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STUDY OF THE COMMUNITY BENEFIT OF A FIXED CHANNEL CROSSING

APPENDICES

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APPENDIX A

RECENT DEVELOPMENTS IN CROSS-CHANNEL TRAFFIC

A.1 DEVELOPMENTS IN TRANSPORT SERVICES

A.1.1 Shipping: Passengers

The previous Channel Tunnel studies examined a wide range of routes from British ports to Continental Europe. It was, however, found, as could have been expected, that the potential for diversion to a fixed crossing fell away as the distance between the ports concerned and the Tunnel portal increased. It was therefore decided in the previous study to concentrate for the passenger diversion forecasts selected routes, as follows:-

(a) the French Straits (Dover/Folkestone - Calais/Boulogne/Dunkerque);
(b) the Belgian Straits (Dover/Folkestone - Ostend/Zeebrugge);
(c) Newhaven - Dieppe;
(d) Southampton - Le Havre/Cherbourg;
(e) Harwich/Felixstowe - Hook of Holland/Rotterdam.

For the freight diversion forecasts a wider set of routes was examined.

Between 1971 and 1977 the following new routes were opened:-

Felixstowe - Zeebrugge
Plymouth - Roscoff
Portsmouth - St. Malo
Portsmouth - Cherbourg
Portsmouth - Le Havre
Sheerness - Vlissingen
Weymouth - Cherbourg
Hull - Zeebrugge

It can be seen that the choice of routes available to cross-Channel passengers increased greatly in this period; between 1977 and 1979 this increase continued with the addition of:-

Felixstowe - Rotterdam
Plymouth - St Malo

In general, the new routes are longer-haul than the established ones and offer less frequent services. They tend to serve more localised catchment districts but nevertheless they are used by passengers who may be diverted to a fixed link crossing the Straits of Dover, even though not to the same extent as travellers using routes nearer to the proposed crossing.

The set of crossings examined was therefore extended to include at the western extremity the routes from Plymouth and at the eastern extremity the routes from Hull. This allows us to consider in addition to the crossings listed above the ferries to Germany, Denmark and Spain.

The number of operators involved in the provision of shipping services has also increased. In 1971 the distribution of traffic between the main operators was as follows:-

(a) the hovercraft services provided by British Rail carried 6% of the total accompanied car and 7% of the classic (i.e. passengers without cars) traffic on routes from Dover to Calais and Boulogne;

(b) the private sector Hoverlloyd hovercraft services from Ramsgate to Calais accounted for 8% of the accompanied car and 6% of the classic traffic;

(c) the private enterprise shipping services, all of which were owned by Townsend Thoresen with the exception of Normandy Ferries, carried about 32% of the accompanied car and 10% of the classic traffic;

(d) the public sector shipping services provided by the Sealink consortium (British Rail, SNCF, Belgian Marine and Zeeland Steam) carried 55% of the accompanied car and 77% of the classic traffic.

These operators have now been joined by Brittany Ferries and Olau Line. The current distribution of UK-origin traffic by route is described in Section A.2 below.

A.1.2 <u>Shipping: Freight</u>

The great majority of ships carrying passengers and cars also carry freight traffic and in particular roll-on/roll-off (ro-ro) goods vehicles. However, there has been a rapid growth in the number of vessels catering specifically for the freight market. Although in many cases these vessels also carry cars and passengers, the passenger capacity is often limited and the operators do little to seek pure passenger traffic.

A summary of the changes in the numbers of ro-ro routes between 1971 and 1978 is given in table A.1.1. A detailed list of the routes operated in 1977, including any changes up to 1979, is given in table A.1.2.

Table A.1.1 Roll-on/Roll-off Shipping Routes in 1971 and 1978

	1971	1978
Britain to:-		
France	13	20
Belgium	7	8
Netherlands	8	7
West Germany	6	6
	34	41

The number of services between Britain and France has expanded rapidly over the period considered, mainly on the more peripheral crossings such as Felixstowe-Dunkerque and Portsmouth-St. Malo. There has also, however, been some increase in the number of services offered on the more central crossings including Dover-Boulogne and Dover-Dieppe. The numbers of crossings to the other three countries considered have remained relatively constant, although there have been some changes in the patterns. For example, if the services between Britain and the Netherlands are considered, of those operating in 1971, three were withdrawn by 1978 and two new services were added; for Belgium, two were withdrawn and three were added; and, for France, one was withdrawn (but subsequently restarted) and eight started. Only for West Germany is the pattern unchanged.

In addition, six services to Denmark were identified in 1978, from Newcastle, Hull, Grimsby, Felixstowe, Harwich and Immingham.

A.1.3 Shipping: Capacity and Technical Developments

The capacity of the cross-Channel shipping services is determined by a number of factors including the number of crossings, the average number of sailings per crossing and the size of vessel. As discussed earlier, there has been a substantial increase in the number of crossings both for passengers and for freight.

The number of sailings on existing crossings increased significantly between 1971 and 1978, and in addition, sailings were provided on a number of new ones. For passengers the effect of this was to increase the maximum number of daily sailings on routes to France, Belgium and the Netherlands from about 140 in 1971 to about 220 in 1978. About two-thirds of the rise came from additional sailings on existing crossings and a third from new ones. A rather similar picture existed for freight traffic, since to a large extent services provide for both types of traffic. Table A.1.2 summarises the information on the frequency of passenger and freight services.

TABLE A.1.2 LIST OF FREIGHT SEA CROSSING ROUTES: RO-RO

Main Route No.	Main Route	Route No.	Actual Routes	Known Operators	Average Freq. Per Day	Total Freq. Per Day	Average Sea Crossing Time (Hours)
1	Hull-Hamburg	1	Hull-Bremerhaven	Argo	0.1		27.0
		2	-Hamburg	Argo	0.3		27.0
		3	Immingham-Copenhagen	Tor Line	0.1		27.0
		4	Grimsby-Esbjerg	DFDS	0.4		22.0
		5	North Shields	DFDS	0.3		20.0
		6	Hull-Rostock	VDSR	0.1	1.3	14.0
2	Hull-Rotterdam	7	Hull-Rotterdam	North-Sea Ferries	1.0		15.0
		8	Hull-Zeebrugge	North-Sea Ferries	1.0		16.0
		9	Hull-Short Sea/Deep Sea	e.g. Adriatica Di			15.0
			(via Rotterdam)	Navigagione	1.8	3.8	15.00
3	Immingham-Rotterdam	10	Immingham-Rotterdam	Tor-Line Vessels	0.9	0.9	15.0
4	Gt. Yarmouth-Rotterdam	11	Gt. Yarmouth-Schevingen	Norfolk Line	2.56	2.56	8.0
5	Felixstowe-Zeebrugge	12	Felixstowe-Zeebrugge	Townsend-Thorensen	3.0		5.0
		13	Felixstowe-Zeebrugge	Roto Line	0.1	3.2	12.0
		14	Felixstowe-Ghent	Roto Line	0.1		
6	Felixstowe-Dunkirk	15	Felixstowe-Dunkirk	SNCF	0.7	0.7	5.5
7	Felixstowe-Rotterdam	16	Felixstowe-Rotterdam	Townsend-Thorensen	4.0		7.3
		17	Ipswich-Rotterdam	North-Sea Ferries	0.9		7.0
		18	Felixstowe-Rotterdam	Transport Ferry Service	3.0	7.9	7.3
8	Harwich-Dunkirk	19	Harwich-Dunkirk	Sealink	0.6	0.6	5.5
9	Harwich-Zeebugge	20	Harwich-Antwerp	CIE Belge	1.0		11.0
		21	Harwich-Zeebrugge	Sealink	2.0		7.5
		22	Harwich-Ghent	Roto Line	0.1	3.1	12.0
10	Harwich-Rotterdam	23	Harwich-Hook	Sealink-Zeeland	2.5	2.5	7.3
11	Harwich-Haburg	24	Harwich-Hamburg	Frizenlinien	0.5		24.8
		25	Kings Lynn-Hamburg	Wash Bay Line	0.3		31.8
		26	Ipswich-Hamburg/ Bremerhaven	Argo	0.1		27.0
		27	Harwich-Esbjerg	DFDS A/S	0.4		20.0
		28	Felixstowe-Esbjerg	DFDS A/S	0.4		20.0
		29	Sheerness/Middlesborugh-Hamburg	Hansen Ferries	0.1	1.8	22.0
12	Harwich-Bremerhaven	30	Harwich-Bremerhaven	Prinzenlinien	0.5	0.5	23.00
13	Dover-Ostend	31	Dover-Ostende	Sealink	7.0		3.8
		32	Folkestone-Ostende	Sealink	2.5	9.5	4.3
14	Dover-Zeebrugge	33	Dover-Zeebrugge	Townsend-Thorensen	7.0		4.0
		34	Sheerness-Vlissingen	Olau Line	2.0	9.0	8.0
15	Dover-Calais	35	Dover-Calais	Sealink	12.0		1.6
		36	Folkstone-Calais	Sealink	4.0		1.8
		37	Dover-Calais	Townsend-Thorensen	20.0	36.0	1.5
16	Dover-Boulogne	38	Dover-Boulogne	Sealink	8.0		1.7
		39	Dover-Boulogne	P & O Normandy	8.0		1.7
		40	Folkstone-Boulogne	Sealink	3.0	19.0	1.8
17	Dover-Dunkirk	41	Dover-Dunkirk	Sealink	6.0	6.0	2.3
18	Dover-Dieppe	42	Dover-Dieppe	Charles Schiaffano	1.0	1.0	6.0
19	Newhaven-Dieppe	43	Newhaven-Dieppe	Sealink	3.0		4.0
		44	(Shoreham-Dieppe)	(Charles Schiaffano)*	(0.9)	3.0	(11.0)
20	Southampton-Le Havre	45	Southampton-le Havre	Townsend-Thorensen	1.0		7.3
		46	Portsmouth-Le Havre	Townsend-Thorensen	1.0		5.5
		47	Southampton-Le Havre	P & O Normandy Ferries	2.0	4.0	7.0
21	Poole-Cherbourg	48	Poole-Cherbourg	Turckline Ferries	3.0		4.5
		49	Plymouth-Roscoff	Brittany Ferries	1.0	4.0	6.0
22	Southampton-Cherbourg	50	Southampton-Cherbourg	Townsend Thorensen	1.0		7.0
		51	Portsmouth-Cherbourg	Townsend Thorensen	1.0		4.0
		52	Portsmouth-St. Malo	Brittany Ferries	2.0		9.0
		53	(Southampton-Bilbao)	(MacPack Services)	(0.6)	4.0	(36.0)

