*		0.0%	33.3%	7.2%	12.7%	0.0%	0.0%	0.0%	53.3%
	UK to overseas	8.8%	0.3%	12.8%			0.0%	11.6%		33.5%
	Overseas		0.0%	10.8%	2.4%		0.0%		0.0%	13.3%
Total		**8.8%**	**0.3%**	**56.9%**	**9.6%**	**12.7%**	**0.0%**	**11.6%**	**0.0%**	**100.0%**

Table 6: Estimated total Food Transport split by transport mode (1992)

		Air		Road			Rail	Sea	Inland waterway	Total
		Long haul	*Short haul*	*HGV*	*LGV*	*Car*				
Tonne km (M)	*UK*		0	36,278	2,092	117	0	400	100	38,987
	UK to overseas	533	8	12,871			0	136,603		150,015
	Overseas		0	13,596	784					14,380
Total		**533**	**8**	**62,745**	**2,875**	**117**	**0**	**137,003**	**100**	**203,382**
Vehicle km (M)	*UK*		0	5,391	4,743	10,644	0	0	3	20,781
	UK to overseas	11	0.2	1,913			0.0	13		1,937
	Overseas		0	2,021	1,777					3,798
Total		**11**	**0**	**9,325**	**6,520**	**10,644**	**0**	**13**	**3**	**26,516**
CO_2 (kt)	*UK*		0	5,429	1,337	2,129	0	0	0	8,895
	UK to overseas	820	36	2,405			0	2,062		5,324
	Overseas		0	2,035	522		0		0	2,557
Total		**820**	**36**	**9,869**	**1,859**	**2,129**	**0**	**2,062**	**0**	**16,776**

Notes:

1. Figures in red are ***very*** approximate estimates.
2. Full details of data sources and assumptions are in Annex 1 (Annex 3 for CO_2).

Table 7: Estimated Food Transport split by transport mode as percentages of total (1992)

		Air		Road			Rail	Sea	Inland waterway	Total
		Long haul	*Short haul*	*HGV*	*LGV*	*Car*				
Tonne km (M)	*UK*		0.0%	17.8%	1.0%	0.1%	0.0%	0.2%	0.0%	19.2%
	UK to overseas	0.3%	0.0%	6.3%			0.0%	67.2%		73.8%
	Overseas		0.0%	6.7%	0.4%		0.0%		0.0%	7.1%
Total		**0.3%**	**0.0%**	**30.9%**	**1.4%**	**0.1%**	**0.0%**	**67.4%**	**0.0%**	**100.0%**
Vehicle km (M)	*UK*		0.0%	20.3%	17.9%	40.1%	0.0%	0.0%	0.0%	78.4%
	UK to overseas	0.0%	0.0%	7.2%			0.0%	0.05%		7.3%
	Overseas		0.0%	7.6%	6.7%		0.0%		0.0%	14.3%
Total		**0.0%**	**0.0%**	**35.2%**	**24.6%**	**40.1%**	**0.0%**	**0.05%**	**0.0%**	**100.0%**
CO_2 (kt)	*UK*		0.0%	32.4%	8.0%	12.7%	0.0%	0.0%	0.0%	53.0%
	UK to overseas	4.9%	0.2%	14.3%			0.0%	12.3%		31.7%
	Overseas		0.0%	12.1%	3.1%		0.0%		0.0%	15.2%
Total		**4.9%**	**0.2%**	**58.8%**	**11.1%**	**12.7%**	**0.0%**	**12.3%**	**0.0%**	**100.0%**

3.3 ANALYSIS AND DISCUSSION

3.3.1 Comparison of tonne kilometres, vehicle kilometres and CO_2 emissions

Figures 6, 7 and 8 show the split of food miles by transport mode in terms of tonne kilometres, vehicle kilometres and CO_2 emissions for 2002. Some immediate observations can be made.

1. Sea transport accounts for 65% of **tonne kilometres,** due to the large distances travelled. Road transport by HGV is next at 33%, of which around two thirds is in the UK. Air accounts for less than 1% of food tonne kilometres travelled.

2. In terms of **vehicle kilometres**, the picture is completely different. HGV transport accounts for 31% of vehicle kilometres, but car transport from shop to home now accounts for 48%. LGVs are much more prominent, accounting for 21% of vehicle kilometres (though only one percent of tonne kilometres). Air vehicle kilometres are less than one percent, and sea vehicle kilometres are less than 1%. This is because of the much smaller loads carried in cars and LGVs than in HGVs, aircraft and especially ships.

3. In terms of **CO_2 emissions**, the picture changes yet again, with the burden split more evenly between modes. Road transport of food by HGV accounts for 57% of the CO_2 emissions arising from food transport. Sea transport is relatively energy-efficient and accounts for only 12% of CO_2 emissions (compared to 65% of tonne kilometres). Air transport is energy-intensive, accounting for 11% of CO_2-equivalent emissions (when the radiative forcing effect of other emissions apart from CO_2 are taken into account[i]), though only 1% of tonne kilometres. Car transport accounts for a significant proportion of CO_2 emissions (13%) although it accounts for less than 1% of tonne kilometres. This is because of the low loads carried – although HGVs produce five times the emissions of cars per kilometre travelled, over 1000 car journeys will be made to carry home the contents of one HGV. LGVs account for 8% of CO_2 emissions.

[i] It is estimated that the radiative forcing effect of aircraft emissions is a factor of 2.7 greater than the CO_2 emissions alone, due to the impact of NOx, water and particulate emissions in the stratosphere.

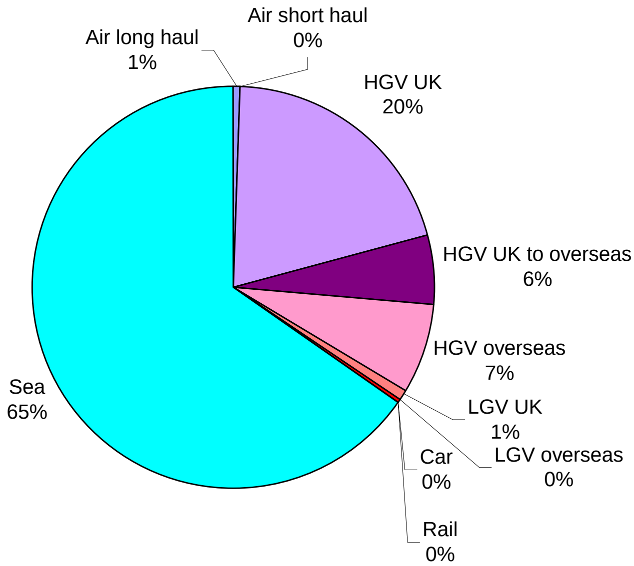

Figure 6 UK food tonne-kilometres by transport mode (2002)

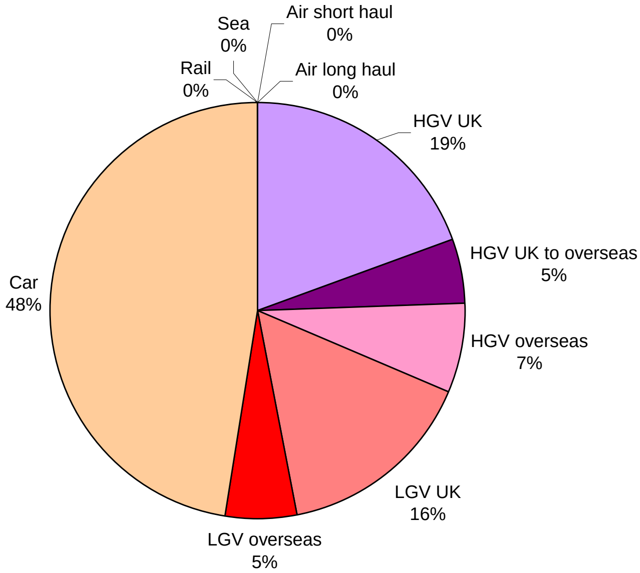

Figure 7 UK food vehicle-kilometres by transport mode (2002)

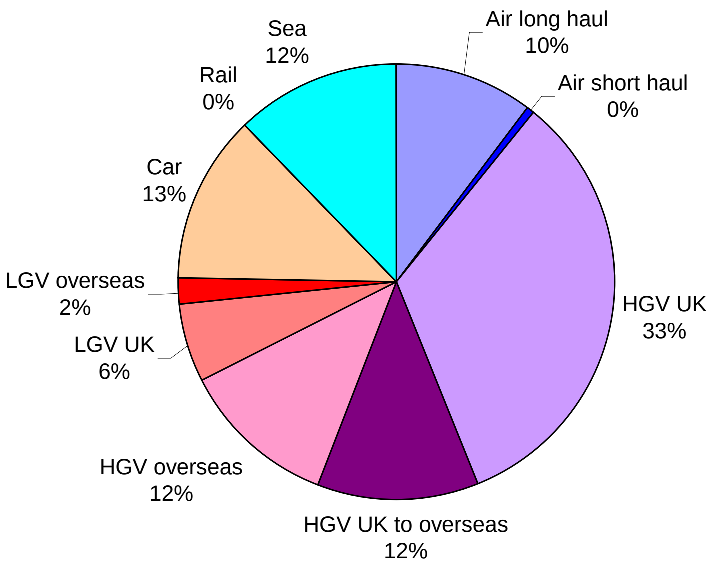

Figure 8 CO_2 emissions associated with UK food transport (2002)

The differences between the various metrics show that is misleading to focus on food transport only (and to only use the metric of 'food miles'. To properly address the problem it is necessary to focus on the sources of the external costs associated with (but not reflected in the price of) food transport. This is discussed in a later section. The following section provides more specific information by mode.

3.3.2 Split of food miles by commodity and mode

UK Road Freight

Figure 9 shows the breakdown of UK HGV tonne kilometres by food type.

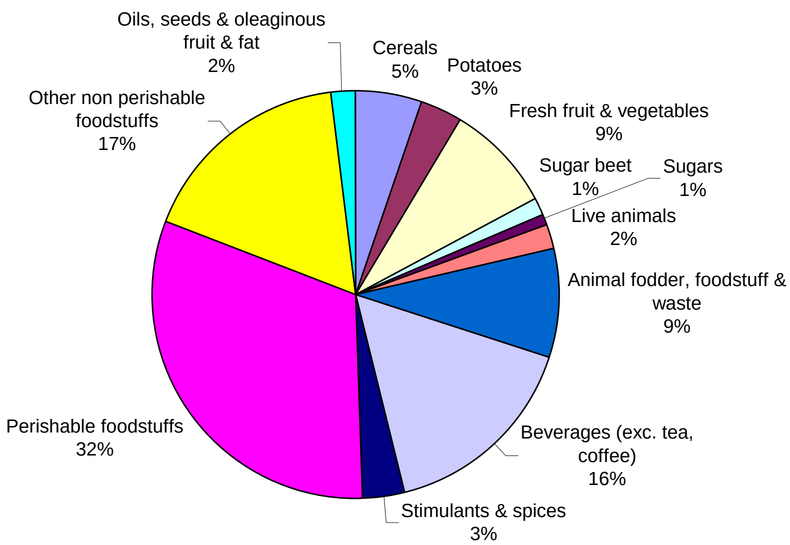

Figure 9: UK HGV tonne kms split by food type

Air freight

There is no data on the transport mode of goods imported from the EU. However, we assume that air freight of food from the EU is negligible (based on expert opinion). For transport within the EU, "air freight" is often actually carried by HGV, even though it is labelled and recorded as being air freighted[41].

For transport from non-EU countries, data split by transport mode is available[42]. This shows that air freight is currently small compared to sea and road freight (less than 1% of both tonne kilometres and vehicle kilometres). However, it has a much greater environmental impact per tonne carried. It is reserved for highly perishable goods (e.g. seafood), high value goods (tobacco, alcohol) or for exports from countries where the road / sea route is less convenient (exotic fruit and vegetables from sub-saharan Africa). 80% of all cargo is currently carried as belly freight on passenger planes, but there is a trend towards more use of air freighters. Indeed, a recent report states that in fact most food freight is now carried on dedicated freighters, because this allows easier handling of pre-packed containers with special storage requirements, and also can provide a more reliable and potentially a cheaper service[43].

Figure 10 shows the split of goods imported or exported by air. The single largest category is vegetables from Africa (green beans, baby corn, mangetout and so on imported from Kenya, Gambia, Egypt etc). In all, vegetable imports account for 40% of food air freight in or out of the UK, fruit imports for 21% and fish imports for 7%.

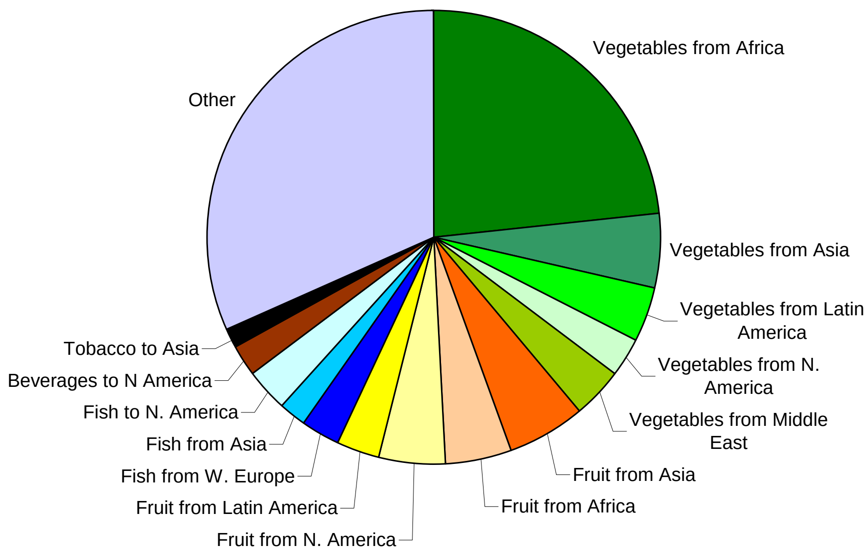

Figure 10: Split of air imports by food type and source / destination.

3.3.3 Significance of CO_2 emissions in terms of UK totals

Table 8 below presents the contribution of food transport to the UK's CO_2 emissions. Food miles generated by the UK produce around 19 Mt of CO_2. Of this, 10 Mt (52%) is produced in the UK (nearly all by road vehicles), and therefore contributes to the UK's reported total CO_2 emissions[i].

The total emissions arising from UK-generated food transport represent 3.4% of the UK reported total CO_2 emissions of 551 Mt, and 16.3% of the 116 Mt arising from road transport. The final column of the table shows that food transport in the UK produces 1.8% of the total reported UK CO_2 emissions from all sectors, and 8.4% of the total UK emissions from road transport.

Table 8: Contribution of food transport to UK CO_2 emissions (2002)

	kt	% from UK-generated food transport (UK and overseas)	% from road food transport in the UK
Total food transport CO_2	18,956		51.4%
Food transport CO_2 emitted in the UK	9,742		
Total UK CO_2 (from all sources)	551,500	3.4%	1.8%
Total UK road transport CO_2	116,600	16.3%	**8.4%**

Source: NAEI, AEAT estimates

3.3.4 Food transport energy as part of total food industry energy consumption

Table 9 shows energy consumption from food transport as a proportion of the energy consumed by the entire food production and distribution industry in the UK – estimated by adding the total final energy consumption of the agriculture and food and beverage industry sectors to our own estimates of food transport and retailing energy consumption. Our analysis estimates that food production, retailing and transport represent 8% of the UK's final energy consumption, and food transport accounts for **47%** of this. As mentioned above, 52% of the energy used to transport food is consumed within the UK. (Note that this analysis excludes energy related to packaging, and also preparation of food at home or by caterers. INCPEN has estimated packaging energy consumption to be 115,000 TJ, and AEA Technology has estimated food preparation and catering to consume 88,000 and 151,000 TJ respectively. If these categories were included in total energy use, food transport would represent 29% of the total).

[i] International air, sea and road emissions are excluded from the UK's reported totals (with the exception of air emissions up to a height of 1000m, but our dataset does not explicitly identify this amount)

Table 9: Food transport as a proportion of the energy consumed by food production and distribution in the UK (2002)

Ktoe	coal	petroleum products	gas	renewables and waste	electricity	total	total TJ	% of total
Food & beverage industry	136	326	2339	0	1048	3849	161,158	**27%**
Agriculture	4	557	130	72	358	1121	46,936	**8%**
Food transport								
UK HGV		*2184*				*2184*	*91,425*	16%
UK LGV		*388*				*388*	*16,261*	3%
UK car		*834*				*834*	*34,932*	6%
Overseas		*3231*				*3231*	*135,296*	23%
Total food transport		6638				6638	277,914	**47%**
Distribution centres			10		89	99	4,140	**1%**
Retailing			468		1871	2339	97,925	**17%**
Total food related energy	140	7521	2947	72	3366	14045	588,073	100%
Total UK final energy consumption	2615	77606	61081	765	28282	172305	7,214,410	8%

Source: DUKES (2003)[44], AEAT estimates[45]
Excludes packaging, catering, and domestic cooking

3.4 DATA QUALITY

The data used to derive the food transport dataset is of varying reliability. The table below illustrates the differences in data quality between the different components of the dataset, together with the relative contribution of each component to estimated CO_2 emissions and vehicle kilometres (as a proxy for the significance of that component in terms of sustainability).

We believe that the data and methodology developed appears to be sufficiently robust to permit the development of a valid indicator. Data is of good quality and available on an annual basis in the most significant sectors. There are two main areas of uncertainty:

- **Overseas food transport** (i.e. food miles for production, processing and transport of food from the overseas producer to the dispatch port or airport). These are based on very uncertain estimates. However, DEFRA have stated that the overseas food transport are of lesser policy significance than the UK food miles, as obviously the opportunities for reduction through UK government actions are very limited. Proposals for satellite tracking of lorries in the EU may provide some useful data at least for the EU countries over the next few years.

- **Emission factors for sea freight** are uncertain because the average size of load carried by sea is poorly known. Further research could help to clarify this issue.

Table 10: Summary of data quality for food transport dataset components

Data component	Data quality	Estimated % of CO_2 emissions	Estimated % of vehicle km
UK HGV	Good (annual CSRGT survey). Can disaggregate food types but not imports and exports.	33%	19%
UK LGV	Good (DfT LGV survey).	6%	16%
UK car	Vehicle km fairly well defined – tonne km uncertain (data for average loads carried per car is poor).	13%	48%
UK sea, rail, inland waterway, air	Little data which separates out food from other freight, but insignificant	Very low	Very low
International air	Good for non-EU countries (HM C&E database). Not available for EU countries but thought to be insignificant.	11%	0.1%
International HGV	Total tonne km for road and sea is available (HM C&E database). Split between road and sea depends on reasonably well-constrained assumptions.	12%	5%
International sea	Total tonne km for road and sea is available (HM C&E database). Split between road and sea depends on reasonably well-constrained assumptions.	12%	0.04%
International rail, inland waterway	Not available but thought to be insignificant.	Low?	Low?
Overseas HGV	Poor – estimate based on country size and handling factor. May be an underestimate.	12%	7%
Overseas LGV	Very poor – based on very poorly constrained estimates but thought to be insignificant.	2%	5%
Overseas rail, air, inland waterway	Not available but not thought to be very significant.	Very low?	Very low?

4 The direct impacts of food transport

We have assessed the environmental, social and economic impacts of food miles – both costs and benefits. The evaluation covers two types of impact:

1. A quantitative evaluation of the direct impacts of food transport with an estimate of the social costs in monetary terms, as short-run marginal costs*.

2. A qualitative assessment and discussion of wider social and economic effects (see Section 5).

The impacts covered are summarised below. More details of the data sources and assumptions are to be found in Annex 3.

Cost category	**Type of assessment**	**Notes**
Direct environmental costs of food transport		
Climate change	Short run marginal costs	CO_2 from transport fuel use. Excludes refrigeration during transport
Air quality	Short run marginal costs	Emissions of NO_X, SO_2, particulate matter (PM_{10}) and volatile organics (VOCs).
Noise	Short run marginal costs	Road transport only (not air). Amenity costs, based on property prices. Excludes health impacts.
Other environmental costs	Listed but not assessed	
Direct social costs of food transport		
Accidents	Average costs (insufficient data for marginal costs)	Quantitative assessment for road transport and partial evaluation for other modes
Animal welfare	Brief discussion	
Direct economic costs of food transport		
Congestion	Short run marginal costs	Quantitative assessment for road transport and partial evaluation for other modes
Infrastructure	Short run marginal costs	
Wider social and economic issues		
Food prices	Qualitative assessment	
Consumer choice	Qualitative assessment	Includes nutrition and food culture
Rural communities	Qualitative assessment	Socio-economic issues and access to food
Developing countries	Qualitative assessment	Socio-economic and environmental issues

* Short-run marginal cost: the cost of an additional unit of burden (e.g. pollution) assuming that infrastructure remains fixed.

4.1 DIRECT ENVIRONMENTAL COSTS OF FOOD TRANSPORT

Table 11 shows the estimated CO_2 emissions, air pollutant emissions and fuel use for all the UK generated food transport in 2002. Full details are in Annex 3 but the main data sources and assumptions are listed below.

4.1.1 Greenhouse gases

We have assessed CO_2 emissions from fuel used during transport of food by all modes. We have not assessed emissions from energy used for refrigeration during transport, nor emissions of non-CO_2 greenhouse gases from refrigeration systems (i.e. HFCs). Emission factors for road transport were based on the UK National Atmospheric Emissions Inventory, and for other modes were based on the DEFRA Company Environmental Reporting Guidelines[40] supplemented by other sources (see Annex 3). The results have already been presented in Section 3 of this report (see pie chart in Figure 8). Around 19 million tonnes of carbon dioxide are produced from UK food transport each year, 10 million tonnes of which are in the UK (1.8% of total reported UK CO_2 emissions).

Greenhouse gas emissions are dominated by road transport, with HGV transport alone accounting for over half of all emissions, and cars and vans accounting for another 21%. However, the contribution of air and sea transport is also significant, and is growing. It is worth noting that international air and sea transport are not included under the Kyoto protocol targets, are not reported in national greenhouse gas inventories and they also benefit from untaxed fuel. Air transport may have a disproportionate greenhouse gas impact due to the location of emissions in the stratosphere, with potentially severe consequences for both climate change and ozone depletion (Box 4). Recent indications are that most food freight is now transported in dedicated freighters, rather than as belly freight in passenger planes (see Section 3.3.2). Freighters tend to be converted from retired passenger aircraft, and therefore would be less efficient and more polluting than modern aircraft.

Valuation of greenhouse gases is based on the Government Economic Service (GES) paper *Estimating the Social Cost of Carbon Emissions*[i], which recommends the use of a value of £70 per tonne of carbon.

4.1.2 Air quality

Transport activities produce a number of pollutants that have potential health effects. These include nitrogen oxides (NO_x), particulate matter (PM_{10}), sulphur dioxides (SO_2), volatile organic compounds (VOCs), benzene, butadiene and organo-metallic compounds. We have assessed the first four of these pollutants (NO_x, PM_{10}, SO_2 and VOCs), as these dominate the known and quantifiable adverse health impacts of transport air pollutants[52].

The evidence for the health impacts of transport emissions is strongest for PM_{10}. This includes direct emissions of PM_{10} and also secondary particulates formed from NO_X and SO_2 emissions in the atmosphere. Ground level ozone is also important, formed by reactions involving NO_x and VOCs in the presence of sunlight. These pollutants may result in premature mortality (deaths brought forward), hospital admissions, and possibly exacerbation of asthma, other respiratory symptoms and loss of lung function[46]. Recent studies also suggest that long-term exposure to these pollutants, especially particles (PM_{10}), may also damage health and may reduce life expectancy (so called chronic mortality) and that these effects are substantially greater than the acute effects above.

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[i] http://www.hm-treasury.gov.uk/documents/taxation_work_and_welfare/taxation_and_the_environment/tax_env_GESWP140.cfm

As well as health impacts, emissions cause damage to crops and buildings, and SO_2 and NO_x emissions cause acid rain which damages ecosystems. We have assessed building damage and crop damage from ozone, but not acid rain effects on ecosystems. We have also not assessed eutrophication of surface water.

Table 11: CO_2, air pollutant emissions and fuel use for UK Food Transport (2002)

Emissions and fuel use in kilotonnes	Mvkm	Mtkm	CO_2	PM_{10}	NO_x	VOCs	SO_2	Fuel
UK HGV	5,812	47,400	**6274**	**1.62**	**59.46**	4.21	0.16	1,996
UK LGV	4,743	2,092	1076	0.71	4.77	0.98	0.03	355
UK car	14,340	158	2392	0.21	8.04	3.51	0.06	763
UK to overseas road	1,577	12,866	2269	0.51	20.49	0.85	0.06	712
Overseas HGV	2,036	16,605	2198	0.57	20.83	1.47	0.06	699
Overseas LGV	1,662	733	391	0.27	1.73	0.31	0.01	124
Overseas rail	0	33	1	0.26	0.01	0.00	0.00	0
UK rail								0
Deep sea	13	146,669	2249	0.84	**35.85**	1.69	**37.95**	716
Short sea	2	5,245	154	0.06	2.46	0.12	2.60	49
UK sea								0
Air long haul	26	1,280	1971	0.22	3.81	1.02	0.25	626
Air short haul	0	21	88	0.01	0.05	0.05	0.00	28
Total	**30,211**	**233,102**	**19,062**	**5**	**158**	**14**	**41**	**6,069**
Total UK emissions (2001)			564,667	208	1,984	1,587	1,220	
% of 2001 UK emissions			3.4%	2.5%	7.9%	0.9%	3.4%	
Cost (£M)			**364**	**247**	**133**	**8**	**50**	

Table 11 shows emissions of the major air pollutants arising from UK generated food transport in 2002, together with the UK reported totals (note these reported totals will not include emissions from international air and sea transport and overseas road transport).

We have applied social costs per tonne of pollution to the emission estimates, based on previous work[52] and recent updates for Defra[47]. The values are consistent with current recommendations and best practice. In reality, the location of air pollutant emissions is important in determining their impact. For road transport, emissions in towns and cities have a higher impact than those in rural areas because of the population exposed. Application of different social cost factors to emissions in urban and rural areas will reduce the costs of HGV transport relative to car and van transport. Although HGVs account for over half of all the air pollutant emissions, we estimate that only 30% of the HGV mileage is in urban areas where the impact is greatest, compared to 50% for cars and 60% for vans. However, as the social costs of air pollution are not one of the key indicators selected for use in the study, and as preliminary investigation implied that the overall effect of differentiating between different locations would not affect the main conclusions of the study, we did not differentiate social costs by emission location.

For sea transport, emissions in mid-ocean will have relatively little impact, whereas emissions near the coast will have some impact. We do not have reliable estimates of how much of the sea emissions are close to the coast, and how much are mid-ocean, although shipping routes often tend to follow the coast where possible. For this report we have estimated that 10% of deep sea emissions of air pollutants occur in coastal regions, and therefore have health impacts, and the remaining 90% have zero social costs. All short sea emissions are assumed to have health impacts. However, the potential effects of SO_2 emissions from ships, including acidification, are significantly underestimated with this approach.

Box 4. How Do Aircraft Affect Climate and Ozone?

Aircraft emissions include the greenhouse gases carbon dioxide and water vapour (H_2O), nitric oxide (NO) and nitrogen dioxide (NO_2) (which together are termed NO_x), sulphur oxides (SO_x), and soot. Aircraft emit gases and particles directly into the upper troposphere and lower stratosphere where they have an impact on atmospheric composition. These gases and particles alter the concentration of atmospheric greenhouse gases, including carbon dioxide CO_2), ozone (O_3), and methane (CH_4); trigger formation of condensation trails (contrails); and may increase cirrus cloud formation - all of which contribute to climate change.

The climate impacts of the gases and particles emitted and formed as a result of aviation are difficult to quantify. Because carbon dioxide has a long atmospheric residence time (ª100 years) and so becomes well mixed throughout the atmosphere, the effects of its emissions from aircraft are indistinguishable from the same quantity of carbon dioxide emitted by any other source. The other gases (e.g., NO_x, SO_x, water vapour) and particles have shorter atmospheric residence times and remain concentrated near flight routes, mainly in the northern mid-latitudes. These emissions can lead to radiative forcing that is regionally located near the flight routes for some components (e.g., ozone and contrails) in contrast to emissions that are globally mixed (e.g., carbon dioxide and methane). It has been estimated that the indirect radiative forcing from aircraft nitrogen oxide emissions and other emissions is a factor of 2.7 times the effect of the CO_2 emissions[48],[49].

Ozone is a greenhouse gas. It also shields the surface of the earth from harmful ultraviolet (UV) radiation. Aircraft-emitted NO_x participates in ozone chemistry. Subsonic aircraft fly in the upper troposphere and lower stratosphere (at altitudes of about 9 to 13 km). Ozone in the upper troposphere and lower stratosphere is expected to increase in response to NO_x increases, and methane (a greenhouse gas) is expected to decrease. Water vapour, SO_x (which forms sulphate particles), and soot play both direct and indirect roles in climate change and ozone chemistry.

Source: IPCC[50]

For air transport, the situation is even more complex. A significant portion of air pollutant emissions occur high in the air, where impacts on human health are minimal. However, aircraft have disproportionately high emissions on take-off and landing (including a high level of emission of particulates from brake wear), and NO_2 pollution levels are often of concern around major airports. Some of these emissions will have an impact on human health. Aircraft emissions in the stratosphere also have complex impacts on climate change and ozone (see Box 4). For this report we have estimated that 10% of short haul and 5% of long haul aircraft emissions of air pollutants occur close to the ground, and therefore have health impacts, and the remaining 90% have zero social costs. These estimates are thought to be an upper bound to the potential impacts. We have adopted the IPCC recommended value of 2.7 as the radiative forcing factor of all aircraft emissions relative to the CO_2 emissions.

The values used for the valuation of health impacts and deaths in this study are taken from a recent analysis for Defra[47]. The social cost of an acute premature death from air pollution is valued using a range of £3,000 to £110,000. This value is adjusted down from a full value of statistical life to take account of the short period of life lost and in some cases the existing low quality of life experienced by people who are chronically ill. The value also includes chronic mortality effects (the change in life expectancy from long term air pollution exposure, which is valued using a years of life lost approach, using a value for a life year of £31,500 to £65,000)). Acute morbidity effects from air pollution are also included.

On the basis described above, the social costs of air pollution from UK food transport in 2002 are estimated at around £439 million. The major health impact arises from particulate and NO_x emissions, through their role in respiratory disease and mortality. The estimates are shown in Table 11 and 18. HGV transport dominates the social costs of air pollution, and this arises roughly equally from PM_{10} and NO_x pollution. These values may be underestimates as they do not adjust for the higher impacts of urban emissions and do not include a number of other potential health and environmental impacts (chronic morbidity effects and impacts on ecosystems). It should be noted that the analysis excludes the impact of acid rain from SO_2 and NO_x emissions. This would be most significant for ships, and would increase the social cost of sea transport.

4.1.3 Noise

Data on the distribution of noise outside dwellings shows that over half the homes in England and Wales are exposed to noise levels exceeding the World Health Organisation recommended daytime level of 55dB(A), above which noise levels cause annoyance. It also found that 7 per cent of homes were above the qualifying level at which sound insulation improvements must be provided if there is an increase in noise resulting from the development of a new road. Most of this noise comes from road and air transport.

The health effects of noise are mostly limited to cases of hearing loss and tinnitus caused by long periods of (occupational) exposure. These effects are generally not important at the typical levels of noise arising from transport. However, a number of studies also point to potential physiological and psychological impacts from the noise levels associated with transport (from road, rail and aircraft), including:

- Speech interference,
- Annoyance,
- Sleep disturbance,
- Performance,
- Cardiovascular and physiological effects,
- Mental health effects.

Overall, while there is general agreement that noise is a source of annoyance, there is still debate about potential effects on health. It is stressed that much of the evidence in support of actual health effects other than annoyance and some indicators of sleep disturbance is quite weak.

Within the UK, the current position is that it is not possible to determine what the possible health effects of noise are, let alone quantify and value these impacts[51]. However noise does have a major impact on amenity (not health), which can be measured directly in economic terms through hedonic pricing studies. Previous studies including the STCC project have used the relationship between noise levels and property prices to estimate a monetary value for the social cost of noise.

The study has taken the marginal social costs of the noise generated by road and rail transport in the UK from marginal cost data in pence per vehicle km for different vehicle classes estimated by the STCC project[52]. The results are shown in Table 18.

Noise from air transport causes considerable nuisance to people living in the vicinity of airports. The total costs of noise impacts for all UK airports has been estimated at around £25 million/year[53]. However, we do not have sufficient data to determine what proportion of these costs should be allocated to food freight.

It was not possible to estimate noise impacts for sea transport within the scope of this project, but the impacts of noise from sea transport will be negligible.

The social costs of noise from road and rail transport are estimated to be £283 million per year, similar in magnitude to the climate change and air pollution costs.

4.1.4 Other environmental impacts

Other impacts not assessed here include:

- Emissions associated with fuel extraction, processing and distribution and other environmental impacts across the fuel lifecycle (including oil discharges to sea).
- Depletion of oil resources.
- Environmental costs of road and air infrastructure, e.g. loss of amenity and damage to wildlife habitats[i].
- Extra packaging required for long distance transport of food.

4.2 DIRECT SOCIAL COSTS OF FOOD TRANSPORT

4.2.1 Accidents

The social costs of accidents in the UK were estimated from data on the involvement rates of different vehicle types in accidents of different severities on different road types, multiplied by the costs of preventing these accidents. For accident costs, data on a Europe-wide basis was not adequate to support the marginal cost approach, so average costs were used instead.

Our estimates of the social costs of accidents are shown in Table 12 and Table 13. We estimate that food transport in the UK cause over 280,000 accidents each year, two thirds of which are by cars, and including 300 deaths and over 2000 serious injuries. The estimated social cost of accidents arising from UK food transport is £1.4 billion.

Cars and LGVs cause more accidents than HGVs due to the higher number of vehicle kilometres travelled and the location of the journeys in urban areas. However, accidents involving HGVs are more severe, resulting in more fatalities per km driven. HGVs are involved in 35% of the 300 fatal accidents. In undertaking food transport they only cover 18% of their vehicle kilometres on urban roads but incur 36% of the food related fatal accidents on this class of road. On the other hand cars are involved in 73% of the food transport related accidents on rural roads.

In the case of both cars and LGVs a relatively high proportion of fatal accidents occur on rural roads. This pattern of accidents is the same as that observed for traffic in general. LGVs carrying food appear to be relatively safe compared with cars, but this is in part a reflection of the fact that cars carrying food shopping are assumed not to travel

[i] These impacts are not included under the section on "infrastructure" as this is based on short run marginal costs which assume that infrastructure capacity is fixed. Also, there is inadequate data to assess the relationship of food miles to the demand for new or expanded road or air infrastructure.

significantly on motorways, which is the road class with the lowest accident rates. Reducing the number of HGVs entering urban areas should in theory reduce fatalities. However, in practice this depends on the alternative transport of food in those areas and the additional vehicle kilometres generated.

Table 12: Estimated Number of Food Transport related Accidents in UK 2002

Category	Fatal	Serious	Slight	DoA	Total
HGV	109	435	2394	37930	40867
LGV	26	248	1731	31671	33676
Cars	166	1549	11793	199275	212783
Total	**301**	**2232**	**15917**	**268877**	**287327**

Source: ITS estimates**.**
DoA is "damage only" accident

Table 13: Estimated marginal cost of food transport related accidents in UK 2002 (£m).

Category	Fatal	Serious	Slight	DoA	Total
HGV	155	74	42	58	327
LGV	36	40	28	45	148
Cars	232	253	191	289	965
Total	**422**	**367**	**260**	**391**	**1440**

Source: ITS estimates.

For accidents overseas, figures from the RECORDIT study[54] were used. This gave the monetary values of accidents (on a willingness to pay basis) and the involvement rates of articulated lorries.

Applying these accident rates to overseas food miles by road gives the estimated number of accidents, including over 270 fatalities. The social cost of accidents overseas is estimated as £566m. Therefore the total cost of accidents from food transport is assessed as **£2 billion**.

Accidents at sea have also been included (see Annex 3 for details). Accidents for rail are insignificant. We have not been able to quantify accidents during air transport.

4.2.2 Animal welfare

Transport of live animals as part of the food chain raises issues of animal welfare. There are welfare controls in the UK, which implement EU directives and apply throughout the 25 members of the EU[i]. In some non-EU countries, the conditions in which live animals are transported (and reared) may be subject to less control than in the EU, and animal welfare impacts may therefore be higher in cases where live animals are imported from these countries (for the part of production and transport chain within that country).

DEFRA state that "UK policy would be best summed up as a preference for slaughter close to the place of production and an end to long distance transport solely for slaughter at the destination (this has to be balanced by the demands of the single market and commercial/economic decisions)". Transport of meat rather than live animals would also lead to a reduction in vehicle kilometres as meat is a more compact load than live

[i] However, animal welfare groups such as the RSPCA express concern that many of the ten million animals transported in the EU each week "suffer acute and chronic stress, injury, dehydration and fatigue". They campaign for controls to be improved (for example to give a shorter journey times, less crowded conditions and to reduce the number of violations that occur).

animals. Live animal transport is often carried out for commercial reasons, for example animals may be transported around several markets to obtain a better price. However, there may also be some economic and commercial benefits from reducing live animal transport. A recent RSPCA report points out that certain stressors encountered during live animal transport can lead to a reduction in meat quality or increased susceptibility to disease, which can lead to commercial losses for the producer[55].

Over 6 million tonnes of live animals were transported by HGV within the UK in 2002, travelling 764 million tonne km and 118 million vehicle km[1]. When discussing the animal welfare impacts of live animal transport, numbers of each types of animal are more relevant than tonnes or vehicle kilometres. This data is not available for animal transport within the UK, but numbers of animals exported and imported are recorded. In 2002, 5 million live animals were imported to the UK and 41 million exported. Most of these were poultry, but there were also imports of 23,000 bovine animals and 230,000 swine, and exports of 32,000 swine and 114,000 sheep[37].

Distances over which live animals are transported within the UK have increased due to the recent closure of many small local abattoirs (and some larger ones), partly as a result of charging systems for hygiene inspections[56]. The increased movement of stock around the country was implicated in the spread of the recent foot and mouth epidemic, which resulted in large economic losses to rural communities[57]. Reductions in live animal movements could help to reduce the rates of spread of animal diseases.

Additional issues may arise when meat or live animals are traded with other countries which have differing welfare standards to the UK. For example, the use of sow stalls is banned in the UK and some other European countries. Therefore reduction of pig meat imports from certain European producers could achieve a potential animal welfare benefit. However in other cases, meat may be imported from farms which exceed the minimum EU animal welfare requirements, for example by providing outdoor access and less intensive stocking densities.

No methodology has yet been developed for valuing animal welfare. One approach would be to use the premiums paid by some consumers for meat produced by systems representing higher animal welfare standards than the minimum (e.g. free range, organic or freedom foods)[58] to indicate their “willingness to pay” for avoidance of animal suffering. However, this approach has several flaws, for example there is a “suppressed demand” for animal welfare from consumers who would like to buy free range meat but cannot afford to. Also there is no direct relationship between price premiums and willingness to pay. Some economists now believe that it is more appropriate to consider certain minimum standards of animal welfare as a “public good” which should be obtained regardless of price. The problem then lies in defining this minimum standard. Of course there are already a set of minimum standards in the UK and EU, but it is not clear whether this would be identical to that determined by consumers. More consumer research is required in this area.

4.3 DIRECT ECONOMIC COSTS OF FOOD TRANSPORT

4.3.1 Congestion

The cost of congestion within the UK is based on data from the STCC study[52]. This estimates marginal social congestion costs based on the time lost by all traffic when an extra vehicle joins the traffic flow, multiplied by the “value of time” as defined in the Highways Economic Note.

The use of marginal costs to estimate congestion costs follows standard government methodology. This method is recommended because the impact of an additional vehicle will depend on the level of traffic already present on the road. The use of "average" costs, in which total congestion costs are distributed evenly between all vehicles on the road, would give lower cost values, although this method is not recommended.

Congestion impacts are highly dependent on time. For the cost evaluation, we split traffic into time bands (based on DfT data) and applied different costs to each time band.

For congestion costs in Europe, the source was the UNITE study[59]. Although these values were on a different basis to those for the UK generated from STCC, it was clear that congestion costs were generally lower in continental Europe.

The total estimated costs for congestion in the UK are shown in Table 14.

Table 14: Estimated food transport congestion costs in the UK, 2002 (£M)

Vehicle category	Motorway	Rural	Urban	All roads
HGV Artic	313	136	469	919
HGV Rigid	62	72	306	440
LGV	40	70	946	1056
Car	0	430	2146	2576
Total	**415**	**709**	**3866**	**4991**

Clearly the costs generated by cars on shopping trips in the UK dominate this category of costs, particularly in urban areas, with over half the UK total of £4900m. LGV congestion is also estimated to be high, related to the assumption that 60% of LGV mileage is on urban roads. Congestion costs in overseas countries are much lower at only £196m (see Annex 3), and are dominated by the international stage of HGV transport on European motorways. This is partly because roads are less congested overseas, so that costs per additional vkm are lower, but mainly because overseas UK-related food transport do not include car food shopping, which dominates congestion costs in the UK.

4.3.2 Infrastructure

The marginal costs produced in the STCC study[52] were used as the basis for estimating infrastructure costs in the UK. These are short run marginal costs, so assume capacity is fixed. Therefore they exclude the cost of building new transport infrastructure, and include only maintenance and operating costs. For infrastructure costs in Europe the source of data was the EU RECORDIT study. Full details are in Annex 3.

The costs of infrastructure per kilometre are higher in Europe, reflecting road networks that receive better maintenance, especially in northern Europe, when compared to the UK, and, with the exception of the Netherlands, generally have lower density of traffic. On the other hand, infrastructure costs in developing countries are generally lower reflecting poor or zero maintenance. Poorly maintained roads generate costs to commercial vehicle operators in the form of repairs (especially to tyres and suspension units), loss of vehicle utilisation and unreliable service to shippers, but these are outside the scope of the current study.

The results are shown in Table 15 and Table 16. HGVs are the major source of road infrastructure costs. The application of the 'fourth power law' to the wear caused by the passage of a vehicle axle means that those vehicles with high axle weights (as a result of carrying the heaviest payloads) are allocated the largest share of the cost of maintaining the road pavement. The outcome is that articulated HGVs account for 72% of the food transport-related infrastructure costs in the UK, and 90% of that on motorways. Most of the remaining costs are caused by rigid HGVs. The overseas infrastructure costs arising from transport of UK food follow a similar pattern, with articulated vehicles being allocated 84% of the total.

Table 15: Total Food Transport Related Infrastructure Costs in UK, 2002 (£m)

Vehicle category	Motorway	Rural	Urban	All roads
HGV Artic	86.1	109.7	91.4	287.2
HGV Rigid	8.7	43.9	46.7	99.3
LGV	0.1	1.0	2.4	3.5
Car	0.0	4.8	4.6	9.4
Total	**94.9**	**159.4**	**145.1**	**399.5**

Source: ITS Estimates.

Table 16: Total Food Transport Related Infrastructure Costs overseas, 2002 (£m)

	Artic	Rigid	LGV	Totals
International (UK to overseas)	141	0	0	**141**
Western Europe				
Motorway	32	3	0	34
Rural	28	12	0	40
Urban	48	17	1	66
Total	107	32	1	**140**
Other developed countries				
Motorway	24	3	0	26
Rural	21	9	0	30
Urban	36	13	1	50
Total	81	25	1	**107**
Developing countries				
Motorway	7	0	0	7
Rural	5	3	0	8
Urban	9	4	0	13
Total	21	7	0	**28**
Total overseas	**209**	**63**	**3**	**275**
Total international + overseas	**349**	**63**	**3**	**416**

Non-road modes

It was difficult to find good sources of data for estimating the congestion, accident and infrastructure costs of rail, sea and air transport. Estimates were made for the costs of accidents at sea, and for rail congestion, infrastructure and accident costs. However it was not possible to estimate costs for air transport. The results for non-road modes are shown in Table 17.

Table 17: Cost of Food Transport by Non-road Modes in the UK (£m)

Cost item	Sea	Rail	Air Long haul	Air Short haul
Accidents	29.4	Negligible	n/a	n/a
Congestion	Negligible	0.2	n/a	n/a
Infrastructure	n/a	0.2	n/a	n/a
Total	-	0.4	-	-

Sources: UNITE D8. ITS Estimates.

N/a = not available.

4.4 SOCIAL COST ESTIMATES

Allocation of social costs was described in the preceding sections for carbon dioxide emissions, air pollution, noise, accidents, congestion and infrastructure. Table 19 and Figure 11 summarise our estimates of those social costs which we have been able to quantify, split by transport mode. The estimates are for short run marginal social costs (except for accidents, see section 4.2.1). The total cost estimate is over nine billion pounds. Of this, congestion accounts for £5 billion and accidents for £2 billion. The dominance of congestion costs over environmental effects reflects the high "value of time" recommended in the evaluation.

While there is considerable uncertainty attached to social cost estimates, the estimate of £9 billion is significant by comparison with the gross value added of the agriculture sector (£6.4 billion), and the gross value added of the food and drink manufacturing sector (£19.8 billion in 2002). It is important to remember that the estimation of social costs is highly uncertain, not all impacts are included and these figures are only indicative of the order of magnitude of the social costs.

Important caveats are:

- no account is taken of the split between urban and rural road air pollutant emissions;
- crude estimates are made of the proportion of sea and air pollutant emissions which are close enough to areas of population to have health impacts (10%), and no account is taken of the complex effects of air emissions on ozone depletion;
- it was not possible to assess noise, accident, infrastructure or congestion costs for air transport;
- many impact categories are excluded (e.g. animal welfare, wider economic and social impacts, acid rain, new transport infrastructure).

Because of the large uncertainty attached to social costs for air transport, this mode has been excluded from Figure 13. The figure and table show the dominance of congestion above all the other social costs, followed by accidents. UK car transport for food shopping accounts for most of the congestion and accident costs. UK HGV transport is the next highest category, with high congestion, accident and infrastructure costs. Sea and air transport appear to have relatively low total social costs, although the air transport social costs are incomplete. However, note that air transport does have high environmental impacts per tonne of food transported.

Table 18: Social cost estimates for UK-generated food transport (2002)

£M	CO_2	Air quality	Noise	Congestion	Accidents	Infrastructure	Total costs
UK HGV	120	165	123	1359	327	387	2480
UK LGV	21	48	27	1056	148	4	1303
UK car	46	24	42	2576	965	9	3662
UK to overseas road	43	54	39	52	115	141	443
Overseas HGV	42	58	43	90	304	272	809
Overseas LGV	7	18	9	54	147	3	239
Rail	0	15	0	0	0	0	16
Deep sea	43	32	0	0	26	nq	106
Short sea	3	22	0	0	3	nq	32
Air long haul	38	1	nq	nq	nq	nq	39
Air short haul	2	0	nq	nq	nq	nq	2
Total	**364**	**439**	**283**	**5187**	**2036**	**815**	**9123**

nq=not quantified
Sources: various (see Annex 3)

Notes

1. Air and sea transport air quality costs are incomplete.
2. Assumes that 10% of short haul air, 5% of long haul air, all short sea and 10% of deep sea emissions of air pollutants are close to land and therefore attract social costs.
3. Social cost estimates are uncertain and this should only be taken as a guide to possible trends and patterns of cost allocation.