* Started 1979

TABLE A.1.2 (continued) CONTAINER AND RAILWAGON

Main Route No.	Main Route	Crossing Number	Actual Routes	Known Operators	Average Frequency Per Day	Total Frequency Per Day Per Route	Average Sea Crossing Time (Hours)
	CONTAINER						
1	Hull-Hamburg	54	Hull-Hamburg	Argo	0.3		27.0
		55	Hull-Bremerhaven	Argo	0.1		27.0
		56	Immingham-Copenhagen	Tor Line	0.1		30.0
		57	Grimsby-Esbjerg	DFDS	0.4		22.0
		58	North Shields-Esbjerg	DFDS	0.3		20.0
		59	Hull-Rostock	VDSR	0.3	1.6	24.0
2	Hull-Rotterdam	60	Hull-Rotterdam	Tor Line	7.0	1.0	27.0
3	Immingham-Rotterdam	61	Immingham-Rotterdam	Tor Line	0.9	0.9	27.0
4	Felixstowe-Dunkirk	62	Felixstowe-Dunkirk	(Various Deep Sea Lines)	0.1	0.1	5.5
5	Felixstowe-Zeebrugge	63	Felixstowe-Antwerp	Ibesca Container	0.3	0.3	5.5
6	Felixstowe-Rotterdam	64	Felixstowe-Rotterdam	Sealand Container Services			7.3
		65	Felixstowe-Rotterdam	Sealink	0.1	2.3	7.3
7	Harwich-Zeebrugge	66	Harwich-Zeebrugge	Sealink	2.0	2.0	7.5
8	Harwich-Dunkirk	67	Harwich-Dunkirk	SNCF	0.6	0.6	7.5
9	Harwich-Rotterdam	68	Harwich-Hook	Sealink-Zeeland	2.5	2.5	7.3
10	Harwich-Hamburg	69	Ipswich-Hamburg	Ibesca Container	0.1		20.0
		70	Felixstowe-Rostock	VDSR	0.1	0.2	22.0
11	Harwich-Bremerhaven	71	Harwich-Bremerhaven	(Various Short Sea Lines)	0.1	0.1	22.0
12	Tilbury-Rotterdam	72	Tilbury-Rotterdam/ Hamburg-Zeebrugge	P & O	0.7		8.5
		73	Tilbury-Rostock	PSR (Bugazione)	0.4		8.5
		74	Tilbury-Hamburg	Comer	0.4	1.5	8.5
13	Southampton-Cherbourg	75	Southampton-Cherbourg	Townsend Thoresen			
			Portsmouth-St. Malo	(Various Deep Sea Lines)	0.5	0.5	7.0
	RAILWAGON						
1	Dover-Dunkirk	76	Dover-Dunkirk	British Rail	6.0	6.0	2.3
2	Harwich-Zeebrugge	77	Harwich-Zeebrugge	British Rail	4.1	4.1	7.3
3	Harwich-Dunkirk	78	Harwich-Dunkirk	British Rail	0.9	0.9	7.5

The second aspect of capacity, ship size, has also shown signs of growth since 1971. If the current fleet is analysed, the vessels that entered service after this date are in general larger, in terms of passenger, car and freight accommodation, than those that entered service earlier. However, exceptions to this arise in the case of some of the newer longer crossings, where smaller boats have entered service, reflecting the lower patronage anticipated.

The period has witnessed few major technical developments in ship design or operation, although, as discussed above, there has been an increase in the size of the new vessels entering the cross-Channel fleet. The use of flexible decking, enabling more efficient use to be made of the ship's capacity, has spread and the next stage of development is the introduction of facilities to enable loading to take place on two decks simultaneously. This will substantially reduce loading and unloading times and enable a more efficient use to be made of the fleet.

A.1.4 Hovercraft and Jetfoil Services

A cross-Channel hovercraft service was first introduced by British Rail in 1968, operating a single craft on the crossing from Dover to Calais/Boulogne. A second hovercraft was introduced on the same crossing in 1969, and in the same year Hoverlloyd commenced operation, with two craft, from Ramsgate to Calais. Both enterprises were using the same type of craft, SRN4's constructed by the British Hovercraft Corporation, which were capable of carrying 254 passengers and 30 cars.

Since 1971, there has been no further extension of the range of crossings served, but available capacity has expanded considerably. Hoverlloyd built up their fleet to 4 craft by 1974, all of which were modified from the original SRN4 to the SRN4 mark 2, which carries 280 passengers and 37 cars. The services provided vary from a minimum of four sailings per day in the winter to a maximum of 27 in the summer peak periods.

British Rail have entered into an agreement with SNCF to operate joint services, which are marketed as 'Seaspeed'. The two British Rail hovercraft were withdrawn from service in turn (the Princess Anne in 1977 and the Princess Margaret in 1978) so that they could be returned to the manufacturers for 'stretching'. A number of major modifications have been made to the hovercraft, of which the most important is the insertion of a new 55-foot centre section, which offers an increase in capacity from 254 to 418 passengers and from 30 to 60 cars. This significant increase in capacity and revenue-earning potential has added about 18% to hovercraft operating costs.

As a result of the withdrawal of the British rail hovercraft, available services have been restricted, particularly in 1977, when only the unstretched Princess Margaret was in service. It had been planned that the new SNCF Sedam N500 craft would be available while the British Rail craft were away. Regrettably, this craft caught fire and burnt out in May 1977, a fortnight after it had begun trials. It finally entered service late in 1978, with a payload of 400 passengers and 45 cars.

With the return of the Princess Margaret, there were three jumbo hovercraft operating on the cross-Channel routes in 1979. These craft should be able to offer more reliable and comfortable services than the SRN4's mark 1 because of their greater size and improved stability in rough seas. For example, the British Rail craft can now operate in a wave height of 3.5 metres, compared to 2 metres before stretching. This should lead to a reduction in the number of cancelled flights, which has stayed roughly constant at 5% of planned flights since 1973. However, there are still operational problems with the SNCF craft, which suffered a 28% cancellation rate in 1978.

The development of hovercraft services has been accompanied by the construction of hoverport facilities, on both sides of the Channel and by both Hoverlloyd and the national railway administrations. Most recently, a £10 million hoverport was opened at Dover in 1978. These improved passenger handling facilities are enabling operators to maintain the turnround times for their services, even with the substantially larger craft now coming into service.

Hovercraft only offer services for foot passengers and passengers who accompany their cars. Neither roll-on roll-off goods vehicles nor other forms of freight are carried. This is as much a marketing as a technical decision; hovercraft are capable of carrying lorries and designs do exist for a roll-on roll-off hovercraft. Moreover, up to three coaches are carried from time to time thought it is necessary to place spreader boards to accommodate the extra weight of these vehicles. However, at present the customs facilities that would enable freight to be carried are not available on hovercraft services.

There have recently been some doubts cast on the commercial future of hovercraft operations. At present, Hoverlloyd is up for sale, and it is considered possible that BR/SNCF may in the near future attempt to sell Seaspeed. As discussed in the main report, the consultants' view is that hovercraft services will only be viable in the long term if a premium fare is charged for cars.

A further development since 1978 has been the introduction of jetfoil services. P & O were the first company to enter the market with a service from a terminal in Central London to Ostend or Zeebrugge. In 1979, this service was operated intermittently. Jetlink Ferries Ltd have a similar craft, and three services a day were provided from Brighton to Dieppe from mid-1979. Both of these services were beset by initial technical problems, especially the ferry to Belgium.

The jetfoil is a very new type of craft; the first commercial version (the 929-100) was only launched in 1974. The 929-115 currently in use is a development of that craft, offering improved performance, payload and reliability. The craft is capable of operating in poor weather conditions, and offers a quality of ride similar to that of an airliner, but present versions offer only passenger carrying capabiilties. The future potential for jetfoils is inevitably a matter for speculation. Boeing are at present conducting an intensive worldwide marketing campaign and craft are available at a price of $8.5 million. In the long term, the jetfoil concept could undoubtedly be developed to provide a vehicle-carrying craft; studies are already in hand to design a 1300 to 1500-ton jetfoil, for military use, which may be compared with the 115-ton weight of the 929-115. The high speed of the jetfoil makes it a relatively fuel-intensive form of transport, and this may prove a disadvantage if fuel prices rise rapidly.

A.1.5 Air

The chief developments in the period 1971-1978 in air services have been the widespread introduction of larger capacity wide-bodied craft, especially from the London airports, and the very recent advent on the market of cut-price fares on long-distance journeys (e.g. Skytrain).

The introduction of craft of larger capacity has meant that while the number of movements (take-offs and landings) from the London airports actually declined by 3.5% in the years 1971-1975, there was an increase of 18% in the number of passengers carried.

The share of passengers carried from London airports (Heathrow, Gatwick, Luton, Stansted and Southend) declined slightly in this period from 70% to 69%, but the share of Heathrow and Gatwick increased at the expense of the smaller airports (especially Stansted).

The advent of cut-price transatlantic fares within the last few years has probably had a great impact on the frequency of holiday travel to North America. It is possible that such fare cutting will in the near future appear on European routes.

There has been a recent trend towards the introduction of larger capacity craft on the shorter European routes (Air France and Lufthansa operate Airbuses on the London-Paris and London-Frankfurt routes respectively) and this will tend to encourage reductions in frequency. Such aircraft might be extended to the Amsterdam and Brussels routes. On the other hand, there is a strong probability that "shuttle" services will be introduced on the London-Paris route in 1980, with the London-Brussels and Amsterdam routes shortly after. This would encourage higher frequencies, and experience of other shuttle services suggests that its convenience increases substantially the attractiveness of air as opposed to surface modes, e.g. on the London-Glasgow and Edinburgh routes where the market share of air increased after the introduction of the shuttle service from 35% to 46%, even with a relative rise in air fares.

No discussion of developments between 1971 and the present is complete without mentioning the effects of the 1973 oil price rise. This event hit airline costs to a greater degree than most activities, and the resulting fare increases had dramatic effects on traffic, with a 10% fall in passengers. The effect was more marked for charter flights, where fuel costs constitute a larger proportion of total costs. However, after 1974, growth in demand for air travel resumed, and the recent availability of cheap charter-type fares on scheduled flights has provided a boost to this growth.

A.1.6 Surface Connections

Although there have been minor modifications, no significant improvements have been made to the national rail networks in areas around the prospective crossing portals since 1971. Further developments will be heavily dependent on the decision reached on the proposed fixed links.

An important change in the available public transport services has been the extension, in 1978, of the Piccadilly line of the London Underground to Heathrow airport. This improved surface access will influence the competition for classic passengers between rail and air, independently of any decision to construct a fixed Channel crossing.

Since 1971, substantial changes have been made to the UK and Continental road networks which might have implications for the pattern of cross-Channel traffic. The M4 (London-Bristol), M5 (Birmingham-Bristol-Exeter), and M3 (London-South Hampshire) motorways have been completed, thereby considerably enhancing the accessibility of ports other than Dover and Folkestone, especially to residents of the Midlands, North and Scotland. In addition, motorways giving access to Hull from West Yorkshire and the North-West (M62) and from South Yorkshire and the Midlands (M18) have been completed, again much improving the accessibility of Hull and hence the competitiveness of the ferries operating from Hull. On the continent, the most important improvements for cross-Channel traffic were the completion of the Paris-Rouen-Caen motorway, giving improved access to Le Havre and Cherbourg, and the addition of motorways on radial links from Paris East and West.

Certain changes to the road network in the future might have an effect on cross-Channel traffic. The main UK road surface access to the Tunnel would be provided by the M20. The previous Tunnel forecasts were based on the assumption that this route would be completed between London and Folkestone by the assumed Tunnel opening date of 1980. We understand from the Department of Transport that it is now expected to complete the remainder of this route to Folkestone by the mid 1980's. The other major road improvement which is likely to influence the distribution of cross-Channel traffic is the planned completion of the M25 to provide the South and North Orbital routes around London. We understand that, according to current plans, further stretches of this will open progressively in the early 1980's with the final sections being completed by the mid-1980's. Improvements are also proposed for the route between the Midlands and the East Anglian ports, especially between the A1 and the M1, and these should be completed by the mid 1980's.

A.2 ROUTES CHOSEN BY UK RESIDENTS IN 1977

A.2.1 Introduction

The published IPS statistics only give a small fraction of the information which is actually collected. In order to get a better idea of the factors determining travellers' choice of route from the UK to continental Europe, we commissioned the UK Department of Trade to give us more detailed information from the 1977 survey. This information included, in addition to that already published:-

(a) a breakdown by UK region of origin;
(b) a breakdown by length of stay;
(c) a breakdown into with and without vehicle;
(d) a breakdown by crossing (for air, by UK airport group);
(e) information on the categories of traveller excluded from published IPS statistics (defined by IPS as "non-tourist").

Table A.2.1 shows the countries to which UK residents travelled in 1977, by mode and by purpose. It should be noted that the IPS definitions of purposes in their published statistics differ from those we have used. Our "business" purpose includes not only their "business" category, but also their "non-tourist" category (principally emigrants and those travelling for the purposes of employment). The "non-tourist" category is completely omitted from their published statistics, but is an important element in the "business" traffic as defined in the studies. This category in 1977 contributed 308,000 travellers (15% of all business travellers) of which 216,000 travelled by air and 92,000 by sea. Furthermore, the IPS published "business" category includes drivers of accompanied freight vehicles, who for our purposes should not be included since this element of demand is dealt with as freight demand. This category was not distinguished in the IPS until 1979. However, it was possible to obtain an estimate of the number of business travellers in "other motor vehicles", a category comprising lorries and motorcycles, for 1977. We estimate that proportion of freight drivers in the business category was 35% of surface business travellers, and 50% of those accompanying a vehicle. These have been excluded from the data presented in this section.

Table A.2.1 shows that the great majority of surface travellers (86%) are going to EEC countries, but that outside the EEC relatively high proportions of travellers use surface transport to Switzerland, Austria, and Scandinavia. A smaller proportion use surface transport for Spain, but the large total number makes surface travel to Spain significant.