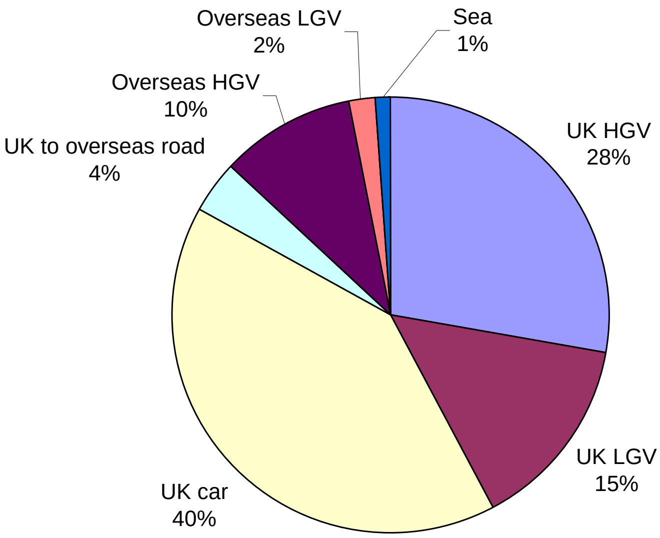

Figure 11. Approximate social costs from UK-generated food transport, 2002 (Excluding air transport, and not differentiated by location of emissions)

5 Wider social and economic issues

5.1 INTRODUCTION

In addition to the direct impacts of food transport identified in Section 4 (pollution, congestion, etc.), food supply is associated with wider social and economic issues. These include:

- food prices;
- consumer choice and nutrition;
- trends affecting UK suppliers;
- changes in food retail structure and accessibility;
- international trade and developing countries.

These are highly complex and controversial issues. A detailed investigation is outside the scope of this project. In this section we list the main points of debate, briefly examine the available evidence, and assess the need for further research.

To set the analysis in context, Box 5 presents a brief description of food supply chains in the UK. Below we also summarise economic activity in the food and drink sector. Unless stated, the measures do not include food and drink transport carried out by logistics companies based outside the sector.

Table 19 shows the economic activity in the food and drink sector. Sales revenue from the sector amounted to £133 billion in 2002, of which almost half was from the catering sector. This was around one fifth of consumers' total expenditure. The food chain accounts for 8% of the UK's GDP. Gross value added by each sector is also shown in the table, together with the level of exports and imports.

Table 19 Economic activity in the UK Food Chain

	£bn	Employment
Total expenditure on food and drink	**133**	
Catering	*62*	
Household	*71*	
Gross value added		
Retailers	*17.6*	1,147,000
Caterers	*16.5*	1,404,000
Wholesalers	*6.9*	191,000
Manufacturers	*19.8*	454,000
Agricultural wholesalers	*0.7*	23,000
Farmers and primary producers	*6.4*	550,000
Fishing	*0.4*	15,000
Total	**68**	**3,784,000***
Imports	18.2	
Exports	8.5	

Source: Food Industry Sustainability Strategy (DEFRA, 2003)
*Plus around 300,000 jobs in the freight and logistics industry (see below)

Employment

The food and drink sector (manufacturing, agriculture and retailing) employs approximately 3.8 million people (13% of total employment in the UK). A breakdown (excluding food freight by third parties) is shown in Table 19. Catering and retail account for around one third of all jobs each, the remaining third being split between farming and manufacturing. In the agricultural sub-sector, employment was approximately 350,000 full-time-equivalent in 2000 - representing 1.2% of UK employment[60]. The freight and logistics industry employs over 1 million people. We do not have data on the proportion of these jobs related to food freight. However, as food is responsible for around 25% of HGV vehicle kilometres, an approximate estimate would be that around 200,000 to 300,000 of these jobs might be related to food freight.

Small and medium sized (less than 50 employees) food businesses represent 10% of the turnover and 10% of the employment in the UK food and drink sector, as well as providing a vital element of innovation and specialisation in the food and drink industry[61].

5.2 FOOD PRICES

Food prices are influenced by a number of factors including:

- the cost of production, packaging and processing;
- the cost of distribution, including transport fuel, warehousing and logistics;
- cost of retail operations, including staff costs, land and property costs, and related to company size and turnover;
- profit margins at each stage;
- market price support (tariffs, quotas, export subsidies) within Common Agricultural Policy (CAP).

"Food miles" are directly related to food prices in two ways:

1. **Sourcing.** Wider (global) sourcing of food offers the potential to decrease the production element of costs, due to cheaper labour or more favourable climatic conditions. However, imports typically involve higher transport costs, due to increased transport distances, and in some cases the need for refrigeration or air freight. Packaging and processing costs will generally also be higher, due to the need to preserve food quality during transport.

2. **Transport and distribution costs**. Different transport and distribution systems have different associated costs. We examine the impact of transport and distribution costs on food prices in Section 5.2.1, below.

It is difficult to isolate these direct effects of food transport on food prices from other factors, such as retail costs and the CAP. We consider these complexities in Section 5.2.2.

Box 5: Food Supply Chains in the UK

The food sector is large, diverse and complex, but can be crudely characterised by a division between "local" and "supermarket" supply chains.

- 85% of food is sold through supermarket chains[75] with global supply systems, and with efficient, highly centralised distribution systems based on large HGVs travelling long distances to and from suppliers, regional distribution systems and stores. The dominance of multiple retailers is likely to increase with their move into the convenience store market.
- A parallel system of more local or regional food supply exists, where small to medium suppliers sell their produce either to wholesalers (who sell on to local shops, markets or caterers), local shops, caterers, or direct to consumers via farm shops, farmers markets or box schemes. Transport is mainly in smaller vehicles and load factors are lower.
- There is little interface between the two systems except that there are some limited sales of local and regional produce to supermarkets. Highly centralised supermarket distribution systems are currently not suited to accept large numbers of direct deliveries from the local food sector.
- There is competition between the two systems, in that smaller shops compete against large superstores, wholesalers are being displaced by supermarket regional distribution centres (RDCs), and smaller suppliers are affected by the reduced numbers of small independent shops and wholesalers.
- Consumers may use any combination of the two supply chains. Many purchase most of their food at supermarkets, using local shops or supermarket-owned convenience stores to "top-up" during the week. However, some use mainly local shops or markets, due to lack of access to a car, personal preference or price considerations (for markets).

The amount of local food stocked by local retail outlets is highly variable. Some outlets, such as farmers markets and some farm shops, stock almost exclusively local produce, whereas some convenience stores (especially those which supply little fresh produce) may stock very little. However, it is much easier for small to medium scale suppliers to sell their produce to local shops than to large multiple retailers, and many local shops and businesses do source much of their fresh produce locally. The Countryside Agency estimates that 55% of local food sales are through local outlets[62], although these outlets account for only 20% of all food sales. This indicates that the proportion of food sold which is locally sourced is on average five times higher in local outlets than in multiple retailers.

The high degree of concentration in the UK grocery retail sector (large proportion of sales through a few companies) coupled with the large proportion of supplies channelled through retailers' RDCs (93.2% by value in 2002), makes it relatively easy for foreign food suppliers to penetrate the UK consumer market. Distributing imported food products through around 70 major RDCs in the UK offers very wide exposure across the UK market. In countries with more fragmented retail sectors and more complex wholesale structure, it would be more difficult to achieve this degree of retail exposure.

5.2.1 The impact of transport and distribution costs on food prices in the UK

The logistical systems of UK supermarket chains are regarded as very efficient by comparison with those of firms in other sectors and grocery retailers in other countries. This is not directly reflected in lower prices for food in UK supermarkets, where prices are 12-16% higher than in Europe[33]. However, other factors may be more significant in this price differential, such as the price of land and the price of fuel, both of which are higher in the UK[33].

Transport costs comprise only a very low proportion of food prices. An annual Institute of Grocery Distribution survey of the logistics operations of major UK food retailers reveal that (unweighted) average expenditure on distribution represents around 3.5% of sales revenue (Table 20). The range between companies with the highest and lowest distribution cost % has steadily widened, however, mainly as a result of some companies experiencing an increase in this critical KPI.

Table 20. Distribution Cost as a % of Sales Revenue

	Average	Range
1998	3.46	2.10-5.10
1999	3.29	2.20-5.90
2000	3.71	2.30-5.00
2001	3.86	2.17-6.00
2002	3.44	2.05-6.40

Source: Institute of Grocery Distribution (2002)[63]

It is surprising that the average proportion of revenue spent on distribution has not dropped over this period, because management of the main logistical activities has become more efficient. Average days of inventory in the retailers' supply chains fell by approximately 18% between 1996 and 2002. Inventories of all the main grocery product groups fell over this period, reflecting the tightening of order lead times and growth of sales based ordering and cross-docking (Figure 12). Between 1993 and 1998 average space utilisation in retailers' distribution centres increased from 82.2% to 87.9%. The average size of distribution centres has also been rising allowing companies to take advantage of economies of scale in warehousing and related activities (Figure 13). Transport efficiency is also likely to have improved by a significant margin as a result of:

- Integration of primary and secondary distribution: involving the backloading of shop delivery vehicles and recent move to factory gate pricing*.
- Growth of primary consolidation upstream of the RDC, particularly for frozen and chilled product.
- Relaxation of company restrictions on the use of dedicated contract vehicles: allowing contractors to use them to carry other companies' products
- Adoption of new computerised vehicle routing and scheduling systems and vehicle tracking.
- Increases in the 'delivery day': with many vehicles operating over a 24 hour cycle
- Improvements in vehicle technology and materials handling equipment.

These efficiency gains may not be reflected in the average distribution cost % for several reasons:

- The quality and complexity of the distribution service has improved over this period: for example, product ranges have expanded, an increasing proportion of grocery sales requires refrigeration, product availability in shops may have improved (though there is no hard data available to confirm this).

- Retailers have taken on new logistical responsibilities for primary distribution upstream of the distribution centre: their role in the food supply chain has expanded

* Factory gate pricing: goods are purchased direct from the factory by retailers, who then arrange collection, replacing the previous system where manufacturers delivered to retailers and included delivery costs in the prices of the goods.

- The average distribution cost % is not weighted by the turnover of the supermarket chains: it, therefore, does not adequately report the improvements in distribution efficiency achieved by the largest and most successful supermarket chains.

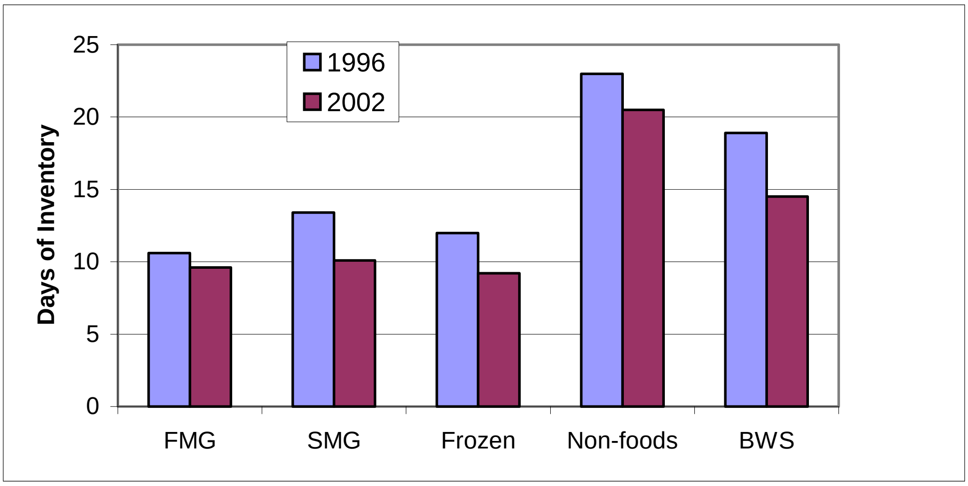

Figure 12. Changes in the Number of Days of Inventory in Grocery Retailers' Supply Chains 1996-2002

source: Institute of Grocery Distribution, 2002[64]
(FMG – fast moving goods SMG slow moving goods BWS beers, wines and spirits)

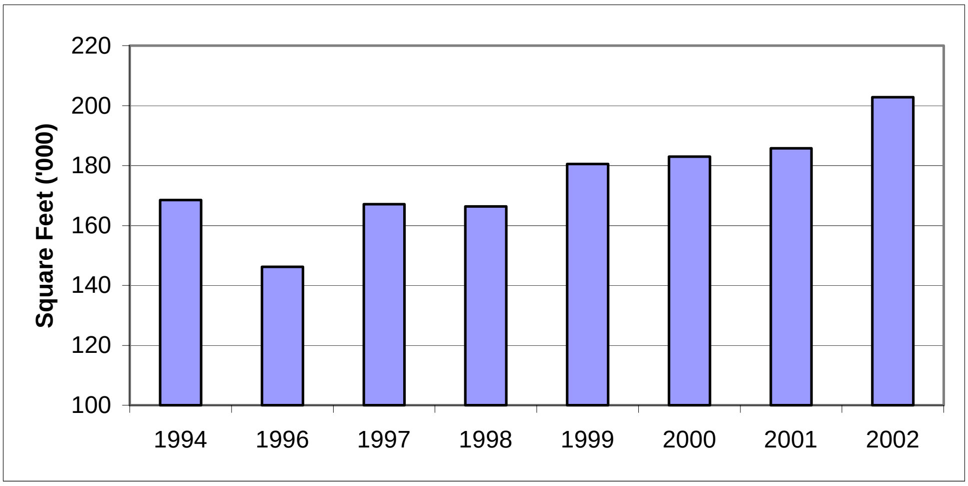

Figure 13. Average Size of Grocery Retail Distribution Centres: 1994-2002

Source: Institute of Grocery Distribution, 2002[64]

5.2.2 Other factors influencing food prices

As well as food sourcing and food transport, food prices are influenced by different retail costs. These are related to many factors, such as land prices, property rental and maintenance costs, company size and turnover, business rates, utility bills and labour costs.

Prices are also influenced by export subsidies and import tariffs see Table 21. The OECD estimates the cost of higher food prices to EU consumers, as a result of the CAP, at around €50billion (source: OECD: Agricultural Policies in OECD Countries: Monitoring and Evaluation 2003, Paris).

Table 21: EU Tariff Equivalents on Major Commodities

Commodity	Import Tariff	Commodity	Import Tariff
Durum wheat	62%	Butter	143%
Beef*	86%	Milled rice	83%
Low & Medium Quality Wheat	60%	Cheese	60%
Pigmeat*	23%	Broken Rice	47%
Rye	107%	Eggs	43%
Sheepmeat*	67%	Sorghum	94%
Barley	74%	Cocoa Paste	10%
Lamb	58%	Triticale	48%
Oats	82%	Tomatoes	9%
Poultrymeat*	25%	Raw sugar	66%
Maize	84%	Apples	9%
Skimmed milk powder	68%	White sugar	168%
Husked rice	61%	Bananas	82%

Representative tariff line except * (average from selected bundle of most sensitive tariff lines)
Source: Defra[65].

5.2.3 Conclusions

The relationship between food miles and food prices is complex:

- There is a trade-off between transport costs and production costs. Global sourcing can reduce production costs but this is offset by increased transport costs.

- For major retailers, transport and distribution costs comprise around 3.5% of food prices. Improvements in the efficiency of centralised distribution systems should have reduced transport costs, but it is difficult to discern any effect on food prices, because of the influence of other factors.

Further research would be required to establish whether there is any clear price differential between “local” food and “high food miles” food. Prices in some local outlets, e.g. markets and discount shops, may be cheaper than supermarkets. However, staple foods may be more expensive in convenience stores, which have lower economies of scale than supermarkets. Supermarkets also compete to offer the lowest prices for “known value items” such as bread and milk.

There may be a trade-off effect between food prices and food miles: some policies to reduce food miles could potentially lead to higher food prices. One example would be the internalisation of the social costs of food transport. However, any food price impacts will depend on the combination of policies used and on responses to those policies by consumers, producers and industry.

5.3 CONSUMER CHOICE, NUTRITION AND FOOD CULTURE

Food miles are related to the issues of consumer choice, nutrition and food culture:

- Global sourcing of food contributes to improved consumer choice, e.g. out-of-season and exotic produce. This may have a beneficial impact on nutrition (see below).
- There may be loss of freshness during storage and transport. This varies depending on the source, distribution system, processing/packing and turnover of the retail outlet.

- Consumers may also value the availability of local food varieties, and the availability of organic and free-range produce.

First we examine the impact of global sourcing on nutrition. Current government policy promotes increased consumption of fruit and vegetables for health reasons (the 5-a-day policy). Consumption of fruit has increased significantly since 1961 (Table 22). The availability of non-indigenous fruit such as oranges and bananas (typically transported by sea) makes a significant contribution to nutrition and health in the UK. In this case, there is some trade-off between food transport and nutrition / choice. There is less impact on nutrition for imported indigenous fruit such as apples, although there may be differences in nutritional value depending on the different varieties available and relative storage times and conditions.

Table 22 Per capita consumption of fruit (kg/year) in the UK

	1961	2000
Oranges, Mandarines	9.4	23.2
Lemons, Limes	0.6	1.0
Grapefruit	1.8	1.9
Citrus, other	0.6	0.2
Bananas	6.7	11.8
Plantains	0.0	0.2
Apples - excl. Cider	10	15.9
Pineapples	1.0	1.4
Dates	0.2	1.3
Grapes - excl. Wine	9.2	9.4
Fruit, other	15.2	17.6
Total	54.7	83.9

Source: FAO[35]

The freshness of food varies depending on the source, distribution system and turnover of the retail outlet. Several vitamins and minerals are depleted during storage and transport of food, especially vitamins C and A[8]. Long transport times (e.g. when shipping produce from New Zealand) may require use of chemical coatings to preserve the produce. In comparison with food which has been transported a long distance, locally produced food may be fresher (e.g. at farmers markets or farm shops) or less fresh (e.g. at a store with a slow turnover).

There are other issues relating to consumer choice. The small/local food sector comprises a wide variety of retail outlets, from “budget” stores, markets, and convenience stores to speciality food shops or box deliveries. Each individual outlet will offer less choice than a supermarket, but conversely they may offer products which are not available in supermarkets. These could include local varieties of fruit or vegetables, organic and home-baked products and speciality foods. Supermarkets have also responded to consumer interest in locally produced and organic / free range foods.

Related to this, another benefit claimed for locally produced food is that it can enhance food culture and the local food heritage, providing consumers with opportunities to experience local varieties of produce, and improving knowledge of the seasonality of produce and the origins of food.

Locally produced food is sometimes equated with less processing. Over dependence on processed food has nutritional implications as such food is generally lower in vitamins and minerals and higher in salt, sugar and fat compared to fresh produce (with some exceptions, e.g. frozen peas can be higher in vitamin C than fresh ones, depending on the length of time between picking and eating the fresh peas). However, it is not clear that local fresh produce would displace purchases of more processed food, as many consumers who choose processed food do so for reasons of convenience.

In summary, the relationship between food miles and consumer choice is complex. A move towards more locally sourced food, whether through local or multiple retail outlets, could have benefits for consumers in terms of increased choice of local varieties of produce, increased freshness and improved contact with local food culture. However, global sourcing of food contributes to consumer choice, and this can have a beneficial effect on nutrition. Key issues for further research would involve work to investigate the trade-offs between sourcing local and global produce, nutrition and consumer choice.

5.4 TRENDS AFFECTING UK SUPPLIERS

Food miles are often discussed in the context of problems currently faced by many UK farmers and small food supply businesses. The key trends are:

- Increased consolidation in food retailing and much of the food and drink manufacturing industry. Multiple retailers account for over 85% of retail food sales in the UK.[75]
- Increased ease of sourcing produce from other countries, due to technological changes such as the increased use of internet technology, together with modest agricultural trade liberalisation and declining transport costs.
- Decline of alternative outlets for UK farm produce (e.g. local shops and wholesale markets).

These changes, which are correlated with increased food transport, have led to a position where large retailers are able to choose from thousands of suppliers worldwide, but suppliers are restricted to a small number of potential buyers. It is claimed that this situation allows large retailers to exert downward pressure on prices paid to UK farmers and other suppliers for their produce.

Below we examine the evidence for these claims. However, the issue is complicated by a number of other factors which affect agriculture and farm gate prices in the UK. These include:

- oversupply in some sectors;
- the BSE and foot and mouth problems;
- exchange rate fluctuations;
- trends in commodity markets.

At first sight, a number of headline statistics appear to confirm the impression of an agricultural sector under pressure:

- Declining employment: 65,000 jobs lost in UK farming between 1996 and 2002[66].
- Low incomes: total income from farming per full time equivalent worker in 2002 was £11,107[67], compared to a national average per capita income of £23,400.
- Effect on rural economies: agriculture now accounts for less than 15% of rural businesses[68]. Although many rural communities are prosperous, there are serious problems in some communities. Eight out of the 10 counties in England with the lowest GDP per capita are rural[69].
- Suicide rates among farmers were 75% higher than the average population from 1982 to 1992[70] and there are high levels of stress in the farming community[71]. Because of their way of life and the passing down of farms through generations, farmers experience much closer ties to their profession than workers in other sectors, and the threat of losing the business is a major source of stress[72].

The issues should be examined in the context of long term trends in UK agriculture (Box 6). The decline in employment can be considered as part of a normal and expected process of structural change in the agricultural sector. In particular, a combination of technical change and rising off-farm incomes have been driving the release of labour out of the agricultural sector and into the broader economy for several decades. To the extent that agricultural incomes lag behind incomes in the rest of the economy, this can be explained by the process of structural adjustment lagging behind market developments. But it is also the case that many farmers are part-time or semi-retired. Official measures of agricultural income are very partial, and do not include income from farm diversification, off-farm income, pensions and social security. A more appropriate comparator would be total agricultural household income. However, social and environmental aspects must also be considered. It may be that the balance of environmental impacts differs between large and small farms (e.g. use of intensive farming techniques, pesticide application, fertiliser run-off, soil degradation, water abstraction, loss of wildlife habitats) although the evidence is unclear and further research is required to assess the social and environmental impacts of different farming styles.

Locally produced food may have a higher labour requirement than mass-produced food. In the UK, farms under 100 acres provide five times more jobs per acre than those over 500 acres[73]. A recent survey showed that farms in the South West producing food which is sold locally employ an average of one additional employee per farm[74]. This could be a benefit in rural areas with surplus labour. However, it should be noted that these jobs may be relatively low wage and low productivity. Also, rural communities are highly heterogeneous, with varying degrees of reliance on the food and farming sectors (though on average, rural employment in farming is around 6%). Some of these communities may have surplus labour, but others may have tight labour markets – in fact rural areas generally have a lower level of unemployment than urban areas.

DEFRA have identified, through the Local Food Working Group and the Sustainable Food and Farming Strategy, that initiatives to promote local food can have important benefits for rural communities. For example, farmers' markets enable closer links between producers and their markets, bring life to town centres, and provide a bigger share of the retail price for producers[75],[4]. Other initiatives with benefits include increased co-operation amongst suppliers, and an increased local food offering from multiple retailers.

There may also be other social and environmental benefits associated with local food: a recent survey showed that local food producers are more likely to be certified organic, make more use of local suppliers, make more use of waste reduction practices and introduce more traditional breeds and varieties than non-local enterprises[76].

Box 6: Social and economic trends in UK agriculture

- The UK's agricultural sector accounts for a relatively small proportion of total national employment and income generation compared to other Member States: agriculture's share of national GVA (at market prices) is 0.4% (compared to an EU15 average of 1.4%) and agricultural employment is 1.4% (compared to an EU average of 4.0%). Agricultural employment in the UK has declined from 876,000 (full time equivalents) in 1960 to 533,000 in 2003 (of which 63,000 were seasonal or casual workers and 228,000 were classified as part-time).

- The structure of agriculture is constantly responding to technological change and the rising level of non-farm incomes. These trends have increased labour productivity in agriculture across Europe, resulting in the migration of labour out of agriculture into manufacturing and service sectors. Migration may accelerate during cost-price squeezes. Agricultural employment in the UK has declined from 876,000 (full time equivalents) in 1960 to 533,000 in 2003 (of which 63,000 were seasonal or casual workers and 228,000 were classified as part-time).

- An increasing number of farmers are classified as being part-time. 41% of UK farmers are classified by Eurostat as full time, compared to 23% across the EU.

- The age profile of farmers is climbing gradually, although the number of older farmers is disproportionately large amongst smaller holdings. Many farmers are semi-retired and drawing a pension whilst they farm. In the UK 51.5% of farmers are aged 55 or over.

- Across the EU, even in agricultural households (defined as households where the main income of the reference person comes from farming), between one third and one half of total household income comes from outside agriculture (although there are significant differences between Member States and between years).

- Only just over a third of UK farmland is currently rented (in 1914, the figure was 89%).

- The UK has been a structural net importer of food for many decades. Over recent years the UK's food self sufficiency levels (for 'indigenous type food') have declined to around 75%, although this compares favourably to the early part of the 20th Century. In 2003, three quarter's of the UK's food imports came from other parts of the EU: France (15%), the Netherlands (12%), the Irish republic (9%), Germany (8%), and Spain (5%)[i].

- Over 80% of UK food production now comes from just one quarter of all farms, with the largest 10% of farms producing over half of total food output, and around 50% of farms considered part time and producing less than 3% of total UK agricultural output. In 2000 in the UK, 10.4% of farmers received 55% of (production related) direct subsidies and 26% of farmers received 81% of the payments[ii].

- There is a very wide range in production costs between different farmers. For example, weighted average costs in the dairy sector in 2002/03 ranged from 28.8 ppl (for herds of 10 to 40 cows) and 20.33 ppl (for herds of 40 – 70 cows) to 16.68 ppl (for herds of more than 150 cows). Other studies have found costs of lamb production varying from 80p to 174p per kilo liveweight, and costs in the beef sector varying by around 55% from the top quartile to the bottom quartile. In the arable and dairy sectors, costs are related to scale of production, but in other sectors this is not the case.

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[i] Defra, 2004. Agriculture in the UK.

[ii] In the EU as a whole, in 2000, 1.26% of farmers received 25.4% of CAP direct payments, and 5.3% of farmers received 50.2% of direct payments.

5.4.1 Farm gate prices

Farm gate prices in the UK fell by 33% over the period 1990 to 2002[80], although yields have also increased over the same period (between 1992/4 and 2003, average milk yields per dairy cow rose by 26%, wheat yields increased by 8%, and the sugar content per hectare of beet production rose by 29%). Between 2001 and 2002 the average price of UK agricultural outputs fell by 3% whilst the price of inputs remained constant[77].

Farmers also receive a decreasing share of the retail price for their produce – DEFRA figures show that farmers' share of the retail price decreased by 27% from 1988 to 2003[79] (see Table 20). The DEFRA figures show that farmers received 41% of retail prices in 2003, for a basket of produce weighted by its importance to farmers, compared to 57% in 1988. A recent study by London Economics has also investigated trends in the spread between farm gate and retail prices across the EU (see Table 24), and shows that UK farmers did relatively well compared to their counterparts in the EU, receiving 12% of retail prices for potatoes, 18% for eggs, 22% for onions and 44% for beef and pork in 2001. More limited surveys by farming groups include estimates by FARM that only 7.5% of end prices go to farmers compared to 50% 50 years ago[26], and a recent NFU survey which showed that for a basket of lightly processed produce (beef, milk, eggs, tomatoes, apples, bread) only 26% of checkout prices go to farmers[78].

Table 23: Comparison of farm gate and retail prices

		Farmgate share in 1988	Farmgate share in 2003	Change In Share	Weight in basket in 2003
Farmers' share of basket		57%	41%	-27%	
Farm gate product	**Retail product**				
Apples	dessert apples per kg	54%	41%	-23%	9
Beef	untrimmed beef (b) per kg	67%	46%	-31%	153
Carrots	carrots per kg	30%	44%	46%	16
Cabbages	cabbage, hearts, per kg	38%	42%	9%	8
Chicken	oven ready roasting chicken, fresh or chilled per kg	47%	30%	-37%	115
Eggs	size 2 eggs per dozen	29%	23%	-22%	71
Lamb	untrimmed lamb (b) per kg	65%	51%	-20%	87
Onions	onions per kg	26%	25%	-4%	3
Pork	untrimmed pork (b) per kg	57%	45%	-20%	90
Potatoes	old loose white potatoes per kg	24%	17%	-28%	65
Tomatoes	tomatoes per kg	48%	60%	26%	11
Wheat	white loaf sliced, 800g	23%	14%	-39%	25
Milk	whole milk (c)	66%	50%	-25%	347

(a) Farm gate prices from Defra, retail prices from the Office for National Statistics and the Meat and Livestock Commission (MLC).
(b) Retail prices for beef, lamb and pork are untrimmed MLC prices adjusted for drip loss.
(c) The average price of one pint of delivered milk and one pint of shop milk (the shop milk based on a two pint purchase).

Source: DEFRA[79]

Table 24. Farm gate prices as a % of retail prices in EU Member States (2001)

Country	AP	CA	PO	ON	CB	TO	BE	LA	PI	BR	FL	EG	CH
UK	36	45	12	22	43	52	44	41*	44	13	20	18	
Austria	20	22	10	18	25	3	15	39	53				
Denmark													
France							33	58	45	4		24	
Germany	23	30	5	25	24	57	43	68	36	3		68	41
Ireland		41		22		43	35	63		9		27	
Italy													
Netherlands			14				24		24	7		39	25
Spain			38							9		70	

Source: after London Economics[80]

Notes: AP Apples, CA Carrots, PO Potatoes, ON Onions, CB Cabbage, TO Tomatoes, BE Beef, LA Lamb, PI Pork, BR Bread, FL Flour, EG Egg, CH Chicken.
* In 2002 the figure is 48%.

There are several possible reasons for these trends. One is an increase in processing and packing beyond the farm gate. However, the trend is apparent even for unprocessed and lightly processed produce. For some commodities, there is over-supply in international markets and this has been linked to a long term decline in global commodity prices.[81] Finally, there are the claims that the trend is partly due to the strong position of buyers compared to suppliers[3]. The issues are complex and a full investigation is outside the scope of this report. However, two recent studies have investigated the issue.

The London Economics study for DEFRA[80] performed econometric modelling which failed to establish a statistically significant relationship, for a number of broad food groups, between concentration in UK food retailing, used as a proxy for market power, and the farm-retail price spread, with the exception of fruit and vegetables. The period analysed was 1990 to 2002. LE also examined the influence of other factors, such as exchange rates, CAP, supply chain costs and supply and demand profiles on the farm – retail price spread, and concluded that the £ - Euro exchange rate was the most significant determinant of the spread over the period examined. However, LE theorised that their results were not inconsistent with the ability of the supermarkets to exercise market power over suppliers under conditions where the former compete with each other aggressively in selling to the consumer. Price reductions extracted from suppliers are passed on in the form of lower retail prices.

The Competition Commission report on supermarkets examined whether declining farm gate prices were adequately reflected in retail prices[33]. The report stated that "*We were satisfied that cost reductions at the farm gate had either been passed through to retail prices or, where they had not, that there had been cost increases elsewhere in the supply chain. In a competitive environment, we would expect most or all of the impact of various shocks to the farming industry to have fallen mainly on farmers rather than on retailers; but the existence of buyer power among some of the main parties has meant that the burden of cost increases in the supply chain has fallen disproportionately heavily on small suppliers such as farmers."* There is therefore some evidence that buyer power affects farm gate prices to some extent.

5.4.2 Trading practices

The claims of unfair trading practices have been investigated by the Competition Commission report on supermarkets[33]. The study found that the buyer power of the five largest multiples was sufficiently strong that their behaviour was adversely affecting the competitiveness of some of their suppliers (see Box 7).

The concerns over the impact of buyer power on suppliers, both in terms of farm gate prices and trading practices, were reflected in recommendations for a code of conduct for supermarkets' relationships with suppliers. A recent review by the Office of Fair Trading found that the code which was implemented in response to these concerns is not currently effective, and investigations are continuing[82].

Box 7. Competition Commission Report into Supermarkets[83]

"... we received many allegations from suppliers about the behaviour of the main parties in the course of their trading relationships. Most suppliers were unwilling to be named, or to name the main party that was the subject of the allegation. There appeared to us to be a climate of apprehension among many suppliers in their relationship with the main parties. We therefore put a list of 52 alleged practices to the main parties and asked them to tell us which of them they had engaged in during the last five years. We found that a majority of these practices were carried out by many of the main parties. They included requiring or requesting from some of their suppliers various non-cost-related payments or discounts, sometimes retrospectively; imposing charges and making changes to contractual arrangements without adequate notice; and unreasonably transferring risks from the main party to the supplier. We believed that, where the request came from a main party with buyer power, it amounted to the same thing as a requirement.

We conclude that five multiples (the major buyers—Asda, Safeway, Sainsbury, Somerfield and Tesco), each having at least an 8 per cent share of grocery purchases for resale from their stores, have sufficient buyer power that 30 of the practices identified, when carried out by any of these companies, adversely affect the competitiveness of some of their suppliers and distort competition in the supplier market—and in some cases in the retail market—for the supply of groceries. We find that these practices give rise to a second complex monopoly situation.

These practices, when carried on by any of the major buyers, adversely affect the competitiveness of some of their suppliers with the result that the suppliers are likely to invest less and spend less on new product development and innovation, leading to lower quality and less consumer choice. This is likely to result in fewer new entrants to the supplier market than otherwise. Certain of the practices give the major buyers substantial advantages over other smaller retailers, whose competitiveness is likely to suffer as a result, again leading to a reduction in consumer choice. We took into account the advantages that can result from buyer power in relation to those suppliers with market power, and other offsetting benefits in relation to certain of the practices. We nonetheless conclude that the exercise of 27 of these practices by the five major buyers meeting the 8 per cent criterion operates against the public interest."

The correlation of food miles with supplier relationships is complex. For example, if the competitiveness of UK suppliers could be improved (for example through an effective code of conduct for supplier relationships with retailers), they could compete more effectively with suppliers in other countries, and food miles from imported produce could be reduced. However, if (as might be expected) a code of conduct applies equally to all suppliers, in the UK and in other countries, then there might not be any net effect on the ability of UK farmers to compete globally, and food miles would not be affected (although there would still be social and economic benefits for farmers). A strengthening of the UK supplier base could also lead to an increase in exports from the UK, and hence an increase in food miles. To assist in monitoring these effects, we recommend that food miles resulting from exports are identified separately within a food miles indicator set.

5.5 EFFECTS OF CHANGES IN FOOD RETAILING

Food miles are also linked to changes in the structure of food retailing in the UK. The main issues are:

- The current trends in food retailing are for an expansion in the market share of large multiple retailers and a decline in the numbers of smaller, independent shops (Box 8).
- This has effects on employment and local economies (discussed below in Section 5.5.1).
- The distance travelled to shops and the use of cars for food shopping increase when local food shops close. In addition, there are impacts on food accessibility. This is discussed in Section 5.5.2.
- DEFRA have identified that initiatives to promote local food can have important benefits for rural communities.

5.5.1 Employment and local economies

Changes in retail structure can result in a redistribution of local employment. One study has suggested that there will be a net loss of 276 jobs in the catchment area of each new supermarket.[84] (However, note that employment is less of an issue in areas with tight labour markets). In addition, many of the new jobs created in supermarkets are low productivity, unskilled and low paid. If independent food shops close, the jobs being lost may be more skilled (specialist butchers, bakers, fruiterers etc) and job satisfaction may be higher, especially where the shop owners are self-employed. A recent survey showed that those involved in the local food sector were nearly four times more likely to have received training than those involved in comparable non-local enterprises.[76]

Several studies suggest that more of the money spent in local shops or directly with local farmers is passed to the local community than for money spent in supermarkets. One study of the multiplier effects of shopping for fruit and vegetables in a supermarket compared to a local organic 'box scheme' showed that every £10 spent with the box scheme was worth £25 for the local area, compared with £14 when the same amount was spent in a supermarket[85]. Of course the same £10 spent in supermarkets on domestic produce would have generated multiplier effects (over and above the £14 generated locally) elsewhere in the UK economy.

5.5.2 Access to food and community services

The average distances travelled for food shopping have increased over the last few years, for both car users and non car users[19]. This is due to the closure of many local shops and markets, and also the loss of van sales services such as local farmers or fishmongers who drove around an area.

For mobile consumers the “one-stop-shop” aspect of supermarkets, with easy parking nearby, is very convenient. However, the closure of local shops can lead to problems for non car-owners, especially the elderly, disabled or those with young children. Low income groups without access to cars and living in deprived areas are more likely to end up in “food deserts”, where the only local shops within reach do not sell a good range of fresh, healthy and affordable produce. In some cases, the arrival of a new supermarket can considerably improve access to nutritious food for these consumers[86].

However, even mobile consumers value the presence of local shops, which are convenient for “top-up” shopping and also can act as a focal point and meeting place for the community. A survey by Spar found that 80% of people felt it was important to have a general store within 10 minutes walk[88]. Some small local shops provide additional community services such as a post-office counter, notice boards and free delivery for elderly customers[87].

Box 8. Decline in small shops in the UK

There is a long term trend towards closure of small shops in the UK. From 1980 to 2000, the number of VAT registered retail outlets fell from 273,000 to 201,000[88]. Between 1994 and 2001, the number of businesses selling food, drink and tobacco fell by 37%, from 68,000 to 43,000[88]. These figures do not include businesses too small for VAT registrations.

Closures are highest in rural areas. Between 1991 and 1997 a total of 4,000 food shops closed in rural areas. The Rural Shops Alliance estimates that there are fewer than 12,000 rural shops left in Britain, and they are closing at a rate of 300 a year. In rural counties monitored between 1965 and 1990, each year 1 or 2% of small settlements experienced closure of their last general store or food shop, representing a loss for around 15% of rural communities over this period. It is claimed that seven out of ten English villages have no shop[88].

A study by the New Economics Foundation (NEF) has suggested that the decline in local shops is linked to a general trend towards loss of local services. Apart from shops, the numbers of, pubs, schools, post offices and banks in rural areas are all decreasing significantly. The NEF study argues that the closure of a local shop results in a loss of money within the local economy, which has knock-on effects for other local businesses and services. This study also highlights the social importance of a local shop to the community.

Source: DEFRA, Rural White Paper[89], NEF [88]

5.6 INTERNATIONAL TRADE AND DEVELOPING COUNTRIES

Food miles are often linked to the issues of international trade, globalisation, and impacts on developing countries. The issues are very complex and controversial and beyond the scope of this report. Recent reports[90,91,92,93] have raised some of the issues, both positive and negative, in terms of development, socio-economic and environmental effects. For this report, we note that only 3.1% of food miles are due to imports from developing countries. We also estimate that around 70% of the imports from developing countries are non-indigenous foods[i] (see Figure 14). Much of these imports will be transported by sea, which has relatively low external costs – however, a proportion is airfreighted which has disproportionately high environmental costs.

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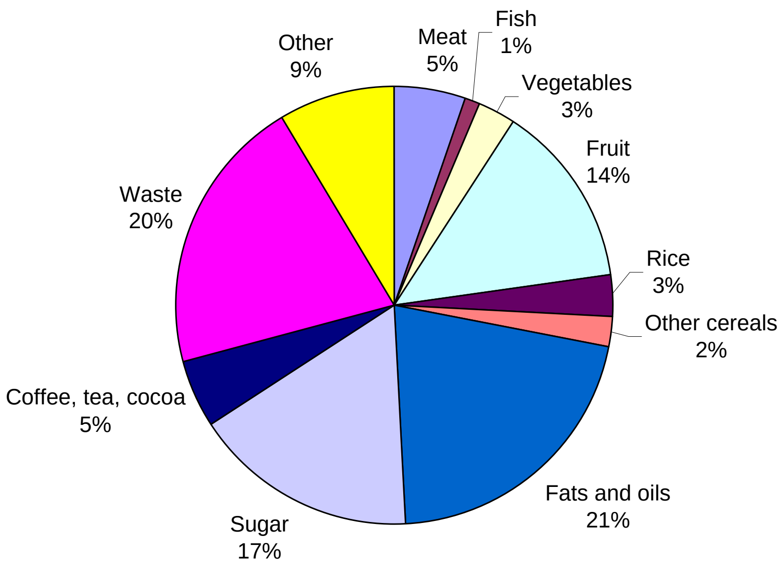
[i] This is not a rigorous definition of "indigenous" and takes little account of seasonality. Sugar is classed as indigenous as it can be produced in the UK from beet, though current levels of production are dependent on the EU "sugar regime" trade rules. We class all meat, animal fats and vegetables as indigenous. Fruit is broken down into indigenous (apples and pears), non-indigenous (bananas, citrus etc) and seasonal (strawberries, apricots and other soft fruit) where half is classed as indigenous to allow for out-of-season imports. Oils and cereals are broken down into indigenous (wheat, maize, oats, rapeseed oil etc) and non-indigenous (palm oil, soya oil, rice, sorghum etc). All waste is classed as non-indigenous.

[iii] There are both existing government-funded activities as part of the Carbon Trust's ActionEnergy programme, and industry efforts. See for example the website of the British Tomato Growers' Association, for information on how energy impacts have been reduced through uptake of CHP (combined heat and power), switch to natural gas instead of oil for heating, and recycling of CO2 from exhaust gases to stimulate growth in the greenhouse. http://www.britishtomatoes.co.uk/health/greenhouse.shtml.

Figure 14. Imports from developing countries, by food type



Further work is needed to address the issues of food transport from developing countries, within the context of wider social-economic and environmental effects

6 Case studies

There are three main issues to address in determining the validity and suitability of food miles as an indicator of sustainable development:

1. Is there adequate data of sufficient quality to readily construct an annual dataset which will accurately reflect changes in food miles arising from the UK food system?

2. Does a decrease in food miles always lead to an increase in sustainability?

3. Is the proposed indicator consistent with other government strategies and objectives?

In Section 3.4 we demonstrated that data quality is adequate to compile a meaningful annual indicator. In this section we use three case studies to explore in detail some of the arguments for and against food miles as an indicator of sustainable development. The last point, consistency with other strategies, is addressed in Section 6.3.

There are many obvious ways in which an increase in food transport has negative environmental and social impacts – particularly through air pollution, climate change and congestion. These impacts have been discussed and quantified where possible in Section 4.

However, it is also argued that the food supply systems which generate high food miles can have some positive impacts on other aspects of sustainability. These benefits include the profitability of the food retailing sector, consumer choice of a wide range of food, and positive health impacts where imported fresh produce not available in the UK can contribute to health (Section 5).

If food miles are to be adopted as an indicator of sustainable development, it is necessary to be confident that the exact indicator used is directly related to sustainability. In other words, a decrease in the indicator should result in an overall increase in sustainability. If there are exceptions to this rule, then either the indicator should be adapted (for example by excluding certain produce types or transport stages from the indicator), or it is necessary to demonstrate with reasonable certainty that the exceptions are insignificant.

When comparing similar food production systems, e.g. conventional European arable crop production on similarly sized farms, then clearly food miles give an accurate indicator of sustainability. Other things being equal, greater transport distances are associated with higher environmental, social and economic impacts. However, where food production systems are significantly different, this can change the balance of sustainability.

To explore the validity of the indicator further, we selected three of the most significant issues for further investigation through a set of case studies:

1. **Case Study 1. Energy balance for imported greenhouse crops.** Does it require more energy to grow unseasonal produce in the UK than to import it from overseas? We investigated this through a case study examining the energy balance for tomatoes imported from Spain compared to those grown under glass in the UK.

2. **Case Study 2. Organic vs local foods**. Is it better to import organic produce or use conventional foods grown in the UK? We attempted to assess the social costs for a sample case of importing organic wheat via three different transport modes.

3. **Case Study 3. Energy balance for processed foods.** Does the energy saved through reheating ready meals instead of cooking fresh produce at home outweigh the extra energy used in processing and transporting the food by the industry? We used data on chicken processing to investigate the issue further.

6.1 CASE STUDY 1 – ENERGY BALANCE FOR SPANISH VS UK TOMATOES

The aim of this case study was to answer the question: "Does it take more energy and produce more emissions to grow tomatoes in the UK than to import them from Spain?"

Around 100,000 tonnes of tomatoes are grown in the UK each year, and 320,000 tonnes are imported, of which 190,000 tonnes are from Spain and the Canary Islands[94]. Tomatoes in the UK are grown mostly in glasshouses, allowing the growing season to be extended from February to November. This extends the outdoor season which is July to October.

The optimum temperature for tomato growth is 16 to 21°C. Glasshouses are heated to this level by mainly natural gas fuelled systems. British tomato growers reduced their energy use by 25 to 30% in the 10 years to 1995, and during this period most of the UK glasshouses were converted to natural gas[94]. Production of tomatoes in the UK now requires 11 kWh of energy per kg of tomatoes[95]. 90% of this energy is required for heating[96], we assume using natural gas. We assume that the remaining 10% is electricity for lighting, ventilation and irrigation.

Tomatoes in Spain are grown outdoors but under plastic sheeting. We assume that no heating is required, but we assume that the electricity use per kg is the same as in the UK, as energy will still be required for irrigation.

We assume that the energy used in transport, processing and packaging of the tomatoes is identical between Britain and Spain, except for the transport from Spain to the UK, which we assume is by road. (Some of the transport is by sea, but road is taken as a worst case).

Based on these assumptions, we have estimated emissions of carbon dioxide, NOx and PM10 for tomato production in the UK and in Spain, and for the additional transport involved in importing Spanish produce. The emission factors used are shown in Table 25 and the results of the analysis are shown in Table 26.

Table 25 Emission factors used for the tomato energy balance

		CO2	NOx	PM10
Gas	kt/Mth	5.5	4.88E-03	3.25E-04
	kg/Mth	5500000	4880	325
UK electricity	kt/TWh supplied	487	1.17	0.06
	kg /TWh	487000000	1170000	60000
	kg /kWh	0.487	0.00117	0.00006
Spanish electricity	t/TJ	131	0.344	
	t/GWh	472	1.24	
	kg /kWh	0.472	0.001	0.00003

Source: NAEI, AEAT calculations, IEA energy statistics.

Table 26 Emissions from energy used for production and transport of tomatoes

	British	Spanish	
Gas for production	9.9	0	kWh/kg
	0.0003	0	Mth/t
CO2 from gas use	1858	0	kg/t
NOx from gas use	1.65	0.00	kg/t
PM10 from gas use	0.11	0.00	kg/t
Electricity for production	1.1	1.1	kWh/kg
CO2 from electricity use	536	519	kg/t
NOx from electricity use	1.29	1.36	kg/t
PM10 from electricity use	0.07	0.03	kg/t
Additional transport to UK	0	1079	km by road
	0	182	km by short sea
CO2 from additional transport	0	111	kg/t
NOx from additional transport	0	1.38	kg/t
PM10 from additional transport	0	0.04	kg/t
Total CO2	**2394**	**630**	**kg/t**
Total NOx	**2.94**	**2.74**	**kg/t**
Total PM10	**0.18**	**0.07**	**kg/t**

The energy balance implies that the energy used for growing tomatoes in the UK significantly outweighs the energy used in importing tomatoes from Spain by road, resulting in over three times the CO_2 emissions. NOx emissions from both cases are similar, as HGV transport by road is a major source of NOx. PM_{10} emissions are roughly double in the UK case.