Table A.2.1 Destinations of U.K. Residents in 1977

Destination	Leisure Travellers											Business Travellers		
	Car Travellers	Independent Non-Car Travellers			Package Travellers			Total Leisure						
		Air	Sea	Total	Air	Sea	Total	Air	Sea	Total		Air	Sea	Total
France	485	158	805	963	161	166	327	319	1456	1775		218	88	306
Belgium & Luxembourg	44	20	124	144	3	84	87	23	249	275		106	48	154
Netherlands	56	62	91	153	24	36	60	86	183	269		155	24	179
Germany (FR)	108	154	134	288	8	40	48	162	283	445		230	50	280
Italy	61	121	36	157	295	45	340	426	133	559		77	6	83
Denmark	23	18	23	41	1	13	14	19	58	78		28	5	33
Total EEC (excluding Irish Republic)	777	533	1213	1746	492	384	876	1025	2374	3399		814	221	1035
Switzerland	29	58	12	70	32	9	41	90	51	141		57	3	60
Austria	16	20	13	33	92	22	114	112	52	164		18	1	19
Spain	87	247	22	269	1335	9	1344	1582	118	1700		56	4	60
Portugal	6	37	1	38	108	1	109	144	9	153		12	*	12
Yugoslavia	3	8	1	9	102	*	102	110	4	114		7	*	7
Greece	7	93	14	107	213	4	217	306	25	331		20	2	22
Turkey	2	91	*	91	163	*	163	254	2	256		12	*	12
Norway & Iceland	21	19	8	27	5	*	6	25	29	44		44	1	45
Sweden	5	13	7	20	1	3	4	14	15	29		43	5	48
Eastern Europe (N)	6	26	5	31	20	1	21	46	12	58		36	2	38
Eastern Europe (S)	2	4	*	5	20	*	21	24	3	27		8	*	8
Total rest of Europe	184	616	84	700	2091	49	2140	3189	317	3506		313	18	331
North Africa	2	44	2	46	364	*	364	408	4	412		38	*	38
America	*	437	4	441	15	*	15	452	4	456		158	*	158
Rest of World	2	412	14	426	68	1	69	480	17	497		360	75	435
Total (excluding Irish Republic)	966	2040	1322	3362	2987	479	3466	5027	2767	7794		1687	317	2004

Source: International Passenger Survey, detailed analysis includes 'non-tourists' but excludes lorry drivers

Units: Thousands of return trips (double to obtain number of individual crossings)

* Indicates an inadequate sample (or zero)

An interesting feature is that there seems to be a sharp division between those destinations largely served by package holidays and the others. The EEC countries (except Italy), Switzerland, Scandinavia, Eastern Europe (North), and America all have low proportions using package holidays, whereas the remaining destinations (Spain, Portugal, Italy, Austria, Yugoslavia, Greece, Turkey, Eastern Europe (South) and North Africa) have proportions higher than 60% using package.

In the following sections we examine the routes chosen by travellers bound for the various destinations for four categories of travellers:-

(a) independent, non-car leisure travellers;
(b) leisure car travellers;
(c) package travellers;
(d) business travellers.

A.2.2 Independent, Non-Car Leisure Travellers

In 1977, a total of 3.36 million U.K. residents made independent leisure trips abroad without a car. Of these, 2.04 million travelled by air, 1.14 million by ship, and 0.18 million by hovercraft. The split between air and surface travel as shown in Table A.2.1 is displayed in Figure A.1; the proportion of these travellers going by surface transport declines, as expected, with distance from the U.K. The horizontal bars extend from the nearest to the furthest airports in the region which may be reached by a direct flight from London. Switzerland appears to have an anomalously low proportion of surface travellers; no explanation for this is immediately apparent.

In the remainder of this section we examine in more detail the pattern of surface transport by European country visited.

Travellers to Scandinavia by surface routes are relatively few in number (about 3% of total surface travellers in this category) and the IPS sample is insufficient to give a detailed pattern of route choice for individual U.K. regions. If flows for the whole U.K. are examined, it appears as shown in Table A.2.2 that travellers to these destinations use the direct routes to Scandinavian ports to a large extent, that is, for Norway, the ferries to Kristiansand and Oslo are used; for Sweden, the Felixstowe to Gothenburg ferry and for Denmark, the ferries to Esbjerg. There is significant use of the Harwich-Hook ferry for Denmark, and individuals using other North Sea ferries were sampled. This pattern suggests that with the possible exception of Denmark it is unlikely that a significant volume of Scandinavian traffic will be diverted to a new crossing facility.

Figure A.1

The proportion of independent, non-car leisure travellers from the UK using surface transport

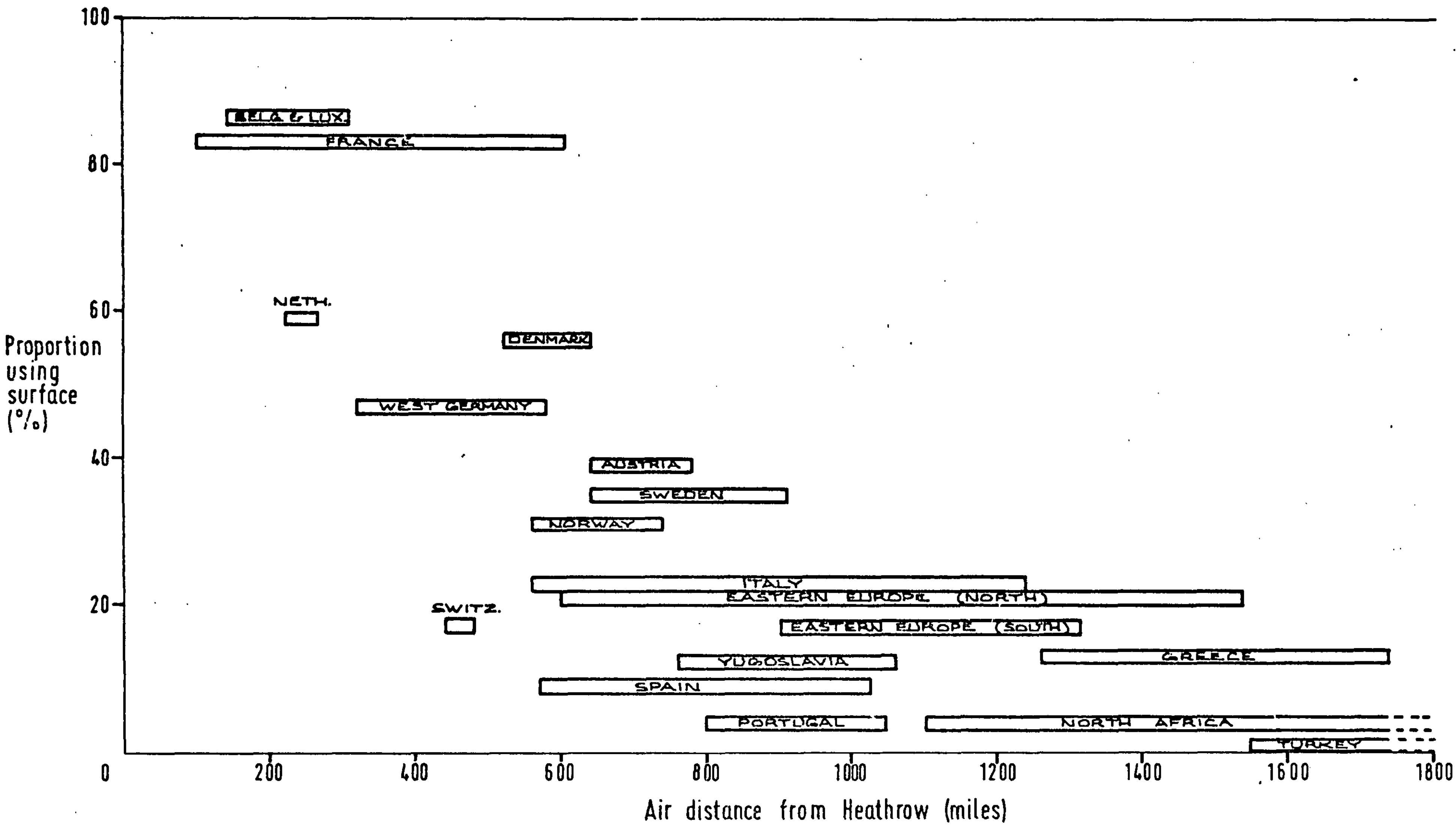

Table A.2.2 Independent Non-Car Leisure Travellers to Scandinavia by Surface Transport (thousands)

Destination	via Norway	via Sweden	via Denmark	via Germany	Other Ferries	Total
Norway	8	*	*	*	*	8
Sweden	*	6	1	*	*	7
Denmark	*	*	20	*	2	23

Travellers to Germany use a variety of routes, the most important of which are the Belgian Straits ferries (51%) and Harwich-Hook (20%). Direct routes to Hamburg and Bremerhaven only account for 7% of the traffic, presumably because they are only appropriate for the far north of Germany. Route choice for these travellers is shown in Table A.2.3. An interesting feature is the strong tendency of Yorkshire and Humberside residents to use Hull.

Travellers to the Netherlands predominately use the Harwich-Hook route. Their choice pattern is shown in Table A.2.4. The Hull-Rotterdam route is used by 14% of travellers, most of these being from north of the Humber, especially Yorkshire and Humberside.

Table A.2.4 Independent Non-Car Leisure Travellers to the Netherlands by Surface Transport

	Total (thousands)	Hull-Rotterdam	Harwich -Hook	Sheerness-Vlissingen	via Belgium	via France
U.K. Total	91	13	56	10	8	4
Scotland, North, Northwest	13	3	7	*	1	1
Yorks, Humberside	9	7	2	*	*	*
Midlands	10	1	7	*	2	*
Rest of England, Wales	59	1	40	10	5	3

Table A.2.3 Independent Non-Car Leisure Travellers to West Germany by Surface Transport

	Total (thousands)	via Denmark	German Ferries	via Hull	Harwich -Hook	Felixstowe -Zeebrugge	Sheerness-Vlissingen	Belgian Straits	via France
U.K. Total	134	2	10	7 (5%)	27	4	2	69	13
Scotland, North, Northwest	28	*	3	2 (7%)	5	*	*	13	5
Yorks & Humberside	11	*	2	5(41%)	2	*	*	2	*
Rest of England, Wales	95	2	5	*	20	4	2	54	8

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Traffic to Belgium and Luxemburg proceeds by a variety of routes, but is dominated by the ferries into Ostend and Zeebrugge and the Ramsgate-Calais hovercraft (the latter presumably using the through London-Brussels coach and hover service). This traffic is summarised in Table A.2.5.

Table A.2.5 Independent Non-Car Leisure Travellers to Belgium and Luxembourg by Surface Transport

	Total (thousands)	Felixstowe -Zeebrugge	Belgian Straits	Ramsgate -Calais hovercraft	Other French Straits	Other Routes
U.K. Total	124	11	94	10	6	3
North of Humber	18	*	12	2	1	2
South of Humber	106	11	82	8	5	*

Route choice for travellers to France is much wider than for other destinations. As well as the French Straits ship and hovercraft crossings (80%) there are crossings from Newhaven to Dieppe (6%), from Southampton and Portsmouth to Le Havre and Cherbourg (8%), Weymouth to Cherbourg (2%), and the ferries to Brittany from Portsmouth (2%) and Plymouth (2%). The remainder go via ports in Belgium and Holland. The pattern of route choice depends very much on the zone of U.K. residence, and is shown in Table A.2.6. Travellers from counties not on the South coast (except the South-West region) have a strong preference for the French Straits routes. Of the South coast counties Kent traffic not surprisingly uses almost exclusively the French Straits, and Sussex traffic has a strong preference for Newhaven. Hampshire and Dorset traffic has a preference for Southampton, and Devon and Cornwall for Plymouth. The South-West region has a strong tendency to use Weymouth, which is less surprising than at first appears, since BR run through services from Bristol to Paris along this route. The Brittany ferries presumably largely serve travellers for Brittany, except for those in the Devon and Cornwall region.

Travellers to Spain and Portugal face the same choice of routes as those to France, but in this case the position of the French Straits is more dominant. The data, summarised in Table A.2.7, are insufficient to give any breakdown by U.K. region.

Table A.2.6 Independent Non-Car Leisure Travellers to France by Surface Transport

	Total (thousands)	French Straits	Newhaven -Dieppe	Hants-Normandy	Weymouth Cherbourg	Portsmouth -St. Malo	Plymouth Roscoff	via Belgium & Holland
Total U.K.	806	646 (80%)	51 (6%)	62 (8%)	13 (2%)	13 (2%)	15 (2%)	6
North of Humber	103	86 (83%)	4 (4%)	5 (5%)	4 (4%)	3 (3%)	*	*
E. Midlands	27	21 (77%)	1 (2%)	3 (11%)	*	*	1 (9%)	1
W. Midlands	30	22 (73%)	1 (2%)	2 (6%)	1	*	3 (10%)	*
Wales	22	19 (82%)	*	*	*	2	*	*
London	162	145 (88%)	6 (4%)	8 (5%)	*	2	*	1
Surrey	48	42 (90%)	4 (7%)	*	*	1	*	*
Kent	148	146 (98%)	1	*	*	*	*	*
Sussex	45	19 (42%)	24 (58%)	*	*	*	*	2
Hants	39	6 (14%)	3 (7%)	28 (72%)	1	2 (4%)	*	*
Dorset	7	1 (20%)	*	4 (63%)	1	*	*	*
South-West	21	8 (37%)	1	5 (23%)	6 (28%)	*	2 (9%)	*
Devon & Cornwall	12	5 (44%)	*	2 (13%)	*	*	4 (38%)	*
Rest of Southern England & East Anglia	142	128 (90%)	7 (5%)	3	*	2	*	1

Table A.2.7 Independent Non-Car Leisure Travellers to Spain and Portugal by Surface Transport

	Total (thousands)	French Straits	Southampton -Bilbao	Newhaven-Dieppe	via Belgium
UK Total	23	20	1	2	*

Table A.2.8 shows that travellers to other destinations overwhelmingly use Dover or Folkestone as their port of departure. Their choice is mainly between a Belgian port or a French port. For Switzerland and Italy the preferred route of 90% is through France whereas for Austria, 65% use Ostend. For destinations further South-East, French ports are again preferred.

Table A.2.8 Independent Non-Car Leisure Travellers by Surface Transport to Other Destinations

	Total (thousands)	French Straits	Belgian Straits	Other Routes
Italy	37	32	4	*
Switzerland	12	10	2	*
Austria	14	3	9	1
Yugoslavia	1	1	*	*
Greece	14	9	4	1
Eastern Europe (S)	1	1	*	1
North Africa	2	1	*	1
America	4	*	*	3
Rest of World	7	2	*	5

A.2.3 Leisure Car Travellers

The destination of leisure car travellers in 1977 are shown in Table A.2.9. This category of travel is dominated by France as a destination, with about 50% of the traffic. The proportion of leisure travellers going by car declines with distance from the UK, but with anomalously high figures for the Scandinavian countries (perhaps because of the existence of car ferries) and low figures for Spain (perhaps because of the predominance of the package trade and the high attractiveness of the Balearic and Canary Islands).

Table A.2.9 Destinations of Leisure Car Travellers in 1977

Destination	Total (thousands)	% of all Leisure Car Travel	% of Leisure Travel to Country going by Car
France	485	50%	27%
Belgium & Luxembourg	44	5%	16%
Netherlands	56	6%	20%
West Germany	108	11%	24%
Italy	61	6%	11%
Denmark	23	2%	30%
Total EEC (excluding Irish republic)	777	80%	23%
Norway & Iceland	21	2%	39%
Sweden	6	1%	18%
Eastern Europe (North)	6	1%	10%
Spain	87	9%	5%
Portugal	6	1%	4%
Switzerland	29	3%	21%
Austria	16	2%	10%
Yugoslavia	3		3%
Greece	7	1%	2%
Turkey	2		1%
Eastern Europe (South)	2		7%
Total Rest of Europe	185	19%	5%
North Africa	2		5%
America	0		0%
Rest of World	2		4%
Total (excluding Irish republic)	966	100%	12%

Travellers to Scandinavian countries largely take the direct routes to Scandinavian ports, as summarised in Table A.2.10. Norwegian ports account for 84% of the Norway traffic, and three quarters of this traffic uses Newcastle rather than Harwich. It appears that while residents in Northern UK regions exclusively use the Newcastle route, residents of Southern UK regions may choose either. In any case, there appears to be little prospect of any of this traffic using a fixed crossing facility. The traffic to Sweden is more spread, with 46% using Gothenburg, 18% Esbjerg and the drive through Denmark and Sweden, and the remaining 36% using Belgian or Dutch ports. This is rather surprising considering the length of the Continental journey and possibly reflects some utility to the traveller obtained from passing through the Netherlands or Germany. It may also reflect capacity restraint on the Felixstowe-Gothenburg ferry. This traffic is clearly susceptible to diversion to the new facility. Traffic to Denmark is dominated by the ferries to Esjberg (86%) but 13% use Dutch or Belgian ferries.