From this case study we can conclude that there are certainly cases where it is better in energy terms to import non-indigenous produce or out of season produce than to grow it in the UK, where growing in the UK requires significant amounts of energy. This conclusion might also apply to other salad crops grown under glass.

However, the analysis has focussed only on the energy balance, and has not taken other sustainability factors into account. These include:

- UK tomatoes on average are grown using fewer pesticides than tomatoes grown overseas, and an increasing number are produced organically. In the UK, natural predators are often used to control pests.
- Closed irrigation systems are increasingly used in the UK to minimise release of excess nutrients to the environment.
- CHP systems are being installed which will further reduce the energy requirements of UK crops in future years. Also in some cases, some CO_2 from the gas heating systems is recycled into the glasshouse to stimulate growth.
- Socio-economic impacts – tomato growing in the UK employs 3,500 people, mainly in rural areas, and has a sales value of £120 million. Reduction in imports would benefit UK producers, at the expense of course of Spanish producers.

A full life cycle analysis would be required to compare the two systems accurately. This would include for example the different use of materials in the two systems (glasshouses vs plastic sheeting).

In addition there are some areas of uncertainty in the analysis. We do not have any figures on the use of electricity in Spanish tomato production. It is claimed that yields are lower, so it is possible that more electricity would be used per kg of product. However, it is also possible that less electricity is required for lighting.

The caveats above emphasise that this case study is not intended to suggest that purchase of tomatoes from Spain is preferable in sustainability terms to purchase of tomatoes from the UK. However, the case study does suggest that it would be better to focus policies for reducing food miles firstly on produce which is imported even when it is in season in the UK.

The issue of energy efficiency applies only to protected crops such as salad or soft fruit which are produced using additional heating. This accounts for a relatively small proportion of total food miles. Therefore we conclude that this issue does not invalidate the indicator.

6.2 CASE STUDY 2 - SOCIAL COSTS OF IMPORTED ORGANIC WHEAT

A potential criticism of using food miles as an indicator of sustainability is that they do not distinguish between types of food being transported and the relative sustainability of different products.

Organic production considerably reduces many of the negative environmental impacts of conventional intensive food production. Ethically traded produce can also reduce some negative social impacts associated with supply of food from developing counties.

Demand for organic produce in the UK is growing strongly. The retail market for organic food reached £1 billion in 2003, increasing by 10% in the year ending March 2003, and sales of organic food in the UK are the second highest in Europe. However, much of the organic produce consumed in the UK is imported. In 2001/2002, imports accounted for 65% of UK organic food sales. The UK share of the market is improving as the quality of UK organic food improves. In 2002/2003, imports declined to 56% of all organic food, and 38% of indigenous organic food. The government has an objective to increase the UK share of the indigenous organic market to 70% by 2010. There is still much scope for improvement – for example a recent survey showed that less than half the organic onions on sale in UK supermarkets were sourced from the UK during November 2003[97]. There have recently been reports that some organic farmers in the UK are planning to switch back to conventional farming as their margins are too low[98].

As transport of food has negative impacts on sustainability, it would be useful to know whether imported organic produce has a lower overall impact than home-grown non-organic produce. If this is the case, then it could be argued that policies to reduce food miles which reduce imports of organic food (without increasing production of UK organic food) could have a negative impact on sustainability.

Organic production has benefits in a wide variety of areas, e.g. biodiversity, landscape, water supply, and energy use. These are compared against transport impacts below.

Table 27 The relative impacts of organic production and transport

Impact	Benefit of Organic impact	Disbenefit of transport impact
Acid rain	-	Low impact
Biodiversity/Wildlife	High benefit	Low impact
Employment	Small benefit	(High benefit)
Energy Use	High benefit	High impact
Eutrophication/nitrate run-off	High benefit	-
Landscape/Aesthetics	Moderate benefit	Moderate impact
Accidents/congestion	-	High impact
Noise	-	High impact
Particulates	-	High impact
Pesticides/pollution of water	High benefit	-
Pharmaceuticals in food	Small benefit	-
Soil quality	High benefit	-
Waste	High benefit	Small impact

We first carried out a simple energy balance analysis for several crops, to illustrate the trade-off between the energy savings which can be achieved with organic production and the energy required to transport organic produce. We then carried out a more detailed comparison of the social costs of imported organic wheat vs conventional UK wheat.

Several crops are shown in the left column of Table 28 below. The second column shows the difference between the energy consumption of producing a kg of each crop in organic agriculture and in non-organic agriculture[99]. The right column of Table 28 calculates the road and air freight distances which would consume the same amount of energy as the saving from organic production in the second column.

Table 28 Road freight distance equivalent to energy savings in organic agriculture

Crop	Energy saving in production (MJ/kg)	Freight distance (km) equivalent to energy saving*	
		Road	Air
Winter Wheat	0.9	782	11
Potatoes	0.4	347	5
Cabbages	0.6	521	7
Onions	0.4	347	5
Leeks	0.5	434	6

*Assuming road freight consumes 1.2 MJ per tonne km and air freight (short haul) 84 MJ/tkm. Source: Emission factors from DETR Guidelines[100] and NAEI[39]. Organic energy savings from ADAS report[99]. Note the units, i.e. 1.2MJ/tkm=0.0012MJkg^{-1}km^{-1}.

The table shows that producing a kilogramme of winter wheat organically can save 0.9 MJ of fuel. However, this energy saving is lost if the organic wheat is transported over an additional distance (compared to UK conventional wheat) of more than 782 km by road, or 11 km by air. This illustrates that after a fairly short transport distance, the energy savings of organic agriculture are cancelled out by energy used for transport. Imports from further away than the Benelux countries or northern France would be associated with a net energy penalty compared to using locally sourced conventional wheat. The equivalent transport distances for other crops are even lower, from 340 to 520 km by road.

However, the simple energy balance above does not take into account the other benefits of agricultural production, e.g. biodiversity, water use, landscape etc. In order to compare these impacts directly, they must be converted into monetary terms. We have based our analysis on a study by Pretty et al[101], which attempts to estimate the total social costs arising from UK agriculture. We have adapted the analysis to estimate equivalent costs for organic agriculture, by omitting costs such as those arising from artificial fertiliser and pesticide use. We focused on arable agriculture. The cost analysis is shown in Table 29. Pretty et al estimate the external costs of UK agriculture (arable and permanent grassland) to be £208 per hectare, or £229 for arable only. We estimate equivalent costs of £65 for all organic farming, or £62 for arable only.

It is important to note that the estimates contain acknowledged areas of uncertainty, and some of the categories assessed are known to be underestimates. The main caveats of relevance to this study are that:

1. The costs are not on a willingness-to-pay basis – they are generally the financial costs to the UK of efforts to rectify the damage caused by agriculture. For example, the water quality costs represent the financial costs of cleaning the water to a standard suitable for drinking.
2. The assessment of biodiversity costs is based on the cost of biodiversity action plans in the UK. Not only will this be an underestimate compared to a willingness to pay measure, but also the action plans do not aim to restore habitats to their full pre-damage state, only to partially mitigate the damage.
3. Health impacts from pesticides represent the cost to the NHS of hospital admissions and GP consultations related to acute pesticide harm. They do not include a willingness-to-pay measure for avoidance of health impacts, which would be much greater. They do not include cases where the link to pesticides is unreported, or cases not resulting in a trip to the doctor (e.g. headaches). There is also no assessment of chronic pesticide effects, in particular cancer, as the links are poorly understood. Therefore the figure for pesticide health impacts is a considerable underestimate.
4. Antibiotic resistance has not been costed. This would increase the costs of conventional livestock farming, although it is not relevant to arable crops.

All the points above tend to increase the costs of conventional farming relative to organic farming.

We applied an estimate of the typical yield of organic and conventional winter wheat to the costs per hectare, to obtain social costs per tonne of wheat. Yields of wheat reported in the literature vary widely, typically averaging 8 to 10 tonnes per hectare for conventional wheat and 3 to 8 t/ha for organic wheat[102]. Wheat appears less suited to organic agriculture than some other cereal crops such as oats, as commercial varieties of wheat bred for conventional agriculture have poor disease resistance[103]. However it appears that for well managed organic farms with successful crop rotation schemes, yields of 60-70% of those of conventional wheat can be achieved[104]. We have assumed a typical yield of 8t/ha for conventional wheat, and 60% of that for organic wheat. This resulted in estimated social costs of £28.6 per tonne of conventional wheat, and £12.6 per tonne of organic wheat.

Table 29 Social costs of conventional and organic agriculture

Category	Impact	Arable and pasture		Arable only	
		£m Conventional	£m Organic	£m Conventional	£m Organic
1	**Water**				
a	Pesticides	120	0	96	0
b	Nitrate	16	8	8	0
c	Phosphate and soil	55	37	27.5	19
d	Zoonoses	23	23	0	0
e	Eutrophication and pollution	6	3	3	1.5
f	Monitoring and advice	11	0	5.5	0
2	**Air**				
a	Methane	280	280	140	140
b	NH3	48	48	0	0
c	N2O	738	0	590	0
d	CO2	47	47	23.5	23.5
3	**Soil**				
a	Erosion	14	14	7	7
b	Organic matter and carbon losses	82	0	41	0
4	**Biodiversity and landscape**				
a	Biodiversity and wildlife	25	0	12.5	0
b	Hedgerows and walls	99	99	49.5	49.5
c	Bee colonies	2	0	1	0
d	Agricultural biodiversity	?	?	?	?
5	**Health - pesticides**				
a	Acute	1	0	0.5	0
b	Chronic	?	0	?	0
6	**Health - nitrate**	0	0		0
7	**Health - disease**				
a	Bacterial	169	169	42.25	42.25
b	Antibiotic resistance	?	0	0	0
c	BSE and nvCJD	607	0	0	0
	Total	2343	728	1048	282
	mha	11.28	11.28	4.58	4.58
	£ Per hectare	**208**	**65**	**229**	**62**
	yield of wheat (t/ha)			8	4.8
	£/t wheat			**28.6**	**12.8**

Source: Pretty et al[101] plus AEAT calculations

We combined the social costs of production per tonne of wheat with the estimated social costs of transport from this study in order to compare the total social costs of imported organic wheat with those of conventional UK wheat (Table 30).

Table 30: Comparison of social environmental costs of imported organic wheat and conventional UK wheat

Import route	USA By sea	USA By air	Italy By road
TRANSPORT IMPACTS			
Distance (km)	6189	5585	1444
Pollution			
Emission factors (g/tkm)			
CO_2	15.3	570.0	98.15
PM10	0.01	0.17	0.03
NOx	0.24	2.98	1.20
VOCs	0.01	0.80	0.06
SO_2	0.26	0.20	0.00
Emissions (kg/t wheat imported)			
CO_2	95	3183	142
PM10	0	1	0
NOx	2	17	2
VOCs	0	4	0
SO_2	2	1	0
Social costs (£/ t wheat imported)			
CO_2	1.8	60.8	2.7
PM10	0.1	1.6	1.5
NOx	0.1	0.7	4.9
VOCs	0.0	0.1	0.0
SO_2	0.5	0.2	0.0
Congestion, accidents, infrastructure and noise			
Social cost factor (£/tkm)			
Congestion	0.000	n/a	0.003
Accidents	0.000	n/a	0.008
Infrastructure	n/a	n/a	0.008
Noise	0.000	n/a	0.002
Social costs (£/ t wheat imported)			
Congestion	0	n/a	4.4
Accidents	1.2	n/a	11.3
Infrastructure	n/a	n/a	11.9
Noise	0	n/a	3.3
Transport social cost summary	**£/t wheat**	**£/t wheat**	**£/t wheat**
CO_2	1.8	60.8	2.7
Air quality	0.7	2.6	6.4
Congestion, accidents, infrastructure and noise	1.2	n/a	30.9
Total	3.7	63.4	40.0
Net social costs	**16.5**	**76.2**	**52.8**

Summary: social costs of winter wheat production and transport to UK

Source	£/t wheat
USA by sea	**16.5**
USA by air	**76.2**
Italy by road	**52.8**
UK conventional	**28.6**
UK organic	**12.8**

Note that the social costs of transport do not currently take account of the location of the emissions. As described in Section 4, we make the crude assumption that 5% of long haul air and 10% of deep sea emissions attract social costs at the same rate as land transport, with the exception of particulate emissions at sea which are assigned zero costs.

The table shows that the social costs of the imported organic wheat vary enormously depending on the transport mode and origin of the wheat. Wheat imported from the USA by ship has a lower social cost than conventional UK wheat. However, organic wheat imported from Italy by road has social costs around a factor of two greater than conventional UK wheat. Wheat transported by air (not that this would normally happen for wheat, but organic vegetables and fruit are a major component of food air freight) has social costs three times greater than conventional UK wheat.

From this case study we conclude that:

1. The full environmental costs of producing organic arable crops can be less than half those of conventional crops.
2. If organic arable crops are imported, there is a social cost penalty relative to locally produced conventional crops, arising from the environmental impacts of transport (pollution, accidents, congestion etc). However this can be offset by the other benefits of organic food. The net environmental costs depend on the transport mode and distance.
3. Imports of organic produce by air do not provide a net environmental benefit.
4. Imports by sea could well provide a net benefit.
5. Our analysis shows no benefit from imports by road, but if the full costs of biodiversity and wildlife loss and pesticide effect on health were included in the analysis, imports by road from Europe could possible provide a net benefit.
6. In all cases, it is of course far preferable to source organic wheat from the UK.

The implications of this for our study are:

1. The size and rapid growth of the organic food market in the UK, the high level of imports and the significant differences in sustainability between organic and non-organic food mean that there is a need to ensure that the validity of an indicator based on food miles is not compromised by treating organic and non-organic food miles in the same way.
2. In practical terms, it is unlikely to be possible to separate out organic and non-organic food miles in a food miles indicator.
3. Organic production is covered by other indicators in the sustainable farming and food strategy.
4. There is of course no difference in the impacts of transporting organic and non-organic food.
5. The food miles indicator would only be compromised if imported organic produce declined and was NOT replaced by UK-produced organic food.

For these reasons we do not recommend producing separate estimates of organic and non-organic food miles as part of the final indicator. However, policies to reduce food miles should be designed carefully to ensure that there are no adverse effects on the UK organic food market.

6.3 CASE STUDY 3 - ENERGY BALANCE FOR PROCESSED CHICKEN

The examples in this study so far, and in many other food miles studies, have focussed largely on fresh, unprocessed produce. However, part of the reason for the increase in food miles over the last decades has been the increase in processing and packaging of food, resulting in the transport of many different ingredients and packaging materials between factories to make the final product. The classic example of this is "The well-travelled yoghurt pot"[105], a study of the movement of materials around Europe to make a pot of yoghurt.

However, the food processing industry has argued that it is more efficient to cook food in a factory and simply reheat it at home than to cook it at home. Therefore the aim of this case study was to examine a more highly processed food, and to ascertain whether the additional energy used to transport and process the food in the factory is outweighed by the savings in cooking energy in the home.

We used a study of the energy balance of the chicken supply chain supplied to us by DEFRA[106].

Two types of chicken for domestic consumption are considered:
a) Fresh whole chicken – bought chilled and cooked using a conventional electric oven
b) Chicken ready meals – bought chilled and cooked in a microwave

The parameters of the model as supplied assumed that there was no difference in the transport of the fresh chicken or the chicken ready meal. This would be a reasonable assumption for the chicken component of the meal, if the chicken processing was carried out at the same factory as the preparation of fresh chicken (as is often the case). However, the other ingredients of the meal have been transported an extra distance to the chicken processing factory. Our approach was therefore to calculate the energy difference between the fresh and processed chicken, and then to convert this energy difference into an equivalent transport distance to find the "break-even" amount of additional transport of added ingredients which would give an equal energy consumption for each type of chicken. This would illustrate whether processed foods could offer any energy savings relative to fresh home cooked foods.

Other assumptions are that:
a) No account is taken of the non-chicken ingredients of chicken ready meals and the energy inputs in their life cycle;
b) Chicken lost to wastage is not used for any other product.

The calculated energy input required for the production of each kilo of chicken are as follows:

	Energy input per kg of product (kWhe/kg)
Whole chicken	13.23
Chicken ready meal	9.67
Difference	3.37

Note: kWhe = one kilowatt hour of electricity (or energy equivalent for a different fuel)

The difference of 3.37kWhe/kg equates to an additional 9.4 tonne km of transport (assuming transport energy usage to be 0.3583kWhe/tkm). Thus for example if 1 kg of chicken ready meal required the transport of 1 kg of additional ingredients and packaging materials, these ingredients could be transported a total distance of 9400 km before the energy benefits of factory processing were lost.

For the two types of chicken product the energy inputs split as follows:

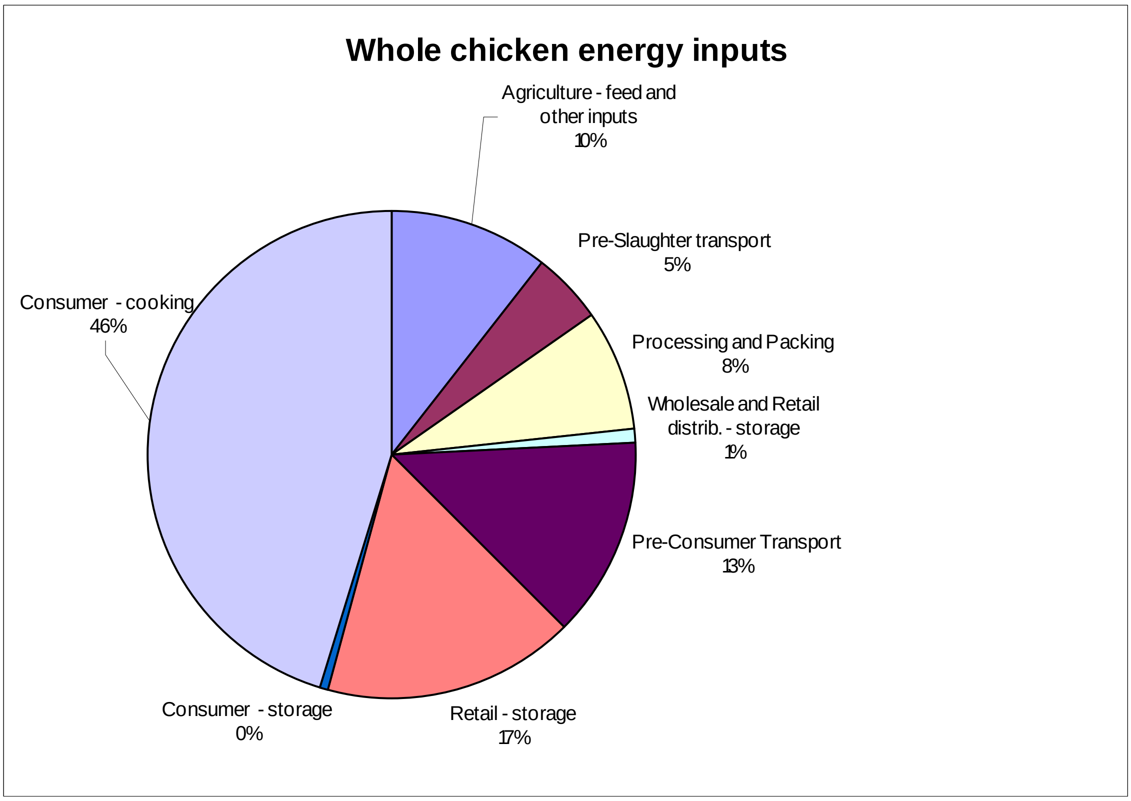


Figure 15 Breakdown of energy inputs: Whole chicken

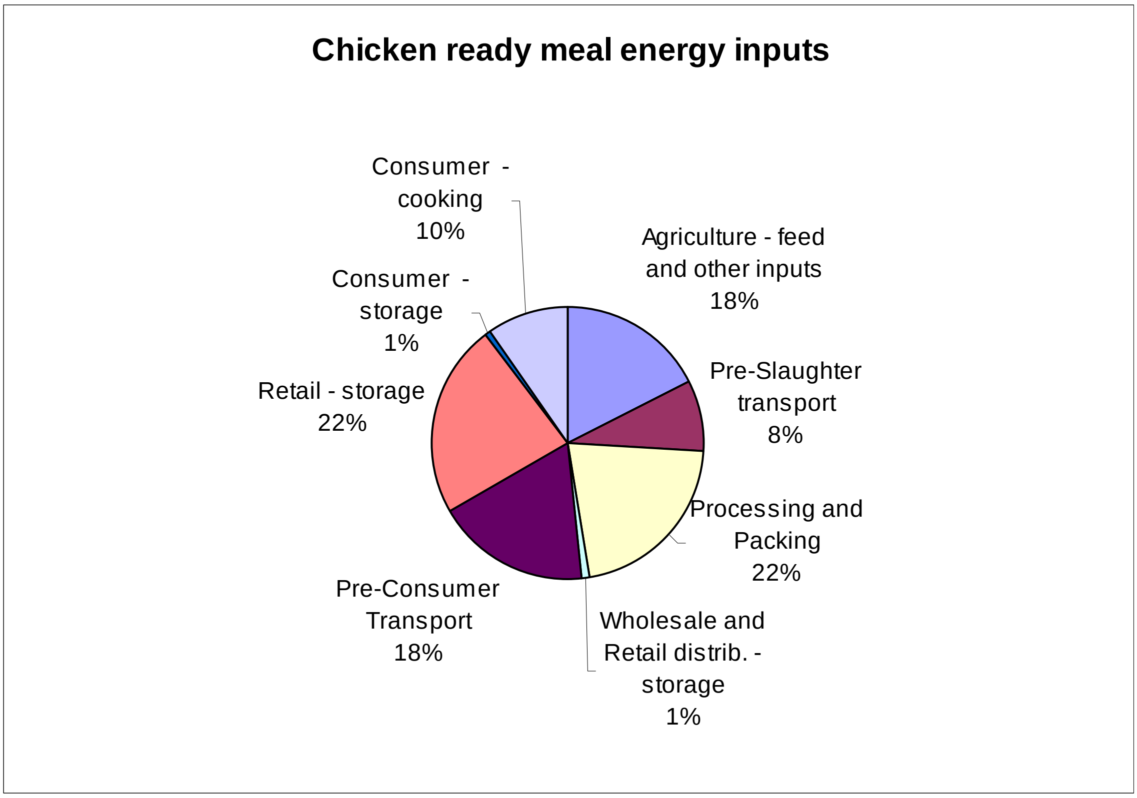


Figure 16 Breakdown of energy inputs: Chicken Ready Meals

It is clear from the above breakdown of energy inputs that energy consumption in cooking a whole chicken at home is a substantial proportion of the total – 46% of total energy inputs. For chicken ready meals the cooking energy at home is only 10% of total inputs. However, this assumes that the home cooked chicken is cooked in an electric oven – the most energy intensive way of cooking. If a less energy intensive cooking method was chosen, such as separating the chicken into portions for grilling or frying, and using gas instead of electricity, this could well alter the balance between the two scenarios. Also, ready meals may often be cooked in an electric oven, which would significantly increase the impact of the ready meal.

There are also health impacts to be considered when evaluating processed food against freshly cooked food. Processed food is generally higher in salt, additives, and often in fat and sugar, than home cooked food. Nutrients are also lost during the preparation and storage processes.

We conclude that it may be possible in some cases that overall energy savings are achieved through manufacture of processed "ready meals" which require only reheating in the home. However, this depends on the cooking method used for the fresh produce. Also the nutritional implications of consumption of processed food need to be considered.

The implications of this finding for a food miles indicator are not significant. Only those additional food miles related to transport of ingredients for manufacturing microwaveable ready meals, over and above the food miles for bringing an unprocessed equivalent to the shop, would be affected by this finding, and this would be a small proportion of all food miles. However, there is a wider issue related to the energy efficiency of production of foods in small local enterprises compared to in large factories, and this would require appropriate monitoring and supporting policies (e.g. to improve energy efficiency of smaller enterprises) should a food miles indicator be introduced.

6.4 ARE FOOD MILES A VALID INDICATOR OF SUSTAINABLE DEVELOPMENT?

Here we summarise the arguments for and against food miles as an indicator of sustainable development (Box 9), and consider whether it is possible to design a valid indicator taking account of the issues identified in the box.

Box 9. Arguments For and Against a Food Miles Indicator

For

Data is adequate for compilation of a valid indicator on an annual basis.

Social costs of congestion, accidents, infrastructure, CO_2, noise and air pollution related to food miles are estimated as over £9 billion per year.

CO_2 emissions in the UK are 1.8% of the UK total, and **NO_x emissions** in the UK are 4% of the UK total, with additional emissions overseas

Some impacts are not covered by other indicators or policies, e.g. CO_2 emissions from international air and sea transport are not in the UK inventory and fuels are untaxed.

Against

Energy intensive horticulture: It could take more energy to produce some crops in the UK than to import them from warmer countries.

If imports decrease, some overseas road transport associated with food manufacture may be replaced by **additional UK road transport**.

Possible increased **van congestion** if local deliveries increase. Also, **reductions in transport efficiency** (using smaller vehicles and lower load factors) could offset the decreases in distances travelled by food. Potential decreases in **food production energy efficiency** as economies of scale are lost.

Wider effects (dependent on policy)

Social and economic benefits: Some lower food miles systems could help to strengthen local economies and communities, improve access to food for non car-owners, improve the competitiveness of UK farmers, build closer links between consumers and producers, reduce transport of live animals and improve food awareness and consumption of fresh produce.

Some options for reducing food miles could reduce **consumer choice** or increase **food prices**. This could lead to reduced consumption of fruit and vegetables, with possible **health impacts**.

Organic and ethically traded food could have net sustainability benefits even if imported.

Possible economic costs – a reduction in food miles could possibly lead to a loss of profitability for large retailers and the transport industry, or economic losses for developing countries.

A certain amount of food transport will always be necessary in order to supply consumers with a good range of healthy, nutritious and affordable food. However, if all other factors are equal, reducing food miles will generally have a beneficial effect on sustainability through reducing the environmental burdens associated with road, sea, air and rail transport.

However, food supply and consumption is a complex system and often other differences between higher and lower food miles options (e.g. transport mode, geographical location of food source, method of food production, distribution of sales through alternative outlets) have a bearing on the net sustainability of the system. This gives rise to cases where a decrease in food miles is not necessarily directly linked to a sustainability benefit. Some of the exceptions we have identified include import of non-indigenous or out-of-season foods where production in the UK would entail excessive energy consumption, or (in some cases) transport of organic food where it displaces non-organic food from a nearer source.

Wider economic effects are hard to assess. Where reducing food miles means sourcing food from a different supplier, or selling it through a different retail outlet, there will be implications in terms of the price paid by consumers and the profitability and employment levels of producers, processors, packers, retailers, caterers, wholesalers and the freight and logistics industry. The magnitude and distribution of positive or negative effects depend on a number of factors which can be influenced by the policies selected to encourage a reduction in food miles.

Finally, moving to a lower food miles system has possible implications for transport efficiency and energy efficiency. If there is a growth in business for smaller producers and retailers, there could be an increase in energy consumption or congestion as smaller vehicles are used and economies of scale in production are lost.

We need to consider whether a food miles indicator and supporting policies can be designed in such a way as to take account of these considerations. The areas of concern identified above and in Box 9 will be addressed in turn below.

6.4.1 Energy balance issues

We have shown that for some protected crops such as tomatoes, production in the UK may entail higher energy consumption than import and transport from a warmer country such as Spain. However, our analysis did not take into account other factors affecting the relative sustainability of the two systems, such as use of pesticides, which is claimed to be lower for British tomatoes[94]. Also, food miles associated with import of salad crops are a relatively small proportion of total food miles, so we do not believe this issue would invalidate the indicator as a whole. For example, tomatoes form only around 1% of total food consumption in the UK[35].

Potential measures to address this issue include further support for measures to improve the energy efficiency and increase use of renewable energy in the UK protected crops sector, such as use of combined heat and power plants or biofuels[iii]. Other measures to improve sustainability could include further reduction in agrochemical input or water use.

An alternative is to encourage consumers to substitute seasonal indigenous produce for out of season and non-indigenous produce. This might be reasonable up to a point (e.g. do we need air freighted cherries and strawberries all year round?) but consumers are unlikely to drastically reduce their consumption of favourite imported foods, and there could possibly be an impact on health if less nutritious varieties were substituted, e.g. apples for bananas or oranges.

6.4.2 Import of organic foods

Our case study showed that, in some cases, it can be more sustainable to import organic foods than to source non-organic foods in the UK, because benefits of organic production can offset transport impacts. The study suggested that there might be a net benefit in cases where organic food is imported by sea or for short distances by road, but that these benefits were lost for air transport or long distance road transport. However, the most sustainable option is to choose organic food produced in the UK. There is already a government objective to expand organic production in the UK, with DEFRA's Action Plan for Organic Food and Farming in the UK and the target of increasing the UK share of the organic market for indigenous food to 70% by 2010. We propose that the UK share of the organic market for indigenous food is included as part of the suite of food miles indicators. One caveat is that there should be accompanying research into consumer demand to avoid situations of over-supply when developing the UK organic market.

6.4.3 Impact on developing countries

Concern has been expressed that policies to reduce food miles could have an adverse impact on imports from developing countries, and for some policy scenarios and some countries and commodities this could be true. However, in Section 5.6 we showed that imports from developing countries account for a relatively small proportion of total food miles (3%), and over 90% of these imports would probably be unaffected by policies to reduce food miles. To address any further concern, it would be possible to monitor the value of imports from developing countries to ensure that policies are not having any adverse economic impact. Policies that affected developing country imports (i.e. to reduce food miles) could also be accompanied by other policies (e.g. trade reform, development assistance and encouragement of more sustainable production[i]).

6.4.4 Consumer choice and food prices

Concern has been expressed that some policies associated with a reduction in food miles could reduce consumer choice or increase food prices, and that this could lead to reduced consumption of fruit and vegetables, with associated health impacts.

Several key avenues for reducing food miles, such as reducing car food shopping, would have no impact on consumer choice or food prices. Others, such as improving freight transport logistics, could even reduce food prices (see Annex 4). However, in some cases it is possible that food prices could increase:

1. If policies to internalise the social costs of transport were implemented, for example through road user charging or fuel tax increases, this could directly increase transport costs and therefore food costs.

2. Locally sourced food can be more expensive than globally sourced food, perhaps because economies of scale are lost (in cases where the local source involves smaller scale production, distribution or retailing), or due to differences in climatic conditions or labour costs.

Distribution costs are currently only 3.5% of food prices. It therefore seems unlikely that any policies to reduce food miles through internalising the social costs of transport would

[i] More sustainable production has the potential to reduce food miles through reducing oversupply of commodities, and focusing on value-added produce. This can be done in a number of ways, for example through demanding minimum social standards of production such as those often used in ethical trading agreements (e.g. no forced labour, workers have the right to form a trade union, no child labour). Environmental standards can also be set, e.g. to protect key ecosystems, conserve fish stocks and reduce pollution

have a significant effect on food prices in general. However, there might be an impact for certain goods and certain modes of transport. For example, there might be noticeable price increases for some very low-priced “value” brands where transport is a higher proportion of the overall price. Also, the price of air-freighted goods might increase significantly if the full environmental impact of air transport is reflected in the fuel price.

If the main thrust of the policy framework is aimed at raising consumer awareness of the impacts of food miles, and stimulating demand for more local foods, then any increases in cost arising from more local sourcing could be largely passed on to the consumer. It seems unlikely that consumer choice would be adversely affected if a demand for more local foods originates with the consumer. Indeed, local food sourcing can increase consumer choice by making more local varieties of fresh produce available in addition to the relatively small number of standardised varieties currently available in supermarkets.

We conclude that policies to address food miles would not be invalidated by concerns over consumer choice or food prices. However it would be important to design supporting policies in such a way that choice, accessibility and affordability are enhanced, not diminished.

6.4.5 Economic impacts

The economic implications depend on a number of factors such as the distribution of sales through different retail outlets, and the choice of policies selected. For example, if sales through local outlets increase, there could be a slight decrease in turnover for the large retailers. A significant decrease seems unlikely as the convenience of shopping at large superstores will almost certainly maintain the current large proportion of food sales through these outlets. The impact on the freight industry is not clear – there could be a reduction in long distance haulage, but an increase in local and regional transport. Some overseas freight associated with production of imported foods could be displaced to the UK. Further work would be required to evaluate economic impacts in more detail.

6.4.6 Exports

Any reduction in exports resulting from policies to reduce food miles would lead to reduced economic benefits for the UK, but increased benefits for whichever country substituted its products for the UK products. Most policies to reduce food miles, such as increasing consumer awareness of the impacts or strengthening local food initiatives, would have no effect on food exports. However, to enable this issue to be monitored, the food miles indicators can be presented both with and without exports.

6.4.7 Decrease in transport energy efficiency and production energy efficiency

Again, impacts depend on the choice of policies to reduce the impacts of food miles. Some policies (such as improvements to freight logistics or reduced car shopping miles) would have a beneficial impact on transport energy efficiency. Policies which resulted in greater consumer demand for UK food compared to imported food would probably not have a dramatic effect on transport efficiency, which would still be orientated around the supermarket regional distribution centres. However, concern has been expressed that increased activity in the “local” food economy, typically defined as foods originating from around 30 miles from their point of sale, could lead to increased congestion if single deliveries in large vehicles are replaced by many deliveries in smaller vehicles. Also there could be a general decrease in transport energy efficiency associated with more use of smaller vehicles, lower load factors and more empty running.

It is possible that any increase will be mainly on rural roads where noise, congestion and pollution impacts are less significant, although CO_2 impacts will be no less important. However, this issue still has the potential to be significant and to offset some of the environmental benefits of a lower food miles system. We therefore recommend further research into these issues, and monitoring of local traffic patterns to assess whether any effects are significant at the local level. Also, it is important that any efforts to boost local food initiatives are accompanied by policies to improve the transport efficiency of local food distribution systems, such as co-operative distribution amongst local producers and retailers to maximise load factors.

There are similar concerns over energy efficiency in food production. It is possible that processing of some local foods might be less energy efficient than for large centralised factories. On the other hand, there is some indication that businesses involved in local food production are also more aware of environmental issues and more likely to be involved in, for example, waste reduction initiatives than comparable non-local businesses[74].

It has also been argued that highly processed foods such as ready meals may save energy overall, due to reduced home cooking energy. However, this depends on cooking method, and the nutritional value of the food must also be considered. Also, a relatively small proportion of food miles is related to transport of ingredients for ready meals.

As for transport, it is therefore desirable that efforts to improve local food systems are accompanied by measures to promote energy efficiency, waste reduction and use of renewable energy amongst these businesses. Further research and monitoring could also be worthwhile.

6.4.8 Summary

The findings of the study suggest that it would be possible to construct a food miles indicator which is a valid indicator of sustainable development. In general it appears that an increase in food miles is correlated with negative sustainability impacts. The exceptions to this can be dealt with in one of three ways:

1. If the exception is valid and significant, it might be possible to deal with it through a modification to the indicator. For example, different transport modes can be separated and food miles could be expressed both including and excluding exports. We recommend a structure for the indicator set in the next chapter.

2. Alternatively, the exceptions can be catered for through the policy measures selected to encourage reduction of food miles. For example, a reduction in consumer choice can be avoided through focusing the policy framework on encouraging consumers and retailers to seek local sources of indigenous seasonal produce, especially organic produce.

3. Issues which continue to cause concern and which cannot be resolved without experience of the way in which a food miles indicator is implemented should be carefully monitored, and policies put in place to minimise any adverse effects. For example, concerns over a loss of transport efficiency should be addressed through surveys of local food distribution efficiency and supporting measures to improve local food logistics and use of cleaner vehicles.

7 Key food miles indicators

7.1 DERIVATION OF A SET OF KEY INDICATORS

This study has shown that the relationship of food miles to sustainability is complex. Two important findings are:

1. The direct impacts of food transport are highly dependent on transport mode.
2. The wider social and economic impacts of food miles are difficult to quantify, and are highly dependent on social, political and economic factors.

It is clear that a simple numerical measure of food miles based on total tonne kilometres would not necessarily be directly correlated with sustainability. We have therefore selected a number of potential indicators, divided into two categories:

1. **Direct indicators**, which reflect the major direct impacts of food transport (congestion, accidents, greenhouse gas emissions, noise, pollution, and infrastructure costs).
2. **Supplementary indicators** which address some of the wider social and economic impacts, and take account of some potential exceptions to the link between decreasing food miles and increased sustainability.

Below we describe how the indicators were selected, we assess their limitations, and we evaluate the potential indicators for the years 1992, 1997 and 2002 to assess the prevailing trends. Finally we select four key "headline" indicators that encapsulate the most significant direct impacts of food transport.

7.1.1 Should indicators be physical or monetary?

We considered two possible ways of measuring the impacts of food transport:

1. As a physical quantity, e.g. amount of pollution emitted.
2. As a monetary cost, derived from the physical quantity.

The monetary cost translates the physical quantities into a measure of the actual damage to society, and also allows different impacts to be compared to each other. However, using social cost estimates, such as those presented in Section 4, to reflect the impacts of food transport is problematic. The degree of uncertainty associated with estimation of the impacts is considerably greater than that associated with quantifying the food miles in terms of vehicle km, particularly when the impacts are monetarised. There is considerable uncertainty involved in costing impacts such as congestion or the health effects of air pollution. Also, inclusion of social cost estimates would make the annual updating of the indicators considerably more complicated, labour intensive and prone to error.

Accordingly, a set of indicators based on impact-related physical quantities is proposed.

7.1.2 Selection of indicators

It is rarely possible to measure the direct impact of food transport in physical terms. Instead, we use proxy indicators to represent the most important negative impacts of food transport. For example, HGV transport is responsible for almost all the social costs of infrastructure maintenance, and so total HGV km have been used as a proxy for infrastructure costs. On the other hand, urban road traffic is largely responsible for congestion, and so total urban food transport km have been used as a proxy for congestion. Air food miles are also included as air transport has the greatest climate change impact per tonne kilometre of any transport mode. The list of potential indicators is shown below.

Direct indicators
- **Urban road vehicle km** as a proxy for accidents and congestion costs (separated into car, LGV and HGV vehicle km).
- **HGV vehicle km** on all road types, as a proxy for infrastructure costs, which arise mainly from HGVs.
- **Air km** important as this is disproportionately environmentally damaging per tonne of food carried (in terms of climate change).
- **CO_2 emissions** proxy for climate change impacts, measured in tonnes.
- **Atmospheric pollution** proxy for health impacts, in tonnes of NO_x, SO_x and PM_{10}.
- **Live animal tonne km** as a partial proxy for animal welfare.

Supplementary indicators
- **Imports of indigenous foods** – to indicate scope for expansion of UK market share
- **Ethically traded foods** related to socio-economic effects in developing countries
- **UK organic market** Proportion of (indigenous) organic food consumed in the UK which is grown in the UK.

The advantage of this approach is that the indicators are relatively simple to quantify, and the data sources and parameters used are relatively reliable. Year-on-year trends will be related to changes in sustainability. The disadvantage is that some detailed information is lost by using proxies. For example, if road safety measures reduce accident rates, thus reducing the impact of food transport to some extent, this will not be reflected in the indicator set, which simply uses urban food km as a proxy for accidents. However, we do not believe that this loss of detailed accuracy will significantly affect policy decisions. Reducing urban food transport will always be beneficial for sustainability (providing this is done through sensible policy initiatives which do not reduce access to food for consumers or supply of food to shops).

7.1.3 Assessment of indicator quality, caveats and limitations

The main caveats relating to the use of the proxy indicators as a measure of sustainability are presented below.

Urban road vehicle km
Urban food transport has been used as a proxy for accidents and congestion costs in the current version of the indicator set. This study has estimated that urban food transport accounts for 68% of all food-miles-related accidents in the UK (see Table 31) and 77% of congestion costs. However, there are two problems with this indicator. Firstly, urban traffic accounts for only 37% of the fatal accidents, with travel on rural roads accounting for 52% of fatal accidents. Secondly, and more seriously, the proportion of travel on different road types is currently estimated using fixed percentages which apply to all travel in the UK. Therefore, changes in urban food km relative to food km on other road types may not be detected by the indicator using the current database methodology.

In order to increase transparency and to allow car shopping effects to be separated out from food delivery operations, we propose to separate urban food km into car, LGV and HGV km. This will allow policies to be targeted more effectively at these different sources of impacts.

It is worth noting that cars account for 75% of all food transport-related accidents in the UK and 54% of all congestion costs, so an alternative proxy for congestion and accident costs could be total car food km. Car food km are estimated from the annual DfT personal shopping survey, and thus annual changes are detected, It would then be useful to monitor LGV transport separately, to establish whether there has been any increase in van traffic (and related congestion and accidents) arising from more local sourcing of food (see Section 5.4.7).

Table 31. Food-miles related accidents in the UK by road and vehicle type

	Fatal	Serious	Slight	Total
urban %	37%	59%	70%	68%
rural	52%	37%	26%	27%
motorway	11%	4%	4%	4%
car %	57%	71%	76%	75%
LGV	8%	10%	10%	10%
HGV	35%	19%	14%	15%

Another limitation with the use of urban food km as a proxy for congestion costs is that no account is taken of the time of travel, which is important when measuring congestion impacts. Current statistics show that car food shopping peaks in the mid-morning, with less during morning or evening rush-hours and little during the evening off-peak period. Time of travel was taken into account in our estimation of the social costs of congestion in monetary terms. However, the use of total urban travel as a proxy for congestion will not detect any changes in travel patterns, such as a switch to shopping at less busy times, which will affect congestion.

HGV vehicle km

We have estimated that HGVs account for 97% of all infrastructure costs arising from food transport on UK roads (see Annex 3). HGV vehicle km are therefore a good proxy for road infrastructure costs. Our social cost estimates are purely the financial costs incurred for maintaining and repairing roads. They do not include the pressure on capacity which may lead to building new roads or widening existing roads, and associated social costs related to loss of countryside, wildlife habitat and visual impact. However, HGV vehicle km are related to these impacts also and so in this case the proxy measure may be more accurate than the social cost estimate. In order to illustrate trends in HGV load factors, HGV food tonne km can also be included.

Air km

This is the most environmentally damaging mode of transport in terms of climate change. Moreover, its impacts cannot be fully quantified as there is little data relating to noise, congestion, infrastructure or accidents arising from air transport. Therefore air km is an important proxy. Air food transport is directly related to pollution (for a given set of assumptions about typical load and aircraft emission factors). The other impacts (noise, congestion, infrastructure and accidents) will depend on the location and timing of the air movements. However, reducing air miles will always reduce these impacts. One problem with this indicator is that there is no data on air miles for imports and exports to the EU. We have currently assumed zero food trade by air with the EU (see Annex 1). However, if air transport activity to or from the EU begin to increase in future, this will not be captured by the indicator. We therefore recommend that efforts are made to gather data related to transport of food by air to and from the EU. The accuracy of the indicator would also be improved by better data on average air freight loads, which are used to convert tonne km to vehicle km for the indicator.

CO_2 emissions
This is a good proxy for climate change impacts as CO_2 emissions are directly related to climate change, and will have the same impact regardless of where, when or how they are emitted.

Atmospheric pollution
We consider only NO_x, SO_x and PM_{10}. However, emissions of other pollutants (dioxins, VOCs etc) will to some extent tend to rise or fall in line with these major pollutants. A more accurate analysis would identify separately the urban and rural emissions, as urban emissions affect a greater number of people. However, reducing air pollution will always reduce these impacts.

Live animal tonne km
Live animal tonne km are used as a partial proxy for animal welfare in transport. There are several limitations with this approach. The most obvious one is that transport of live animals is only one aspect of animal welfare related to the food and farming industry. Other impacts may be related to different welfare standards, both within the UK and in countries which trade meat with the UK. Finally, the welfare impact will be related to the transport conditions, not just the transport distance. Nevertheless, a reduction in live animal tonne km would seem to be a valid aim. The consideration of an indicator for live animal transport would be consistent with UK policy, which would be best summed up as a preference for slaughter close to the place of production and an end to long distance transport solely for slaughter at the destination (though this has to be balanced by the demands of the single market and commercial/economic decisions)

Imports of indigenous foods
Imports of indigenous foods are examined for two reasons: firstly in order to establish a realistic potential for increasing sourcing of food from the UK. Secondly, this is to some extent related to socio-economic impacts on UK farmers and growers (see section 5.4).

Ethically traded foods
Measures to reduce food miles are unlikely to reduce the demand from consumers for staple imports such as bananas, coffee and cocoa. However, alternative sourcing from ethically traded food suppliers can have significant socio-economic benefits for producers in developing countries without increasing food miles, thus increasing sustainability overall. The price increases to consumers need not be noticeable. For example, the cocoa in a bar of ethically traded chocolate may cost less than one penny more than that in a standard bar of chocolate, yet that small amount (out of 5 pence) makes a significant difference to the producer. It was therefore felt useful to include a separate indicator for annual sales of ethically traded foods in the UK. The aim, obviously, is for this indicator to increase.

UK organic market
Case Study 2 (Section 5.2) demonstrated that imports of organic food can in some cases be more sustainable than consumption of non-organic UK produce. However, far preferable in sustainability terms would be more consumption of organic UK produce. Therefore another important indicator is the proportion of indigenous organic food consumed in the UK which is grown in the UK. The aim is for this indicator to increase. In the past, estimates have been provided by the Soil Association. However, as increasing the UK share of the organic market is now an objective of DEFRA's Action Plan on organic farming, we assume that a reliable annual estimate will be provided by DEFRA.

7.1.4 Selection of four headline indicators

From consideration of all the potential indicators, we propose a set of four key "headline" indicators (see Table 33). The key indicators focus on the most important direct impacts of food transport: congestion, accidents, infrastructure costs and greenhouse gas emissions. Air pollution impacts were not included separately as the HGV and urban food km indicators will also be good proxies for air pollution effects, and also emissions are declining due to adoption of improved Euro standards.

The supplementary indicators capture some of the complexities and trade-offs discussed in previous sections of this report. However, for most of these areas, related indicators or policies already exist as part of other government strategies. For example, the UK share of the organic food market is covered in DEFRA's action plan for organic food and farming, live animal transport is covered by the animal health and welfare strategy, and ethical trading is an indicator in the food industry sustainability strategy. Therefore these have not been included as key indicators.

Table 32: Four key headline indicators

Indicator	Notes
Urban food km in the UK, split by car, LGV, HGV.	Urban food km account for most of the accident and congestion costs. The impact of air pollution is also much higher in urban areas. (As discussed in section 7.1.3, this indicator relies on the assumption that the urban/rural travel ratio is the same for food transport as for all other transport. An alternative proxy for congestion and accident costs would be total car food km).
HGV food km	This covers HGV transport both in the UK and overseas. HGV transport is responsible for the majority of infrastructure, noise and air pollution costs.
Air food km	Air freight of food is rapidly growing and has a higher environmental impact than any other transport mode.
Total CO_2 emissions from food transport	Emissions of CO_2 from the transport sector are highly significant and are growing. This indicator includes estimated CO_2 from transport fuel use both in the UK and other countries. Currently excludes CO_2 and other greenhouse gas emissions from refrigeration during transport, although it would be desirable to include this in future.

7.1.5 Use of the indicator set

It is envisaged that the indicator set would be updated yearly, following publication of the key underlying datasets. The timing of the data releases are as follows:

- HM Customs and Excise data on imports and exports is released on a monthly basis, typically with a 2-3 month delay, so data for a calendar year would be available from around March onwards in the next year.
- The CSRGT data (for HGVs) is published in May the following year.
- The van survey data is split into private and company vans. The private van survey was a one-off study, which may or may not be repeated in the future. After 2003, therefore, this part of the dataset will have to be estimated based on the ratio between company and private van food km for 2003, until the private van survey is repeated. Private vans account for about one third of the total van food mileage. The company van survey is due to be published in August each year.

- Data on car food shopping is collected on a rolling basis, but only published every 3 years as part of the Personal Travel Survey (the next report is due in February) 2005. However, the data is available from DfT on an ad-hoc basis. Data for 2003 has been available since September 2004.

Updates for a calendar year can therefore be made in October the following year, after release of the personal travel survey data.

Because of the complex relationship between food transport and sustainability, great care must be exercised in interpreting any changes observed in the indicators. It will be important to establish the underlying causes and statistical significance of such changes and to consider all the economic, social and environmental implications before drawing conclusions or formulating policy responses.

We emphasise that this indicator set focuses on the direct adverse impacts of food transport: congestion, pollution and accidents. It is not designed to directly measure wider economic and social impacts, or to detect trends such as changes in food sourcing and food retailing, although policy initiatives in these areas may well have detectable impacts on the indicators.

7.1.6 Evaluation of indicators for 2002

Table 33 shows the key indicators estimated for 2002. The indicators are shown with and without the food km related to the export of food. This is to enable the government to take into account the economic benefits to the UK of food exports when evaluating the impacts of food transport.

Table 33: Food Transport Key Indicators for 2002 (Headline indicators in bold)

		Including exports			Excluding exports		
		Total	In UK	Overseas	Total	In UK	Overseas
Total tonne kilometres	billion tonne km	234	50	183	197	43	154
Total vehicle kilometres	billion vehicle km	30	25	5	29	24	5
Urban road food km	million vehicle km		11,778			11,306	
	HGV mvkm		*6,975*			*6,975*	
	LGV mvkm		*2,974*			*2,697*	
	Car mvkm		*1,828*			*1,633*	
HGV food km	million vehicle km	9,425	5,812	3,613	8,284	5,193	3,091
	million tonne km	*76,871*	*47,400*	*29,471*	*67,565*	*42,352*	*25,212*
Air food km	million vehicle km	27	0	27	23	0	23
Total CO_2 emissions	million tonnes	19	10	9	17	9	8
Total PM_{10} emissions	thousand tonnes	5	3	3	4	2	2
Total NO_x emissions	thousand tonnes	158	72	85	137	65	72
Total SO2 emissions	thousand tonnes	41	0.25	41	34	0.23	34
Live animal food miles	million tonne km	764	764	NK			
Imports of indigenous foods	million tonnes	16.15	16.15				
Retail sales of ethically traded foods	million £	63	63				
% of indigenous organic food grown in the UK		62%	62%				

NK=Not known

7.2 TRENDS 1992-2002

Table 34 shows the key indicators (including exports) for 1992, 1997 and 2002.

The key trends to note are:

- **Tonne kilometres** have increased by 15% since 1992 and food transport vehicle kilometres by 21%. The increase in vehicle kilometres is largely due to the increase in car shopping for food.

- **HGV food km** increased by 8% between 1992 and 1998, but then declined by 7% to 2002, giving a net increase of only 1% from 1992 to 2002. This is due to a slower increase in tonne kilometres, and an increase in vehicle load factor. This trend is observed both for UK and overseas food kilometres, although it should be noted that we have assumed the same increase in load factor for overseas transport as for the UK, and this is not necessarily the case. In recent years there has been a trend to increase food trade with nearer EU countries (France, the Netherlands and Ireland) at the expense of Spain, Italy and Greece, and this has decreased vehicle km for the international stage of transport. However, as food imports have increased, the associated road transport within overseas countries has also increased steadily.

- **Air freight** has increased by 140% since 1992, although it still accounts for only 0.1% of total vehicle km. However, it accounts for 12% of CO_2 –equivalent emissions, when the effect of non-CO_2 aircraft emissions in the stratosphere is taken into account.

- **CO_2 emissions** from food transport increased by 12% from 1992 to 2002.

- **Pollutant emissions** (e.g. PM_{10} and NO_x) have decreased over this period, despite the increase in vehicle kilometres. This is because of the introduction of Euro standards for all vehicles[i], and also because the increase in vehicle kilometres is dominated by cars, which pollute less per vehicle km than other vehicles. Nevertheless, pollution from food transport is still significant – NO_x food miles emissions in the UK are 4% of the UK total.

- **Live animal food km** increased from 1992 to 1997. The 2002 figure is lower than the 1997 figure, perhaps due to the impact of foot and mouth disease in 2001.

- **Imports of indigenous foods** are growing steadily.

- **Sales of ethically traded food** are growing rapidly, although they still form a very small proportion of the market.

- **The UK share of the organic food market** is improving, up from 35% in 2001/2002 to 44% in 2002/2003, and taking 62% of the indigenous organic food sales.

[i] Estimates of CO_2 and pollutant emissions for 1992 and 1997 are currently underestimates as they use 2002 emission factors. These will be replaced by the appropriate emission factors in the final version of this report.

Table 34: Trends in Key Indicators 1992-2002 (Headline indicators in bold)

Including exports		**Total**			**In UK**			**Overseas**		
		1992	**1997**	**2002**	**1992**	**1997**	**2002**	**1992**	**1997**	**2002**
Total tonne kilometres	billion tonne km	203	222	234	39	49	50	164	173	183
Total vehicle kilometres	billion vehicle km	27	29	30	21	23	25	5.7	5.5	5.3
Urban road food km	million vehicle km				9,847	11,015	11,778			
Car	*million vehicle km*				*5,178*	*6,108*	*6,975*			
LGV	*million vehicle km*				*2,974*	*2,974*	*2,974*			
HGV	*million vehicle km*				*1,696*	*1,932*	*1,828*			
HGV food km	million vehicle km	9,325	10,026	9,425	5,391	6,145	5,812	3,933	3,881	3,613
	million tonne km	*62,745*	*75,270*	*76,871*	*36,278*	*46,131*	*47,400*	*26,467*	*29,139*	*29,471*
Air food km	million vehicle km	11	22	27	0	0	0	11	22	27
Total CO_2 emissions	million tonnes	16.9	18.7	19.1	8.9	9.9	9.7	7.9	8.7	9.2
Total PM_{10} emissions	thousand tonnes	9.5	7.3	5.3	5.6	4.1	2.5	3.8	3.1	2.8
Total NO_x emissions	thousand tonnes	206	201	158	105	102	72	101	98	85
Total SO_2 emissions	thousand tonnes	51	42	41	8.81	2.51	0.25	43	40	41
Live animal food km	million tonne km				870	884	764	NK	NK	NK
Imports of indigenous foods	million tonnes				13.55	14.20	16.15			
Retail sales of ethically traded foods	million £				0	13	63			
% of indigenous organic food grown in the UK	%				NK	NK	62%			

NK=Not known

7.3 CONSISTENCY WITH OTHER GOVERNMENT POLICIES AND OBJECTIVES

Any proposed food miles indicator should be consistent with the approach and objectives of two main government strategies:

- The Sustainable Farming and Food Strategy
- The proposed Food Industry Sustainability Strategy (FISS)

In its Strategy for Sustainable Farming and Food, the Government set principles for a sustainable food chain. In Box 10, we compare our proposed indicator set against those objectives to ensure consistency. The effects of a food miles indicator depend considerably on the selection of policies for reducing food miles, which are addressed in Section 7. The comments in Box 10 show that our Key Indicators are almost entirely consistent and strongly synergistic with the principles on which both the Sustainable Farming and Food Strategy and the draft Food Industry Sustainability Strategy are based. There are some potential exceptions which require special policy measures or monitoring. These include the less informative labelling of some local foodstuffs, the potential for net energy penalties if UK production of greenhouse crops increases, and the possible decrease in transport efficiency and increase in van miles through increased local sourcing.

The draft FISS strategy takes a more detailed look at the impacts of the food chain beyond the farm gate. Indicators for the FISS have been categorised within a set of priority areas (see Table 35).

Table 35. Priority Areas of the draft Food Industry Sustainability Strategy

Primarily environmental	Primarily social	Primarily economic
Sustainable Consumption & Production	Food safety	**Educating consumers**
Energy use and climate change	Equal opportunities	Better regulation
Water	Health & Safety	Science-based innovation
Waste	**Ethical trading**	Workforce skills
Emissions from Transport – including food miles	Tackling retail crime	
	Corporate Social Responsibility	

Those which interact with the Food Transport (Food Miles) indicators are highlighted in bold type. Below we assess the interactions between the two sets of indicators.

Box 10. Principles for a sustainable food chain

♦ *Produce safe, healthy products in response to market demands, and to ensure that all consumers have access to nutritious food, and to accurate information about food products.*

Progress against a food miles indicators should not compromise access to nutritious food, and may improve access where, for example, consumption of fresh local produce replaces processed or less fresh food. Measures to reduce car food miles may improve access for non-car owners (see Section 7). The indicator should encourage better country- of-origin labelling, but local foods may present less labelling information to consumers. For example, local bread or jam sold through a farmers market may not be labelled with a full list of ingredients or nutritional information, even though such food is less likely to contain additives.

♦ *Support the viability and diversity of rural and urban economies and communities.*

This is entirely consistent – more local sourcing of food will boost UK farming communities (especially smaller farms), encourage more diverse food enterprises, strengthen local economies, especially rural economies, and support valuable local services such as local shops.

♦ *Enable viable livelihoods to be made from sustainable land management, both through the market and through payments for public benefits.*

This is consistent – local sourcing of food will improve the market for organic and other forms of sustainable agriculture, through offering more market opportunities for smaller producers, who tend to use less intensive methods. The current system whereby the bulk of food is sourced from very large farms, whether in the UK or overseas, encourages intensification of agriculture. This arises from the demands of supermarkets for large quantities of consistent and cosmetically perfect produce, which can lead to more use of fertilisers, pesticides, herbicides and fungicides.

♦ *Respect and operate within the biological limits of natural resources (especially soil, water and biodiversity).*

Consistent (see above). Although this is not an explicit aim of the indicator, this objective will be encouraged by the component which measures UK share of the organic market.

♦ *Achieve the highest standards of environmental performance by reducing energy consumption, minimising resource inputs, and using renewable energy wherever possible.*

Transport energy consumption will be minimised, although if increased UK production of greenhouse crops (e.g. salad crops) is a result then there may also be energy penalties. Therefore it is important to also continue efforts to increase energy efficiency and use of renewable energy in these sectors (see Section 7). It is also necessary to monitor any increase in van miles and consequent reduction in transport efficiency which could offset the benefits of the indicator.

♦ *Ensure a safe and hygienic working environment and high social welfare and training for all employees involved in the food chain, here and overseas.*

Consistent through the indicator relating to ethically traded food.

♦ *Achieve the highest standards of animal health and welfare, compatible with society's right to access to food at a fair price.*

Consistent through the live animals food miles indicator, although trade-offs with welfare production standards should be monitored.

- *Sustain the resource available for growing food and supplying other public benefits over time, except where alternative land uses are essential to meet other needs of society.*

Consistent through support for smaller, more sustainable producers (see above).

These principles should apply to all food which is grown and processed overseas, and consumed here, as well as all food which is grown and processed in this country.
Yes, we have included the whole food chain including food produced overseas in our indicator.

Energy and climate change
The FISS indicators are:
- Total energy use by the food, drink (& tobacco) manufacturing industry;
- Energy use per unit of output in the food, drink (& tobacco) manufacturing industry;
- CO_2 saved under food and drink sector Climate Change Agreements;
- CO_2 per unit of output saved under food and drink sector Climate Change Agreements.

A reduction in food miles, if implemented through appropriate policies, should lead to a reduction in transport energy use and CO2 emissions. As transport accounts for a significant proportion of total food and farming industry energy consumption (48% according to our estimates) this should contribute significantly to the FISS objectives for energy and climate change. However, there are two caveats. Firstly, it will be important to monitor any decrease in transport efficiency resulting from a move to more local sourcing of food, and to assess the extent to which this offsets the CO_2 reductions from reduction of transport distance. Secondly, the effect of more local sourcing on the energy efficiency of food production is not clear. Some small scale food production might be more energy efficient (e.g. as more preparation might be done by hand instead of by machine) and some might be less efficient (e.g. as economies of scale are lost for cooking and baking). It will therefore be important to continue to encourage energy efficiency and use of renewable energy where possible in the local food sector, as well as promoting improved transport logistics and use of cleaner vehicles for local food distribution.

Water use
The FISS indicator will be total water consumption per tonne of product by the food, drink (& tobacco) manufacturing industry per year.

As above, it is not clear what effect more local sourcing of food will have on water consumption. Smaller producers could be either more or less water-efficient. It will be important to monitor any changes in the pattern of water use and to continue to offer support and encouragement to improve water management in the local food sector through the Envirowise programme and other initiatives.

Waste
The FISS indicators will be paper and card waste used by the food, drink (& tobacco) manufacturing industry; and the level of “food waste” across all sectors

On the whole, it is hoped that a reduction of food transport will also reduce the need for packaging. Food which is transported short distances and sold on the same day (such as through a farm shop, farmers market or box scheme) requires little packaging. Vegetables, for example, may be sold in a paper bag or delivered in a cardboard box, whereas food transported a long distance and sold in a supermarket tends to be packaged in plastic trays, film or bags. Obviously a full life cycle analysis comparing plastic packaging and paper bags is outside the scope of this project. However, paper and cardboard originate from renewable resources (if the wood comes from a managed plantation and recycled paper is used as much as possible). To reduce impacts still further, it would be worth encouraging more use of recycled paper and cardboard in the local food sector.

Emissions from transport
The FISS proposes a set of indicators of transport logistical efficiency derived from the recent benchmarking study of Key Performance Indicators for food freight:

- vehicle fill
- empty running
- time utilisation
- deviations from schedule
- fuel consumption.

The output of the present study is intended to contribute to development of indicators based on the impacts of food miles on sustainability.

Ethical trading
The FISS indicator is the percentage of firms which follow a recognised ethical trading code of practice. These codes encourage suppliers to meet certain standards, such as avoidance of child labour, payment of “a living wage” and no cruel or inhumane treatment.

Our proposed indicator is annual sales of ethically traded produce in the UK. The FISS and Food Miles indicators are complementary, and there is good synergy between the two strategies. The FISS initiatives to promote ethical trade should be extremely helpful in reducing the adverse social impacts related to imports from developing countries, and should boost sales of ethically traded produce in the UK, thus contributing to the objective of the food transport indicator.

Educating consumers
The FISS has identified that consumers do not always exert their purchasing power in such a way as to encourage more sustainable practices in the food chain, for example through purchases of locally sourced food. FISS initiatives to improve food labelling, raise awareness of regional food and drink, and the launch of the Sustainable Development Action Plan for Education will all complement and support progress towards the Food Transport indicators.

Summary
In summary, there is generally very good synergy between the Food Transport indicators, the objectives of the Sustainable Farming and Food Strategy and the proposed indicators for the Food Industry Sustainability Strategy. In most areas, the policies and indicators will reinforce each other strongly. There are some potential areas of conflict, where additional monitoring, research and policy measures may be needed. These are:

1. Effect of more local sourcing of food on energy efficiency of food production (and possibly water consumption, packaging use and waste management).
2. Effect of more local sourcing of food on transport efficiency.

We recommend that these areas are carefully monitored and that significant efforts are devoted to improving the sustainability of the local food sector through measures to improve energy efficiency, improve transport logistics, encourage use of cleaner vehicles and renewable energy, encourage use of recycled, low impact packaging materials and improve water management.

8 Conclusions

Food transport has been increasing steadily over the last few decades, due mainly to three factors:

- Wider sourcing of foods, both within the UK and overseas;
- Centralisation and consolidation of food production and retailing operations in order to improve economic efficiency;
- Increased use of cars for food shopping.

This increase in food transport has significant negative impacts on sustainability including increased congestion, road infrastructure costs, pollution and greenhouse gas emissions, which we have estimated as giving rise to social costs of over £9 billion per year. Many of these impacts are not included in existing indicator sets (e.g. international air and shipping).

Food transport has a complex relationship to sustainability, and there can be trade-offs between environmental, social and economic factors. The case studies we investigated showed that, in general, the exceptions to the link between decreasing food miles and increasing sustainability are either marginal or can be accommodated through an appropriate indicator set. They can also be addressed through careful and integrated design of policies. In other cases, such as the issues surrounding the social and economic benefits of food trade, we conclude that further work would be necessary for a full evaluation. We stress that even if social or economic benefits offset the direct impacts of food transport in some cases, it is valid (indeed desirable) to monitor the direct negative effects of food transport. This will enable appropriate policies to be formulated to ensure that there is a balance between economic, social and environmental sustainability.

We have also demonstrated that adequate data exists to compile an annual food transport indicator. However, because of the complexities and trade-offs involved, a single indicator based on total food miles is not appropriate. We propose four key indicators based on the main direct impacts of food transport on sustainability: urban food km (split into cars, HGV and LGV); HGV food km; air food km and total CO_2 emissions from food transport. This indicator set is not designed to directly measure the wider social and economic impacts of food transport.

We recommend further investigation of the potential economic impacts and any redistribution of benefits through a switch towards more local food sources. We also recommend careful monitoring of any increase in congestion from increased deliveries and decrease in overall transport efficiency as a result of a switch to more local food. Policies to increase the distributional efficiency of the local food sector will be important in maximising the benefits of a switch towards more localised food production.

Various recent studies have proposed policies to reduce the adverse impacts of food miles[34,43,8]. Potential policies tackle food miles in various ways:

1. Sourcing food more locally where appropriate (e.g. consumer awareness, public procurement, support for local food initiatives, strengthening UK suppliers)
2. Reducing car food shopping (e.g. home delivery, support for local and in-town shops, provision of safe cycle and pedestrian access)
3. Reducing transport impacts (cleaner vehicles, improved logistics, rail freight)
4. Internalising the social costs of transport

5. Improving the wider sustainability of the food chain (e.g. ethical trading to maximise the social benefits of imported food, improved energy efficiency in the local food sector)

Many potential policies tie in with existing government objectives and initiatives, e.g. for improving transport logistics, encouraging cleaner modes of transport, stimulating local and regional food initiatives and boosting UK organic farming. The proposed indicator is consistent with the approach and objectives of DEFRA's Sustainable Farming and Food Strategy and the proposed Food Industry Sustainability Strategy.

Recommendations for further work

There are several areas where more research would be beneficial to investigate some of the more complex areas of the food miles debate. These include improvements to the dataset, further work into the validity of the indicator and appropriate supporting policies.

Dataset improvements

1. Improvement of the estimates of the key indicator of urban food transport (currently food transport cannot be distinguished from other transport on urban / rural roads). This would require new surveys to be conducted.

2. Improved estimates of the burden arising from SO_2 and NO_x emissions from shipping. Marine fuel oil is very high in sulphur and several recent studies have suggested that shipping emissions account for a much higher proportion of European sulphur and nitrogen deposition than previously thought. The contribution of shipping is also becoming increasingly important, given the decrease from land-based sources due to existing legislation. As well as revising estimates of total SO_2 emissions, it will be necessary to improve our estimate of the percentage of sea transport which is close enough to land to cause a significant impact on terrestrial ecosystems or human health. This can be done through a study of shipping routes, perhaps together with atmospheric dispersion modelling.

3. Improved estimates of average vehicle loads for air and sea transport. Assessment of the environmental impacts of air and sea transport is strongly dependent on assumptions concerning the average load size carried by ships and aircraft. More detailed investigation of the typical spread of food freight across different types and sizes of ship and aircraft, typical load factors, and the percentage of food wasted during transport over long distances would help to refine estimation of the impacts. Improved emission factors, if better data become available, would also be useful.

4. Emissions of CO_2 and other greenhouse gases (HFCs) are associated with refrigeration during transport. It would be useful to estimate the magnitude of these emissions so that they could be included in the database.

5. Estimates of transport overseas are very crude. These estimates could be refined through a more detailed study, focusing on the main countries exporting to the UK. Although it is not expected that national statistics from overseas countries would necessarily identify food miles, let alone explicitly identify food miles related to exports to the UK, some estimates could be made based on the ratio of available data (e.g. tonnes lifted) to comparable UK data, and the proportion of food produced which is exported to the UK. Any available country specific data on load factors, emission factors and typical journey lengths would also be valuable (at present we use UK load factors and emission factors for all countries, although this is known to be inaccurate).

6. DEFRA has indicated that it might be useful for policy purposes to identify indicators on a regional basis. This would be constrained by the available data. It might be possible to split UK HGV, LGV and car food shopping estimates into geographical regions, but it is less likely that the impacts of imported food can be differentiated regionally.

Validity of indicator

7. Further assessment of the statistical validity of the indicator (e.g. confidence limits for the four main headline indicators).

8. Further investigation of the wider social and economic impacts of a reduction in food miles. As mentioned above, the economic impacts of a decrease in food miles are still unclear, as is the size and nature of any redistribution of economic benefits which may occur. Further investigation could help to clarify this issue and enable the correct design of policies to maximise the benefits, and minimise any adverse economic impacts on particular sectors of the food and drink manufacturing, retail and freight industry.

9. Further research is needed to investigate the effect of a switch to more local or regional sourcing of food on the overall transport efficiency of UK food distribution. A switch to using smaller vehicles and less consolidated loads may offset some of the environmental benefits of a reduction in food miles. In particular, opportunities for improving the transport and logistics distribution of the local food sector need to be explored, perhaps drawing lessons from other countries such as France where distribution of local food is often carried out in a more co-operative manner, thus potentially achieving efficiency savings.

Policies

10. The impacts of any changes in food sourcing or food transport depend to a large extent on the policy framework, and on the response of consumers, producers and industry to those policies. A study of potential policies to reduce the impacts of food transport would help to examine the advantages and disadvantages of different policies, and design a suitable integrated framework to reduce the adverse impacts of food transport. Potential policies include:
    - Sourcing food more locally where appropriate (e.g. consumer awareness, public procurement, support for local food initiatives, strengthening UK suppliers);
    - Reducing car food shopping (e.g. home delivery, support for local and in-town shops, provision of safe cycle and pedestrian access);
    - Reducing transport impacts (cleaner vehicles, improved logistics, rail freight);
    - Internalising the social costs of transport (to reflect the costs to society of pollution, congestion, accidents, noise and so on in the prices paid by transport users);
    - Improving the wider sustainability of the food chain (e.g. ethical trading, improved energy efficiency in the local food sector).

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Annex 1
Food Miles Dataset – Data sources and assumptions

CONTENTS

1 Introduction

This annex describes the methodology, assumptions and data sources used to compile the food miles dataset.

The aim is to obtain estimates of food miles associated with each of the following links of the supply chain:

Overseas produce

1. Overseas producer to overseas processor
2. Overseas processor to overseas distribution centre
3. Overseas distribution centre to overseas port or airport
4. Overseas port or airport to UK port or airport
5. UK port or airport to UK processor
6. UK processor to UK distribution centre

UK produce

7. UK producer to UK processor
8. UK processor to UK distribution centre

All produce

9. UK distribution centre to UK retailer or caterer
10. UK retailer to consumer

This is of course a simplistic representation of the supply chain. Depending on the product, some stages may be omitted (e.g. overseas produce may not go to an overseas processor, if it is processed in the UK). Some produce may have a more complex transport route (e.g. via more than one processor or distribution centre, perhaps through several countries).

Both imports and exports are included in the dataset, as they all have impacts (positive or negative) on sustainability. For exports, stages 4, 5 and 6 above are reversed. However, for exports we do not assess the stages from the overseas port or airport onwards to the overseas shops and consumers, as this transport would occur anyway, with substitute produce from a different country, even if UK exports were reduced. Therefore it is outside the influence of UK policy.

2 UK HGV data

Data on food-related HGV transport in the UK is based on the Department for Transport's Continuing Survey of Road Goods Transport (CSRGT)[1]. This is a continuous survey of a random sample of operators of heavy goods vehicles over 3.5 tonnes gross vehicle weight registered in the UK. Statistics included in the published report are for vehicles registered in GB only, i.e. excluding vehicles registered in Northern Ireland. However we obtained statistics for vehicles registered throughout the UK from the DfT. Statistics for the year 1997 were not available due to a problem with the database, so we used 1998 data instead.

Foreign registered vehicles are not included in the survey. We made a separate estimate of activity by foreign registered vehicles based on the DfT's statistics on activity by foreign registered vehicles in the UK (see Section 2.3).

As the CSRGT data covers all road transport by HGV in the UK (with the exception of that by foreign-registered lorries), it provides a total figure for the sum of all HGV transport under stages 5 to 9 in the list in Section 1 above. It is not possible to separate out the individual stages from the data collected in the survey. It is possible that estimation of the relative contribution of the different stages could be made through detailed discussions with operators, trade associations and other sources. However, the estimation would be relatively unreliable, it would be time consuming and it is not clear that this would be necessary for the purposes of compiling a useful food miles indicator. Therefore we have not attempted to split the data into the different stages. However, we have provided a separate estimate of food miles carried out by supermarket fleets (see Section 2.2.1).

The CSRGT survey is based upon a sample of about 365 vehicles each week (there are around 423,000 HGVs registered in the UK). The operator of the goods vehicle is asked to provide details of all trips undertaken in one week: the domestic part of any trips which start or end in a foreign country are included. The operator records the origin and destination of each journey, type and weight of vehicle, length of haul and commodities carried.

From the survey responses, DfT staff estimate the HGV activity throughout the UK. The published statistics include tonne km and vehicle km split by type of vehicle, commodity carried, length of haul etc. We corrected the data on loaded vehicle km travelled to account for the empty running associated with food transport as follows:

Total vehicle km = loaded vehicle km / (1-empty running%)

2.1 SPLIT OF HGV DATA INTO COMMODITIES

Commodities are entered freehand by the operators, and DfT staff then classify them into 19 major groups, based on the NST (Nomenclature Statistique de Transport) codes used in the European Communities. The relevant groups for food are “Agricultural Products”, “Beverages” and “Other foodstuffs”. For this project we obtained a more detailed breakdown from DfT, which identifies 12 separate categories of food produce (Table A1-1 and Figures A1-1 and A1-2). The data relates to the year 2002.

Table A1-1. UK-registered HGV activity in the UK, 2002

	Goods lifted thousand tonnes	Goods moved million tonne-kms	Loaded vehicle kms (thousands)
Cereals	28,022	2,345	99,512
Potatoes	11,623	1,513	86,747
Fresh fruit & vegetables	24,012	3,800	317,529
Sugar beet	10,912	601	23,774
Live animals	6,675	764	118,715
Sugars	2,740	429	20,176
Beverages (exc. tea, coffee)	52,418	7,143	533,156
Stimulants & spices	10,546	1,461	150,832
Perishable foodstuffs	106,001	13,999	1,569,438
Other non perishable foodstuffs	57,997	7,635	879,969
Animal fodder, foodstuff & waste	35,004	3,874	252,583
Oils, seeds & oleaginous fruit & fat	6,650	912	58,240
Total food transport	**352,600**	**44,477**	**4,110,671**
Total all goods transport	**1,684,960**	**154,047**	**16,718,827**
Food as % of all goods transport	21%	29%	25%

Source: DfT[2]

The figures reported above were adjusted to account for empty running of vehicles, using empty running factors reported by the DfT (25% for food and drink). When empty running is taken into account, the vehicle kms increase from 4.1 billion to 5.4 billion.

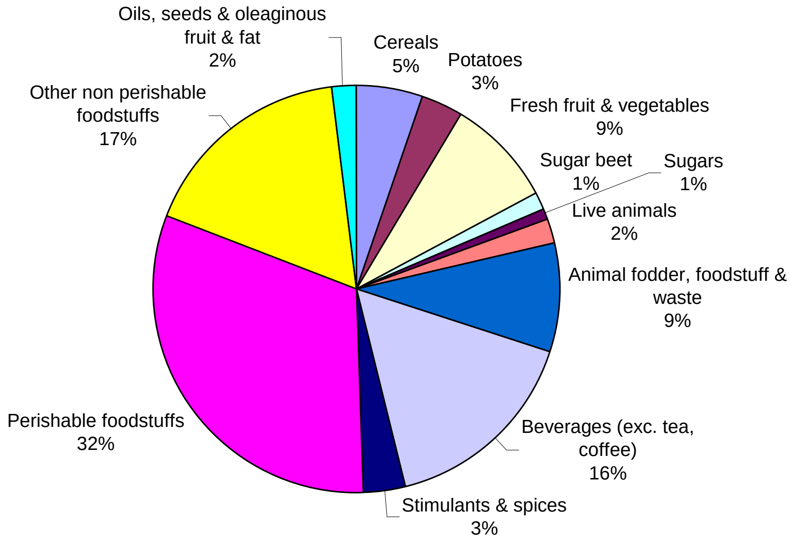

Figure A1-1 UK HGV tonne kms split by food type

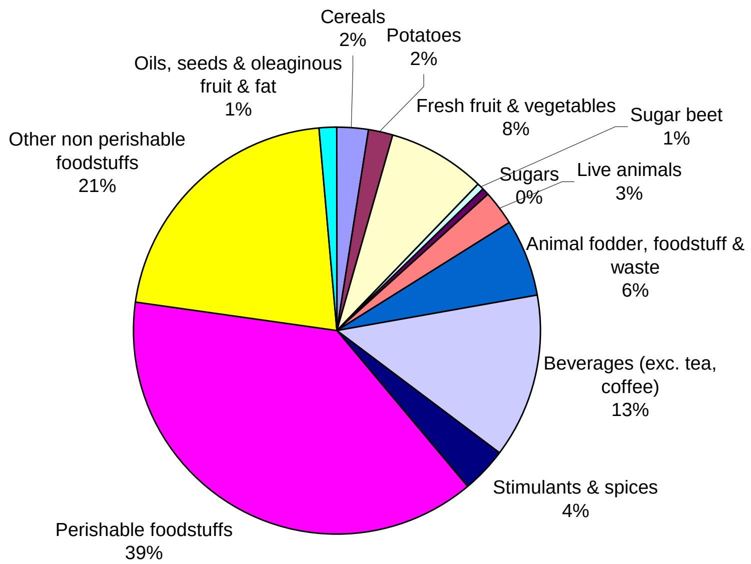

Figure A1-2 UK HGV vehicle kms split by food type

2.2 RELIABILITY OF THE CSRGT DATA

As the data is collected continuously by the national government, and covers a reasonably large sample, its fundamental reliability is believed to be good. The data shows good consistency between years, with smooth trends. However, there are two sources of uncertainty: the treatment of mixed food and non-food loads destined for supermarkets, and the comparison with roadside count surveys.

2.2.1 Mixed loads

The CSRGT assigns a large proportion of HGV transport activity to the two categories “other manufactured articles” and “miscellaneous articles”, which together account for 28% of both tonne-km and vehicle km. During earlier work by members of the study team a few years ago, information from DfT suggested that some mixed loads comprising food together with household goods and clothing destined for supermarkets might be classified as miscellaneous goods. This suggested that the actual amount of transport activity attributable to food products could be even higher than that presented above. However, information from the DfT for this study is that mixed loads for supermarkets are classified as food. This implies that the figures above could possibly be an overestimate.

To investigate this issue further, we made an independent estimate of the food miles travelled by supermarket distribution fleets. We obtained data on transport activity from the websites of two major supermarket chains, and combined these with data on the market share of these supermarkets to estimate transport activity by all supermarket fleets. The results imply that around 1.5 billion vehicle kms are travelled by supermarket distribution fleets – about 25% of the total of 5.4 billion HGV vehicle kms reported by the CSRGT (including empty running).

The remaining 3.9 billion vehicle kms would include transport of animal feed, food waste, transport of imports and exports to and from ports, transport of food from farms to factories for processing and onwards to supermarket distribution centres or wholesale markets, and transport from factories to shops by non-supermarket fleets.

It seems likely that mixed loads for supermarkets would be classified as either “perishable foodstuffs” or “other non-perishable foodstuffs”, as all other food categories are specific (cereals, potatoes, oils etc). The total of these two categories, adjusted for empty running, is around 3 billion tonne km. The estimate of 1.5 billion tonne km by supermarket fleets seems reasonable in this context - the remainder of this category would cover loads of meat, dairy produce etc travelling from farm to factory, and also food retail distribution by non-supermarket fleets.

This analysis provides reassurance that even if the 1.5 billion tonne km estimated by supermarket fleets includes some non-food items, it seems unlikely that these would form a high proportion of the total HGV vehicle kms reported in the CSRGT. For example, if 20% of the loads were non-food items, this would only represent 5% of the total HGV vehicle kms – within the margin of error of the dataset. Therefore we feel justified in using the CSRGT data without adjustment for mixed loads.

2.2.2 Roadside count data

There is a 28% gap between estimates of road transport by HGVs arising from the CSRGT and from roadside count data. However, both methods are subject to their own uncertainties, and would not be expected to agree precisely[3]. Sources of uncertainty include:

- Roadside counts underestimate freight transport activity as they are not carried out at night;
- Foreign vehicles are not included in the CSRGT;
- Both sources are subject to sampling errors;
- Roadside counts cannot reliably distinguish the exact cut-off point above which a vehicle is classified as a HGV.

2.3 FOREIGN REGISTERED VEHICLES

We made a separate estimate of activity by foreign registered vehicles, based on DfT statistics for activity by these vehicles. The statistics are based on surveys of foreign registered vehicles. Data are only reported for EU countries. There are two types of transport involved:

imports and exports where one end of the journey is in the UK and the other in a foreign country; and journeys entirely within the UK (referred to as "cabotage" when undertaken by foreign operators). A survey of cabotage found it to be minimal, so we only included estimates of import and export journeys.

The bulk of the distance travelled on an import or export journey is already accounted for in our analysis, whether undertaken by UK or foreign vehicles, as the analysis of the "UK to overseas" leg of the food chain covers the distance between London and the major city of the trading country. Therefore we only need to account for the distance travelled by foreign registered HGVs beyond London. We estimate the average distance travelled beyond London to be 200km (regional data shows that most transport activity takes place in the south east of the country, and many journeys would actually end before London).

The DfT survey data does not identify the commodity type carried, but it provides an estimate of the share of imports and exports to and from the UK carried out by vehicles registered in each European country. Our estimates therefore multiplied import or export tonnages to each EU country by the share of imports or exports attributable to foreign registered vehicles, and multiplied this by the estimated distance of 200km to obtain an estimate of activity in tonne km (Table A1-2).

Table A1-2 Estimation of additional food miles by foreign registered lorries (2002)

	UK Food Trade		Share (%)		Estimated Mtkm		
	Imports (t)	Exports (t)	Imports	Exports	Imports	Exports	**Total**
FRANCE	4,852,036	1,128,720	58	54	563	122	685
NETHERLANDS	3,459,402	1,001,570	63	56	436	112	548
IRISH REPUBLIC	2,009,726	2,117,153	90	90	362	381	743
SPAIN	1,780,615	1,392,162	65	46	231	128	360
GERMANY	2,008,588	816,471	43	26	173	42	215
BELGIUM	1,188,607	593,280	30	20	71	24	95
ITALY	1,249,999	428,907	24	16	60	14	74
DENMARK	679,079	218,084	75	61	102	27	128
PORTUGAL	123,511	282,969	87	85	21	48	70
GREECE	144,990	100,918	10	0	3	0	3
SWEDEN	59,361	101,871	25	0	3	0	3
Total					**2025**	**898**	**2923**

Source: DfT, AEAT estimates.
Note: excludes travel from port to London.

2.4 SEPARATING OUT EXPORTS

In order to present food miles indicators both with and without exports, it was necessary to estimate the proportion of UK HGV miles travelled which were carrying food destined for export.

A very simple estimate can be obtained by simply assuming that the proportion of vehicle kilometres travelled due to exports is the same as the proportion of food (by weight) exported from the UK, as a total of all food produced and consumed in the UK. This figure is 15%. However, this takes no account of different lengths of the transport chain for exported food as compared to imported and domestically consumed food. Differences will arise as some of the processing may be done overseas, and also the retail leg of the chain will be excluded. These differences would be expected to result in a lower proportion of food miles travelled than the 15% which is obtained by considering the weight of food exported as a % of the UK total.

We therefore made some crude estimates to correct for these factors. Customs and Excise data was used to establish exports of foodstuffs from the UK split by food category. We assigned a "processing factor" to each food type, to correspond to the degree of processing within the UK for food which was exported. Food was assigned a processing factor of zero for unprocessed food, one for lightly processed food or two for highly processed food. The factors were assumed to correspond approximately to the number of processing stages involved. These factors were then weighted according to the weights of each food stuff which are exported. The weighted processing factor was estimated to be 0.9 for exported food. We therefore assumed that on average, one processing stage is involved for exported food.

The distance travelled by exported food was then assumed to correspond to the following stages:

1. Farm to processor. Assumed to be 126 km (the average length of haul for UK food transport, from CSRGT statistics).
2. Processor to port. Assumed to be 250km (own estimate, high uncertainty).

The total is 376 km. This seems reasonable when compared to the average distance travelled by food produced in the UK which is 429km (total HGV food related tonne kilometres divided by total tonnes of food produced and imported).

The food miles related to production and transport of food destined for export is therefoew estimated as 376 km multiplied by the weight of food exported (11 million tonnes) giving a total of 4.1 million tonne kilometres, or 509 million vehicle kilometres (assuming an average payload of 8.1 tonnes, including empty running). Therefore the percentage of food-related UK HGV vehicle kilometres related to exports is estimated as 9%. Although the estimate of distance travelled is highly uncertain, the resulting estimate seems reasonable compared to the 15% of food by weight which is exported.

3 UK LGV data

At present there is no reliable data on LGV movements in the UK. Fortunately, the DfT is in the process of a CSRGT-type survey for light goods vehicles. Results were not available within the timescale of this project.

For this study, we have estimated LGV food transport based on a 1992/93 study by the Department of Transport[4]. The study estimated goods lifted and goods moved by LGVs to be around 5% of the total (the remaining 95% being by HGVs) (Table A1-3).

Table A1-1. Estimates of LGV activity

	Goods lifted		Goods moved		Estimated vehicle kms	
	million tonnes	% of total	billion tonne-kms	% of total	million vehicle kms	% of total
PLG HGV*	27.6	1.8%	1.7	1.3%	2005	9.7%
PLG light vans**	64.1	4.1%	4.2	3.3%	6604	31.8%
Total small commercial vehicles	**91.7**	**5.9%**	**5.9**	**4.6%**	**8608**	**41.5%**
Goods vehicles over 3.5 t	1463	94.1%	121.3	95.4%	12130	58.5%
All commercial vehicles	**1554.7**	**100.0%**	**127.2**	**100.0%**	**20738**	**100.0%**

*PLG HGV: Vehicles in the Private and Light Goods tax class with body types which are considered appropriate for HGVs. Some vehicles in this category are over 3.5t GVW.
**PLG vans: Vehicles in the Private and Light Goods tax class with van type bodies.

Source: 1992/93 DoT survey[4] (goods lifted and goods moved); authors own estimates (vehicle kms) based on assumed load sizes (see text).

We have estimated the corresponding vehicle kilometres based on assumed average load sizes. For a HGV-type PLGV we assumed that a typical vehicle with a gross weight of 3.5t had a maximum payload of 1.6t (from manufacturers' information). Typical load factors for HGVs in the food sector are 53%, giving a load of 0.85t. For a van-type PLGV we assumed a typical maximum load of 0.8t, giving a load of 0.64t when a load factor of 53% is applied[1]. The typical load carried by a HGV was assumed to be 10 tonnes, based on the average loads carried by HGVs in the food supply chain from a recent benchmarking study[5]. This load was confirmed by dividing the total HGV tonne kms from the CSRGT survey by the total vehicle kms, giving an average payload of 10.8 tonnes.

We then adjusted the vehicle kilometres for empty running, assuming empty running of 30% for large vans and 40% for small vans (figures estimated based on the assumption that empty running would be higher for vans than for HGVs, where the figure is 25%, and obviously 50% would be an upper limit). The weighted empty running factor for both large and small LGVs is 37%.

The 1992/93 survey did not identify the commodities carried by the vehicles. Therefore it is necessary to estimate the proportion of LGV goods carried which are food products. The CSRGT shows that 29% of all HGV tonne km are for food products. However, it would be an oversimplification to assume that the same percentage applies to LGVs. Many of the goods carried by HGVs are unlikely to ever be carried by LGVs (coal, oil, steel, large machinery etc). Therefore it is likely that a higher proportion of the LGV tonne km are for food products.

Based on the CSRGT results, we estimated the proportion of goods carried by HGVs which might also be carried by LGVs. After excluding goods deemed unlikely to be carried by LGVs we found that around 64% of goods moved by HGV might also be carried by LGVs. Of these goods moved by HGV which could also be moved by LGV, food accounted for 45%.

In view of the uncertainties in the LGV data, our approach was to derive an upper estimate and a lower estimate for food-related LGV activity, and take the mid-point of the two values as our best estimate.

The lower estimate was derived by simply assuming that the ratio of HGV to LGV transport in 1992/93 was the same as the ratio of HGV to LGV food-related transport in 2002. This gave an estimate of around 2 billion tonne km for LGV food transport in 2002. As discussed above, this is likely to be an underestimate as proportionately more of the LGV transport will be due to food.

The upper estimate was derived by first scaling up the 1992/93 total LGV activity based on the ratio between the 1992/93 HGV food activity and the 2002 HGV food activity. This may well result in an overestimate because although total van usage is increasing, much of this may be related to service activity rather than goods activity. In the food sector, although total tonne kms are increasing, it is possible that because of the consolidation of supply chains and reduction in back of store deliveries etc, (see Annex 2), the increase in HGV food km has displaced some LGV food km. The scaling-up step resulted in an estimate of 7.5 billion tkm for LGVs in 2002, compared to 6 billion tkm in 1992/93. Next we estimated the proportion of this activity which was due to food. As reported above, we estimate that 45% of HGV tonne kms which could be carried by LGVs is due to food. This gives an estimate of 3.4 billion tonne km for LGV food transport in 2002.

Our best estimate for LGV food transport in 2002 is therefore the midpoint of the upper and lower estimates, i.e. 2.7 billion tkm. Using the load factors reported above and adjusting for empty running, this translates into 6.1 billion vehicle km.

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[1] This assumes that the same load factor applies to LGVs as to HGVs – in fact the load factor for LGVs may well be smaller, as the HGV load factor is optimised as far as possible by fleet managers. LGV vehicle kms could therefore be even higher than estimated.

4 UK domestic air, sea and inland waterway transport

UK domestic air, sea and inland waterway transport of food is assumed to be negligible. Official government statistics assign all domestic transport of food products to road[6]. National statistics do not generally identify food as a separate category of freight for these transport modes.

Sea transport

Government statistics show that dry bulk agricultural products were carried 400 million tonne kilometres by coastwise domestic sea transport and 100 million tonne kilometres by inland water transport in 2001[2]. An additional 2.9 billion tonne kilometres were travelled by unitised products (i.e. in containers), which could include food. As it is not possible to tell how much might be food, we have excluded container transport from the dataset at this stage. Further research might be able to establish an approximate figure for the percentage of container transport which is food.

Air transport

Figures for total air freight are available from the CAA, but categories of freight are not identified. According to the CAA, two million tonnes of freight were moved by air in 2002. Government statistics[3] show that one million tonnes of cargo and mail were moved over 5 billion tonne kilometres by UK airlines in 2001. Only 88,000 tonnes of this was domestic freight, travelling 34 million tonne kilometres. This is insignificant compared to the 44 billion tonne kilometres of food travelling by HGV, and in any case most of this would be mail. Also, much domestic air transport of freight is in fact transferred to HGVs (with flight numbers), as road transport is faster over UK intercity distances (Box A1-1).

Rail transport

National rail freight statistics do not identify food as a separate category of freight. Most rail freight is for bulk goods such as coal, metal products and building materials. Of the 20 billion tonne kilometres of freight moved by rail in 2001/02, 7 billion tonne km were defined as “other” freight and so could potentially include some food, the remainder being coal, oil, metals and construction materials[4]. However the opinion of transport logistics experts on our team was that very little food travels by rail in the UK.

[2] Table 1.2 in DfT Transport Statistics Bulletin “Waterborne freight in the UK 2001”.
[3] Table 7.3 of DfT Transport Statistics for Great Britain 2002.
[4] Table 5.12 of DfT Transport Statistics for Great Britain 2002.

Box A1-1: Transport of Air Cargo by Lorries

For transport of air freight within the UK, or even to nearby European airports such as Paris or Amsterdam, road trailers are often substituted for aircraft due to:

♦ a lack of space on predominantly narrow bodied aircraft plying the main Intra -European air routes;

♦ the recognition that short haul air freight services often suffer from disproportionately long pre and post shipment delays at airport transit sheds, while awaiting handling and customs formalities;

♦ substituting trailers for aircraft on short haul routes can often be cheaper and may also reduce cargo handling costs.

There is currently no distribution of air cargo by rail due to:

♦ the difficulty in consolidating sufficient volumes of air cargo to make rail economic;

♦ lack of intermodal rail facilities at airports, contributing to making rail uneconomic;

♦ the flexibility, convenience and low cost of road haulage.

Ref: UK Air Freight Study Report, DfT.

5 Imports and exports – the overseas stage

Our data for imports and exports of food is based on HM Customs and Excise data. The HM C&E trade database[7] reports the weight of each product category imported or exported by country and by month or year. Data is collected annually via customs declarations forms for non-EU countries, or via the Intrastat system for EU countries. Customs declarations forms collect the transport mode (i.e. air, sea or rail) but Intrastat does not. Imports and exports from our main trading partners are shown in Table A1-3. It can be seen that 62% of food trade is with the EU, and our main trading partners are the closest countries to the UK – France, the Netherlands and Ireland (which together account for 35% of the UK's food trade). Leading non-EU trading partners are the USA, Brazil, Canada, Argentina and South Africa, which together account for 16% of the UK's food trade. The split by food type is shown in Table A1-4

For this study we purchased from HM C&E a more detailed breakdown of the 2002 data which gave the transport mode for non-EU countries. The mode is split into air, rail, or sea transport, with the sea transport further split into goods carried by vehicles, unaccompanied trailers, or in containers. The data is shown in Figure A1-3.