Table A.2.10 Route Choice by Leisure Car Travellers to Scandinavia

Destination	Total (thousands)	via Norway	via Sweden	via Denmark	via Belgium	via France	via Netherlands
Norway	21	18	1	*	1	*	*
Sweden	6	*	3	1	1	*	*
Denmark	23	*	*	19	1	*	2

Route choice to West Germany is summarised in Table A.2.10. Very few travellers use the 'direct' sea routes to Hamburg and Bremehaven. The vast majority of the traffic (73%) uses Kent ports, with 27% on the French Straits, 44% on the Belgian Straits, and 3% on Sheerness-Vlissingen. There appear to be three distinct patterns of route choice. Regions north of the Humber may use Hull; the East Midlands, Essex and East Anglia have a high propensity to use Harwich and Felixstowe; other regions almost invariably use Kent ports. The choice between Continental ports out of Dover is presumably largely dependent upon the part of Germany to which the traveller is going.

Travellers to Eastern Europe (North) follow much the same routes as those to Western Germany.

Table A.2.11. Leisure Travellers to West Germany and Eastern Europe (North) by Car

	Total (thousands)	Via Denmark	Harwich Germany	Via Hull	Haven -Belgium & Neth	Sheerness Vlissingen	Belgian Straits	French Straits	Other French	% Kent	% Haven	% Hull
To West Germany												
U.K. total	109	1	2	6	15	3	48	29	1	73	14	7
North of Humber	22	1	*	6	6	*	5	4	*	40	32	28
E. Midlands, Essex and E. Anglia	19	*	*	*	8	*	7	3	*	53	47	*
Rest of U.K.	68	*	2	*	*	3	36	22	1	97	3	*
To Eastern Europe (N)												
U.K. total	6	*	*	*	2	*	2	1	*	66	34	*

Table A.2.12. Leisure Travellers to the Netherlands by Car

	Total (thousands)	Hull - Rotterdam	Harwich - Hook	Felixstowe - Zeebrugge	Sheerness - Vlissingen	Belgian Straits	Via France	% Hull	% Haven	% Kent
U.K. total	56	3	16	5	8	15	9	5	36	59
North of Humber	8	3	2	*	*	2	1	40	20	40
South Coast & Surrey	17	*	1	1	3	7	4	*	12	88
Rest of England & Wales	31	*	13	4	5	6	4	*	55	45

Travellers to the Netherlands are diverse in their choice of routes. Only 48% of the travellers use the Dutch ports (Hook, Rotterdam, Vlissingen), 36% using Belgian ports and 16% French ports. As for the non-car travellers, Hull-Rotterdam is the dominant route for those north of the Humber, and is not used by those south of the Humber. Travellers from countries on the south coast (plus Surrey) are much less likely to use Harwich and Felixstowe. This pattern, similar to that observed from West Germany, may be the result of a reluctance to cross London. These results are summarised in Table A.2.12.

Travellers to Belgium and Luxembourg travel mainly from Dover to Ostend or Zeebrugge, with a large minority using the French Straits route. This choice appears to depend little on UK region, and is shown in Table A.2.13.

Table A.2.13 Route Choice of Car Leisure Travellers to Belgium and Luxembourg

	Total (thousands)	Felixstowe -Zeebrugge	Belgian Straits	French Straits	Other Routes
UK Total	44	3	27	13	1

The route choice of travellers to France is shown in Table A.2.14. A wide variety of crossings is available, with 47% using the French Straits, 27% Southampton or Portsmouth to Normandy ports, and 13% ferries to Brittany. Weymouth and Newhaven also attract significant amounts of traffic. Scotland, the North and Yorkshire display a pattern close to the UK average. Travellers from the North-West, West Midlands and Wales show a lower than average propensity to use the Kent ports and Newhaven, and higher than average to use Southampton, Portsmouth and Plymouth. The East Midlands and East Anglia also show a higher than average propensity to use Southampton but not in this case Plymouth. London, Essex, Kent, Bucks and Herts all show a much higher tendency to use the Kent ports and are relatively reluctant to use Southampton, Portsmouth, Weymouth and Plymouth, whereas Surrey, Berks and Oxon shows a pattern more like the UK average. The South coast counties, not surprisingly, shows a strong preference for using local ports, most markedly for Hants, where 89% of the travellers use Southampton or Portsmouth. For the South-West region, Southampton and Portsmouth are the favoured ports, and for Devon and Cornwall, Plymouth and Weymouth.

Table A.2.14. Leisure Travellers to France by Car

	Total (thousands)	French Straits	Newhaven - Dieppe	Hants Normandy	Weymouth - Cherbourg	Portsmouth - St. Malo	Plymouth - Roscoff	Other Routes
Total U.K.	485	230 (47%)	41 (8%)	131 (27%)	26 (5%)	32 (7%)	28 (6%)	5
Scotland, North, Yorks & Humberside	58	26 (49%)	4 (7%)	11 (19%)	3 (5%)	5 (9%)	5 (9%)	*
North-West, West Midlands, Wales	87	32 (37%)	2 (2%)	27 (31%)	6 (7%)	6 (7%)	10 (11%)	*
East Midlands, Beds, East Anglia	43	18 (42%)	2 (5%)	15 (35%)	2	3	1	2
Essex	22	17 (77%)	3	2	*	1	*	*
London, Bucks, Herts	103	73 (71%)	7 (7%)	11 (11%)	2	7 (7%)	2	1
Kent	27	21 (78%)	1	2	1	1	*	*
Berks, Oxon	18	7 (42%)	1	6 (33%)	2	*	*	*
Surrey	36	17 (45%)	4 (12%)	10 (27%)	*	3 (9%)	2 (5%)	*
East Sussex	11	4 (34%)	6 (60%)	*	*	*	*	*
West Sussex	10	1 (8%)	6 (60%)	2 (24%)	*	*	*	*
Hants	24	2 (8%)	1	17 (69%)	1	3 (12%)	*	*
Dorset	9	3 (29%)	*	3 (34%)	2 (29%)	*	1	*
South-West	24	5 (22%)	*	12 (51%)	2 (7%)	1	4 (15%)	*
Devon and Cornwall	14	2 (14%)	*	4 (31%)	4 (26%)	*	4 (29%)	*

Travellers to Spain and Portugal have a similar choice of crossings to those going to France, with the addition of the long crossing from Southampton to Bilbao. The Kent ports account for 39% of the traffic Newhaven-Dieppe is used by a higher proportion of travellers to Spain (14%) than of those to France, whereas the ferries from Hampshire to Cherbourg and Le Havre are used by a lower proportion (15%). Clearly Dieppe is a better port of disembarkation for a car journey to Spain than Calais, but so would Le Havre be. Perhaps the crucial factor here is the availability of the Southampton-Bilbao ferry from the same port. The route choice for car travellers is summarised in Table A.2.15.

Traffic to other destinations largely uses the Kent ports, although small numbers use Harwich-Hook, Felixstowe-Zeebrugge, Hull-Rotterdam and the South coast ports. The choice between the Belgian route or the French route is more equal for motorists than for non-motorists, with about 60% using the French Straits and 20% the Belgian Straits. The information is summarised in Table A.2.16.