This approach excludes transport of food internationally before it reaches the country from which it is exported to the UK. For example, if jam made in France for export to the UK contains apricots from Greece and sugar from Mauritius, the transport of the apricots and sugar from Greece and Mauritius to France is excluded from our database (simply for lack of data). Also, for transhipments, only the last shipment is included. International food miles are thus likely to be underestimated in our database.

Table A1-3. Imports and exports of food to and from the UK (tonnes)

	Imports	Exports	Total
FRANCE	4,852,036	1,128,720	5,980,756
NETHERLANDS	3,459,402	1,001,570	4,460,972
IRISH REPUBLIC	2,009,726	2,117,153	4,126,878
SPAIN	1,780,615	1,392,162	3,172,777
GERMANY	2,008,588	816,471	2,825,059
USA	2,019,510	449,721	2,469,231
BRAZIL	2,125,021	15,138	2,140,160
BELGIUM	1,188,607	593,280	1,781,888
ITALY	1,249,999	428,907	1,678,906
DENMARK	679,079	218,084	897,163
CANADA	609,555	81,060	690,615
ARGENTINA	629,927	2,169	632,096
SOUTH AFRICA	535,057	96,686	631,743
MAURITIUS	533,362	4,344	537,707
AUSTRALIA	367,582	103,765	471,348
MALAYSIA	435,310	26,435	461,746
PORTUGAL	123,511	282,969	406,481
INDONESIA	361,596	13,770	375,366
NEW ZEALAND	281,211	14,170	295,382
ISRAEL	137,514	151,630	289,144
THAILAND	171,222	98,785	270,007
INDIA	253,158	7,569	260,727
GREECE	144,990	100,918	245,907
EGYPT	114,146	131,363	245,509
TURKEY	221,232	12,584	233,817
Others	4,217,587	1,740,234	5,957,822
Total	30,509,545	11,029,659	41,539,204
EC total	17,653,745	8,254,838	25,908,583
EC %	58%	75%	62%

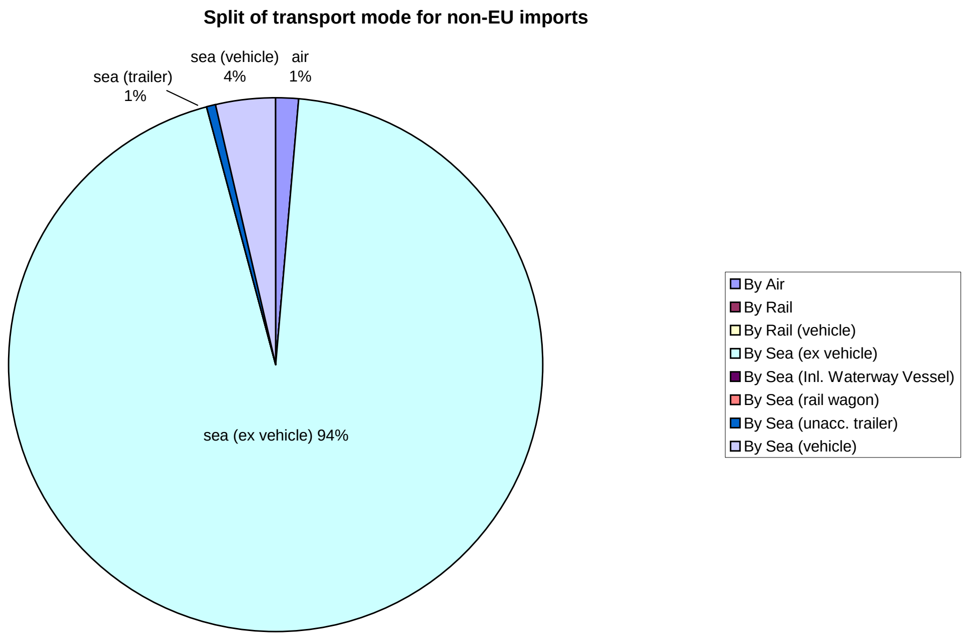

Figure A1-3. Split of transport mode for non-EU imports and exports.

Table A1-4. Imports and exports of food to the UK by food type (tonnes)

	Imports	Exports	Total
Cereals	3,479,969	2,768,108	6,248,077
Food residues, waste and prepared animal fodder	4,289,553	806,357	5,095,910
Beverages, spirits and vinegar	3,089,405	1,756,722	4,846,128
Vegetables, roots and tubers	3,524,872	686,901	4,211,773
Fruit and nuts	3,274,988	83,952	3,358,940
Sugar and confectionery	2,359,780	709,258	3,069,037
Preparations of vegetables, fruits and nuts	1,889,960	188,455	2,078,415
Oil seeds, industrial plants, straw and fodder	1,724,587	243,704	1,968,292
Animal or vegetable fats and oils	1,381,368	469,791	1,851,159
Meat and offal	1,320,288	442,699	1,762,988
Preparations of cereals, flour, starch or milk; pastrycooks products	862,510	599,601	1,462,111
Dairy produce, eggs and honey	789,989	547,416	1,337,405
Products of the milling industry; malt, starches, gluten	404,010	727,501	1,131,511
Miscellaneous edible preparations	570,988	316,552	887,540
Fish and shellfish	373,712	363,045	736,758
Preparations of meat, fish and shellfish	588,573	56,989	645,562
Cocoa and cocoa preparations	416,740	184,458	601,198
Coffee, tea, mate and spices	341,288	46,874	388,163
Lacs, gums, resins and other vegetable extracts	180,044	14,638	194,682
Live animals	21,761	18,221	39,982
Total	**30,884,387**	**11,031,243**	**41,915,630**

99% of goods from non-EU countries enter the UK by sea, and 1% by air. However, the C&E data does not indicate whether the goods arriving by sea have travelled the whole distance by sea, or partly by road followed by a short-sea crossing from a north European port. We therefore made assumptions concerning the transport mode for the remainder of the journey.

Our assumptions were that:

1. Air transport of food from within the EU is negligible.
2. All sea imports from European countries travel by HGV to the nearest major north European port (Le Havre, Calais, Antwerp, Rotterdam or Hamburg), from where it travels to the nearest major English port (Southampton, Dover, London or Felixstowe). Exports travel the same routes in reverse. Exceptions are for Spain, Portugal and Ireland where we assumed that 50% travels entirely by sea and 50% by road/ short sea.
3. For Russia and the Baltic States we assumed that 50% travels entirely by sea and 50% by road/ short sea from Hamburg. For other Former Soviet Union states we assumed all food travels by road then short sea from Hamburg.
4. For Middle Eastern countries we assumed that food travels by road then short sea from Hamburg.
5. For all other countries (America, Australasia etc) we assumed that all non-air food travels entirely by sea.

Distances by air are straight line distances between London and the capital city of each country[8], road distances are the distance on major roads[9], and shipping distances are used for sea transport[10]. .

5.1 AIR FREIGHT

Air freight is currently small compared to sea and road freight, but has a much greater environmental impact per tonne carried. It is reserved for highly perishable goods (e.g. seafood), high value goods (tobacco, alcohol) or for exports from countries where the road / sea route is less convenient (exotic fruit and vegetables from sub-saharan Africa). 80% of cargo is currently carried as belly freight on passenger planes, but there is a trend towards more use of air freighters (Figure A1-4). A recent report states that in fact most food freight is now carried on dedicated freighters, because this allows easier handling of pre-packed containers with special storage requirements, and also can provide a more reliable and (when properly managed) a cheaper service[11].

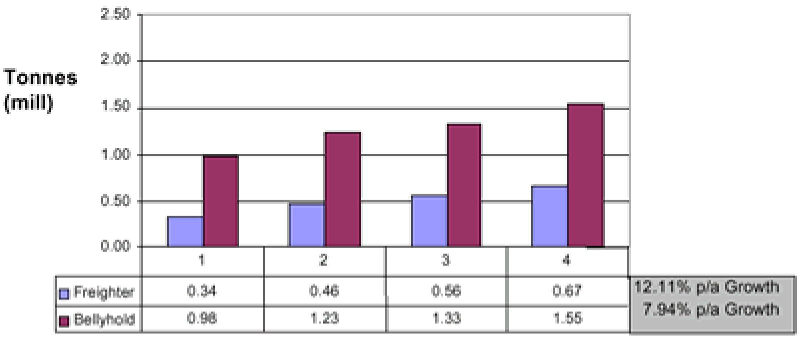

Figure A1-4 Transport of air freight: Freighter or Bellyhold (1992-1998)[12]

Figure A1-5 shows the split of goods imported or exported by air. The single largest category is vegetables from Africa (green beans, baby corn, mangetout and so on imported from Kenya, Gambia, Egypt etc). In all, vegetable imports account for 40% of food air freight in or out of the UK, fruit imports for 21% and fish imports for 7%.

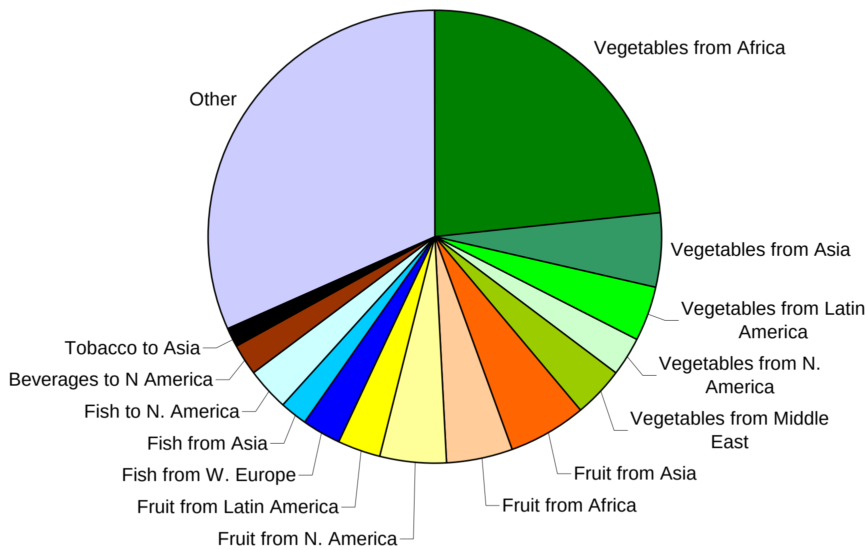

Figure A1-5. Split of air imports by food type and source / destination

Payloads for air freight carried on popular dedicated freighters range from 39 tonnes (for a converted Airbus 310) to 150 tonnes (for a new Airbus 380-800F). New A300F4-600R freighters can carry 54 tonnes[13]. Boeing 747s can carry 60-70 tonnes payload in a passenger plane, of which up to 30% (18 tonnes) could be available as belly freight, or 110-120 tonnes in a dedicated freighter[14]. Air freighters designed for outsize cargo can carry up to 250 tonnes, but this type of freighter would not normally be used for routine food freight. These payloads are maximum payloads – for very long flights (e.g. London to South Africa or Argentina) payloads will be reduced. Also the maximum payload will not be fully utilised. Globally, the average load factor for air freight is 67%[15]. To estimate the average payload for food freight transport to or from the UK, we used figures from a DfT report on air freight in the UK[16] which showed the amount of UK air freight carried by aircraft type.

Table A1-5 UK air freight carried (tonnes) by type of aircraft 1998

Aircraft Type (grouped)	Passenger Aircraft		Cargo Aircraft			
	Freight carried	% share	Freight carried	% share	Approx. payload (t)	weighted payload (t)
Airbus A300 - A340	176,378	12%	33,079	5%	40	3.07
Boeing 727	553	-	118,360	19%	26.3	7.23
Boeing 737	51,597	4%	11,604	2%	18.7	0.50
Boeing 747	564,137	39%	169,870	27%	110	43.42
Boeing 767-777	319,030	22%	26,556	4%	50	3.09
McDonald Douglas MD11-88	44,581	3%	70,882	11%	92	15.15
All above	1,156,276	80%	430,351	68%		**72.5**
Total all aircraft	1,438,518	100%	626,920	100%	At load factor 67%	**49**

Note: Original source DfT UK air freight study report, based on CAA figures. Weighting carried out by multiplying payload by freight carried by cargo aircraft of that type divided by freight carried by all cargo aircraft listed in the table (430,351 tonnes).

No adjustment has been made for food wastage during air freight. Figures as high as 40% wastage have been quoted, which would almost double the impact of air transport per tonne of food imported. However, no reliable reference has been found to confirm this figure.

6 Transport from overseas producer to dispatch point

Apart from international transport from an overseas port, airport or cargo dispatch centre to the UK, it is also important to take into account the transport stages from the overseas producer to the dispatch point (as these displace similar transport stages in the UK). However we do not believe that the transport stages for food exported from the UK to travel from the receiving port or airport to the overseas shop should also be included. This is because policy changes in the UK cannot affect the total transport in these stages. If the food was not imported from the UK, other sources for the food would be found and roughly the same amount of transport would occur within the other country.

It is not practicable to assess the overseas transport stage individually for every country involved in food trade with the UK. Although some of these countries have national transport statistics, few if any of these statistics would separately identify food exported to the UK. Therefore we have assessed these transport stages by estimating the distance travelled from the producer to the road, sea or air dispatch point for each country. This distance is based roughly on the size of the country and the complexity of the food supply chain for the main products imported (e.g. degree of processing overseas). First the approximate average distance from the food source to the dispatch port or airport was estimated: generally about half the radius of the country. This was then multiplied by a “handling factor” to account for additional journeys associated with processing and transport logistics. The handling factor was 2 for developed countries, and 1.5 for developing countries.

These distances are then multiplied by the number of tonnes imported to obtain estimates of tonne-km. Typical vehicle loads are used to convert tonne-km to vehicle km. The vehicle load will vary by country, as not all countries achieve the relatively high load factors achieved in the UK, and some countries may make more use of smaller vehicles, e.g. vans or smaller HGVs, in their food supply chains. However, in the absence of reliable information we have simply used typical UK load factors. This will probably result in an underestimate of vehicle km overseas.

After the method above was used to obtain estimates of HGV activity, a corresponding LGV distance was based on the ratio of UK HGV to LGV tonne kilometres. As the UK LGV figures themselves are very uncertain, the overseas LGV figures are even more so. This method could result in an overestimate as overseas LGV transport will not include the retail distribution stages, where van travel is probably more significant than in the food supply end of the chain.

There may well be some transport of food by rail or inland waterway overseas. For example, 30% of all freight travels by rail in the USA, because of the greater distances involved[17]. It was not possible to obtain reliable data on this within the scope of this study, but the amount of food transport by these modes is unlikely to be significant compared to other sources of uncertainty in the data.

7 Shop to home – the consumer stage

The consumer stage comprises transport of foodstuffs from shop to home, either by the consumer or by delivery vehicles. We have estimated the distance driven by consumers in private cars. We have not separately addressed delivery of shopping by vans – an increasing feature in recent years, milk delivery in milk floats or collection of take-aways. However, delivery in vans will be included in the LGV survey when results become available in the next year or two.

The annual DfT personal travel survey[18] gives data on the average distance travelled for food shopping annually per person, both for people in households without cars and for those in households with cars. This includes multipurpose trips – the survey asks respondents to state the main purpose of the trip only. Shopping trips where shopping was not the main purpose are therefore not included.

This showed that on average from 1999 to 2001, the average GB resident made 117 trips each year for food shopping, travelling 349 miles. The average trip length for food shopping was 3 miles (1.6 miles in households without a car; 3.4 miles in households with a car). Most trips were made by car: 39% as car drivers, 21% as car passengers, 30% on foot, 8% by bus and 3% by other modes.

To estimate the distance driven by car for food shopping, we first multiplied the average number of food shopping trips per UK household resident per year (117) by the UK population living in households (57 million, from the Census). We then multiplied this by the percentage of trips by car drivers (39%) to get the annual number of trips by car (2.6 billion). Finally we multiplied the number of trips by car by the average trip distance for food shopping in households with cars (3.4 miles) to get an estimate of 9 billion vehicle km per year driven for food shopping in the UK.

To convert vehicle km to tonne km we needed to make assumptions concerning the average weight of shopping carried in each car. To do this we first attempted to calculate the total weight of food shopping purchased in the UK each year. This was based on the DEFRA National Food Survey of food consumption per household in the UK in 2000, multiplied by the number of UK households. We increased the amount by 10% to account for packaging[19] (the food consumption figure includes wastage). This gave an estimate of around 34 million tonnes of food purchased annually.

The number of shopping trips by car and by other modes is known from the personal travel survey (see above). We adjusted estimates of the amount of shopping carried per trip by car and by other modes until we obtained a fit to the estimate of total food purchased (ignoring home delivery for the time being). We arrived at estimates of 11 kg shopping per trip by car, and 2 kg per trip by other modes. These figures are not well constrained, i.e. the amount per trip by car could be greater, but only if the amount per trip by other modes is less. It should be noted that trips include empty trips to the shops, so this would imply that the average amounts carried on the return trips are greater: 22kg by car, and 4kg by other modes. Although the estimate of tonne km is uncertain, it is included only for the sake of completeness, as vehicle km are a more important indicator of sustainability impacts.

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Annex 2
Factors driving food miles

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CONTENTS

Reasons for the Increase in Food Miles

The conventional view, quoted in various articles and reports, is that the rising trend in 'food miles' is simply the result of supermarket chains sourcing their supplies from more distant locations. While this has certainly been an important cause, it is only one of many factors that have contributed to the growth in food movement.

In this section, we examine these factors in the context of a framework developed to explain the overall growth of freight traffic.

Several studies have analysed freight traffic growth at both national and international scales. One of the most widely-used analytical frameworks was originally developed by McKinnon and Woodburn (1996) and subsequently adopted by the EU-funded REDEFINE and SULOGTRA projects. It was also recommended by SACTRA (2000) and a recent study for the DfT (Williams et al 2002) as providing a sound basis for freight modelling. The analysis is divided into three stages:

STAGE 1:

This stage in the analysis decomposes the relationship between economic output, usually expressed in monetary terms, and freight traffic on the ground, usually measured in vehicle kms, into a series of key aggregates and ratios (Figure 1). Early studies, which focused on the growth of freight traffic on the road network, identified five key ratios:

Value density: *ratio of product value to weight.*

This converts monetary estimates of industrial output or consumption into physical quantities of product, usually measured by weight.

Handling factor: *ratio of tonnes-lifted to product weight.*

Government surveys of freight tonnes lifted record the weight of goods loaded onto vehicles at the start of a journey. As the average product makes several discrete journeys between raw material source and final point of sale, the tonnes-lifted statistic substantially exceeds the total weight of goods produced or consumed in a given time period. The handling factor effectively measures the degree of multiple-counting and can be considered a crude indicator of the number of separate links in the supply chain. Several studies in the UK have estimated that the average handling factor for food products is between four and five (McKinnon and Woodburn, 1996; NEI et al 1999). This suggests that the UK food supply chain comprises 4-5 links.

Modal split: *ratio of road tonne-kms to total tonne-kms*

As the studies were primarily concerned with road transport, the modal split was defined in terms of relative dependence on road transport.

Average length of haul: *ratio of road tonne-kms to tonnes-lifted.*

This ratio indicates the average length of each link in the supply chain.

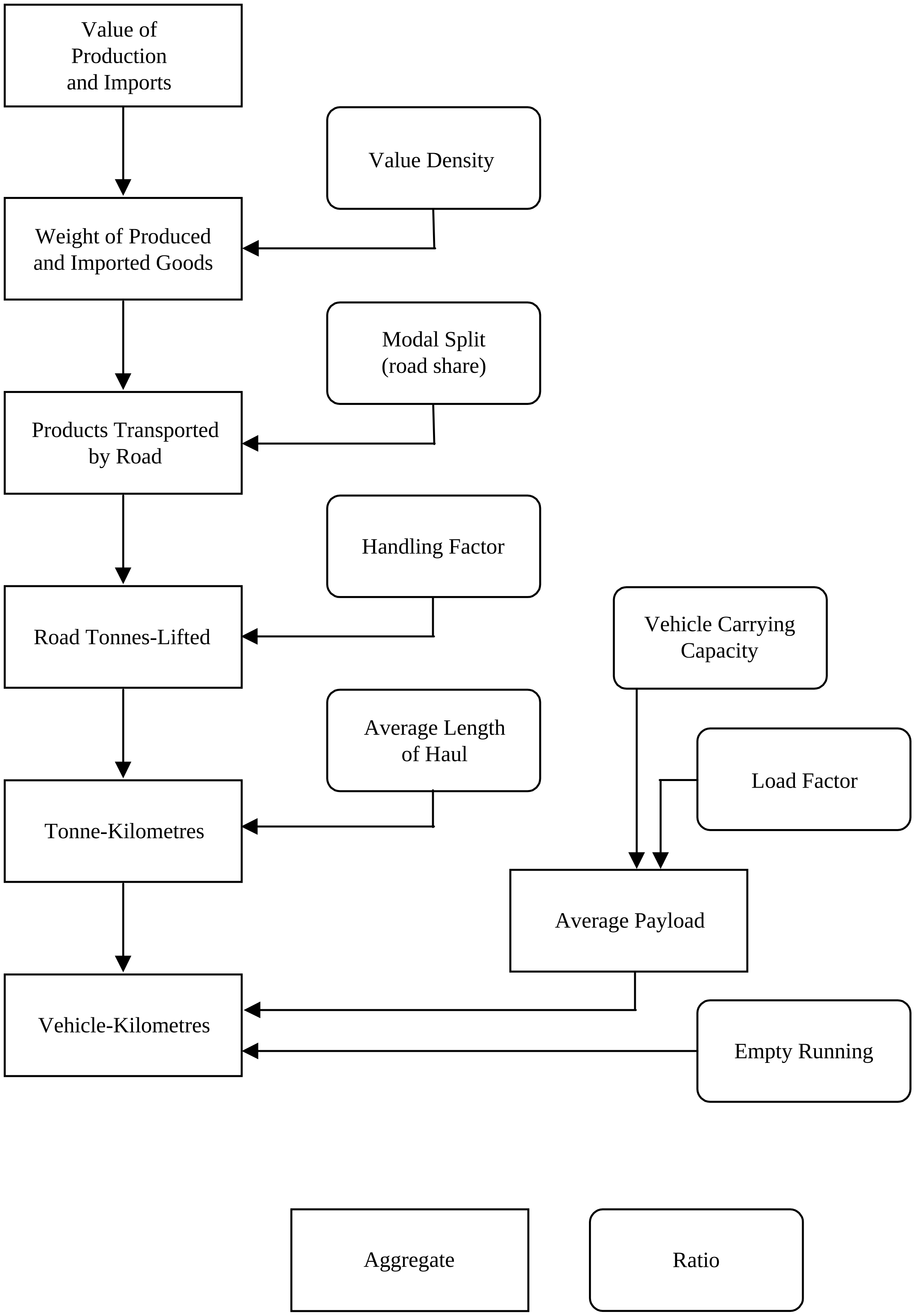
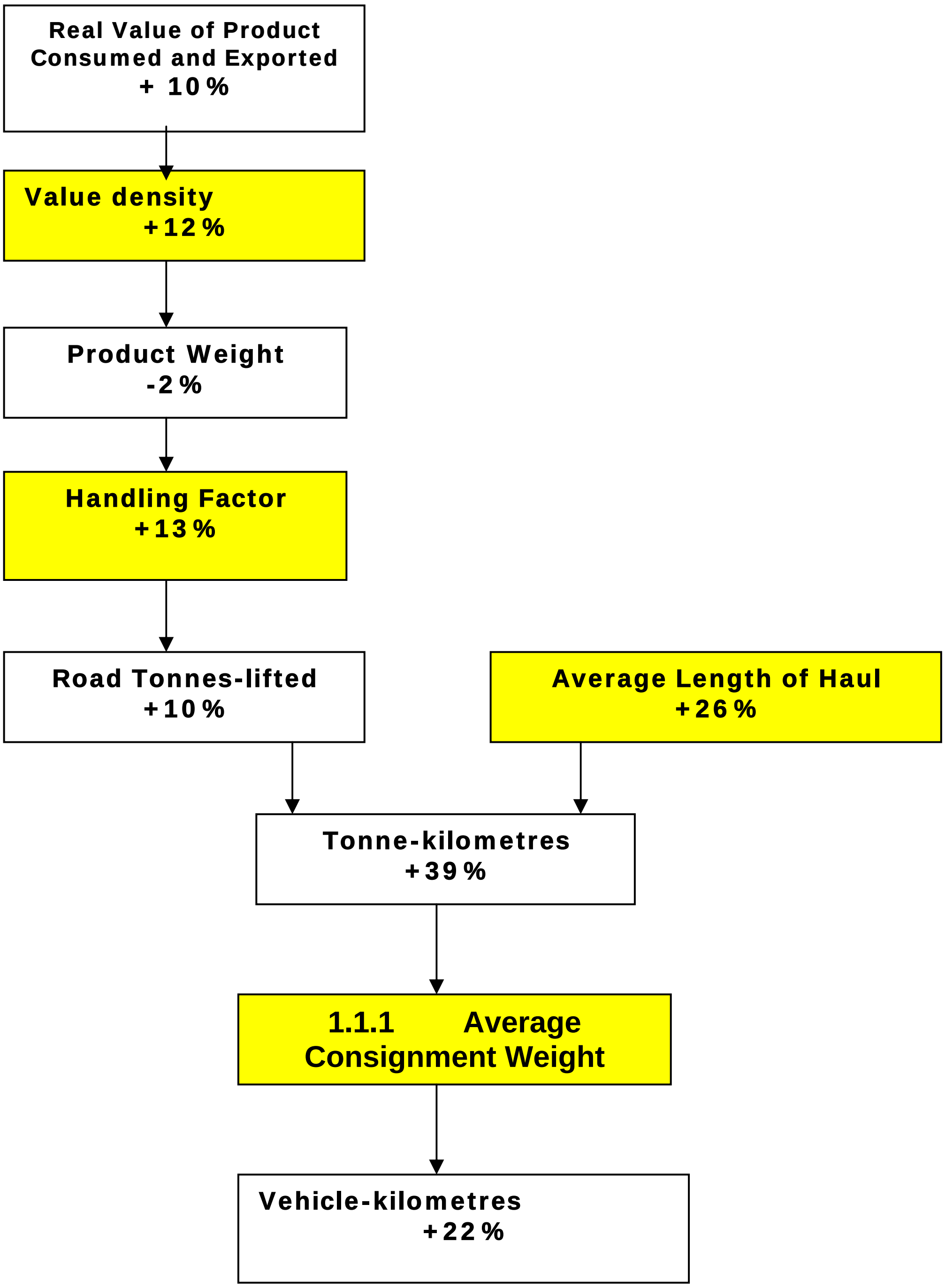


Figure 1 : Framework for Modelling the Relationship between Industrial Output and Road Freight Traffic: EU REDEFINE Project (NEI et al, 1999)

Figure 2: Logistical Changes in the UK Food and Drink Sector, 1983-1991
(Source: McKinnon and Woodburn, 1996)



Average payload weight: ***ratio of road tonne-kms to vehicle-kms.***

This ratio translates the volume of freight movement, measured in tonne-kms, into vehicular traffic by taking account of the average loading of the vehicles. A distinction can be made between the average load factor on laden trips (measured by the ratio of tonne-kms to laden-kms) and empty running (proportion of vehicle-kms run empty).

An attempt was made in the early 1990s to assess the relative contribution of these various parameters (excluding the modal split ratio) to the growth of food and drink traffic on the UK road network (McKinnon and Woodburn, 1996). This analysis, which related to the period 1983-1991, revealed that the average number of links in the food supply chain rose by around 13%, while their average length increased by 26%, resulting in a 39% increase in tonne-kms (Figure 2). Vehicle-kms grew by a significantly smaller margin because average payload weight also increased by around 14%.

STAGE 2:

The second stage of the analysis involved compiling a list of the logistical and supply chain trends likely to be affecting these key ratios. In the original study (McKinnon and Woodburn, 1996), these trends were divided into four categories corresponding to different levels in the management decision-making hierarchy:

1. ***Restructuring of logistical systems***: affected by strategic decisions on the number, locations and capacity of factories, warehouses and terminals:

    Dominant trends:

    1.1 Spatial concentration of production:
        a) reduction in production locations
        b) increased specialisation at production location ('focused production')

    1.2 Spatial concentration of inventory

    1.3 Development of local break-bulk operations

    1.4 Creation of hub-satellite networks

    1.5 Primary consolidation

2. ***Realignment of supply chains*****:** affected by commercial decisions on sourcing, sub-contracting and distribution channels. These decisions determine the pattern of freight flow between a company's premises and those of its trading partners.

    Dominant trends:

    2.1 Creation of more complex production networks

    2.2 Vertical disintegration of production

    2.2 Increase in single sourcing

    2.3 Wider sourcing of supplies

2.4 Increase in retailer's control over the supply chain

2.5 Concentration of international trade on hub ports.

3. ***Rescheduling of product flow*:** the scheduling of production and distribution operations translates inter-company transactions into discrete freight flows. Changes in the scheduling of these activities can have a major impact on freight traffic levels.

Dominant trends:

3.1 Adoption of just-in-time / quick response replenishment

3.2 Growth of 'nominated day' deliveries

4. ***Changes in the management of transport resources*:** within the framework defined by decisions made at the previous three levels, there have been significant changes in the choice of transport mode, routing of vehicles and utilisation of transport capacity.

Dominant trends:

4.1 Modal shift

4.2 Outsourcing of the transport / logistics function

4.3 Changes in vehicle size, weight and type

4.4 Changes in handling systems

4.5 Increased use of computerised vehicle routing and scheduling (CVRS)

4.6 Increase in return loading

The growth of freight traffic is the result of a complex interaction between decisions made at these different levels. Decisions at levels 1 and 2 determine the quantity of freight movement measured in tonne-kms while decisions at levels 3 and 4 translate this movement into vehicle traffic, measured in vehicle-kms. If 'food miles' are defined in terms of tonne-kms (i.e. the volume of freight movement) attention will focus on the trends listed under the first and second headings. If they are defined in relation to the amount of vehicle traffic on the ground (i.e. vehicle kms), consideration must also be given to the trends identified under the third and fourth headings.

STAGE 3:

The third stage in the analysis examines the relationship between each of the logistical trends and the five key ratios that link output / consumption to the vehicle traffic levels. As we are concerned primarily with the total volumes of food traffic, measured by tonne-kms and vehicle-kms, the value density and modal split ratios will be omitted, while the utilisation of vehicle capacity will distinguish partial loading of laden vehicles from empty running. Table 1 shows the relationship between the key ratios and the list of eighteen logistical trends. Up and down arrows, with differing degrees of bolding, have been used to indicate the direction and strength of the relationship. This is partly based on the results of three empirical studies (McKinnon and Woodburn, 1996; NEI et al, 1999 and Technical University of Berlin et al., 2002), supplemented by expert judgement.

Key Logistics Trends	Key Ratios			
	Handling factor	Avg. length of haul	Load factor	Empty running
1 Restructuring of logistics systems				
1.1 Spatial concentration of production; either through				
Reduction in no. of product locations or		↑	↑	
Increased specialisation ('focused production')		↑	↑	
1.2 Spatial concentration of inventory		↑		
1.3 Development of local break-bulk operations	↑	↓		
1.4 Creation of hub-satellite networks	↑	↓		
2 Realignment of supply chains				
2.1 Insertion of more production stages	↑			
2.2 Vertical disintegration of production	↑			
2.3 Increase in single sourcing			↑	
2.4 Wider sourcing of supplies		↑		
2.5 Increase in retailer's control over supply chain		↑	↑	
2.6 Concentration of international trade on hub ports		↑		
3 Rescheduling of product flows				
3.1 Adoption of JIT / quick response replenishment			↓	
3.2 Growth of 'nominated day' deliveries			↑	
4 Changes in management of transport resources				
4.1 Modal shift	↑			
4.2 Outsourcing of transport / logistics function			↑	
4.3 Changes in vehicle size, weight and type			↑	
4.4 Changes in handling systems / packaging			↓	
4.5 Use of computerised vehicle routing / scheduling			↓	↓
4.6 Increase in return loading				↓

↑= strong positive impact ↓= strong negative impact

↑= weak positive impact ↓= weak negative impact

Table 1: Effects of the Dominant Logistical Trends on Key Freight Transport Ratios in the Food Sector (adapted from REDEFINE analysis [NEI et al 1999])

Review of Logistical Trends

1 Logistical Restructuring

1.1 SPATIAL CONCENTRATION OF PRODUCTION

Food processing companies have been concentrating their production capacity in fewer locations to take advantage of economies of scale in manufacturing. Analysis of Census of Production data and more recently Prodcom data reveals that in many sectors of the food industry factory numbers have been declining while average output has been rising. Many firms have reduced the number of plants they operate. Others have adopted a 'focused production' strategy, retaining the same number of plants but concentrating the manufacture of particular items in particular locations. This process of plant specialisation has been pronounced within the Single European Market as companies have moved from nationally-based to pan-European production. Further back along the supply chain, a similar trend of agricultural specialisation has been occurring at different spatial scales.

By increasing the average distance between the point of production and the final consumer, centralisation generates additional tonne-kms. It can result in a less than proportional increase in vehicle-kms, however, where centralisation is accompanied by a consolidation of flows along fewer corridors, permitting an increase in vehicle load factors.

1.2 SPATIAL CONCENTRATION OF INVENTORY

The centralisation of production has also had the effect of concentrating inventory in fewer locations. It is not known what proportion of manufacturers' inventory is held at the production site rather than off-site warehouses, though it is likely to be at least half of it. 'Off-site' inventory, either of industrial inputs or finished product, has also become concentrated in fewer, larger warehouses. No official statistics are available on the centralisation of food stocks. A reasonable amount of survey data have accumulated, however, to suggest that over the past 40 years storage capacity in the food manufacturing sector has become much more concentrated (McKinnon, 1989; Browne and Allen, 1998).

Inventory centralisation has also been occurring in the wholesale and retail sectors. Most of the larger retailers operate a two-tier stockholding system, with inventory held at both shop and warehouse levels. Within the retail distribution channel inventory has been centralised in three respects:

- by transferring the stockholding function from shop to warehouse level
- by concentrating inventory in a smaller number of larger warehouses
- by concentrating inventory of particular categories of products (such as slow-moving lines or frozen products) within existing warehouse systems. This '*focused distribution strategy*' results in warehouses becoming more specialised by product type, speed of turnover etc.

By reducing the number of stockholding points in their production and distribution systems companies exploit the so-called 'square root law' of inventory, cutting the amount of safety stock required to maintain a given level of customer service (Maister, 1976). For example, according to this 'law,' moving from a decentralised system with fifteen regional distribution centres to a completely centralised system focused on a single national warehouse should, other things being equal, cut the amount of safety stock by roughly three-quarters. This remaining inventory can also be stored and handled much more efficiently as there are economies of scale in the construction and operation of warehouses.

As in the case of production, the centralisation of the stockholding function usually generates more freight movement per tonne of product distributed. The associated transport cost penalty is usually quite small relative to the savings in inventory and storage costs. Figure 3 shows how, in centralising their inventory, companies trade-off higher transport costs at local delivery level for lower inventory and warehousing costs. As discussed earlier in the context of production centralisation, centralisation (at both the manufacturing and warehousing levels) is usually associated with a consolidation of trunk movements. By moving products in greater bulk on 'primary distribution' links between larger factories and warehouses companies can generally cut transport costs per tonne-km. This also partly offsets the increase in transport costs at the local delivery level. As explained below, it is possible for firms to minimise the increment in delivery costs by establishing break-bulk networks.

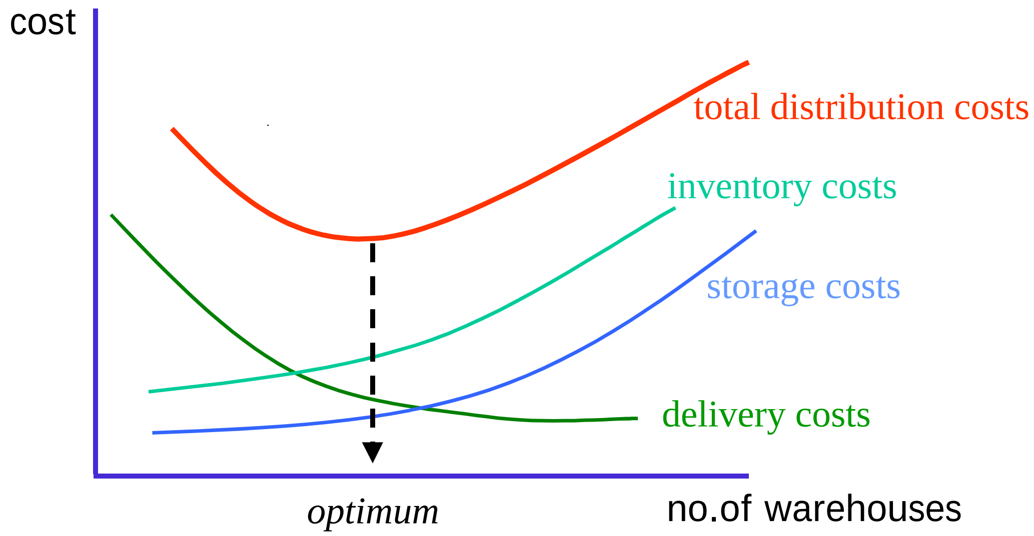


Figure 3: Logistical Cost Trade-offs in the Inventory Centralisation Decision

1.3 DEVELOPMENT OF LOCAL BREAK-BULK OPERATIONS

Longer distance freight movements are often split into a trunk- (or line-) haul and a local delivery operation. Loads are moved in large bulk over the trunk haul to take advantage of economies of scale in transport. These are then disaggregated at local 'break-bulk' points for final delivery in smaller orders to individual customers often on multiple drop-rounds made by smaller vehicles. In the traditional distribution system, stockholding / storage and break-bulk functions were combined at local distribution depots. Some food manufacturers have now geographically separated these functions, centralising inventory while retaining a network of non-stockholding, break-bulk facilities to maintain the efficiency of the transport operation. This has enabled them to continue consolidating loads on long distance trunk hauls and confining the movements of small delivery vehicles to local 'hinterlands'. While this reduces the delivery cost penalty associated with inventory centralisation, it adds an extra node and link to the distribution channel and typically makes the routing of the product more circuitous. This invariably increases tonne-kms, but can actually reduce total vehicle-kms.

1.4 CREATION OF HUB-SATELLITE NETWORKS.

With the move to just-in-time / quick response replenishment (discussed below) average order size has diminished. It is much more efficient to distribute small orders through hub-satellite networks than through conventional echelon systems, comprising several tiers of warehousing (Figure 4). Within the UK there has been extensive development of hub-satellite networks for parcels and pallet-loads, the latter being more relevant to the present study as much greater volumes of food are transported in pallet-loads than in parcels. Pallets of food products (in less than truck [LTL] loads) are collected from several suppliers and aggregated at local 'satellite' depots. They are then trunked to a central hub, in most cases located in the Midlands, where they are sorted for onward trunking to the local depot closest to their destination. The operator of this local depot arranges final delivery. The main advantages of this system lie in the speed and efficiency of centralised sortation at the hub and the high vehicle load factors achieved on the radial, trunk movements to and from the hub.

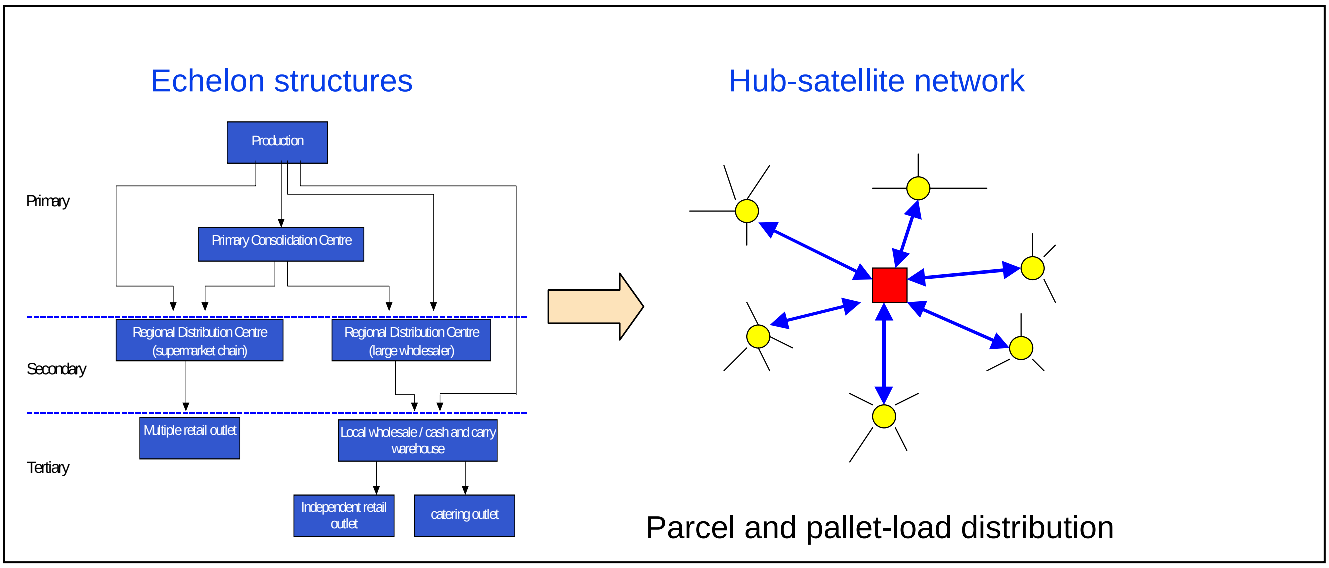


Figure 4: Shift from Echelon to Hub-Satellite Networks

Channelling products through hub-satellite networks, however, results in the addition of an node and link to the supply chain and more circuitous routing. This increases tonne-kms per tonne of product delivered. This increase in tonne-kms is not necessarily reflected in an increase in vehicle-kms, however, because the vehicles trunking the pallets to and from the hub achieve higher load factors than would be possible within the alternative echelon networks. No attempt has been made to compare the transport intensity of food distribution through hub-satellite and echelon networks with respect to tonne-kms and vehicle-kms. It is safe to say, however, that tonne-kms will be higher in hub-satellite networks. The effect on vehicle-kms is less clear.

1.5 PRIMARY CONSOLIDATION

Where the volumes of product flow is large enough, it is possible to dispense with the local 'satellite' depots and trunk products directly between factory and hub and from the hub to the regional distribution centre of a retailer or wholesaler. Even large food manufacturers do not distribute enough output from particular plants to particular retail chains to support efficient daily delivery in accordance with the retailer's quick response requirements. One large food and drink manufacturer has estimated that it would need to supply 750,000 cases per annum to a regional distribution centre (RDC) to provide cost-effective daily delivery. As the large supermarket and wholesale chains in the UK operate around 70 RDCs, the company would have to sell around 50 million cases per annum. Very few food manufacturers achieve this scale of production, certainly at a single plant.

By channelling their output through 'primary consolidation centres' (PCCs), manufacturers can combine their daily orders to individual RDCs with those of other suppliers to ensure high vehicle load factors both between factory and PCC and between PCC and RDCs (McKinnon and Campbell, 1998). As with hub-satellite systems, however, this adds an extra link and node to the supply chain and generally results in more circuitous routing. Tonne-kms per tonne delivered therefore rise, though any increase in vehicle-kms is likely to be much more modest, and in some cases vehicle-kms may be reduced.

A large proportion of frozen food now goes through primary consolidation networks. An increasing proportion of chilled and ambient food supplies is also distributed through similar networks.

2 Realignment of Supply Chains

This has affected both the number and length of links in the supply chain.

2.1 INSERTION OF MORE STAGES IN THE PRODUCTION PROCESS

As processed foods have increased their share of the diet and as fresh produce undergone more preparation prior to sale (washing, grading, freezing, packaging etc.) additional nodes and links have been added to the supply chain.

2.2 VERTICAL DISINTEGRATION OF PRODUCTION.

Over the past 20 years firms have been concentrating their resources on core activities and contracting out ancillary functions which can often be performed more cheaply and effectively by other companies. This vertical disintegration of manufacturing operations has effectively added extra links to the supply chain. Activities that were previously undertaken in close proximity on the same production site now take place in different locations creating a demand for additional freight movement. This has added extra links to the supply chain and increased the transport-intensity of production operations.

This trend has been particularly pronounced in sectors such as electronics, automotive manufacturing and mechanical engineering. It has been much less common in process industries such as food and drink. It is not thought, therefore, to have been a major cause of the growth in 'food miles', though this requires further investigation.

2.3 INCREASE IN SINGLE SOURCING

Many food producers have been cutting the number of suppliers. In the past, companies often preferred to buy the same materials from several suppliers to spread the risk of disruption and promote competition among vendors. The trend over the past 20 years has been for firms to reduce the number of suppliers and in many cases move to 'single-sourcing'. The rationalisation of the supply base is closely associated with the adoption of just-in-time (JIT) and total quality management, techniques which require close supply chain integration.

Single sourcing can benefit the transport operation by consolidating inbound flows of supplies, allowing firms to achieve higher load factors and lower delivery costs per unit. This is particularly important where firms are operating within a JIT regime. Had JIT not been accompanied by a reduction in supplier numbers, its impact on the transport system would undoubtedly have been much greater. The traffic effects of JIT are discussed more fully below.

2.4 WIDER SOURCING OF SUPPLIES

This is generally regarded as the main cause of the increase in 'food miles'. Manufacturers, wholesalers and retailers are sourcing more of their supplies from further afield for many reasons:

- They can be purchased at lower prices than from local producers
- Product quality is often higher
- Diversification of the product range beyond what can be produced locally: this is partly supplier-led and partly consumer-led (e.g as consumers are exposed to a broader range of food products by foreign travel, cookery programmes and eating out in ethnic restaurants)
- Greater product availability, particularly for seasonal items which consumers now expect to able to purchase all year round.
- Greater regional specialisation in agriculture at both national and international scales
- Relative cost of long distance transport has declined in real terms
- Opportunity for wider sourcing from smaller suppliers created by the development of retailers' distribution centres (see section 2.5 below)
- Liberalisation of international trade, particularly within trading blocs, has facilitated the importation of food.
- Advances in IT have increased the 'visibility' of long supply chains and made them easier to manage.
- Development of B2B e-commerce, including e-marketplaces for food products such as Transora, has enabled companies to extend geographically their search for suitable suppliers.
- Large food manufacturers and retailers have adopted global procurement strategies

It is worth noting that the trend to wider sourcing is not confined to the food sector. Other sectors have been experiencing a similar trend, to differing degrees. Quinquennial surveys of 500-1000 businesses by the consultancy firm A.T. Kearney for the European Logistics Association have shown how, on average, a declining proportion of purchases and sales are being made within the domestic market and a higher proportion at European and global levels. Available evidence suggests that this trend has been more pronounced in the food sector.

2.5 INCREASE IN RETAILER'S CONTROL OVER THE SUPPLY CHAIN

Over the past 30 years there has been a huge increase in multiple retailers' control over the food supply chain. While expanding their share of the retail market, they have been assuming greater responsibility for food distribution from the factory and farm. They initially seized control of 'secondary distribution', channelling supplies through distribution centres and consolidating deliveries to shops. This centralisation of the distribution function was closely associated with the centralisation of purchasing. Shop managers ceased to have any responsibility for buying, sales representatives no longer visited shops and purchasing negotiations were thereafter confined to the retailer's head office. Any links that had previously existed between shop managers and local suppliers were severed and managers were unable to exert much influence of the product range available in their stores.

This transfer of responsibility for shop delivery from supplier to retailer diverted flows of food products from manufacturers' distribution depots (and wholesale warehouses) to retailers' RDCs. The substitution of retailer-controlled RDCs for manufacturers' depots and wholesalers' warehouses maintained the number of links of the logistical channel. As the RDCs were much more centralised and served wider hinterlands, however, the move to retailer-controlled distribution considerably lengthened the last link in the chain from warehouse to shop. This increased separation of warehouse and shop is likely to have increased food tonne-kms though the consolidation of retailer-controlled deliveries in much larger vehicles may well have reduced total vehicle-kms (McKinnon and Woodburn, 1993).

Any reduction in lorry traffic at the secondary distribution level must be set against increases in traffic volumes at the primary distribution level, upstream of the RDC. One of the main ways in which these traffic volumes have expanded is through the centralised sourcing of food supplies from smaller producers. Prior to the development of retailers' distribution systems, small suppliers lacked the means of distributing their products to all the shops in a retail chain. This either prevented them from securing a contract with the retailer or confined their sales to branch stores in a particular region. By channelling their products through retailers' RDCs smaller producers can gain access to national chains of shops, substantially expanding their market areas. For products sourced from small regional producers, the development of retailers' distribution systems has, therefore, greatly increased 'food miles' measured by both tonne-kms and vehicle-kms. The market dominance and centralised distribution systems of UK supermarket chains also make it easier for foreign food producers to penetrate the UK market. Bulk deliveries to a relatively small number of RDCs can give them wide exposure across major supermarket chains. In other countries with much more fragmented retail and wholesale sectors, importers face much greater logistical constraints.

Ironically, the large, highly centralised retail logistics system which enabled small producers to hugely extend their market areas made it virtually impossible for them to deliver directly to local chain stores. Over the past thirty years, supermarket chains have greatly increased the proportion of supplies channelled through their RDCs (Figure 5), leaving only a few lines of 'morning goods' (e.g. milk, bread and eggs) to be delivered directly to the shop by suppliers. Back store reception facilities and storerooms have been redesigned to handle the arrival of supplies in large consolidated loads palletised on articulated vehicles. Companies replenishment systems are based on centralised ordering and receipt of goods at the RDCs where they are checked and sorted for onward distribution. These systems make it impossible for all but a few product lines to penetrate the retailer's supply chain anywhere but the RDC. To the layman, this creates logistical anomalies. A sandwich company in Derbyshire, for example, supplies its products to a major supermarket chain and has a plant within a few hundred metres of one of its shops. The sandwiches arriving on this shop's shelves, however, have to be routed through one of the retailer's RDCs on a round-trip of approximately 160 kms. At an aggregate level, however, the centralised systems are more efficient and achieve higher levels of vehicle utilisation.

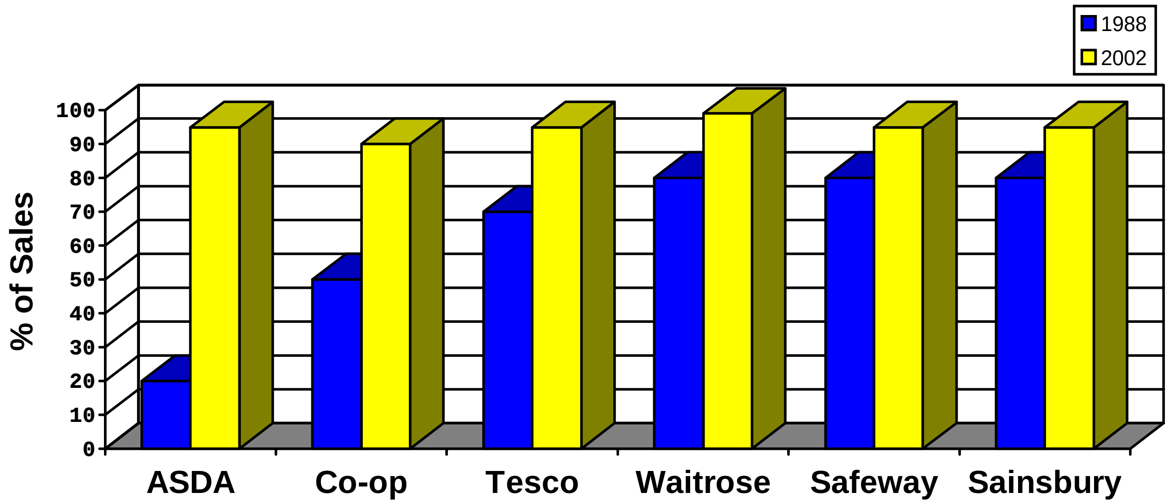


Figure 5: Percentage of Grocery Sales Channelled through Regional Distribution Centres
Source: Institute of Grocery Distribution (Patel, 2003)

2.6 CONCENTRATION OF INTERNATIONAL TRADE ON HUB PORTS AND AIRPORTS.

There has been a concentration of port capacity and trade flows partly as a result of the 'hubbing' strategies of deep-sea container shipping lines and air freight operators. Direct deep-sea container services have been withdrawn from regional ports, forcing exporters and importers to transport consignments longer distances overland to hub ports. There has also been a concentration of European road and rail traffic on a smaller number of ro-ro ferry ports and the Channel Tunnel. Much of Britain's trade in food and drink has been affected by these trends, generating additional food miles on international movements.

3 Production and Distribution Scheduling Decisions

The way in which transactions between trading partners materialise as discrete freight journeys depends on the scheduling of production and distribution operations. Over the past decade the scheduling of these operations has been transformed by the introduction of new management systems designed to minimise inventory levels

3.1 ADOPTION OF JUST-IN-TIME / QUICK RESPONSE REPLENISHMENT

Firms operating on a just-in-time (JIT) basis minimise inventory by sourcing supplies in small quantities at frequent intervals. 'Quick response' (QR) can be regarded as the application of the JIT principle to retail distribution (Fernie, 1994; Hadjiconstantinou, 1999). As the ratio of total sales to inventory (ie. the 'stock turn rate') is critical to retail profitability, retailers have a strong incentive to minimise stock levels.

Clear evidence of a JIT / QR trend in the food sector emerged from a survey of 42 producers of frozen food in 1998 (McKinnon and Campbell, 1998). This showed delivery frequency increasing, while order lead time and average order size was diminishing (Figure 6). It is alleged that, by reducing average consignment weight and increasing delivery frequency, JIT / QR generates additional road traffic, increasing the ratio of vehicle-kms to tonne-kms and to total tonnes delivered (e.g. Whitelegg, 1995). If JIT / QR were having a pronounced effect on road freight operations, one would expect to see average payload weights declining. An analysis of the trend in average payload weights over the period 1982-1997 found that the three main food and drink categories, agricultural products, other foodstuffs and beverages, experienced a significant increase in average payloads over this period, among the highest of all commodity classes (Table 2) (McKinnon and Marchant, 1999).

There is no disputing that JIT / QR pressures in the food supply chain have been fairly intense at both primary and secondary levels (Marchant et al, 2000; Patel, 2002). The fact that average payloads have risen suggests that the potentially adverse effects of JIT / QR on vehicle utilisation have been avoided as a result of structural changes in the grocery logistics system, in particular primary consolidation and the centralisation of distribution operations in RDCs. It is likely, however, that in the absence of JIT / QR pressures, the degree of load consolidation would have been even greater, permitting a larger reduction in vehicle-kms.

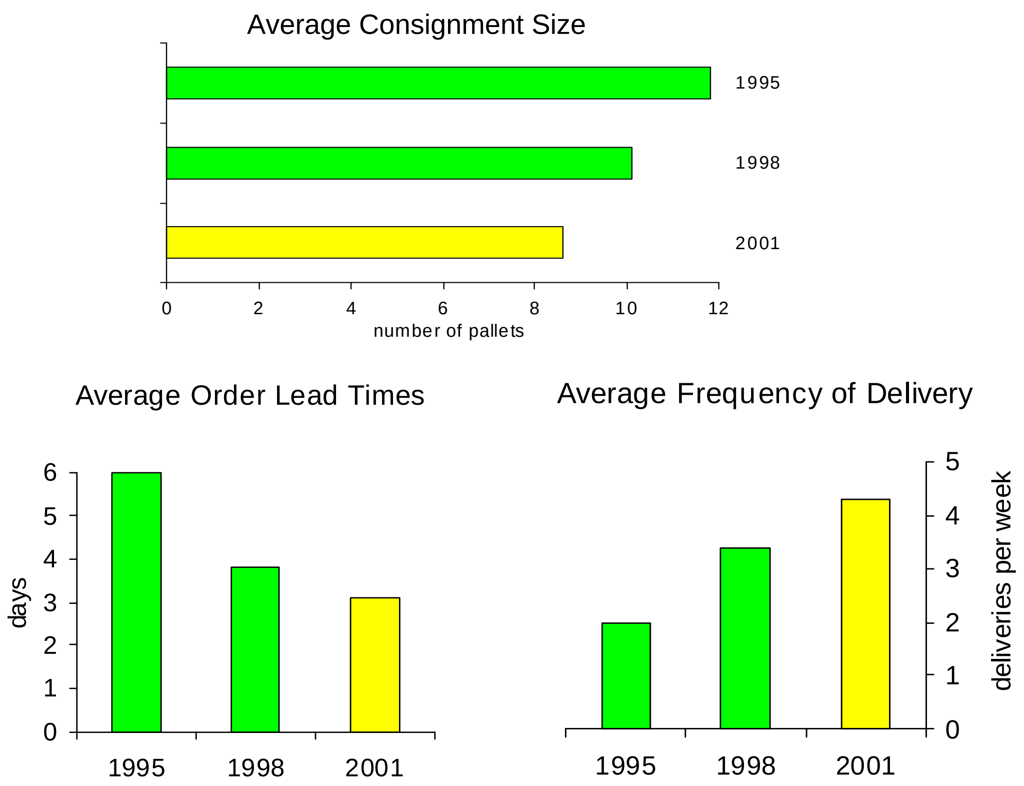


Figure 6: Effects of Quick Response Pressures in the Frozen Food Supply Chain

Table 2: % Change in Average Payload Weight, 1982-1997 (All vehicles over 3.5 tonnes)

	% change
Textiles,man-made fibres	112
Agricultural products	34
Beverages	33
Other foodstuffs	31
Fertliser	29
Textiles & leather	27
Cements	27
Transport equipment	22
Wood, timber and cork	21
Chemicals	18
Other manufactured articles	16
Petrol & petroleum products	14
sand, gravel & clay	12
Other raw animal	11
Other building material	8
Other metal products nes	7
Coal & coke	5
Machinery	4
Iron & steel products	0
Other crude minerals	-1
Miscellaneous articles	-1
Ores	-2
Paper pulp & waste paper	-4

3.2 GROWTH OF NOMINATED DAY DELIVERIES.

There has been a widespread adoption of the 'nominated day' principle over the past 20 years. Firms operating a nominated day delivery system achieve much higher levels of transport efficiency by forcing customers to adhere to an ordering and delivery timetable. Customers are informed that a vehicle will be visiting their area on a 'nominated' day and that to receive a delivery on that day, they must submit their order a certain period in advance. The advertised order lead time is thus conditional on the customer complying with the order schedule. By concentrating deliveries in particular areas on particular days, suppliers can achieve higher levels of load consolidation, drop density and vehicle utilisation. This has little effect on tonne-kms but by increasing the ratio of tonne-kms to vehicle-kms it cuts traffic levels.

A significant proportion of food deliveries were subject to nominated day constraints during the 1970s and early 1980s when suppliers controlled much of the secondary distribution to shops. With the decline in small-scale grocery retailing and supplier-controlled delivery, this practice has declined in importance in the food sector, though continues to be widely used by food wholesalers and in the food service sector where catering outlets and hotels typically get deliveries on particular days of the week. It is worth noting that in many companies this practice has been resisted by sales and marketing managers who fear that by imposing constraints on customers' freedom to order when they like their company will suffer a loss of competitiveness.

4 Changes in the Management of Transport Resources

Decisions made at the previous three levels dictate a company's overall demand for freight transport. Operational decisions made by transport and distribution managers determine how much vehicle movement is required to meet this demand.

4.1 MODAL SHIFT

Choice of transport mode can influence both total tonne-kms and vehicle-kms. Where a rail line-haul connects rail-connected premises at which food would have been processed or stored anyway, the net effect on tonne-kms and vehicle-kms will depend on the relative directness of hauls across the road and rail networks. In the case of intermodal services, flows must be routed via railhead depots adding extra road feeder movements and increasing tonne-km and vehicle-km figures. As very little food and beverage traffic moves by rail in the UK, this is likely to have had very little effects on total 'food miles'. Even if a modal shift to rail (or water) were to significantly increase road tonne-kms, this might still be beneficial in environmental terms, given the much lower level of emissions per tonne-km for rail transport.

4.2 OUTSOURCING OF THE TRANSPORT / LOGISTICS FUNCTION

Since the early 1980s, there has been a substantial increase in the proportion of food movement handled by outside contractors (McKinnon, 2003) (Table 3). Where these contractors have been able to provide a 'groupage' or shared user service to several clients, levels of vehicle utilisation have generally been improved, reducing the ratio of vehicle-kms to tonne-kms. Much of the transport of food and drink product, however, has been outsourced on a dedicated basis to particular clients, limiting the opportunities for load consolidation. For example, in recent years most large UK food retailers have contracted out between 50 and 100% of their transport requirements to logistics service. The vast majority of this work is done on a dedicated basis in client-liveried vehicles. In recent years, however, retailers have been relaxing restrictions on the use of these dedicated vehicles become more willing to share vehicle capacity. This has increased the opportunity for rationalising the movement of food.

Table 3: Percentage of Transport Outsourced by Major Food Retailers

	2000	**2001**	**2002**
Budgens		100	
Co-op		19	11
Iceland	75	75	75
Nisa	100	100	100
Safeway	60	60	
Sainsbury	68	68	
Somerfield		86	89
Tesco	32		
Waitrose	48	47	47

No data available for vacant cells

Source: Institute of Grocery Distribution, 2002

4.3 CHANGES IN VEHICLE SIZE, WEIGHT AND TYPE.

Vehicle carrying capacity has been increasing as a result of increases in maximum legal weight (from 38 tonnes to 40/41 tonnes in 1999 and to 44 tonnes in 2001) and changes in vehicle design. The lorry weight increase was of limited value to the food sector as most food products have a relatively low density and tend to 'cube out' before they 'weigh out' (Marchant et al, 2001) As shown in Figure 7, a relatively high proportion of loads in the food sector are 'volume-constrained'. Nevertheless, for those food suppliers distributing dense products, such as canned vegetables or cartons of juice, the increase in the weight limit will have permitted greater load consolidation and a reduction in the ratio of vehicle- to tonne-kms. Companies distributing less dense products have derived greater benefit from the use of double-deck trailers and draw-bar trailer combinations which substantially increase the available deck-area (McKinnon and Campbell, 1998). The extensive use of multi-compartment vehicles by supermarket chains, combining products moved at different temperature regimes, has also permitted a substantial increase in load factors. Had none of these changes occurred, the number of vehicle-kms of food-related road traffic would have been significantly higher.

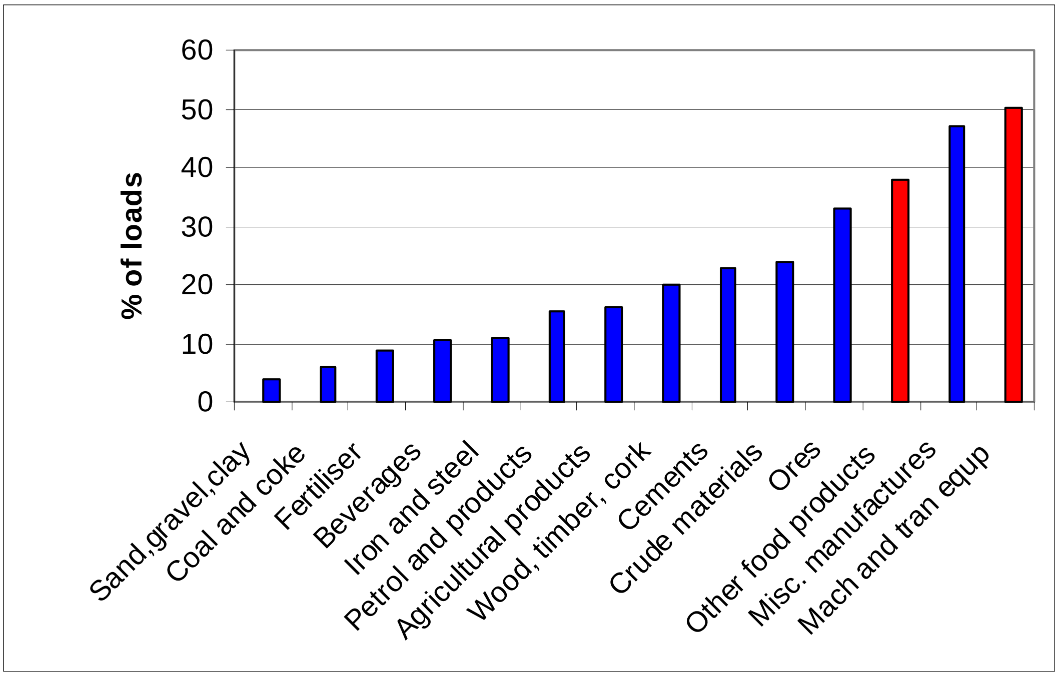


Figure 7: Proportion of Truck Loads Subject to Volume-constraint by Commodity

4.4 CHANGES IN HANDLING SYSTEMS

Equipment designed to improve ease of handling can impair vehicle utilisation. The standard wooden pallet, for instance, takes up around 10-12% of the cubic capacity of a vehicle, while the roll (or cage) pallets now extensively used in retail distribution require around 40% more (A.T.Kearney, 1997). Through their choice of unitised loading systems, firms have been trading greater efficiency in handling against lower vehicle utilisation and hence higher transport costs (University of St. Gallen, 2000). The volume of primary and secondary packaging has also been increasing, further augmenting vehicle space requirements. By using returnable trays, containers and stillages, firms have been able to reduce the quantity of packaging material, though not necessarily improve vehicle load factors.

The way in which handling equipment is used also has implications for vehicle utilisation. A key factor here is the height to which pallet loads are built. The design of warehouse racking systems often restricts pallet heights to a lower level than can be handled by road vehicles and thus causes a loss of vehicle operating efficiency.

The growth in the use of packaging and less space-efficiency handling equipment, which has been pronounced in the food and drink sector, has been generating extra vehicle-kms per tonne of product consumed (McKinnon and Forster, 2001).

4.5 INCREASED USE OF COMPUTERISED VEHICLE ROUTING AND SCHEDULING (CVRS).

The use of computerised vehicle routing packages can cut transport costs and distance travelled by between 5 and 10%, depending on the quality of the previous manual load planning (Freight Transport Association, 2001). As these packages are now widely used by manufacturers, wholesalers and retailers in the food sector, they may have significantly reduced total vehicle-kms. As no general surveys have been done to establish the level of CVRS adoption in the sector or the average level of vehicle-km reduction, the net effect on traffic levels is unknown.

4.6 INCREASE IN RETURN LOADING

Since the early 1980s there has been a fairly steady decline in the proportion of road vehicle-kms run empty. In recent years the DfT has published empty running statistics disaggregated by the main type of commodity carried on the previous laded trip. This indicates that the level of empty running in the agricultural sector is significantly above the average for all road freight operations, while in the case of 'other foodstuffs' and beverages it is lower (Figure 8). Unlike the trend in total empty running which has been following a steady downward trend, the levels for food products have tended to fluctuate. Since 1995, however, there has been a fairly steep decline in the empty running figure for 'other foodstuffs' from 27% to 23%. This may partly reflect the success of backloading initiatives in the food sector, particularly the 'supplier collection' collection and 'onward delivery' schemes operated by supermarket chains such as Tesco (DETR, 1999). It is also likely to a consequence of the lengthening of lorry journeys, the increasing number of drops per trip, the expansion of load-matching services and a growth in the reverse flow of packaging material / handling equipment (McKinnon, 1996).

Improved backloading and the resulting decline in empty running is reducing the ratio of vehicle-kms to tonne-kms, thereby offsetting the traffic growth pressures induced by many of the other logistical trends outlined above.

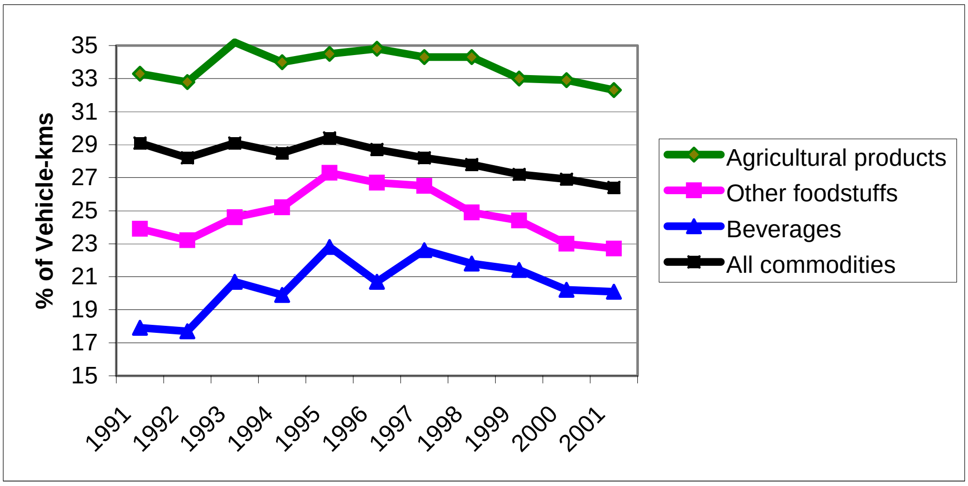


Figure 8: Variations in the Empty Running of Road Vehicles by Commodity Carried on Previous Loaded Trip

5 Conclusions

The growth in food miles is not simply the result of retailers buying their supplies from further afield. It is caused by the complex interaction of numerous logistical and supply chain trends, some of which are mutually-reinforcing and others counteracting. The main drivers of the increase in food tonne-kms appear to be wider sourcing, the spatial concentration of production and inventory and the addition of extra nodes and links to the supply chains of processed foods. The impact of the growth in tonne-kms on traffic levels has been mitigated by a net increase in the degree of load consolidation. Vehicle load factors in the food supply chain have improved despite the intensification of JIT / QR pressures. This can be partly attributed to the restructuring of retail distribution channels, with a sharp increase in the proportion of grocery supplies being channelled through primary consolidation centres and the regional distribution centres of major supermarket chains.

In analysing the reasons for food production and distribution becoming more transport-intensive, it is important to distinguish tonne-km from vehicle-km trends and to focus attention on three key parameters: handling factor, average length of haul and average payload weight.

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Annex 3
Evaluating the impacts of Food Miles

CONTENTS

1 Introduction

This Annex describes the data sources and assumptions used in deriving the estimates of environmental impacts arising from food miles. We have assessed, quantified and valued in monetary terms the following impacts:

- CO_2 emissions
- SO_2, NO_x, PM_{10}, VOC emissions
- Noise
- Congestion, accidents and infrastructure.

We have also considered in more qualitative terms the economic and social impacts of food miles. The methodology and results are described in Section 4 of the main report. This Annex presents additional technical details as follows:

1. Estimation of emission factors for CO_2 emissions and air pollutants for road, sea, air and rail transport;
2. Determination of the external costs of greenhouse gases and air pollution;
3. Details of the estimation of the external costs of congestion, accidents and infrastructure.

2 Emission factors

We have assessed CO_2 emissions from fuel used during transport of food by all modes. However, we have not assessed emissions from energy used for refrigeration during transport, nor emissions of non-CO_2 greenhouse gases from refrigeration systems (i.e. HFCs). This is a recommendation for further study.

2.1 ROAD FREIGHT EMISSION FACTORS

Emission factors for road transport were based on the UK National Atmospheric Emissions Inventory (see Table A3-1 for 2002 figures – similar sets of figures were used for 1992 and 1997). It was assumed that 14% of cars are diesel and 84% of LGVs are diesel.

Table A3-1. Emission factors for road transport in the UK, 2002

g/km		CO2	PM10	NOx	VOCs	SO2	Fuel
Petrol cars	Urban	169.94	0.00	0.44	0.35	0.00	58
	Rural	166.12	0.01	0.67	0.21	0.00	49
	Highway	186.69	0.01	0.87	0.21	0.00	67
Diesel cars	Urban	160.52	0.08	0.55	0.05	0.00	45
	Rural	158.99	0.07	0.59	0.02	0.00	32
	Highway	188.62	0.09	0.78	0.01	0.00	39
All cars	Urban	168.61	0.02	0.46	0.31	0.00	56
	Rural	165.11	0.01	0.66	0.19	0.00	46
	Highway	186.96	0.02	0.86	0.18	0.00	63
Petrol LGVs	Urban	233.26	0.01	0.72	0.67	0.01	79
	Rural	230.62	0.02	0.93	0.31	0.01	62
	Highway	288.30	0.03	1.13	0.45	0.01	90
Diesel LGVs	Urban	209.11	0.14	0.99	0.18	0.01	89
	Rural	218.56	0.18	1.00	0.10	0.01	80
	Highway	293.69	0.29	1.30	0.08	0.01	112
All LGVs	Urban	212.97	0.12	0.95	0.25	0.01	87
	Rural	220.49	0.16	0.99	0.14	0.01	77
	Highway	292.82	0.25	1.27	0.14	0.01	108
Rigid HGVs	Urban	583.82	0.22	6.32	1.16	0.01	177
	Rural	563.67	0.18	6.05	0.80	0.01	163
	Highway	609.98	0.18	6.28	0.67	0.02	190
Artic HGVs	Urban	1401.80	0.41	13.37	0.93	0.04	382
	Rural	1361.33	0.33	12.68	0.66	0.03	314
	Highway	1438.45	0.33	12.99	0.54	0.04	334

Source: NAEI 2003

2.2 SEA FREIGHT EMISSION FACTORS

For sea transport of freight, emission factors were based on the DEFRA Guidelines for Company Reporting on Greenhouse Gas Emissions (DEFRA 2001), supplemented by other sources. The DEFRA guidelines are aimed at companies wishing to assess their CO_2 emissions. They give an estimate of CO_2 emissions per tonne of freight carried for several different ship types: small and large ro-ro, liquid bulk and dry bulk. Liquid bulk transport represents only a small portion of food transport (mainly for oils and fruit juices). However, container ships, which were not included in the DEFRA guidelines, also carry a high proportion of food freight. We derived our own estimates of emission factors for container ships based on the average of a ro-ro and a bulk transport ship. We then made assumptions for the percentage of food freight carried by each type of ship, for both short sea and deep sea transport, and used these to derive weighted emission factors for short sea and deep sea freight (Table A3-2).

Table A3-2. Sea Freight Emission Factor Derivation

	kg CO_2/tkm	short sea mix	weighted emission factor (kg CO_2/tkm)	deep sea mix	weighted emission factor (kg CO_2/tkm)
small ro-ro	0.060	27%	0.0162		0
large ro-ro	0.020	27%	0.0054		0
all ro-ro		54%		0	
small bulk	0.014	19%	0.0026	10%	0.0013
large bulk	0.007	9%	0.0007	29%	0.0020
all bulk		28%		38%	
small container	0.037	9%	0.0033	15%	0.0057
large container	0.014	9%	0.0012	46%	0.0063
all container		18%	**0.0294**	62%	**0.0153**

Source: DEFRA (2001) (ro-ro and bulk); AEAT estimates (container ships)

The mix of ship types was derived by an analysis of how much of the imported and exported foodstuff is dry bulk (i.e. cereals, oil seeds, animal feed and waste) both in Europe and the rest of the world (based on HM Customs and Excise statistics). It was assumed that all dry bulk was carried by dry bulk ships. For short sea transport we assumed that one third travelled in large dry bulk ships and two thirds in small ships. For deep sea transport we assumed 75% in large and 25% in small ships.

Of the remainder, it was assumed that for short sea transport, 75% travelled by ro-ro and 25% by container, with half in large ships and half in small ships. For deep sea transport it was assumed that all the non-dry bulk travelled by container, with 75% in large and 25% in small ships.

The ratio of NOx, PM_{10} and VOCs to CO_2 emissions were derived from the MEET report (Kalivoda and Kudrna, 1997). Sulphur dioxide emissions were estimated by assuming that the average sulphur content of marine diesel fuel is 2.7% (ENDS, 2003). Emission factors for sea, air and rail freight are summarised in Table A3-1.

Table A3-1. Emission factors for non-road modes (g/tkm)

	rail	deep sea	short sea	air long haul	air short haul
CO_2	30.000	15.335	29.381	570	1580
PM_{10}	7.752	0.006	0.011	0.17	0.57
NO_x	0.305	0.244	0.468	2.98	2.61
VOCs	0.029	0.012	0.022	0.80	2.36
SO_2	0.038	0.259	0.496	0.20	0.18

2.3 AIR FREIGHT EMISSION FACTORS

For air transport of freight, the emission factor was taken from the DEFRA Guidelines for Company Reporting on Greenhouse Gas Emissions (DEFRA 2001), which gives a value of 0.57 kg CO_2 per tonne km for long haul flights, and 1.58 kg CO_2 per tonne km for long haul flights. This was then multiplied by 2.7, which is the IPCC recommended radiative forcing factor to account for the warming effect of non-CO_2 emissions from aircraft, such as NOx and water vapour (IPCC 1999). Emission factors for other pollutants were derived from the NAEI database (Table A3-2).

Table A3-2. Air Freight Emission Factor Derivation

	kt/mt fuel
CO_2	859
PM10	0.20
NOx	18.11
VOCs	2.81
SO2	0.80

Source: NAEI (2003)

2.4 RAIL FREIGHT EMISSION FACTORS

For rail transport of freight, the emission factor was taken from the DEFRA Guidelines for Company Reporting on Greenhouse Gas Emissions (DEFRA 2001), which gives a value of 0.03 kg CO_2 per tonne km.

3 External environmental costs

3.1 EXTERNAL COSTS OF CLIMATE CHANGE

The external cost of carbon emissions is assumed to be £70/tC, based on the central figure recommended by DEFRA (2001), which are based on a central value taken from ExternE (CEC, 1999). This value is based on the IPCC IS92a scenario, assuming equity weighting, a time horizon of damages to 2100, and a 3% discount rate. The value has been inflated to current prices.

It is stressed that the uncertainty associated with climate change is very large and these values should only be considered as illustrative of possible costs.

Table A3-3. Recommended external costs of climate change from DEFRA, 2000.

Costs (£) per tonne of Carbon, C (£2000 prices)		
Low	**Central**	High
35	**70**	140
Costs (£) per tonne of Carbon Dioxide, CO_2 (£2000 prices)		
Low	**Central**	High
9.5	**19.1**	38.2

3.2 EXTERNAL COSTS OF AIR POLLUTION

Transport activities produces a number of pollutants that have potential health effects. These health effects include a range of endpoints, such as premature mortality (deaths brought forward), respiratory and cardio-vascular hospital admissions, and possibly exacerbation of asthma, other respiratory symptoms and loss of lung function. The evidence for these effects is strongest for the pollutants PM_{10} and ozone (though plausibly also SO_2 and at high concentrations, NO_2) and the relationships are widely accepted as causal. Recent studies also suggest that long-term exposure to these pollutants, especially particles (PM_{10}), may also damage health and may reduce life expectancy (so called chronic mortality) and that these effects are substantially greater than the effects above.

We have assessed emissions of the main air pollutants affecting human health: NOx, PM_{10}, SO_2 and VOCs. The main health endpoints quantified in the UK are deaths brought forward, respiratory hospital admissions, and chronic mortality (see the COMEAP 1998[1] quantification report and the 2001 update on chronic mortality[2]). All of these health endpoints are associated with the pollutant PM_{10}. SO_2 is associated with the first two of these endpoints (deaths brought forward and respiratory hospital admissions). It also reacts in the atmosphere to form secondary particulates, which are treated similarly to PM_{10}. Both of these pollutants are also important in other impacts – SO_2 is the major cause of building corrosion (e.g. of stone surfaces) and PM_{10} is the main pollutant involved in building soiling (the darkening of building surfaces).

The health effects of NO_X emissions are more complex to assess. There is some evidence for the direct effects of NO_2 though this is controversial, and COMEAP only recommended quantification of respiratory hospital admissions from NO_2 as a sensitivity. However, NO_X does have health impacts from the secondary pollutants it forms – secondary particulates (nitrates) which generally fall into the PM_{10} size fraction, and ozone (formed from NO_X and VOCs). These effects are more complex to assess, because they involve detailed regional modelling. Similarly, VOC emissions form ozone. Ozone has direct health impacts (deaths brought forward and respiratory hospital admissions). It is also important in damage to certain types of materials, and is the major pollutant of concern in relation to crop damage.

The analysis of the air pollution costs was assessed in the surface transport costs and charge study[3]. Recent work for the DEFRA and DfT by AEA Technology Environment (Air Quality Evaluation, to be published March 2004, and an update of the STC&C numbers) has updated these values, to take account of changes in the evidence, especially in relation to monetary valuation of health endpoints.

Notes.

1. PM_{10} includes deaths brought forward, respiratory hospital admissions and chronic mortality.

2. NO_X includes the effects of secondary particulates, with valuation consistent with the analysis above for PM_{10}. The potential effects of NO_X on ozone are not included in the values, due to the variation with local and regional scale formation.

3. VOC include the potential effects from ozone formation, which includes deaths brought forward and effects on crops. The variation reflects the valuation of deaths brought forward (as for PM_{10} above).

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[1] COMEAP (1998). Quantification of the Effects of Air Pollution on Health in the UK. Department of Health. London. The Stationery Office.
[2] COMEAP (2001). Long-term Effects of Particles on Health. Draft Statement and Report. COMEAP/2001/1. Department of Health, London.
[3] Sansom T, Nash CA, Mackie PJ, Shires J, Watkiss P (2001) Surface Transport Costs and Charges Great Britain 1998. Final Report for the Department of the Environment, Transport and the Regions. Institute for Transport Studies, University of Leeds, Leeds, July 2001. ISBN 0 85316 223 9.

4. SO_2 includes local-scale deaths brought forward and respiratory hospital admissions and regional scale secondary particulates (with valuation consistent with PM_{10} above).

The external cost of an acute premature death from air pollution has a range of £3,000 to £110,000. This value is adjusted down from a full value of statistical life to take account of the short period of life lost and in some cases the existing low quality of life experienced by people who are chronically ill. The value also includes chronic mortality effects (the change in life expectancy from long term air pollution exposure which is valued using a years of life lost approach), valued at £30,000 based on the IGCB analysis, and £65,000 under the IOM analysis respectively. Respiratory hospital admissions are valued at £2,625 per case. Acute morbidity effects from air pollution are also included.

In practice, the emissions will vary with location for all pollutants, though the exact effects differ with pollutant. Tail-pipe emissions of PM_{10} and SO_2 from road vehicles are released at ground level, often in urban areas, where population densities are very high. They therefore have a high population exposure and potential health risk. Emissions in rural areas, or the majority of motorways, will be in areas of low population density where the population exposed will be low. Emissions of VOCs and NO_X from road vehicles are independent of emission location, because the health impacts are related to the formation of secondary pollutants. For this reason, it would be preferable to differentiate between urban and rural emissions of PM_{10} and SO_2 from road vehicles. Most motorway kilometres are outside of urban areas, and so would be treated similarly to rural emissions.

However, as the external costs of air pollution are not one of the key indicators selected for use in the study, and as preliminary investigation implied that the overall effect of differentiating between different locations would not affect the main conclusions of the study, we did not correct for emission location.

Table A3-4. Percentage of vehicle km travelled by road type and vehicle type

UK 2000	Cars	LGV - UK	LGV – overseas	Rigid	Artic
Rural highway		12%	20%	30%	55%
Urban highway		3%	4%	6%	11%
Total highway		15%	25%	36%	67%
Rural non-highway	51%	25%	32%	31%	18%
Urban non-highway	49%	60%	43%	33%	15%
Total rural	51%	37%	52%	61%	73%
Total urban	49%	63%	48%	39%	27%

The emissions from ships and aircraft are also location dependant. Clearly emissions released at sea or high above ground are less damaging to human health than emissions from docks or along coastal routes. We have applied a crude correction to account for this effect, as described in the main report.

4 Congestion, Accidents and Infrastructure

4.1 INTRODUCTION AND SOURCES OF DATA.

The starting point for the analysis of the costs of congestion, accidents and infrastructure was a breakdown of food miles by country, vehicle type and road type. The data is shown in Table A3-5.

Table A3-5. Vehicle km generated by UK food miles, by country

	HGV Mvkm	Artic Mvkm	Rigid Mvkm	LGV Mvkm	car Mvkm
UK	5,453	3,229	2,225	4,133	14,340
UK to or from Europe*	1,189	1,189	0	0	.
FRANCE	269	159	110	204	
NETHERLANDS	64	38	26	48	
IRISH REPUBLIC	56	33	23	42	
SPAIN	82	49	34	62	
GERMANY	111	66	45	84	
USA	374	222	153	284	
BRAZIL	180	106	73	136	
BELGIUM	22	13	9	17	
ITALY	46	27	19	35	
DENMARK	13	7	5	10	
CANADA	68	40	28	51	
ARGENTINA	35	21	14	27	
SOUTH AFRICA	30	18	12	23	
AUSTRALIA	51	30	21	39	
NEW ZEALAND	13	8	5	10	
INDIA	18	11	7	14	
CHINA	11	7	5	9	
PAKISTAN	6	3	2	4	
RUSSIA	8	5	3	6	
TURKEY	9	5	4	7	
Other	75	44	30	56	
Total	1541	912	628	1167	

*Assume all on motorways by articulated HGVs.

Table A3-6. Split of Vehicle Category by Road Class.

UK 2000	Cars	LGV UK	LGV overseas	Rigid	Artic
Motorway and rural dual carriageway	0%	15%	25%	36%	67%
Rural	51%	25%	32%	31%	18%
Urban	49%	60%	43%	33%	15%

Source: AEAT

Food miles by non-road modes were estimated to be:

	car	sea	rail	air long haul	air short haul
Mvkm	14,340	119	0.22	36	0.57
Mtkm	143	151,914	33	1,280	21

Though some cost data was available for individual countries there were many gaps. As a result it was decided to use average costs within broad geographic categories and the food miles by road overseas were aggregated into three geographic areas as shown in Table A3-7 and Table A3-8.

Table A3-7. Overseas Food Miles by Geographic Category (Mvkm).

Country	HGV Mvkm	Artic Mvkm	Rigid Mvkm	LGV Mvkm
UK to and from Europe	1189	1189	0	0
France	269	159	110	204
Netherlands	64	38	26	48
Irish Republic	56	33	23	42
Spain	82	49	34	62
Germany	111	66	45	84
Belgium	22	13	9	17
Italy	46	27	19	35
Denmark	13	7	5	10
Turkey	9	5	4	7
Western Europe	*672*	*397*	*275*	*509*
USA	374	222	153	284
Canada	68	40	28	51
Australia	51	30	21	39
New Zealand	13	8	5	10
Other developed countries	*506*	*300*	*207*	*384*
Brazil	180	106	73	136
Argentina	35	21	14	27
South Africa	30	18	12	23
India	18	11	7	14
China	11	7	5	9
Pakistan	6	3	2	4
Russia	8	5	3	6
Other countries	75	44	30	56
Developing countries	*363*	*215*	*146*	*275*
Total overseas	1541	912	628	1168

Source: AEAT and ITS estimates.

Table A3-8. Overseas Food Miles by Road Classification and Region (Mvkm).

	Artic HGV	Rigid HGV	LGV
UK to and from Europe	1189	0	0
Western Europe			
Motorway	265.99	99	127.25
Rural	71.46	85.25	162.88
Urban	59.55	90.75	218.87
All roads	397	275	509
Other developed countries			
Motorway	201	74.52	96
Rural	54	64.17	122.88
Urban	45	68.31	165.12
All roads	300	207	384
Developing countries			
Motorway	144.05	52.56	68.75
Rural	38.7	45.26	88
Urban	32.25	48.18	118.25
All roads	215	146	275

Source: AEAT and ITS estimates.

The aim was to estimate values of social and other costs of transport that result from UK food consumption. Average costs per vehicle kilometre were required for each of the three cost items by vehicle category and class of road. Data was obtained on the average costs of accidents that involved various categories of vehicle on three road classes (motorway, rural and urban) from HEN 1 (DfT 2000), as well as the involvement rates of the relevant vehicle types. In the case of the UK the latter was obtained from Road Accidents Great Britain-The Casualty Report (DfT 2002b) whereas for Europe and elsewhere estimates of costs and involvement rates were derived from data published by the RECORDIT project funded by the EU (www.recordit.org).

In the case of congestion costs and infrastructure costs for surface transport in the UK, the findings of the 'Surface Transport Costs and Charges' study were used (Sansom T. et al 2001). It was decided that the marginal cost approach used in that study was the most appropriate and those in Table 7.4 of that report were used as the basis for the current work in the case of infrastructure and congestion costs in the UK.

Similar costs had been produced for a selection of European countries as part of the RECORDIT project. The data produced in deliverables 1 and 3 of that work were averaged for EU countries (excluding the UK) and applied as the cost per vehicle for food miles on the European mainland. These values were also applied to movements in other developed countries. Costs in developing countries used the average costs of the former COMECON countries included in the RECORDIT data. However, the data relating to congestion costs was not only dated but had been produced on a different basis, so the figures published in the UNITE project for road delays were used to produce the costs contained in this study. They are significantly lower than those contained in STCC covering only the UK.

In the case of accident costs STCC only produced the external marginal costs. In order to produce full accident costs we initially used the approach adopted in both RECORDIT and UNITE projects.

Cost data for marine and air transport had to be obtained from other sources, and tended to be on the basis of fully allocated costs rather than on a marginal cost basis. Another EU study, UNITE (Tweddle G. et al 2002), was thought to provide the best source of such data for rail congestion costs. However, suitable data on infrastructure costs of sea and air have not been obtained, nor have marine congestion costs. The RECORDIT study concludes the latter are negligible. Unlike railway and roadway infrastructure, sea and air transport benefit from the ‘way’ being provided by nature. The costs incurred are in the form of regulation (traffic control and safety) and the more substantial costs of terminal facilities. In the case of air accidents statistics show that aircrew casualties UK aircraft averaged 2.8 fatalities, 0.8 serious injuries and 1.6 minor injuries per year between 1992 and 2001 (CAA 2002). Unfortunately usable data with an application to food has not been found, though air accident costs will not be significant.

4.2 METHODOLOGICAL ISSUES.

Before attempting to calculate the cost of food miles transport in terms of accident, congestion and infrastructure costs, the methods used in other studies were considered. Potential problems that required consideration were the combination of various sources of cost data, as no single study had reported the range of cost applications over the geographic area being examined in the current study.

Members of the study team having undertaken similar studies in the past, notably Surface Transport Costs and Charges (STCC) and UNITE, firstly examined the results and valuation of social costs in previous studies, and how these values should be updated. However, all these unit costs were based on averages and there is an implicit assumption that vehicles carrying food do not vary significantly from the average.

It was thought the STCC study was probably the most best starting point, though it may be appropriate to change these values should one of the following apply:

1. *In order to reflect inflation and new data.*
2. *New evidence is available from other studies.*
3. *If experience has shown an alternative method to be more appropriate for this study.*

Since the completion of the STCC other work has been undertaken in the area we are investigating, notably studies for the EC called UNITE and RECORDIT. The latter have the benefit of providing valuations on a standardised basis for many countries in Europe, not just within the EC as well as providing some costs for non-road modes.

In general the view was that STCC provided a good basis for UK marginal costs on a consistent basis by road and rail modes. In the case of articulated vehicles the ‘low’ estimates in Table 7.4 of STCC were thought to be robust, although even these are higher than the values used by the SRA in the assessment of grants for the transfer of freight from road to rail which mainly apply to HGV artics (www.sra.gov.uk).

4.2.1 Inflation and new data.

The GDP deflator has been used to adjust most UK prices to 2002 levels. As the Treasury produces figures for financial years these were converted to calendar years (Table A3-9). In the case of congestion costs the change in GDP was used.

In the simplest case, figures given in the STCC (such as those in STCC Table 7.4) were inflated from 1998 prices and applied to vehicles carrying food. Similarly the values in

HEN 1 were inflated from 2000 prices. The latter are produced in the form of the benefits of prevention of road accidents and casualties, many accidents involving more than one casualty, based on previous 'willingness to pay' (WTP) work.

A report produced prior to STCC by NERA dealt with the social costs of transport, but its main focus was road infrastructure costs. One area where new values were available concerned the valuation of accidents as a result of the updated figures contained in Highways Economic Note No. 1 (DfT 2000), better known as HEN 1.

Table A3-9. GDP Deflator, Conversion of Financial to Calendar Year.

Financial year	GDP deflator	Calendar year	GDP deflator
1992-93	79.816	1992	N/a
1993-94	81.790	1993	81.297
1994-95	82.874	1994	82.603
1995-96	85.236	1995	84.645
1996-97	87.939	1996	87.263
1997-98	90.652	1997	89.974
1998-99	93.143	1998	92.520
1999-2000	95.398	1999	94.834
2000-01	97.561	2000	97.020
2001-02	100.000	2001	99.390
2002-03	103.035	2002	102.276
2003-04	105.806	2003	105.113

Source: UK Treasury (www.treasury.gov.uk). ITS Estimates.

Previous studies that estimated road accident costs have used the values in HEN 1 in conjunction with statistics from Road Accidents GB (RAGB) (DfT 2002b). At the time of the current phase of this study accident figures for 2002 are due shortly but the latest published RAGB relates to 2001 statistics. As in most cases the involvement rates of goods vehicles have been fairly steady, though with a slow decline for a number of years, the application of 2001 involvement rates to 2002 would seem to be a reasonable assumption. One possible exception is an increase in the involvement of HGV's in accidents with slight casualties in recent years, though no adjustment was made to the published figure.

As a result of the examination of alternative evidence the primary source of valuation data for food miles in the UK is STCC. The exception being accident related costs, where the values given in HEN 1 were used. The costs estimated are the total accident costs, including elements that are internal to road users, mainly as a result of insurance cover for damage to vehicles and some injury costs.

4.2.2 New evidence is available from other studies.

Recent studies which may provide data for the current project include UNITE, undertaken for the EC, which examined the transport accounts of a large proportion of European countries, and thus provides evidence of values for food miles undertaken in these countries. The methodology in general was based on fully allocated costs rather than the marginal cost approach.