A.2.4 Package Travellers

As mentioned above, the destination for UK leisure travellers fall fairly sharply into two categories:-

(i) predominantly independent (% independent shown in brackets)

(i) predominantly independent		(% independent shown in brackets)
	France	(82%)
	Belgium & Luxembourg	(69%)
	Netherlands	(78%)
	Germany (FR)	(89%)
	Denmark	(83%)
	Switzerland	(70%)
	Norway	(89%)
	Sweden	(64%)
	Eastern Europe (North)	(64%)
	America	(97%)
	Rest of the World	(86%)

Table A.2.15. Car Leisure Travellers to Spain and Portugal

	Total (thousands)	French Straits	Newhaven - Dieppe	Hants Normandy	Weymouth - Cherbourg	Via Bilbao	Via Brittany	Other Routes
U.K. total	93	36	13	14	3	13	1	1

Table A.2.16. Car Leisure Travellers to Other Destinations

	Total (thousands)	Harwich - Hook	Belgian Straits	French Straits	Other French	Other Routes
Italy	60	2	9 (15%)	42 (69%)	3	4
Switzerland	29	*	6(20%)	20 (69%)	3	*
Austria	15	*	5 (32%)	7 (49%)	*	3
Yugoslavia	3	*	1	1	*	*
Greece	7	*	2	4	*	*
Turkey	2	*	1	1	*	*
Eastern Europe (S)	2	*	1	*	*	*
North Africa	2	*	*	*	2	*
Rest of World	2	*	*	1	*	*

(ii) predominantly package (% package shown in brackets)

Spain	(79%)
Portugal	(71%)
Italy	(61%)
Austria	(70%)
Yugoslavia	(88%)
Greece	(66%)
Turkey	(64%)
Eastern Europe (South)	(71%)
North Africa	(88%)

Route choice for package tourists is likely to be determined by criteria rather different from those guiding independent travellers. It appears from the data in Table A.2.1 that package tourists are less likely to use a sea crossing. Part of this is of course because the typical package destination is further away. In fact, the destinations providing most of the sea package traffic are largely those belonging to the 'predominantly independent' group, in particular France and Belgium. In the following analysis we consider the surface routes chosen by package tours to EEC countries and to Switzerland, Austria, and Spain which cover 89% of all surface package travel.

Of the 13,000 surface package tourists for Denmark, the vast majority go via Esbjerg, with individuals sampled using Ostend. For West Germany and the Netherlands, patterns are broadly similar to those for independent non-car travellers, except that the tendency for residents North of the Humber to use Hull is greatly magnified. This may be associated with the marketing policies of North Sea Ferries. Similarly, the Felixstowe-Zeebrugge ferry is more heavily used by package travellers to Belgium and the Netherlands than by independent travellers. For travellers to France, the emphasis on Kent ports is much less (49% as opposed to 80% of independent travellers), with increased shares for Newhaven and the Hampshire ports, and to a less extent, Weymouth and Plymouth. For Italy, the dominant route is over the Belgian Straits, in contrast with independent travellers who largely use the French Straits. The same is true to a lesser extent for Austria. These data are summarised in Table A.2.17.

Table A.2.17. Route Choice of Surface Package Travellers in 1977

Destination	Total (thousands)	Via Denmark	Via Hull	Harwich - Hook	Felixstowe - Zeebrugge	Sheerness Vlissingen	Belgian Straits	French Straits	Newhaven Dieppe	Hants Normandy	Weymouth Cherbourg	Portsmouth - St. Malo	Plymouth - Roscoff
Denmark	13	12	*	*	*	*	1	*	*	*	*	*	*
Germany(FR)	40	*	12	7	*	1	20	6	*	*	*	*	*
Netherlands	36	*	8	6	9	5	6	2	*	*	*	*	*
Belgium & Luxembourg	80	*	4	*	12	1	55	9	*	*	*	*	*
France	166	*	3	1	*	*	3	81	24	52	8	*	*
Italy	45	*	*	*	3	*	25	6	*	*	*	*	*
Austria	22	*	*	*	*	*	12	10	*	*	*	*	*
Switzerland	9	*	*	*	*	*	5	4	*	*	*	*	*
Spain	9	*	*	*	*	*	*	9	*	*	*	*	*

A.2.5 Business Travellers

Reference to Table A.2.1 shows that business travellers have a much higher propensity to use air, whatever the distance. Of the 239,000 business travellers who use surface transport, roughly half (113,000) use a car. The vast majority of them (204,000) are going to France, West Germany, Belgium, Luxembourg and the Netherlands.

Patterns of route choice, summarised in Table A.2.18, resemble those for package travellers more than independent travellers, with heavy use of Hull, and less emphasis on the Dover-France routes. This will presumably be strongly affected, especially in France, by the fact that the pattern of business origins and destinations will differ greatly for leisure travel.

Table A.2.18. Route Choice of U.K. Business Travellers (surface) in 1977

Destination	Total (thousands)	Using Car		Total	Via Denmark	Via Hull	Via Germany	Felixstowe - Zeebrugge	Harwich - Hook	Sheerness Vlissingen	Belgian Straits	French Straits	Newhaven Dieppe	Hants - Normandy	Weymouth Cherbourg
France	88	41%	Car	36	*	*	*	*	*	*	*	20	4	6	*
			No Car	52	*	*	*	*	*	*	2	32	6	9	*
Belgium & Luxembourg	48	50%	Car	24	*	3	*	4	*	*	11	6	*	*	*
			No Car	24	*	1	*	*	*	*	18	5	*	*	*
Netherlands	24	54%	Car	13	*	2	*	*	1	2	3	4	*	*	*
			No Car	11	*	2	*	*	5	1	3	*	*	*	*
Germany (FR)	44	57%	Car	25	*	4	*	1	1	*	7	9	*	*	*
			No Car	19	*	1	*	*	7	1	9	*	*	*	*

A.3 DEVELOPMENTS IN FREIGHT TRAFFIC

A.3.1 Recent Developments in Unitised Cross-Channel Traffic

In this section we describe the major trends in road ro-ro and container traffic between Great Britain and the Continent over the period 1970-1977. It is largely based on National Ports Council (NPC) statistics and the results of the Department of Transport's Quarterly ro-ro Survey (QRRS).

Table A.3.1 demonstrates the increasing importance of unitised traffic, particularly the ro-ro component. Over the period 1970-1977 total import volumes have grown somewhat erratically. However, the totals for the unitised modes, especially road-hauled ro-ro, have grown much faster; the annual growth rate for ro-ro has been on average 22% for imports and 23% for exports. Despite the dampening effects of the 1974-1975 recession, the substantial high growth in ro-ro movements is remarkable. From carrying 4% of imports and 8% of exports in 1970, by 1977 ro-ro vehicles had increased their market share to around 15% and 25% respectively. Other Unit Load imports had made a corresponding advance from 12% to 18%, but merely maintained their 26% share of the export trade.

Table A.3.2 gives a more detailed breakdown, again derived from NPC Statistics, of near-sea unitised traffic in 1970, 1974 and 1977. A number of conclusions can be drawn from this tabulation, of which the most important are as follows:-

(a) ro-ro services are the principal mode used in British near-sea unitised trade; total volume was 13.2 million tonnes in 1977. Specialised ro-ro traffic in 1974 was already over double that estimated for lo-lo, and since then container movements have effectively stagnated while ro-ro near-sea carriage has grown substantially;

Table A.3.2 British Non-Fuel Trade with Near and Short Sea areas,[(a)] 1970-1977

	1970	1971	1972	1973	1974	1975	1976	1977
Imports	35,619	34,225	36,940	43,492	45,725	39,479	45,022	41,356
of which:								
ro-ro	1,557	1,916	2,621	3,536	4,734	4,967	5,621	6,185
(%)	(4%)	(6%)	(7%)	(8%)	(10%)	(13%)	(12%)	(15%)
Other Unit Loads[(c)]	4,324	4,801	5,659	6,940	7,158	6,502	6,902	7,317
(%)	(12%)	(14%)	(15%)	(16%)	(16%)	(16%)	(15%)	(18%)
Exports	15,196	15,344	16,388	19,147	20,038	19,285	19,630	20,833
of which:								
ro-ro	1,201	1,409	1,887	2,681	3,454	3,823	4,860	5,185
(%)	(8%)	(9%)	(12%)	(14%)	(17%)	(20%)	(25%)	(25%)
Other Unit Loads[(c)]	3,883	4,025	4,355	5,021	5,030	4,676	5,149	5,372
(%)	(26%)	(26%)	(27%)	(26%)	(25%)	(24%)	(26%)	(26%)

Notes: (a) "Near and short sea areas" as defined by NPC includes many countries outside the scope of our study, including Scandinavia, USSR, North Africa and the Near East.