A second study for the EC, RECORDIT, used the similar methodology as UNITE and other EC projects (notably PETS). It applied costs to both road and intermodal transport on specific corridors. Its main value to the current project is that in Deliverables 1, 3 and 4 it provides tables of estimated values of external road, water and rail costs applied to traffic moved across Europe along the corridors chosen as examples in the study, as well as data for a range of EU countries. The results for the movement of a unit of transport (ie a 20 ft container) are also produced. The reports can be found on the web (www.recordit.org).

Unfortunately the data provided by RECORDIT was not disaggregated to the extent required by the current work. In order to produce the categories of vehicle used in this report (notably the split between HGV rigids and artics) the difference between the UK average HGV and the two categories was used as a factor applied to the average European HGV value given in RECORDIT. In addition data on 'damage only accidents' (DoA's) was not produced, nor were any alternative sources of this data found which applied to European road traffic. A value for DoA's overseas was produced by using the proportion of the costs of DoA's in the UK to the total cost of injury accidents. As in the UNITE study the cost of accidents was based on fully allocated cost methods.

The work undertaken by NERA (which pre-dated STCC) concerned the allocation of track and external costs to HGV's. As it does not cover cars or LGV's it would not give a standardised set of figures for our purposes.

Data produced in RECORDIT and UNITE relating to the valuation of accidents, congestion and infrastructure overseas was used to establish the cost of food miles outside the UK. RECORDIT also gave accident rates for UK rail, while UNITE gave similar evidence for maritime accidents.

4.2.3 If experience has shown an alternative method to be more appropriate for this study*.*

In the case of STCC we now feel that it may be difficult to support some of the 'high cost' scenarios in the results tables and in the current study propose concentrating on the lower range, which can be more readily supported even though they may be conservative. In general the results of the STCC study appear to provide the most suitable basis for application to the DEFRA study for transport of food within the UK.

However, the accident costs need to be re-run with more up to date data. In addition some thought given to changes in the level of congestion and infrastructure costs since 1998, though these are likely to be relatively small. In the case of congestion the change in the Value of Time (VOT) is believed to follow GDP so the cost of congestion has been inflated by the change in GDP. However, no adjustment was applied to reflect the change in traffic volumes.

As far as the movement of food in Europe is concerned values given in the RECORDIT and UNITE studies appear to provide the most appropriate basis for the values of external costs of transport by various modes. The study also produced some costs for non-road modes in the UK.

4.2.4 Sources of Data Used in Estimating Costs.

It proved impossible to find a source of data that presented costs on a consistent basis. Although the marginal costs approach was preferred suitable data could not be found universally. As a result some overseas costs and all non-road modes costs use fully allocated cost methods, adjusted to provide marginal costs by assuming the same ratio of marginal costs to average costs in the UK. Table A3-10 gives the source of cost data by cost category.

Table A3-10. Sources of Data.

Cost Category	UK	Overseas
Road accidents	HEN 1 RAGB TSGB	RECORDIT D4 Tables 6 and 10
Road congestion	STCC Table 7.4	UNITE D14 Table 8 TSGB 2002 Table 8.4
Road infrastructure	STCC Table 7.4	RECORDIT D1 Table 9
Rail accidents	RECORDIT D4 Table 17 HEN 1	Not required
Rail congestion	UNITE D8	Not required
Rail infrastructure	STCC Table 8.7	Not required
Marine accidents	UNITE D8 HEN1	Not required

4.3 ACCIDENTS

4.3.1 Food Miles Related Accidents by Road in the UK.

As accident data was produced using 'willingness to pay' data rather than marginal costs. This approach assumes accidents in which vehicles carrying food are involved would not take place in the absence of those vehicles. This probably represents an upper estimate of the marginal accident costs of food transport.

Initially an estimate of the number of food transport related accidents in 2002 was made using vehicle involvement rate data from RAGB, by vehicle type and road class (Table A3-11). The values of preventing such accidents are given in HEN 1 and these values, adjusted to 2002 prices, were then applied to give the food miles related accident costs in the UK (Table A3-12).

Table A3-11. Accident Involvement Rates (per 100 mill vkm).

Severity	**Fatal**	**Serious**	**Slight**
HGV			
Motorway	1	2.8	19.2
Rural	2.6	10.4	37
Urban	3.2	15.8	99
LGV			
Motorway	0.3	1.5	10.2
Rural	0.8	4.4	19.8
Urban	0.5	6.5	50
Car			
Motorway	0.3	2.3	19.4
Rural	1.5	8.5	45
Urban	0.8	13.2	121

Source: DfT (2002b) RAGB 2001. ITS estimates.

Table A3-12. Average Value of Prevention per Accident by Severity and Class of Road (£ June 2000).

Road class	Urban	Rural	Motorway
Accident severity			
Fatal	1,260,780	1,361,440	1,469,780
Serious	145,320	169,680	179,160
Slight	14,530	17,400	20,560
Damage only	1,280	1,890	1,820

Source: DfT 2000, HEN 1.

A summary of the results is presented in Table A3-13. While HGV's are generally driven safely when they are involved in an accident, damage and injuries are more severe, and they are involved in 35% of the 290 fatal accidents. In undertaking food transport they only cover 18% of their vehicle kilometres on urban roads but incur 36% of the food related fatal accidents on this class of road. On the other hand cars are involved in 73% of the food miles related accidents on rural roads.

In the case of both cars and LGV's a relatively high proportion of fatal accidents occur on rural roads. This pattern of accidents is the same as that observed for traffic in general. The overall pattern is for LGV's carrying food appears to be relatively safe compared with cars, but this is in part a reflection of the fact that few cars carrying food use motorways, which is the road class with the lowest vehicle involvement rates. Though clearly reducing the number of HGV's entering urban areas should theoretically reduce fatalities, in practice this would depend on the alternative transport of food (or any other goods) in those areas and the additional vehicle kilometres generated.

Table A3-13. Estimated Number of Food Miles related Accidents in UK 2002.

Category	Fatal	Serious	Slight	DoA	Total
HGV	102	408	2246	35590	38346
LGV	23	216	1508	27599	29345
Cars	166	1549	11793	199275	21783
Total	**290**	**2173**	**15547**	**262464**	**280474**

Source: ITS estimates**.**

Table A3-14. Estimated Cost of Food Miles related Accidents in UK 2002 (£m).

Category	Fatal	Serious	Slight	DoA	Total
HGV	145.2	68.8	39.4	54.2	307.6
LGV	31.2	34.6	24.1	38.9	128.8
Cars	232.2	253.3	190.6	289.0	965.1
Total	**408.6**	**356.7**	**254.1**	**382.1**	**1405.1**

Source: ITS estimates.

The costs in Table A3-15 represent costs of accidents per vehicle kilometre.

Table A3-15. Estimated Cost of Food Miles related Accidents in UK 2002 (p/vkm).

Category	Fatal	Serious	Slight	DoA	All Severities
HGV	2.66	1.26	0.72	0.99	5.64
LGV	0.75	0.84	0.58	0.94	3.12
Cars	1.62	1.77	1.33	2.02	6.73

4.3.2 Food Miles Related Accidents by Road Overseas.

In estimating the number and cost of food miles related accidents by road to UK food consumption, but which occur outside the UK, figures produced by the RECORDIT study (www.recordit.org) in tables 6 and 10 of Deliverable 4 were used. These tables gave the monetary values of accidents (on a willingness to pay basis) and the involvement rates of articulated lorries respectively.

The data was grouped to produce average figures for Western Europe (excluding the UK) and Eastern Europe, which mainly contained former COMECON countries. Table A3-16 shows the values after conversion from Euros (at €1=£0.68) and adjustment to 2002 prices. The Western European values were applied to that area together with food miles on European Motorways and other developed countries (such as the USA). The average value for East European countries was applied to food miles in developing countries such as India.

Table A3-16. Monetary Value of Casualties (£/case at 2002 prices).

	Fatality	Severe injury	Slight injury
Western Europe	855594	113975	8751
Other developed countries	855594	113975	8751
Developing countries	456104	57717	4316

Source: RECORDIT D4 Tables 6 and 10, ITS estimates.

Table A3-17 gives the estimated involvement rates of articulated lorries for the same geographic regions. For comparison, the figures for fatalities on UK motorways given in the same table of the REDORDIT study as only 6.7 per Bvkm, only 16% of the European average, and only 4% of the 156.5 per Bvkm in Spain. The involvement rates for rigid HGV and LGV were estimated based on the proportionate involvement rates to articulated lorries in the UK. As a result of the relatively low accident rates in the UK, accident costs per kilometre are much lower, even though the value of life is generally higher than in most overseas countries.

Applying the accident rates to overseas food miles by road gives the estimated number of accidents by geographic region and severity, 205 fatalities and 1313 serious accidents (Table A3-18). The external cost of accidents overseas is estimated as £308m, plus an estimate of £112m for Damage only accidents (DoAs) (Table A3-19), giving total costs of £421m. As no evidence of DoA's overseas has been found, they have been calculated on the basis that they would form the same ratio to the costs of all injury accidents as was the case in the UK.. Therefore the total cost of accidents from food miles is assessed as £1.8 billion.

Table A3-17. Accident Involvement Rates (per Bvkm)

		Artic	Rigid	LGV
Western Europe				
Motorway	Fatalities	41	25	12
Rural	Fatalities	152	94	47
Urban	Fatalities	129	40	20
Motorway	Severe injuries	277	263	131
Rural	Severe injuries	558	446	223
Urban	Severe injuries	893	658	329
Motorway	Slight injuries	598	598	312
Rural	Slight injuries	1178	1178	589
Urban	Slight injuries	3340	3227	1613
Other developed countries				
Motorway	Fatalities	41	25	12
Rural	Fatalities	152	94	47
Urban	Fatalities	129	40	20
Motorway	Severe injuries	277	263	131
Rural	Severe injuries	558	446	223
Urban	Severe injuries	893	658	329
Motorway	Slight injuries	598	598	312
Rural	Slight injuries	1178	1178	589
Urban	Slight injuries	3340	3227	1613
Developing Countries				
Motorway	Fatalities	81	49	24
Rural	Fatalities	242	149	75
Urban	Fatalities	241	75	38
Motorway	Severe injuries	540	512	256
Rural	Severe injuries	887	710	355
Urban	Severe injuries	1637	1206	603
Motorway	Slight injuries	1263	1263	659
Rural	Slight injuries	1890	1890	945
Urban	Slight injuries	6071	5866	2933

Source: RECORDIT D4. RAGB. ITS estimates.

Table A3-18. Number of Food Miles Related Casualties Overseas.

	Artic HGV	Rigid HGV	LGV	Totals
UK to and from Europe				
Fatalities	49	0	0	49
Severe injuries	181	0	0	181
Slight injuries	153	0	0	153
Subtotal	**384**	**0**	**0**	**384**
Western Europe				
Fatalities	30	14	14	57
Severe injuries	167	124	125	416
Slight injuries	442	452	489	1383
Subtotal	**639**	**590**	**627**	**1857**
Other developed countries				
Fatalities	22	11	10	43
Severe injuries	126	93	94	314
Slight injuries	334	341	369	1044
Subtotal	**483**	**444**	**473**	**1400**
Developing Countries				
Fatalities	29	13	13	54
Severe injuries	165	117	120	402
Slight injuries	451	435	475	1361
Subtotal	**645**	**565**	**608**	**1817**
Total	**2149**	**1599**	**1709**	**5458**

Source: ITS estimates

Table A3-19. Estimated Overseas Accident Costs.

	Cost per casualty (£)	Total (£m)
UK to and from Europe		
Fatalities	855,594	42
Severe injuries	113,975	21
Slight injuries	8,751	1
Subtotal		**64**
Estimated DOA costs		23
Total		**87**
Western Europe		
Fatal	855,594	49
Serious	113,975	47
Slight	8,751	12
Subtotal		**108**
Other Developed countries		
Fatal	855,594	37
Serious	113,975	36
Slight	8,751	9
Subtotal		**82**
Developing countries		
Fatal	456,104	25
Serious	57,717	23
Slight	4,316	6
Subtotal		**54**
Total injury accidents overseas		**244**
Estimated DOA costs		89
Total estimated costs		**421**

Table A3-21 shows the average accident cost per kilometre for the three categories of commercial vehicle considered in this study. Costs are lower on European Motorways as a result of relatively low involvement rates by articulated vehicles on this category of road.

Table A3-20. Estimated Accident Cost Overseas per Vehicle Kilometre (p/Vkm).

	Artic	Rigid	LGV
UK to and from Europe			
Fatalities	3.5	0.0	0.0
Severe injuries	1.7	0.0	0.0
Slight injuries	0.1	0.0	0.0
Western Europe			
Fatalities	6.4	4.4	2.3
Severe injuries	4.8	5.1	0.9
Slight injuries	1.0	1.4	0.8
Other developed countries			
Fatalities	6.4	4.4	2.3
Severe injuries	4.8	5.1	2.8
Slight injuries	1.0	1.4	0.8
Developing Countries			
Fatalities	6.1	4.0	2.1
Severe injuries	4.4	4.6	2.5
Slight injuries	0.9	1.3	0.7

Source: ITS estimates.

4.4 CONGESTION COSTS.

The costs of congestion within the UK use data from the STCC study (Sansom et.al. 2001). This project disaggregated these costs to a much greater extent than is required for the current study, particularly with regard to urban roads where there are 25 categories. These were re-aggregated into three road types: motorway, urban and rural, by estimating the total costs of congestion generated by each vehicle category, then deducting that estimated for motorway and rural roads from the estimated total congestion costs allocated to each class of vehicle. The congestion costs per vehicle km were then calculated, inflating the figure by 10.547% to reflect the change in the value of time between 1998 and 2002 (based on the change in GDP over the same period). See Table A3-21.

Table A3-21. Congestion costs in the UK (pence per Vehicle km) 2002 prices.

	Motorway	Rural	Urban
Cars	5.57	5.88	30.54
LGV's	5.59	5.94	33.22
HGV Rigids	7.24	9.84	39.07
HGV Artics	13.59	22.08	90.79

Source: STCC, UK Treasury, ITS estimates.

The source of congestion costs in Europe was UNITE which gives average values in Table 8 of Deliverable 14. Although these values were on a different basis to those for the UK generated from STCC, it was clear that congestion costs were generally lower in continental Europe. The breakdown of the data in UNITE was for total delay by country in most European countries, while traffic volumes in each of these countries were obtained from TSGB 2002 Table 8.4. Where data in the latter was missing, traffic estimates were made using the average increase in other Continental countries (excluding the UK). The results produce costs per vehicle kilometre lower than those in STCC for the UK.

As no suitable marginal cost evidence was found relating to congestion in developing countries the lowest estimate in UNITE for a European country (that of Portugal) was used. This is based on the supposition that while values of time are generally low in the developing world, congestion in many large cities can be severe, and traffic speeds very low. On the other hand congestion in most rural areas is negligible and it is in these areas that most food miles are generated (Table A3-22).

Table A3-22. Congestion costs Overseas (pence per Vehicle km) 2002 prices.

	Motorway	Rural	Urban
Developed Countries			
Cars	1.34	1.41	7.33
LGV's	1.34	1.43	7.98
HGV Rigids	1.74	2.36	9.38
HGV Artics	3.26	5.30	21.80
Under Developed Countries			
Cars	0.08	0.08	0.44
LGV's	0.08	0.09	0.48
HGV Rigids	0.10	0.14	0.56
HGV Artics	0.20	0.32	1.30

Source: UNITE D14 Table 8. TSGB 2002 Table 8.4. ITS estimates.

Using the costs presented in tables A3-23 and A3-24 the total costs of relevant congestion were calculated for the UK and overseas. See Table A3-25 and Table A3-24. Clearly the costs generated by cars on shopping trips in the UK dominate this category of costs, particularly in urban areas, nearly half the total of £4770m.

The assumed percentage of distance travelled by LGV's of 43% on urban roads overseas has resulted in them generating significant congestion costs on these roads, though costs in these countries form a small part of the total. The other significant cost relates to articulated HGV's on European Motorways, almost one third of the total overseas road congestion costs.

Table A3-23. Total Food Miles Congestion Costs in UK (£m).

Vehicle category	Motorway	Rural	Urban	All roads
HGV Artic	294	128	440	862
HGV Rigid	58	68	287	413
LGV	35	61	824	920
Car	0	430	2146	2576
Total	**387**	**688**	**3696**	**4771**

Source: ITS Estimates.

Table A3-24. Total Food Miles Congestion Costs Overseas (£m).

	Artic	Rigid	LGV	Total
International (UK to overseas)	39	0	0	**39**
Western Europe				
Motorway	9	2	2	**12**
Rural	4	2	2	**8**
Urban	13	9	17	**39**
Total				**59**
Other developed countries				
Motorway	7	1	1	**9**
Rural	3	2	2	**6**
Urban	10	6	13	**29**
Total				**45**
Developing countries				
Motorway	0	0	0	**0**
Rural	0	0	0	**0**
Urban	0	0	1	**1**
Total				**2**
Total	**84**	**22**	**38**	**106**

Source: ITS Estimates

4.5 INFRASTRUCTURE COSTS.

The marginal costs produced in the STCC study were used as the basis for estimating infrastructure costs in the UK. As with congestion costs the categories were re-aggregated, using the distances travelled by each of the relevant classes of vehicles as weights. The results are shown in Table A3-27.

Table A3-25. Infrastructure costs in the UK (pence per Vehicle km) 2002 prices.

	Motorway	Rural	Urban
Cars	0.011	0.065	0.065
LGV's	0.011	0.085	0.085
HGV Rigids	1.03	5.97	5.97
HGV Artics	3.74	17.71	17.71

Source: STCC. ITS Estimates.

For infrastructure costs in Europe the source of data was RECORDIT. Unfortunately these costs are on the basis of average costs in fourteen EU countries (produced as 1994 prices which have been re-valued to 2002). Again, HGV costs are given as an average in RECORDIT rather than being split between rigid and articulated vehicles.

There is no specific data that could be applied to developing countries. Using the lowest cost country in each of the categories would produce the estimates in the right hand column of Table A3-28. The infrastructure costs for the UK produced by the RECORDIT study are given for comparison and these were used to factor the infrastructure costs for developed, and developing, countries by vehicle category and road class on the assumption that the ratio of marginal to average cost is the same as in the UK (Table A3-29).

Table A3-26. Average infrastructure costs in EU (13) (pence per Vehicle km) 2002 prices.

	Motorway	All Roads	*UK Comparison, all roads*	*Developing countries*
Cars	2.5890	3.044	*2.1049*	*0.7577*
LGV's	N/a	3.2752	*1.1768*	*0.6736*
All HGV	N/a	9.2362	*3.8730*	*3.3678*
HGV Rigids	N/a	N/a	*N/a*	*N/a*
HGV Artics	N/a	N/a	*N/a*	*N/a*

Source: RECORDIT D1 Table 9. ITS Estimates

Table A3-27. Estimated marginal infrastructure costs in the EU (pence per Vehicle km) 2002 prices.

	Motorway	Rural	Urban
LGV's	0.028	0.22	0.22
HGV Rigids	2.46	10.61	14.40
HGV Artics	8.92	28.88	61.03

Source: ITS Estimates.

The higher costs of infrastructure per kilometre in Europe reflect road networks that receive better maintenance, especially in northern Europe, when compared to the UK, and, with the exception of the Netherlands, generally have lower density of traffic. On the other hand, infrastructure costs in developing countries are generally lower reflecting poor maintenance, and in some countries lack of it. The poor roads generate costs to commercial vehicle operators in the form of repairs (especially to tyres and suspension units), loss of vehicle utilisation and unreliable service to shippers, but these are outside the scope of the current study (Table A3-30).

Table A3-28. Estimated Infrastructure costs in the Developing Countries (pence per Vehicle km) 2002 prices.

	Motorway	Rural	Urban
LGV's	0.006	0.046	0.46
HGV Rigids	0.89	3.87	5.25
HGV Artics	3.25	10.53	22.25

Source: ITS Estimates.

HGVs are the major source of road infrastructure costs. The application of the 'fourth power law' to the wear caused by the passage of a vehicle axle means that those vehicles with high axle weights (as a result of carrying the heaviest payloads) are allocated the largest share of the cost of maintaining the road pavement. The outcome is that HGV artics account for 72% of the food miles related infrastructure costs in the UK, and 90% of that on motorways (Table A3-31).

Table A3-29. Total Food Miles Related Infrastructure Costs in UK (£m).

Vehicle category	**Motorway**	**Rural**	**Urban**	**All roads**
HGV Artic	80.8	102.9	85.8	269.5
HGV Rigid	8.2	41.2	43.8	93.2
LGV	0.07	0.9	2.1	3.0
Car	0.0	4.8	4.6	9.4
Total	89.1	149.8	136.3	375.2

Source: ITS Estimates.

The overseas infrastructure costs of the transport of UK food follows a similar pattern with articulated vehicles being allocated 84% of the total (Table A3-32).

Table A3-30. Total Food Miles Related Infrastructure Costs Overseas (£m).

	Artic	Rigid	LGV	Totals
International (UK to overseas)	106	0	0	**106**
Western Europe				
Motorway	24	2	0	26
Rural	21	9	0	30
Urban	36	13	0	50
total	81	25	1	**106**
Other developed countries				
Motorway	18	2	0	20
Rural	16	7	0	23
Urban	27	10	0	38
Total	61	18	1	**80**
Developing countries				
Motorway	5	0	0	5
Rural	4	2	0	6
Urban	7	3	0	10
total	16	5	0	**21**
Total	**264**	**48**	**2**	**313**

Source: ITS Estimates

4.6 COSTS RELATED TO NON-ROAD MODES.

Little food is transported within the UK other than by road, though international traffic does use sea extensively and air to a lesser extent. Data on the costs of these modes has been produced from various sources, though as marginal cost data is only available for UK rail infrastructure (from STCC), other sources were examined.

STCC gives the marginal costs of infrastructure per train km as £0.88 in the case of 'other' freight traffic, the most suitable category for food. The fully allocated cost equivalent is £3.33 per train km.

RECORDIT Deliverable 4 gives risk of casualties from goods trains in the UK but these produce insignificant costs resulting from low level of food miles by rail. Congestion costs are ignored as being negligible. The latter applies to accident and congestion costs on inland waterways. On the other hand, Railfreight congestion costs have been estimated as €20.6mpa (£15.485 at 2002 prices, an estimated cost of £0.973 per train km) by the UNITE study for all commodities (Tweddle G. et al 2002)

Calculation of air cargo congestion costs was attempted using the figure in UNITE (Tweddle et al 2002) of €2.0m for 1998 and the total Air Traffic Moments (ATM's) of 1.516m. This equates to £1.36m, or an average of £0.77 per tonne lifted at 2002 prices. However, this is the result of each aircraft on average carrying a small amount of cargo in the belly hold of passenger flights. It does not reflect the delays caused by freighter aircraft that may delay an unknown number of passengers on other flights and we have not been able to determine any difference between long and short haul flights. As a result it was decided that insufficient data in a suitable form was available to estimate air congestion.

In the case of accident costs it has not proved possible to separate the costs that should be allocated to passengers and those which should be allocated to cargo. However, the amount is probably fairly small given that average aircrew fatalities for all UK registered commercial aircraft average 2.8 per year (CAA 2002).

UNITE also provided statistics relating to UK marine crew accidents, which in 1998 totalled 2 fatal and 317 other casualties. These casualties may not be related just to domestic freight but to freight carried on British ships. Domestic sea freight totalled 56.8btkm moved by sea, and 2.0btkm by inland waterway. The figures have been used as the only data available. Nevertheless, using UK marine accident figures provides a reasonable basis as British merchant marine service may have a better than average safety record, so the estimates in Table A3-31may be conservative when applied to the 154,556 Mtkm of UK food transported by sea.

Table A3-31. Cost of Food Miles by Non-road Modes in the UK (£m).

Cost item	Sea	Rail	Air Long haul	Air Short haul
Accidents	29.4	Negligible	n/a	n/a
Congestion	Negligible	0.2	n/a	n/a
Infrastructure	n/a	0.2	n/a	n/a
Total	-	0.4	-	-

Sources: UNITE D8. ITS Estimates.

4.7 SUMMARY OF RESULTS.

The costs estimated in this study show that the most significant, by a large margin, are the shopping trips carried out by car. Of the overall estimated cost of £7455m car congestion forms 33% of the total (**Table A3-32**). Cars also account for 166 fatal accidents, 34% of the total of an estimated 494 fatalities resulting from the transport of food consumed in the UK.

Costs incurred in all overseas countries by the road transport of food for UK consumption are estimated to form 12% of the total. However, if the estimated costs of £3550.5m related to cars are deducted, over 22% of the remaining costs of supplying the UK market by commercial transport are incurred overseas.

Table A3-32. Summary of UK Food Miles Costs for Three Attributes Estimated (£m).

Cost Item	UK Cars	UK Commercial Road Vehicles	UK to and from Europe	Overseas Road	Other Modes*	Total
Accidents	965.1	436.4	87.4	333.5	29.2	1851.6
Congestion	2576.0	2194.6	38.8	105.8	0.2	4915.4
Infrastructure	9.4	365.7	106.0	207.1	0.2	688.4
Total	3550.5	2996.7	232.2	646.4	29.6	7455.4

Note: *Only includes costs shown in Table 6.2.
Source: ITS Estimates.

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Annex 4
Win-win company policies in food logistics systems

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CONTENTS

1 INTRODUCTION

This document discusses company policies that could help reduce the environmental and social impacts of food logistics systems and which do not have adverse effects on other aspects of sustainability (e.g. economic benefits). The policies discussed include:

- Outsourcing of transport / shared user services
- Computerised vehicle routing and scheduling (CVRS)
- In-vehicle IT and telematics
- Strategic models concerned with the physical supply chain
- B2B e-commerce and freight exchange systems
- Return loading
- Factory gate pricing
- Fleet management and driver training
- Vehicle engines and fuels
- Grocery home delivery

The company policies list above can help to reduce the environmental and social impacts of food logistics systems in several different ways including:

- Reducing empty running
- Improving vehicle time utilisation
- Improving vehicle fill
- Improving fuel consumption rates
- Reducing CO_2 and other pollutant emissions

Empty running, vehicle fill, vehicle time utilisation and increases in maximum permissible gross vehicle weight are presented in Annex 2 (Factors driving food miles) and have not therefore been discussed in detail in this document.

Finally, a number of issues and trends in transport logistics may act as a barrier to reducing food miles, or offset the benefits of the other policies discussed. These are presented at the end of the Annex.

2 OUTSOURCING OF TRANSPORT / SHARED USER SERVICES

Since the early 1980s, there has been a substantial increase in the proportion of food movement handled by outside contractors (McKinnon, 2003). Where these contractors have been able to provide a 'groupage' or shared user service to several clients, levels of vehicle utilisation have generally been improved, reducing the ratio of vehicle-kms to tonne-kms. Much of the transport of food and drink product, however, has been outsourced on a dedicated basis to particular clients, limiting the opportunities for load consolidation. For example, in recent years most large UK food retailers have contracted out between 50 and 100% of their transport requirements to logistics service. The vast majority of this work is done on a dedicated basis in client-liveried vehicles. In recent years, however, retailers have been relaxing restrictions on the use of these dedicated vehicles become more willing to share vehicle capacity. This has increased the opportunity for rationalising the movement of food.

Shared user operations can be organised in several different ways. In some cases, goods are taken to RDCs for consolidation with other customers' loads as part of a multi-drop operation. In other cases, such as the Securicor example below, the operation involves the direct delivery of a customer's goods with the distribution company using the vehicle for another job near the point of delivery if there is no return load. In some cases, such as the JRL example below, two or more distribution companies may share their vehicle and warehousing capacity to provide tailored solutions for a single customer.

Examples of shared user include the services offered by Securicor Omega Logistics which operates 70 shared user distribution centres (or as they prefer to call it 'multi-user'). They have a fleet of more than 2,000 vehicles and make extensive use of IT applications to manage the network (Securicor Omega Logistics, 2003). Further examples of shared services and outsourcing are provided in the boxes below.

Example of shared user services: NET Logistics (Wincanton, 2000)

NET Logistics is Wincanton's shared-user distribution initiative, which provides customers with the opportunity to improve vehicle utilisation and reduce costs by sharing vehicles with other companies. NET Logistics uses a transport management system, known as DCSi.Logistics, that helps to managing vehicle movements centrally within the operation, including those of sub-contractors. The system provides NET with greater visibility of the entire shared-user distribution network it is operating and thereby provides opportunities for efficient utilisation of the transport capacity. The system is also able to communicate with in-cab computers and WAP technology. It also incorporates an event manager function, which monitors the status of consignments and alerts the transport planners of any potential difficulties in the plan. The system was introduced in 2000.

Example of outsourcing and sharing resources: Joint Retail Logistics (JRL)

Joint Retail Logistics (JRL) is an initiative in non-food retail. It has brought together the combined resources and skills of two logistics providers to whom logistics activities are outsourced with the use of information technology to reduce environmental impacts and at the same time achieve more efficiency and better service to customers.

JRL is a joint venture between Exel and Tibbett & Britten. It has resulted in these two competing logistics service providers being able to work together to provide unified service to Marks & Spencer. The objectives of JRL were:

- To maximise efficiency in the general merchandise transport operation while maintaining current service criteria.
- To appoint a single contractor to manage the general merchandise transport, with responsibility for the total transport supply chain between supplier and store.
- To build on current environmental initiatives and ensure that Marks & Spencer continues at the forefront of minimising the environmental impact of its transport operations.

Benefits of JRL to date include:

- Greater efficiency in operation – savings in km run of 11%. Number of tractors reduced by 26% (trailer requirements down 8%).
- Reduced congestion at distribution centres and at delivery points for stores (i.e. in the high street of towns and cities).
- Delivery to store vehicles also able to handle reverse logistics of packaging and handling media.

In JRL, Exel has been responsible for providing technologies that would optimise the distribution system in an integrated fleet approach, involving back-loading and use of drivers across all of their working day, and the use of vehicles over a 24-hour period. The five technological applications implemented by Exel in JRL are:

- A web-deployed MTS host system to track an order from source to destination
- Integrated scheduling that optimises on cost
- Integration with Isotrak's real time fleet management toolkit to control and manage multi-site fleet operations
- Project and change management control to implement the new management model
- Planning and management expertise to realise the benefits across the supply chain

The above technologies have been deployed by Exel to support the whole transport management process.

Information provided by Exel (2000)

3 COMPUTERISED VEHICLE ROUTING AND SCHEDULING (CVRS)

The use of computerised vehicle routing packages can cut transport costs and distance travelled by between 5 and 10%, depending on the quality of the previous manual load planning (Freight Transport Association, 2000). As these packages are now widely used by manufacturers, wholesalers and retailers in the food sector, they may have significantly reduced total vehicle-kms. As no general surveys have been done to establish the level of CVRS adoption in the sector or the average level of vehicle-km reduction, the net effect on traffic levels is unknown.

A recent Good Practice Guide (Freight Transport Association, 2000) highlights the scope for computerised vehicle routing and scheduling (CVRS) to help business improve the utilisation of their transport resources. Use of CVRS can help reduce journey times and vehicle mileage, reduce costs and improve the reliability of delivery schedules. Although there is no information about the precise uptake of CVRS, a postal survey of 2,300 Freight Transport Association members conducted in 1998 revealed that 138 out of 600 respondents were using some form of CVRS. According to articles in the professional press it is still mainly the larger companies that use these systems although smaller firms are showing more interest (Anon, 1999).

There are two types of CVRS system: journey planners and the more sophisticated scheduling systems. Journey planners are typically used for single routes where the user decides the calls to be allocated to each trip and determines the best route and call sequence by using the journey planner. This is effective for small and relatively simple operations. Vehicle scheduling systems process information about customer locations, quantities and types of goods and match this to available vehicle capacity to produce economic routes. They can be used for daily or weekly planning and for strategic exercises. The operator can test alternative solutions and make manual adjustments where necessary.

Applications are now available that can link with mobile tracking systems and on board computers to provide ‘real time’ information on the location and progress of each vehicle and on road traffic conditions. Access to real time information has allowed systems to be developed which automatically re-processes data according to the latest information on the ground, reacting to changes as they happen and informing the fleet controller of the best re-scheduling and re-routing options (Matthews, 2001). However, these initiatives are still in an early stage and not all software can be used in this way.

In general, the issue of congestion is dealt with by manual intervention and by changing the flow speed on selected parts of the network or on particular links. Some CVRS systems accommodate more sophisticated intervention than others and can allow travel speeds to be varied for certain links at different times. This allows operators to consider the viability of alternative solutions but relies to a large extent on the knowledge of the planner/scheduler.

Examples of the transport and financial benefits of one CVRS system (Paragon) are summarised by the company as follows: “Substantial transport efficiency savings are being achieved leading to a fast return on software investment, often in a matter of months. Safeway, for example, delivering grocery products to its nation-wide store base, has reported an 18% fuel reduction. Magnet Joinery, involved in retail and home delivery, cut transport cost by 20%. Watson & Philip, a leading food wholesaler, reported a 13% cost reduction. Wavin Building Products, Woodward Foodservice, Henkel and Thames Valley Foods all reported transport cost reductions between 15 and 20%. Domino's Pizza has also reported savings amounting to thousands of pounds per week, and BOCM Pauls, distributing animal feed from its regional feed mills to farms reported an overall transport cost reduction of £250,000 per year on a 40-vehicle operation in the South East” (Nockold, 2001).

Paragon has also been used to achieve more efficient routing and order volume smoothing through the week for the food wholesaler Cearns & Brown. This has resulted in their nation-wide distribution operation fleet size being reduced by 13% and has reduced delivery kilometres per pack by 14% (Paragon, 2003).

Meanwhile, another CVRS system, Optrak, has been used to reduce home delivery mileage by 23% for one company. In addition, driving hours were reduced by 14%, and the total cost by 15%. Optrak was also used to analyse the operation of a nationwide distributor of home improvements products. The system produced results that reduced mileage by 15%, drivers' hours by 13%, used 12 fewer vehicles, and reduced the running costs by 14% (Matthews, 2001).

Example of CVRS: Woodwards Foodservice (FTA, 2000)

Woodwards has 5,500 customers and makes up to 1,200 deliveries per day during peak periods. Woodwards decided that it was necessary to change from manual routing and scheduling for its vehicle fleet to a computerised system. Paragon software was selected, and was implemented at one of their depots in north Wales.

An interface was used to link Paragon to the warehouse management, order processing and stock control systems already being used. This made it possible for Paragon to be run during the late afternoon to schedule and route deliveries for the next day, these schedules are then passed to the warehouse during the evening for picking. Implementing this routing and scheduling system has resulted in the following benefits for Woodwards:

- Reduced daily vehicle mileage by 10%
- Reduced the fleet from 30 to 25 vehicles
- Reduced planning time to create the delivery schedules
- Increased picking/loading productivity by 50%
- Balanced load sizes more evenly to enable the work to be shared out more efficiently

4 IN-VEHICLE IT AND TELEMATICS

Many larger freight operators have placed a growing importance on information systems over the last decade. For many smaller and medium-sized operators it will be necessary to improve the internal information systems of the firm in order to operate efficiently in a highly competitive market.

Telematics applications available in the freight sector include (TransportEnergy, 2003a):

- Vehicle and driver data
- Vehicle tracking
- Trailer tracking
- Text messaging
- Paperless manifest and proof of delivery
- Traffic information
- On-board navigation

Mobile Data Communications (MDC) equipment allows a transport operator to monitor the position of a vehicle and can enable the base and driver to exchange messages. This in turn means that the efficiency of road freight operations increases and better quality information can be provided to the transport operator's customers (e.g. providing information about precise arrival times). As well as tracking vehicles, some companies also use systems to track the flow of consignments within their network so that they can keep customers informed of progress.

A consequence of the dramatic increase in the use of technology has been the increased complexity of in-vehicle or in-cab equipment. For example, in order to exchange messages via a satellite link it is necessary to have an on-board computer. The computer can also be used to record many details of the journey as well as to monitor vehicle performance and load condition.

IT systems are also widely used to assist with distribution network planning, vehicle routing and scheduling, for fleet management and driver safety purposes and for efficient vehicle loading.

Table A4-1 shows the telematic systems used by fleet managers to help minimise the impact of traffic congestion.

Table A4-1: Telematics systems used by fleet managers to minimise the impact of congestion

Telematic system	Proportion of fleet managers using this approach (multi-response)
Messages flashed on a screen above/on side of road	38%
Traffic news on broadcast media	30%
Traffic information on the internet/mobile phone	19%
CD-rom/internet based route planning	12%
In-cab route finder/congestion warning device	6%
None of these	4%

Notes: the results are based on a survey of 200 freight transport fleet managers.
Source: Lex Transfleet, 2001.

If improved information and communications systems are implemented successfully then the following benefits can be expected:

- better vehicle productivity
- improved time-keeping
- reduced fuel consumption
- reduced mileage (in the case of on-board navigation especially for multi-drop work)
- higher levels of customer service

Typically, the smaller the operator, the fewer IT applications they are likely to consider critical to their business operations. If a company has only one or two trucks then a computerised vehicle routing and scheduling package will have limited use.

In general, IT applications will yield bigger benefits and have more appeal to those operators with:

- complex operations
- a high number of transactions
- wide ranging responsibilities for supply-chain management

Inevitably these complex logistics services will tend to be the province of the larger operator. However, in many cases, medium-sized firms are likely to be in competition for this business and may well also consider the scope for using IT to significantly enhance their competitive position.

Examples of the benefits of telematics systems include (TransportEnergy, 2003a):

- Exel achieved a 7.2% reduction in fuel use at its Bawtry depot after introduction of an Isotrak system for in-cab communication and information telematics. The system helped Exel to identify vehicle engine idling (due to cold cabs which was overcome by fitting heaters in cabs) and particular driving styles that were not fuel efficient (which was addressed through driver training).

- Tesco has achieved fuel savings of 4-5% as a result of introducing the Isotrak in-cab communication and information telematics system. This is equivalent to a saving of approximately £2 million for the company.

5 STRATEGIC MODELS CONCERNED WITH THE PHYSICAL SUPPLY CHAIN

Logistics and supply chain modelling can be used to address issues such as (d'Este, 2001):

- Developing and testing alternative supply chain and logistics strategies, such as alternative transport and inventory options;
- Optimising supply chain and distribution arrangements;
- Optimising the number, location and size of distribution points to meet delivery deadlines and cost requirements;
- Testing the robustness of logistical arrangements to changes in scale and pattern of demand;
- Testing system velocity and reliability;
- Finding lowest cost approach to meeting required service levels;
- Supply chain capacity analysis and finding bottlenecks, weak links and system limits;
- Evaluating the impact of investment to remove capacity and service constraints;
- Evaluating cost trade-offs such as warehousing and transport, and manufacturing location and shipping costs;
- Testing synergies between products or companies to test whether overall system efficiency could be improved by combining logistics operations;
- Resource allocation.

Strategic models concerned with modelling physical distribution operations typically use information about the quantity and location of goods produced, consumed, imported and exported in order to analyse depot networks (in terms of the cost, customer service levels, and physical distribution activity associated with different depot locations and depot numbers). The box below describes the main features of one such commercially available model named CAST.

Example of strategic modelling tool: The main features of CAST

CAST is a strategic and tactical supply chain modelling tool. Designed to create a computer model of a complex distribution operation (dedicated or network), it allows strategies to be run against that model to find a least cost solution. It is used to examine depot location and the flow of product groups throughout the entire supply chain. It optimises the cost of a proposed strategy by evaluation of the full range of costs including warehousing/transhipment, MHE, stockholding, handling and transport. Modelling can be within a single country, across a group of countries, or extend world-wide. CAST includes a worldwide road network database to enable modelling of supply chains in any single country, group of countries or globally.

Isochrone Modelling - In an increasingly competitive world, the cost to serve is an essential element to consider when optimising a supply chain network. CAST uses isochrone modelling techniques to display detailed service level information in both graphical and tabular formats, to assist the user in maximising customer satisfaction within specified service level criteria.

Transport Tariffs - The ability to model a wide range of transport options has long been regarded as one of the strengths of CAST. Now a new method of costing transport tariffs has been added to allow for the approach to handling vehicle costs used in North America.

This method will also have application worldwide and confirms CAST as the most powerful tool available for modelling a transportation network.

Inventory Modelling - The stock planning model has been constructed as a time-phased simulation using industry-standard decision-making algorithms. The facility is fully integrated within the CAST network planning model and provides clear graphical results, as well as a D.R.P. table displaying period by period output. Users are able to amend all the stock planning parameters and then instantly rerun the inventory model to calculate the implications of the changes, without running the main strategy model.

Centre of Gravity Modelling - CAST features both volume and cost based centre of gravity modelling. Used in conjunction with the heuristic network and stock strategy modelling options, centre of gravity modelling is used to make facility location decisions. The new volume based centre of gravity model includes a proprietary algorithm devised by Radical's development team. Centre of gravity models can be run with fixed facility locations, according to product group, supply and demand exclusions. To save time when project deadlines are pressing, the number of iterations considered by the centre of gravity model may also be limited.

Interfaces to Routing and Scheduling Packages - Three interfaces to routing and scheduling packages are now available and more will be developed in accordance with user demand. Interfaces to Paragon, Roadshow and ArcLogistics Route are now available. This makes it possible to take the results of a 'best case' strategy developed using CAST and 'drop' the results into one of the routing packages listed above. This avoids the problems of delays, cost and potential for error involved in the manual data manipulation.

MIP Optimiser - Historically developed using a heuristic approach to modelling, CAST now includes optimiser modelling, providing users with the opportunity to use either or both techniques. Input to the Optimiser consists of all the supply and demand points with their associated volumes, costs of operating all potential depots, and the costs of all feasible flows between the suppliers, depots and delivery points. The user has the choice of requesting the optimum number of depots or a specific number of depots that achieve the lowest cost. The user can then specify that certain depots must be used. The Optimiser will analyse all the volumes, flows and costs to select the optimum number and type of depots, and their location, for a given network. The result is then input to CAST's strategy model for detailed analysis and costing.

Source: CAST, not dated., product information, http://www.radicalglobal.com/products/index.htm

J Sainsbury, the UK food retailer, use strategic distribution planning software to analyse their distribution network. They use CAST–dpm to determine the optimum number and location of Regional Distribution Centres (RDCs) for the future. The software allowed them to study where they should site future RDCs and to measure the impact of opening or closing an RDC on the rest of the supply chain. J Sainsbury have also used CAST-dpm to identify the potential locations of intermediate warehouses (CAST, not dated).

6 B2B E-COMMERCE AND FREIGHT EXCHANGE SYSTEMS

At present the impact of business to business (B2B) e-commerce on transport remains uncertain. E-commerce will influence the freight transport system in two ways:

1. through online trading of food products in electronic market-places
2. through the online trading of freight capacity in freight exchanges

Figure A4-1 maps the complex inter-relationship between the growth of B2B and changes in freight traffic levels (McKinnon, 2003). A distinction is made between the online trading of commodities and logistics services. The trading of food products through e-marketplaces, such as Transora, has been reducing prices partly as a result of an intensification of competitive pressures but also through productivity improvements (see http://www.b2business.net/eMarketplaces/Major_Markets/Vertical_Industries/Food_&_Beverage/ for listing of the main e-marketplaces specialising in the trading of food products). These price reductions are likely to stimulate a growth in demand and hence increase in the quantity of food to be transported. E-marketplaces also make it easier for companies to trade with more distant suppliers and customers. This has the effect of lengthening supply lines and reinforcing the growth of tonne-km. These trends may be partly offset by a reduction in the wastage of food products and unnecessary movement of inventory. This is based on the reasoning that online trading and improved supply chain 'visibility' should improve the co-ordination of the supply and demand for foodstuffs. Overall, this is likely to moderate the increase in tonne-kms.

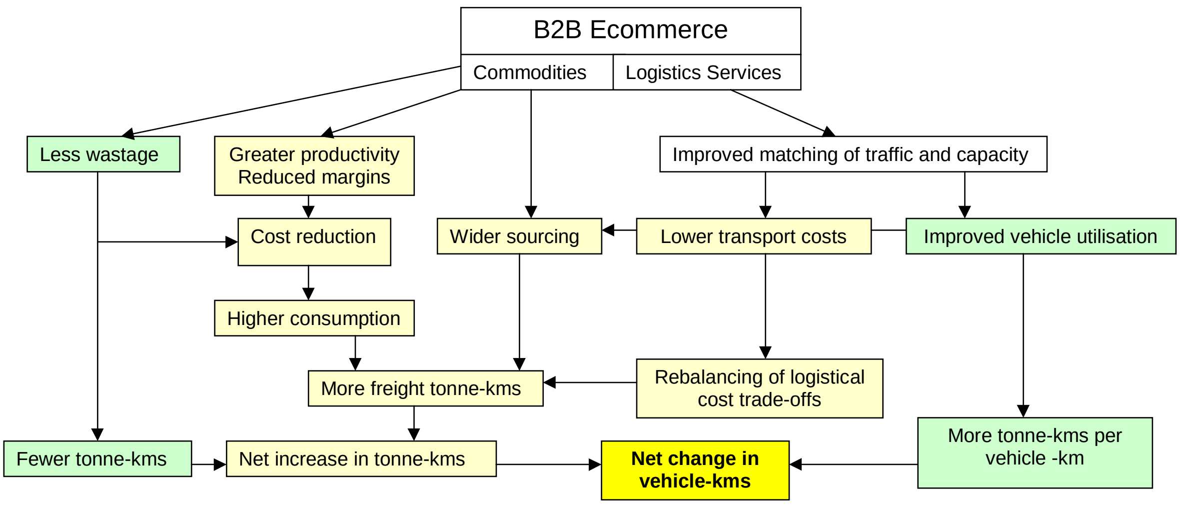


Figure A4-1: Possible Effects of B2B E-commerce on Freight Traffic Levels

The growth of online freight exchanges is likely to match traffic flows more closely to the available transport capacity. This has been demonstrated by the recent experience of web-enabled tendering in the European road haulage market. Vehicle load factors will therefore rise and the greater efficiency will be reflected in a reduction in haulage rates. This reduction in rates will be reinforced by a strengthening of competitive pressures within the e-market and some narrowing of margins. The decline in transport costs will indirectly encourage the trend to wider sourcing of products. It will also cause companies to rebalance their logistical cost trade-offs between transport, inventory, warehousing and production, promoting a shift to more centralised systems which generate more tonne-km per tonne distributed. This will reinforce the tonne-km growth associated with online commodity trading. This increase in tonne-kms, however, will not translate into a corresponding increase in vehicle-km on the ground. Improved utilisation of vehicle capacity will reduce the ratio of vehicle-km to tonne-km, mitigating the net effect on traffic volumes. It is impossible at present to quantify this net effect as it is subject to many countervailing forces whose relative strength has yet to be measured.

Example of Major European Online Freight Exchange: Freight-traders.com

Freight-traders, which is owned by the Mars Group, is one of Europe's largest online freight exchange. In 2002, it transacted approximately 1 billion Euro of haulage business. It has signed up 172 consignors and 1000 carriers (Rowlands, 2003). The company's Managing Director, Garry Mansell argues that, "The newly introduced Freight-traders TM internet-based cargo matching scheme is bound to make a significant contribution to improving the environment on and around the roads of Europe" (Mansell, 2000). He believes that, "Through the reduction in the number of trucks running empty - by creating the circumstances under which carriers can locate "backload" cargoes more effectively - total truck usage is expected to be substantially reduced. Overall, the result will be fewer trucks on the road, reducing both the levels of traffic congestion and the amount of air pollution created" (Mansell, 2000).

As well as potentially resulting in mileage reductions through backloading and reduced empty running, freight exchanges also offer the potential for transport cost savings for customers. For instance Kellogg's, European Distribution Procurement Manager, Ian McCartney has said, "The reason we use Freight Traders is the ease with which it is able to collect offers from a large amount of carriers at the same time. Irrespective of any freight cost savings, using Freight Traders significantly reduces our administration costs because we are not spending hours coordinating and chasing up carriers' offers. It offers one of the most straightforward systems to use, for both shippers and carriers, available in the marketplace and offers sufficient flexibility for us to be able to easily tailor each tender as we require" (McCartney, 2002). Numico NV a leading global manufacturers of baby food and infant nutrition products has reported that it reduced its freight rates by 12% year on year - a saving worth hundreds of thousands of Euros by using a freight exchange system (Freight Traders, 2002).

7 RETURN LOADING

Since the early 1980s there has been a fairly steady decline in the proportion of road vehicle-kms run empty. In recent years the DfT has published empty running statistics disaggregated by the main type of commodity carried on the previous laded trip. This indicates that the level of empty running in the agricultural sector is significantly above the average for all road freight operations, while in the case of 'other foodstuffs' and beverages it is lower. Unlike the trend in total empty running which has been following a steady downward trend, the levels for food products have tended to fluctuate. Since 1995, however, there has been a fairly steep decline in the empty running figure for 'other foodstuffs' from 27% to 23%. This may partly reflect the success of backloading initiatives in the food sector, particularly the 'supplier collection' and 'onward delivery' schemes operated by supermarket chains such as Tesco (DETR, 1999).

Return loading is likely to increase further with the expansion of load-matching services and a growth in the reverse flow of packaging material / handling equipment. It improves the vehicle utilisation and increases the number of drops per trip, thereby helping to reduce the total vehicle fleet required (McKinnon, 1996). Improved backloading and the resulting decline in empty running is reducing the ratio of vehicle-kms to tonne-kms.

Example of return loading: Tesco (DETR, 1997)

'Supplier collection' involves Tesco vehicles travelling from the RDCs to the stores, making a delivery, and then travelling onto suppliers to collect a primary load before returning to the RDC. 'Onward delivery' involves primary distribution vehicles operated by suppliers or third party providers. These vehicles traditionally delivered goods from the supplier's depot to the Tesco RDC and then returned without a load. Tesco was charged for this unproductive work. In the onward delivery scheme, after having carried out their primary distribution trip these vehicles are used to deliver goods from the RDC to stores. They then return to the supplier's depot (stores are selected on the basis of proximity to the supplier's depot). This helps to reduce unproductive, empty mileage. Trailer conversation was necessary in order to equip the vehicles for both primary and secondary distribution.

This scheme has required that trailers can carry both pallets (primary distribution) and store cages (secondary distribution). In addition, temperature-controlled vehicles had to be able to operate as single and multi-compartment, multi-temperature vehicles.

'Supplier collection' resulted in the total mileage (primary and secondary distribution) operated by Tesco being reduced by 3 million miles. This also resulted in a reduction in fuel consumption of 1.7 million litres and fuel cost savings of £720,000, together with a 4,600 tonne reduction in CO_2 emissions.

'Supplier collection' also resulted in better vehicle utilisation in terms of vehicle fill and usage. Over a five-year period (1993-1997) the scheme resulted in a 26.5% increase in the annual volume of goods carried by each trailer, and a 20% increase in the distance travelled by each trailer. This has enabled Tesco to meet its growing goods flows without having to make a proportionate increase in its vehicle fleet.

8 FACTORY GATE PRICING

One of the main developments in the UK food supply chain in recent years has been the move to factory gate pricing (FGP). This has been driven by the large supermarket chains, particularly Tesco and to a lesser extent Sainsburys. Suppliers are asked to quote prices with and without delivery costs to the retailers' RDC. Once the transport cost is separately itemised the retailer can determine if it would be able to collect the goods more cheaply either by:

1. backloading a shop delivery vehicle
2. having one of its vehicle make a separate trip
3. employing a haulier to pick up the goods

By taking responsibility for supplier collections, retailers can make more intensive use of their existing fleets (either of own account or dedicated contract vehicles). The volume of inbound supplies now governed by FGP now exceeds the excess capacity available in these fleets. Retailers are also employing hauliers to collect these supplies. Given their transport buying power, the large chains can generally obtain lower freight rates than the suppliers, cutting inbound delivery charges. As the Logistics and IT Director of Tesco explained, suppliers '…are not expert at buying and operating transport. We are. I have my own fleet to utilise and I can also buy transport on the secondary markets at good rates' (quoted in Aujla et al 2003).

This move to FGP is the culmination of a process which began in the 1960s when many supermarket chains began to extend their control back along the supply chain. Initially, this was confined to secondary distribution and involved retailers setting up regional distribution centres (RDCs) and taking responsibility for delivery from these RDCs to the shops (i.e. secondary distribution). In the late 1980s retailers began to exert more control over inbound flows into their RDCs (i.e. primary distribution): for example, requiring suppliers to channel their products through primary consolidation centres (PCCs). Over the past decade they have also increasingly used returning shop delivery vehicles to collect inbound supplies. This has been done on a fairly opportunistic basis. FGP represents a much more systematic effort to wrest control of primary distribution from suppliers. Retailers can then more effectively integrate primary and secondary distribution, mainly to improve the utilisation of vehicle capacity and cut supply chain costs.

By February 2003, Tesco had negotiated FGP arrangements with 500 of its suppliers which were collectively responsible for 30% of its inbound supplies, representing 30 million cases per annum. Sainsbury had FGP arrangements in place with 200 of its suppliers.

An analysis by researchers at the University of Cardiff (Potter et al, 2003) has suggested that, by combining FGP with the use of inbound consolidation centres, Tesco should be able to achieve a 28% reduction in the number of vehicle-kms required move supplies into its distribution centres (equating to 64,000 vehicle-kms per week).

While an individual supermarket chain, such as Tesco, may be able to cut its transport costs and traffic levels by a significant margin, there is no guarantee that across the grocery sector as a whole there will be savings. Suppliers, after all, have still to maintain a distribution system to service other smaller customers. The abstraction of the large orders to chains such as Tesco and Sainsbury is likely to reduce load factors on their remaining deliveries. No analysis has yet been done to assess the industry-wide effects of FGP on transport efficiency.

It has been suggested that the move to FGP will induce some restructuring of the food supply chain. A larger proportion of smaller retailers and catering establishments may now be served indirectly via wholesalers, rather than directly by suppliers. The Chairman of the large food wholesaler P&H McLane, for example, has stated that, 'If 40% of a supplier's distribution is removed through factory gate pricing, the cost of supporting the other 60% goes up, which is where wholesalers come in.' (quoted in Aujla et al., 2003, p.19). Suppliers are also likely to switch more of their less-than-truckload orders to hub-and-spoke pallet-load networks.

Another possibility is that by cutting retailers' inbound transport costs, FGP will encourage the trend to wider sourcing of food products. The upward trend in food tonne-kms may then be reinforced. If this is accompanied by improved loading of vehicles, at least those serving the large supermarket chains, the net effect on lorry traffic levels (measured in vehicle-kms) might still be positive in environmental terms.

9 FLEET MANAGEMENT AND DRIVER TRAINING

Fleet management and driver training can help to increase fuel efficiency and improve driver safety. Using fuel more efficiently can result in the following benefits:

- Lower costs
- Improved profit margins
- Reduced emissions
- Improved environmental performance

Safer driving can result in:

- Fewer accidents involving goods vehicles (leading to fewer injuries and fatalities)
- Less accident damage to vehicles
- Less unproductive downtime for vehicle repair
- Reduced insurance premiums
- Improved resale vehicle values
- Reduced running costs (in terms of maintenance and tyres costs)

The UK government has been actively promoting fleet management and driver training programmes for several years. It has been estimated that fuel management programmes are likely to result in fleet-wide fuel saving costs of approximately 5% (Fuelwise, 2001).

The Safe And Fuel Efficient Driving (SAFED) Standard has recently been launched by the Department for Transport (TransportEnergy, 2003b). In this scheme, the candidate's driving is initially assessed by a qualified instructor. The candidate then receives training on best practice in safe and fuel efficient driving techniques. The candidate's driving is then reassessed to record improvements in driving performance and actual fuel consumption. The final grade allocated to each candidate depends on performance in safety check and theory test exercises as well as the number of faults recorded during the day's practical driving sessions. Successful candidates receive a certificate of achievement. Trials conducted with seven different drivers of varying experience, using a range of vehicles from 7.5 to 44 tonnes maximum permissible weight, over a variety of training routes as part of the pilot phase of the SAFED project resulted in fuel savings of between 4.3% and 9.2% among these drivers and vehicles (University of Huddersfield, 2003).

The government are promoting this scheme as being of benefit to operators (in terms of reduced costs, better vehicle resale values and less disruption to operations caused by vehicle accidents), to drivers (in terms of improved confidence in driving performance and reduced stress while driving) and to the environment (in terms of reduced fossil fuel use, CO_2 and other pollutant emissions, reduced accident rates and better health and safety culture within companies).

Several facts concerning driver performance and vehicle maintenance are provided by the government in their promotion of the scheme are shown in Table A4-2.

Table A4-2: Facts about driver performance and vehicle maintenance

Topic	Fact
Braking	Smooth and progressive braking will save fuel and reduce stress on the driver, vehicle and load.
Clutch Control	Double-declutching is not necessary on synchromesh gearboxes. It increases clutch wear and wastes fuel.
Cruise Control	To maximise fuel economy, cruise control should be used whenever safe and appropriate.
Exhaust Brake	Use of the exhaust brake will contribute to smoother decreases in speed, increase the lifespan of brake linings and save fuel.
Adjustable Aerodynamics	Correctly adjusted air deflectors will save fuel.
Forward Planning	By planning well ahead and keeping the vehicle moving, gear changes will be reduced And fuel will be saved. Forward planning also helps to improve road safety.
Gear Selection	Keeping the engine speed within the green band and using the highest gear possible optimises fuel consumption.
Hazards	Use of information gained through observation gives more time to plan ahead and systematically avoid hazards.
Height of the Load	The height of a trailer or load should be kept to a minimum to reduce aerodynamic drag.
Positioning a Load	The positioning of a load, particularly on a flat trailer, can influence fuel consumption.
Skip Gears or Block Changes	The fewer the gear changes, the less the physical activity needed by the driver and the more fuel efficient the operation.
Overfilling the Fuel Tank	Overfilling the fuel tank allows fuel to leak through the breather.
Momentum	Using the momentum of the vehicle will save fuel.
Speeding	Speeding is illegal, jeopardises road safety and reduces fuel efficiency.
Plan Your Route	Effective route planning minimises the total amount of fuel used.
Low Revs, Low Noise, Low Emissions	Quiet operations produce less air pollution.
Motorways and Dual Carriageways	Use of constant speeds on motorways and dual carriageways will enable full use of cruise control, leading to less gear Changes.
Tyres	Correctly inflated tyres offer less resistance on the road, increase fuel economy, give greater stability and reduce the risk of accidents.
Vehicle Technology	Technology will only assist in fuel economy and safe and efficient operation if the driver is fully familiar with the vehicle's systems.
Weather Conditions	Derv does not burn as efficiently in bad weather due to a poor fuel/air mix and adverse weather conditions make driving more hazardous.

Source: adapted from Transport Energy, 2003b

Example of a fuel management and driver training programme: Thorntons
(DETR, 1999a)

In 1994, Thorntons (the manufacturer of chocolates, toffee and ice cream) joined a programme funded by the European Commission's SAVE programme. The aim of the programme was to develop a simple method of fuel management for goods vehicle fleets which could be readily applied in other companies. The first phase of the project involved (DETR, 1999a):

- Accurately monitoring the fuel performance of a sample of similar vehicles in the fleet
- Inform the drivers of how they were performing
- Train and encourage the drivers to improve the fuel efficiency of their vehicles
- Monitor and report the improvements

Both manual and automated data capture of vehicle performance was used in the project. This first phase of the project resulted in fuel savings of 3% in the first year across the entire fleet which was equivalent to a fuel expenditure saving of £7,300. Taking into account the staffing costs of the scheme which were £4,200, the net annual cost saving in year one was £3,100. Given that the set-up costs for the scheme were £3,050 (for software, in-cab computer and management time) the project had a payback period of one year.

In phase two of the project eight vehicles were fitted with in-cab data loggers capable of recording date and time, engine speed, road speed, idling time, distance, number of brake applications, harsh braking and rapid acceleration). These devices were therefore used to help identify the source of fuel efficiencies. Data loggers are also estimated to reduce accident rates by approximately 50%. Set up costs for phase two were £9,000 plus £700 for management time. Annual running costs of the project were £4,120 (to produce weekly reports and for staff time with the manual system which continued in other vehicles not fitted with the data loggers). A 5.8% reduction in fuel consumption was achieved, which is equivalent to a £14,500 reduction in fuel costs. Net annual savings were therefore £10,380 and, given the set-up costs, the payback period for the scheme of 11 months. Lower maintenance costs and reduced accidents which were also expected as part of the project have not been included in these calculations.

Example of a fuel management and driver training programme: McKelvie & Co
(DETR, 1999b)

A low-cost driver training scheme was set up in 1992 at McKelvie & Co a division of TDG. The company offered mainly dedicated distribution services throughout the UK. It operated a fleet of 152 vehicles. The intention of the scheme was to achieve reductions in fuel use, pollution and accident rates. The scheme resulted in fuel savings of 6% in the first year, rising to 8% by year three. The company reduced its annual CO_2 emissions by an estimated 740 tonnes, and accident rates per driver were also reduced. The set up costs of the scheme were £3,000, and the cost of running the scheme was £35,200 in the first year and £31,400 in subsequent years. The annual fuel savings in the first three years of the scheme were £49,000, £81,600 and £113,000 respectively. Net annual savings worth a total of approximately £145,000 were achieved over the first three years. In addition, vehicle accident costs fell by approximately £11,000 over the first three years, and maintenance costs were also reduced. The payback period of the scheme was calculated as nine months in year one; this has reduced to three months by year three (DETR, 1999b).

Example of a fuel management and driver training programme: BOC Gases
(Energy Efficiency Best Practice Programme, 2002)

BOC operates approximately 2,000 HGVs. Its Bulk Gas Delivery section operates approximately 200 vehicles with an annual fuel expenditure of £5 5 million. A fleet of over 700 vehicles, delivering gas cylinders, consumes fuel with a similar value. The bulk gas delivery vehicles are specialist tank vehicles distributing oxygen, nitrogen, carbon dioxide carbon monoxide, hydrogen and argon.

BOC Gases decided to set fuel saving targets for the Bulk Gas Delivery Fleet of £340,000, which represented about 3% of the previous year's fuel costs. This was achieved by a range of measures including:

- Nominating a 'Fuel Champion' to monitor and target fuel usage
- Continuous support, involvement and commitment from top management
- Introduction of in-house driver trainers
- An accurate method of collecting real-time vehicle mileage and fuel data
- Setting up fuel consumption benchmarks for specific routes and vehicles
- On-board vehicle and driver performance monitoring

Through this approach BOC Gases managed to reduce both its fleet energy costs, and the amount of exhaust emissions. Savings achieved through driver training amounted to £240,000 or 4.3% of the annual fuel expenditure with a three to six month payback. Another £110, 000 was saved by optimising the bulk storage of fuel. Aerodynamic kits demonstrated a potential fuel saving of 4% on the selected vehicle routes with a five-month payback.

Improvements in fuel used to refrigerate food products during transportation

The Transport KPI surveys in the food sector have revealed that refrigerated vehicles often wait fully loaded for 4-5 hours prior to despatch with the refrigeration equipment operating (McKinnon, 1999). Much more energy is required to keep products cold in a temperature-controlled vehicle than in the average cold store. The main reason for this pre-loading of vehicles is that cold store managers try to smooth the workload in the warehouse or get staff to load vehicles before the end of a shift. Warehouse efficiency is given priority over transport efficiency. In frozen and chilled distribution, more could be done to co-ordinate cold store and delivery operations to reduce total energy consumption.

Aerodynamics

Aerodynamic styling of goods vehicles can help to reduce fuel consumption. Such devices can also result in other benefits including spray reduction, soiling reduction, a reduced sensitivity to side winds and improved performance at high speeds. A publication by the Energy Efficiency Best Practice Programme in estimated that suitable aerodynamic styling fitted to a vehicle used on long distance routes could result, on average, in a 6-12% reduction in fuel consumption (compared with a vehicle with no aerodynamic styling or poorly adjusted features). Many of these devices have been calculated to have payback periods of less than 3 years, with some devices having payback periods as low of 3 months (ETSU & MIRA, 2001).

10 VEHICLE ENGINES AND FUELS

An important factor in the quantity of fossil fuel use and pollutants emitted by goods vehicles is the fuel efficiency of the vehicle. Some of the operational factors that can help to improve fuel efficiency such as fleet management and driver training, computer vehicle routing and scheduling systems and in-vehicle telematics have already been discussed (see section 9). The UK government has acknowledged that, "Good practice in vehicle specification, maintenance, operation and driving has far greater potential for fuel consumption improvement than fuel or engine based interventions" (Department for Transport, 2003).

However, fuel or engine based interventions can play a part, albeit relatively small, in improving the fuel consumption of goods vehicles. They can also play a role in reducing pollutant emissions. This can occur in two ways: first efforts to improve the fuel efficiency and reduce the pollution associated with diesel engines, and secondly, the use of alternative, less polluting fuel sources.

These approaches are applicable across all industries using goods vehicles and are not only limited to food supply. Therefore only summarised material on these interventions are provided in the following sections. However, a lot of documentation on best practice in this field has been produced (see for example TransportEnergy, 2003c; TransportEnergy, 2003d).

Diesel engines – emissions reductions

Since October 2001, goods vehicles over 3.5 tonnes are being manufactured to Euro III engine standards, which has helped to reduce local air pollutant emissions. However, there is debate about the effect of Euro III standards on fuel efficiency, with some reports suggesting that fuel efficiency has worsened by 3%, with CO_2 emissions actually increasing as a result (Garnett, 2003).

There are a range of measures that can be taken to reduce emissions from existing diesel vehicles. These includes different types of exhaust after-treatment technologies and the use of cleaner diesel fuels:

- Particulate traps
- Oxidation catalyst
- Selective Catalytic Reduction
- Exhaust Gas recirculation
- Repowering
- Water Diesel Emulsion
- 10ppm sulphur diesel
- Biodiesel

However, whilst reducing pollutant emissions, these approaches do not necessarily reduce fuel consumption. For instance, particulate traps can increase fuel consumption, "Fuel consumption can increase by a few percent in urban areas, but is likely to be minimal for motorway driving or if the trap is properly maintained (TransportEnergy, 2003c).

Grants are available from the government (under the CleanUp programme) to encourage fleet operators to fit the devices listed above to reduce emissions from commercial diesel vehicles. These grants are intended to help offset the cost of purchasing and fitting a range of different emissions reduction technologies. Some of these devices (such as particulate traps and Selective Catalytic Reduction) can result in increased vehicle maintenance costs.

Reduced Pollution Certificates (RPCs) have been available since 1997 as an incentive for operators to use vehicles that emit fewer pollutant emissions. Vehicles with RPCs obtain a £500 reduction on the normal VED. RPCs are available for new vehicles that meet the required emissions criteria, and also for retro-fitting existing vehicles. However take up of vehicles that qualify for RPCs has been relatively low to date. The review of VED that resulted in significant reductions in Vehicle Excise Duty (VED) for the heaviest goods vehicles in November 2000 has made the financial benefits of RPCs less attractive.

Examples of companies adopting these approaches include Tibbett and Britten which has fitted particulate traps to 32 new heavy goods vehicles. These vehicles are used on the company's contract with B&Q. Tibbett and Britten had to pay £33,700 and received government grants totalling £100,000. Gist has fitted particulate traps to 100 of their 28-tonne tractor units. Gist had to pay £80,000 in total for these traps and received government grants of £240,000 towards the cost (75% of the total) (Distribution Business, March 2002).

Diesel engines – fuel efficiency through fuel supply and engines

The UK Government has been actively encouraging companies to consider their existing fuel supply systems and the efficiency of diesel-powered vehicle engines in order to save both fuel consumption and money. They have identified five stages in which fuel inefficiencies can occur "for a road vehicle with an internal combustion engine from delivery to the storage point to the final dissipation of all of its latent energy" (Department for Transport, 2003). These are:

- Delivery, storage and issue
- Vehicle tank to engine.
- Through engine to flywheel
- Flywheel to road wheels
- Energy to vehicle motion

The fuel consumption of goods vehicles can be improved by "improving the efficiency of the engine as a converter of fuel into useable mechanical energy at the flywheel" Department for Transport, 2003). This can occur in two ways (Department for Transport, 2003):

1. by reducing the internal losses in the engine itself and to its ancillaries,

2. by improving the basic process of conversion of fuel to gaseous heat and pressure and hence to mechanical energy.

There are several methods by which each of these can be achieved (Department for Transport, 2003):

Reduce Internal Parasitic Losses (Reduce internal friction, pumping losses and power to ancillary drives)
- Mechanical and fluid friction losses
- Cooling system
- Secondary drives and systems
- Induction and exhaust losses

Improve Energy Conversion Rate (More energy delivered to the piston per unit mass of fuel)
- Fuel quality and chemical effects
- Mixing fuel and air
- Timing effects and engine management
- Mechanical design factors

Alternative fuels

Alternative fuels that are less polluting than diesel are available for specially-designed or adapted goods vehicles. These include liquified petroleum gas (LPG), natural gas

(CNG/LNG) and electricity. Grants are made available by the UK government through the Powershift scheme to assist with purchasing new vehicles fitted with these fuel systems as well as for retrofitting older vehicles. Examples of companies that have adopted these fuels are provided in the boxes below.

Examples of companies using LPG: Joynson Bruvvers and Sutton and East Surrey Water

Joynson Bruvvers Ltd (JBL) is a family-owned independent office supply company based near Oxford. They have a fleet of six distribution vehicles, three of which run on LPG. The vehicles are used for multi-drop work around Oxfordshire, with a typical route involving 40 drops per day and a total monthly mileage of around 1,500 miles per vehicle. The LPG vehicles are used on all routes. The LPG vehicles emit 9% less CO_2, 46% less CO and 57% less HC and NOx than the comparable petrol vehicle. There is a small loss in payload volume and weight due to the additional LPG tanks. The total running costs of the LPG vehicles are similar to those of the diesel vehicles (TransportEnergy, 2002a).

Sutton and East Surrey Water operate 21 bi-fuelled LPG/petrol-powered vehicles (3 cars and 18 vans) in their fleet of 156 vehicles. The 18 LPG Vauxhall Astra vans travel approximately 270,000 miles per year in total and it is estimated that using LPG will result in a total emission saving of nearly eight tonnes of CO2 when compared to the petrol-fuelled vehicles. The LPG vans emit 11% less CO_2, 39% less CO and 33% less HC and NOx than the comparable petrol vehicle. The fleet manager, has estimated that the annual fuel cost savings are £17,000. The total additional purchase cost for the fleet of 21 LPG vehicles was £21,150 (compared to the petrol version). The company received a 75% grant from TransportEnergy PowerShift. The company therefore had to pay £5,290 in additional purchase costs, or an average of £250 per vehicle (TransportEnergy, 2003e).

Examples of companies using CNG in the food sector: Safeway and Warburtons

One of the biggest users of CNG-powered goods vehicles is Safeway which currently operates 85 CNG-powered vehicles. This represents 11.5% of the total fleet. The company has its own network of CNG refuelling stations. As the company says in its Corporate Social Responsibility Report for 2003/4, “Safeway continues to work with manufacturers in order to encourage investment in CNG vehicles suitable for the supermarket sector. Third party operators, such as hauliers and suppliers, are also being encouraged to use CNG by refuelling at the depots with workshops held to demonstrate the business case for CNG, in Safeway’s case total life costs of CNG and 10% less than for diesel equivalent vehicles” (Safeway, 2003).

Warburtons, the bakers, operate CNG-powered vehicles in their delivery fleet. In March 1999 they added two ERF dedicated CNG Cummins-engined large commercial vehicles to their fleet, which already comprised 10 CNG vehicles that they had acquired in 1998. They also have refuelling facilities at their Bolton depot. All the vehicles are used to deliver the company’s bread products to food stores throughout the country. The two vehicles purchased in 1999 emit 3% less CO_2, 80% less CO and 34% less PM and 57% less HC and NOx than the comparable diesel vehicle. The cost of a CNG vehicle is between £10,000 and £13,000 (on rigid vehicles) and approximately £20,000 (for tractor units) extra than conventional diesel vehicles. Warburtons received a 50% TransportEnergy PowerShift grant towards these additional purchase costs. In terms of fuel economy and costs the company has calculated that the vehicles’ fuel consumption is about 1.5 miles per kg of CNG compared to 2.5 miles per litre of diesel. Given that CNG is far cheaper than diesel, this has resulted in a reduction in fuel costs of approximately 10% (TransportEnergy, 2002b).

11 GROCERY HOME DELIVERY AND CAR-BASED SHOPPING TRAVEL

Grocery home delivery operations have been expanded significantly in recent years. Total home delivery grocery sales was £197 million in 1999 (Insightresearch.co.uk quoted in Powell, 2000). This was estimated to have increased to £530 million in 2000 (Verdict 2001). This was equivalent to approximately 0.7% of total multiple grocery retailer sales in the UK, and about 0.3% of total retail sales in the UK. In 2002, Verdict forecast that grocery home delivery will increase rapidly over the next five years; it estimated growth of 269 per cent to £5 billion over the next five years (thereby estimating current UK grocery home shopping sales of approximately £1.35 billion in 2001) (reported in e.logistics, 2002).

Grocery home delivery operations result in passenger trips to supermarkets being replaced by goods vehicle deliveries. These operations therefore have the potential to alter the tonne-kilometres and vehicle-kilometres associated with this last leg of the supply chain. Several studies have examined the effect of grocery (and DIY) home delivery on vehicle trip generation.

Farahmand and Young (1998) modelled the vehicle trip effects of home delivery for a typical UK grocery store with gross floor area of $2500m^2$, and a typical DIY store with gross floor area of $10000m^2$. They assumed pre-home delivery weekday PM peak hour trip rates of 18 trips per $100m^2$ for the grocery store and 10.2 trips per $100m^2$ for the DIY store, that 10% of shoppers at both stores would switch to home shopping, and that delivery vehicles would carry nine customers’ loads on each round trip. The results of their modelling are shown in Table A4-3.

Table A4-3: Summary of results

	Total trips generated prior to home deliveries	Total trips generated in home delivery system	Reduction in vehicle kilometres for trips previously made by home shoppers (%)
Grocery store	450	410	87
DIY store	1020	930	87

Note: It is important to note that the 87% reduction in vehicle kilometres refers to the comparison between those trips previously made by car which, as a result of the home delivery service, are now made by vans. It does not mean that the total vehicle kilometres travelled to and from the shops by all customers is reduced by 87%.
Source: Based on data in Farahmand and Young (1998).

Cairns (1999) modelled grocery home deliveries in Witney in Oxfordshire in the UK. Her findings indicated that if 10-20% of total shoppers were to use home shopping, the switch from customer car journeys to multi-drop van deliveries could lead to a 7-16% reduction in trip numbers (as vans replace car trips) and a 70-80% reductions in vehicle kilometres (for those customers using the home shopping service), even if each delivery van only carried eight loads of shopping. Cairns notes that even "if deliveries have to be within tight time constraints, there are still likely to be savings, since this will simply mean that more vans are required, each carrying a lower number of shopping loads. In the worst case, of course, vans would simply act as if they were cars, carrying one load of shopping each, and delivering to only one household. Hence, a delivery service would never generate *more* travel than individual car trips, when operating from a local base, providing all users got to the shops some other way, or ordered their shopping from home, and assuming no other changes in customer behaviour" (Cairns, 1999).

Punakivi and Saranen (2000) modelled the potential mileage effects of grocery home shopping in Finland. It was assumed that 1.63% of the 202,000 population spread over an area of 135 km^2 used the home shopping service. The calculations were based on actual shopping data for one week from five grocery shops in Finland's second largest grocery chain and actual details of customers' homes. All orders over 150 FIM were modelled as home deliveries; 1639 such purchases were made during the week. Four different home delivery services were modelled; these varied in terms of how long after the order the delivery was made and the time window offered. Table A4-4 shows the effect on mileage travelled.

Table A4-4: Effect Of Home Delivery On Mileage And The Number Of Delivery Vans Required

	Mileage per week (Car = 100)
Use of own car (current system)	100
Home delivery – next day in 1 hour slots	46
Home delivery – same day in three 2 hour slots	24
Home delivery – next day in reception box	13
Home delivery – chosen day in reception box once per week	7

Source: based on data in Punakivi and Saranen (2000).

Punakivi and Saranen (2000) also calculated the cost to the grocery chain of providing these different customer service thresholds. It was estimated that to offer next day delivery within a one hour time slot would be more than three times as expensive as delivery on a chosen day into a reception box at the customers' homes (so that the delivery could be made at any time of day) once per week.

Reductions in vehicle emissions were also calculated by Punakivi and Saranen (2000). For the best home delivery scenario CO emissions would be reduced by 98%, HC by 95% and NO_x by 75%.

Palmer (2001) modelled grocery home shopping using a large database of shopping activity and actual store locations. Two scenarios were examined for 2003, 2005 and 2010: (i) delivery from existing stores, and (ii) delivery from a mixture of stores and dedicated fulfilment centres. The results suggest that if one-third of all affluent households used grocery home shopping by 2010, there would be an overall reduction of approximately 20% in the total vehicle mileage associated with grocery transport of all affluent households.

These studies all indicate that home delivery could prove beneficial in reducing vehicle trip rates and the total distance travelled. This could obviously help to reduce traffic congestion as well as environmental impacts such as fossil fuel use and pollutant emissions and accident rates. However, it should be noted that vehicle-kilometres reductions are dependent on whether these households substitute grocery shopping trips for other types of trip. Also, grocery home shopping will also result in increases in the number of goods vehicle trips in residential areas, which may impose environmental and social impacts.

Companies operating home delivery services can use IT to help make these services as efficient for possible. For instance, Tesco uses Paragon (computerised vehicle routing and scheduling system). Customers place their orders online and select a two-hour delivery window. The order is then allocated by postcode to a local store and the data is transferred to Paragon at that store to plan the delivery. Paragon then communicates the order back to other Tesco IT systems to generate picking lists and delivery manifests for the driver. This system functions automatically and requires no operator intervention on a day-to-day basis (Distribution, 1999).

11. FACTORS LIKELY TO OFFSET THE WIN-WIN POLICIES

Factors which may reduce or outweigh the benefits of the policies described in the preceding sections include:

- Quick response product replenishment
- Impact of congestion on journey reliability
- Drivers hours legislation/driving licence changes
- Sourcing strategies (length of haul over which food products are moved from source to point of sale)
- Increase in product range and availability
- Use of air freight for food transportation

11.1 Quick-response

Quick response generally entails more frequent delivery of smaller orders. Other things being equal, one would expect it to reduce the average size and weight of consignments. In a survey of 44 UK frozen food suppliers carried out in 1998 (McKinnon and Campbell, 1998) it was found that average consignment size has, in fact, declined from 11.7 pallets to 9.8 over the previous three years (Figure A4-2). It was predicted that this average would drop further to 8.4 pallets by 2001 (no follow-up survey was undertaken to check the accuracy of this prediction). When these averages were weighted by company turnover, however, a different picture emerged. This suggested that the average order size had been fairly stable and would drop only slightly over the next three years.

Several of the larger firms acknowledged that quick-response had been exerting a downward pressure on order size but this had been largely offset by an underlying growth in sales volumes.

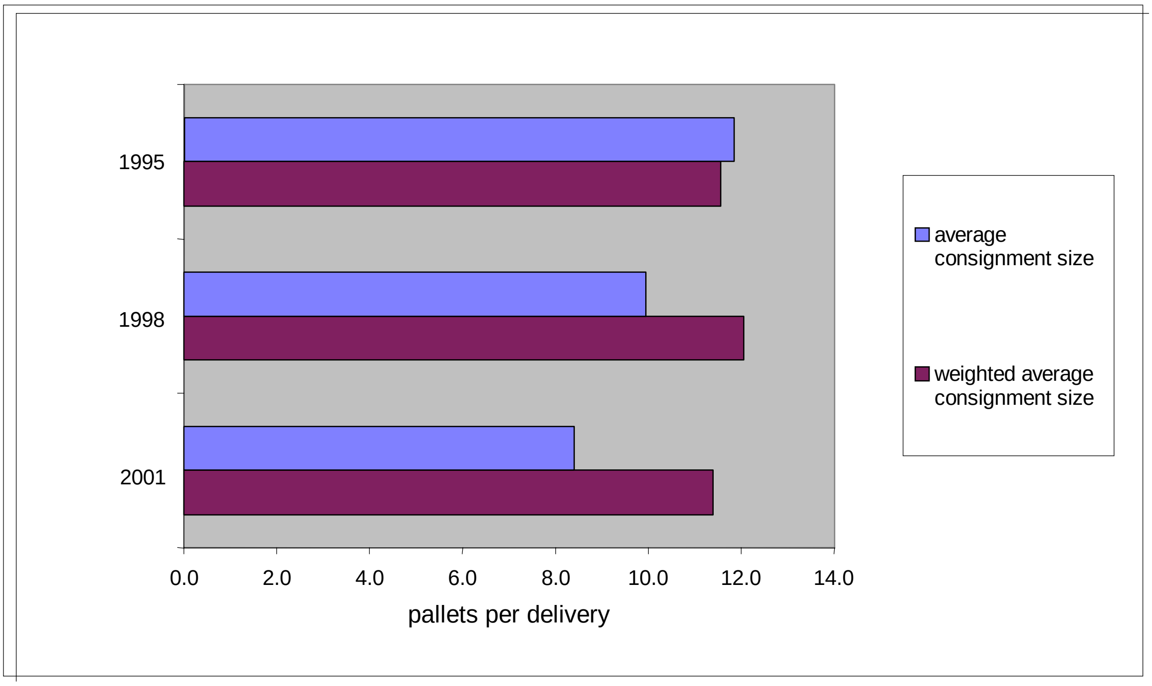


Figure A4-2. Average Consignment Size for Frozen Food Products, 1995-2001

It is often argued that the move to more frequent ordering of smaller quantities is reducing vehicle load factors and thereby generating extra lorry traffic per tonne of product delivered. It is important, however, to emphasise the distinction between order size and vehicle payload. As several orders can be consolidated in a single load, a decline in average order size need not result in a contraction of the average payload. Assuming that the capacity of the vehicle remains unchanged, a reduction in average order size can be offset by an increase in the degree of load consolidation. The 1998 survey evidence indicated that several developments have been increasing the level of consolidation:

- concentration of production capacity in fewer plants; in some cases this has followed company mergers / takeovers, in others it has involved the internal restructuring of a single firm's product operation.

- concentration of manufacturers' cold storage space at fewer sites:

- concentration of retailers' cold storage capacity in fewer RDCs, resulting in flows of frozen food being channelled through fewer locations: for example, between 1993 and 1998, J. Sainsbury reduced the number of RDCs with a cold store from 13 to 4 7.

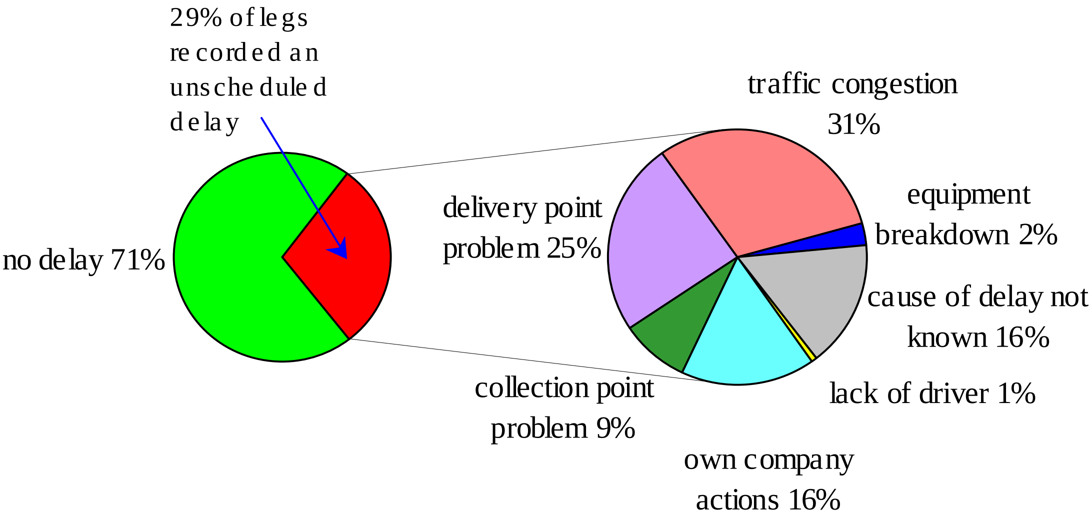
- greater use of third-party consolidation services provided by logistics service firms

These trends tended to counteract the downward pressure on order sizes which many firms reported. The net effect on vehicle utilisation was difficult to determine, however. This is partly because many of the firms consulted were unable to provide utilisation data but also because of difficulties in establishing a consistent measure of vehicle loading.

11.2 Impact of Congestion on Journey Times:

The 2002 Transport KPI survey in the food supply has shed some light on the relative importance of traffic congestion (Figure A4-3). Of the 15,250 journey legs monitored, approximately 29% were subject to a schedule deviation. Traffic congestion was the main cause of 31% of these delays. A much larger proportion of delays (50%) resulted from problems at the delivery or collection point or actions by the company responsible for the delivery. Focusing on the main cause, however, overlooks the inter-relationship between by these different causes and possibility that a delay originally caused by heavy traffic can be amplified by booking in restrictions at distribution centres and shops. Many companies are, however, building additional slack into their schedules to buffer against these various forms of delay. This is increasing delivery costs and partly offsetting the efficiency trends outlined earlier.

Figure A4-3. Main Causes of Schedule Deviation in the Food Supply Chain

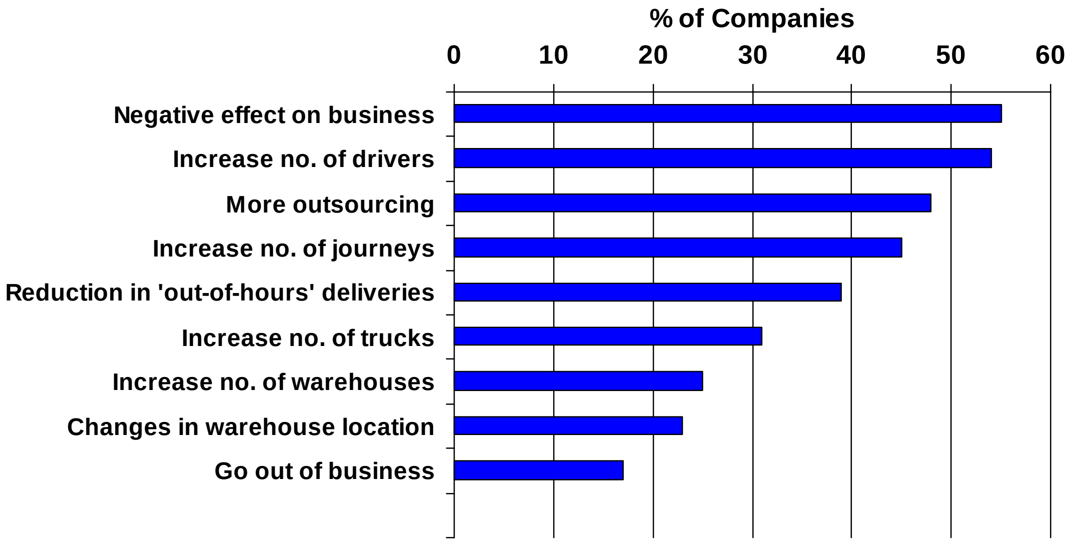


Source: 2002 Food KPI Survey (McKinnon and Ge, 2003)

11.3 Effect of the Working Time Directive on Distribution Operations

The Lex Transfleet / FTA 2002 survey of around 200 fleet managers enquired about the likely effects of the working time directive (WTD) on their companies and transport operations (Figure 5). Just over half of them anticipated that it would have a negative effect on the business, mainly by increasing the number of drivers required. As there is an acute driver shortage in some parts of the country, finding the additional drivers may prove difficult. Roughly 45% of the respondents predicted that the number of separate journeys would have to increase, presumably because the working time limits would restrict the length of some journeys, particularly during the night. Night time operations are likely to be most serious effected by the WTD. It may limit opportunities for night-time working and force a higher proportion of deliveries to made during the day when the road network is more congested.

Figure A4-4. Predicted Effects of the Working Time Directive



Source: Lex Transfleet / FTA (2002)

11.4 Effect of US Bioterrorism Act on the global distribution of perishable food

The long distance movement of food by air to and through the United States has been complicated by the imposition of the Bioterrorism Act (BTA) of 2002. This legislation, which is designed to improve the traceability of food across the international supply chain, requires all importers and carriers of food products to notify the US Food and Drink Administration at least 8 hours prior to their arrival at a US port or airport. If this advance warning is not provided, the food consignments are impounded. This regulation applies both to imports and food transhipped via the US ports and airports. This has created particular problems for companies distributing fresh produce by air via the United States. Given the reduction in production and distribution lead-time, to enhance product quality and cut inventory levels, airfreight companies often only get details of consignments shortly before they are despatched. Airfreight information systems, linking airlines, freight forwarders, transit shed operators and importers, are often unable to respond rapidly enough to meet the requirements of the new legislation. A significant amount of perishable food is not 'flown as booked', risking 'administrative detention' at a US airport. As temperature-controlled storage facilities are very limited at most US airports (with the exception of Miami, which has become a major food distribution hub), there is an increased risk of airfreighted food consignment being wasted. It has been estimated that worldwide around 40% of the air freighted food is already lost as waste (*Distribution Business*, October 2001). The European Commission has also expressed concern that the BTA is acting as a 'burden on trade' particularly for food and drink consignments transiting the United States.

11.5 Sourcing strategies

The UK food industry is likely to continue to increase the quantity of food sourced from overseas (Garnett, 2003). A report entitled The Future of Global Sourcing by the Institute for Grocery Distribution in 2002 predicted that "factors such as declining trade barriers, rising price transparency and advances in technology will combine to make global trade easier. As a result, retailers will seek out new suppliers in new markets to meet consumer demands, particularly those related to variety, availability and price"

(IGD, 2002c). All other things being equal, as the proportion of products being sourced from more remote locations increases, so too does the total transportation required to supply these products to consumers.

11.6 Increases in product range and availability

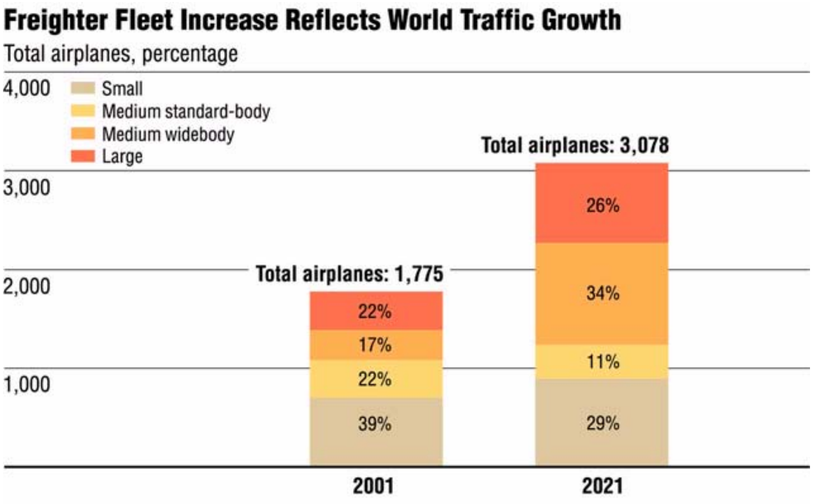
Hart (1999) studied changes in product assortments in several food and mixed retailing operations over a 5-10 year period. "Each retailer gave a total figure for current product lines compared with the total number of lines ten years previously. Examining the percentage change in product lines across both retail sectors there is seen to be a clear difference in trends between the food and mixed retail businesses in the sample….. Food retailers had all expanded their lines, from a minimum of 7 per cent to a maximum of 400 per cent. The relative number of lines also varied. Food A demonstrated 120 per cent growth, from 9,000 lines in 1984 to 20,000 lines in 1994; Food B, indicating a 10 per cent growth, had expanded from 22,500 lines to 25,000 lines. In the most extreme case, Food D had expanded by 400 per cent from 600 lines to 3,000 lines. Interestingly, an optimum limit of 25,000 lines appeared to have been reached by the food retailers generally, although not all stores carried the full range. These figures may be related to the growth in store sales area which peaked during the time of the study. Furthermore, the overall increase in lines during this period could be attributed to the more sophisticated space modelling and sales-based ordering systems which have enabled a higher concentration of lines per square foot, resulting in more effective space utilization."

Increases in the variety of products being sold in food stores are likely to continue in future (including exotic items grown overseas), as is the trend in providing seasonal products on a year-round basis. As Urban (1998) has noted, "It has long been acknowledged that displayed inventory has an effect on sales for many retail products". These increases in product range and availability may well result in increases in food transportation, depending on the extent to which consolidation of these product flows can be achieved.

11.7 Use of air freight

Forecasts for air cargo indicate that demand will increase over the next two years, and will result in a level of demand that will overcome the downturn that started at the end of 2000 (Boeing, 2003).

The greater cargo security requirements for passenger airlines that have come into force in the last couple of years are resulting in an increase in shippers' preference for dedicated freighter services. Belly-hold services for air cargo on commercial passenger planes currently provide just over half of air freight capacity. However, passenger fleet belly-hold capacity is forecast to grow more slowly than overall cargo traffic, creating a greater reliance on dedicated air freighters over time.



Historically the freighter fleet has doubled every 10 years to meet the growing demand for air cargo. Given the greater average payload of air freighters now being manufactured (average payload is projected to increase by 23% over the period 2001 to 2021) the freighter fleet is forecast to rise by 75% by 2021 (see figure below - Boeing, 2003).

The forecast growth in demand for air cargo services coupled with the shift from passenger to freighter aircraft is likely to result in significant increases in air cargo miles for food and other sectors. However, this will be partly offset by the increase in freighter payload.

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