(b) Units are thousands of tonnes, these are net for the totals, but include packaging for the sub-totals for the unitised modes.

(c) Other Unit Loads is mainly lo-lo containers but also includes railway wagons, import/export vehicles and other miscellaneous traffic.

Source: NPC, Annual Digest of Port Statistics 1970-1977.

(b) road vehicles and trailers are the predominant ro-ro component. French, Belgian and Netherlands ports accounted for 88% of the near sea total in 1977; in 1974 the proportion was even higher at around 95%. In both years the high market share was evenly balanced between inward and outward flows. Assuming the 1974 estimates to be reasonably representative, the above relative decline does suggest a small but fairly rapidly expanding direct road ro-ro trade with the Irish Republic and West Germany;

(c) railway wagon traffic, limited as it presently is to ferries between Great Britain and France and Belgium, shows an undramatic but nevertheless significant annual increase of 9% between 1974 and 1977;

(d) specialised lo-lo container traffic services to France carry negligible traffic; lo-lo traffic is only significant for Belgian and Netherlands ports. Together the latter two countries accounted for 3.1 million tonnes or over 60% of the respective 1977 near sea total, a proportion very similar to that in 1974.

(e) in general, carriage of lo-lo containers on conventional near-sea cargo services is now very limited, and virtually negligible on the principal French, Belgium and Netherlands routes.

The above general review of recent growth in unitised seaborne trade between Great Britain and the Continent has highlighted the rapid and increasing importance of the road ro-ro mode. The next section examines in more detail the growth of traffic using this mode.

This growth has been more marked on the shorter sea crossings, on which a higher proportion of the traffic is accompanied rather than trailer-only. This is indicated in Table A.3.5.

The Strait of Dover ports (Ramsgate, Folkestone and Dover) offer the shortest sea crossings to Belgium and France. Between 1973 and 1977 total outward ro-ro traffic through these ports (principally through Dover) doubled, their market share increasing from 36% to 44%. In contrast, the corresponding North Sea and Channel port group shares fell from 48% to 43% and from 15% to 13% respectively.

Table A.3.5 Outward ro-ro Movements by British Port Group 1973-1977

(thousands of Units)

Port Group (a)	1973	1974	1975	1976	1977
Powered Vehicles:					
North Sea	33	41	49	51	51
Strait of Dover	80	110	121	131	181
Channel	31	37	39	40	41
Total All Ports	144	187	209	223	273
Unaccompanied Vehicles:					
North Sea	107	134	140	155	155
Strait of Dover	26	31	29	27	29
Channel	14	16	14	18	24
Total All Ports	147	181	184	199	208
All Vehicles:					
North Sea	141	175	190	206	206
Strait of Dover	106	141	151	158	210
Channel	45	53	53	58	64
Total All Ports	291	368	393	421	480

Note: (a) Port groups are defined as follows:
North Sea - all east coast ports north of the Thames;
Strait of Dover - Ramsgate, Folkestone and Dover; and
Channel - all south coast ports west of Folkestone.

Source: Department of Transport, QRSS.

A.3.2 Road ro-ro Traffic Growth

The Department of Transport's QRSS was begun in 1971 to "monitor the growth of international road transport and to provide information on the numbers and nationalities of goods vehicles travelling between Great Britain and the Continent".[1] The coverage was later enlarged to include the Irish Republic and theoretically allows tabulation of all powered and unaccompanied goods vehicles, by country of registration, by ferry route, by inward or outward trip. In practice, problems associated with confidentiality, data quality and differing ferry operator response impose various constraints. Where necessary these limitations are annotated to the relevant tables.

Allowing for a reasonable margin of error because of known definitional differences between sources, evaluation of the QRSS returns by country of disembarkation provides considerable support for the conclusions developed from the NPC data above. Table A.3.4 below summarises the development of traffic on ro-ro ferries, outward movements only, between 1973 and 1977.

Table 1.6.6 Road ro-ro Movements between Great Britain and Continental Europe By Country of Disembarkation, 1973-1977

('000/Percentage)

Country	1973	1974	1975	1976	1977
France	92 (31%)	116 (31%)	120 (30%)	137 (32%)	164 (34%)
Belgium	72 (25%)	94 (25%)	109 (28%)	110 (26%)	150 (31%)
Netherlands	77 (26%)	99 (27%)	104 (26%)	114 (27%)	103 (21%)
Denmark & West Germany[a]	40 (14%)	44 (12%)	44 (11%)	43 (10%)	43 (9%)
Other Countries[b]	12 (4%)	16 (4%)	17 (4%)	18 (4%)	21 (4%)
Total All Countries[c]	291(100%)	368(100%)	393(100%)	421(100%)	480(100%)

Notes: (a) Combined for reasons of confidentiality.

(b) Finland, Norway, Sweden, Spain and Portugal.

(c) Refers to outward movements from Great Britain only.

Source: Department of Transport, QRSS.

(1) See "Report on the Development of International Road Goods Transport By Roll-on/Roll-off Ferry Between Great Britain and Continental Europe 1970-1978", Internal Note by G.S. Charles, Department of Transport, January 1979.

This growth has been more marked on the shorter sea crossings, on which a higher proportion of the traffic is accompanied rather than trailer-only. This is indicated in Table A.3.5.

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Strait of Dover - Ramsgate, Folkestone and Dover; and
Channel - all south coast ports west of Folkestone.

Source: Department of Transport, QRSS.

Review of QRSS data on total ro-ro traffic does not reveal any significant evidence of seasonality. When disaggregated, however, there is some indication of a tendency for last quarter unaccompanied traffic to be relatively low and powered vehicles to be relatively high.

A.3.3 Conclusions

The main conclusions that emerge from the above analysis of recent developments in unitised cross-Channel traffic are as follows:-

(a) the rapid 1973-77 expansion of near and short sea unitised trade is largely attributable to the high sustained growth rate of road ro-ro movements. Indeed ro-ro is now easily the predominant cross-Channel transport mode;

(b) traffic volumes carried by specialised lo-lo container services, principally to Belgium and the Netherlands, have been virtually static;

(c) both rail wagon and import/export vehicle trade have increased in recent years;

(d) the increasing emergence of through haulage (i.e. accompanied vehicle carriage) has led to market concentration on the shortest ferry routes, principally those from Dover and Folkestone to France and Belgium. In 1977 the combined volume of ro-ro traffic through the three main east coast ports (Hull, Felixstowe and Harwich) was substantially lower than that achieved by Dover alone;

(e) there does not appear to be any significant seasonality in ro-ro ferry traffic.

APPENDIX B

MODELS OF ROUTE CHOICE

B.1 INTRODUCTION

The analysis of route choice behaviour in the context of Channel crossing differs from most studies in the large number of possible choices open to any individual traveller. Travellers from a given UK zone to a given continental zone are observed to use may of the available routes, and it is quite possible for a single individual to choose different routes for his outward and return journeys. Accordingly, it was necessary to use a non-deterministic model, in which the route chosen by a given traveller was not simply a function of his measured characteristics; instead, travellers with given characteristics are assigned probabilities of choosing a variety of routes.

For the purpose of route choice we divided leisure travellers into three categories:-

- car travellers;
- independent, non-car travellers;
- package travellers.

The models used for these three categories have the same basic structure, as does that for freight route choice.

B.1.1 Manipulation of Route Data

In order to implement such a model, it was necessary to consider the characteristics not only of the routes chosen by a given traveller, but of all feasible routes. It was decided that the most practical way of assembling and manipulating these data was to construct transport networks from which the required items could readily be obtained. This approach has the additional advantage of flexibility - one's assumptions can readily be changed - and of ease of handling - standard computer packages are available for the processing of such networks.

B.1.2 Network Processing

The journey from the UK to the Continental Europe is a mixed-mode journey. All journeys of this type will involve, at some stage, the use of some public transport facility. This suggested that the package chosen should be a public transport package. Such packages have the disadvantages that they are invariably designed with urban transport in mind, but the package chosen (Urban Transportation Planning System, produced by the US Department of Transportation) proved to be readily adaptable to our purposes. In addition, no package is available which will perform the multiple route assignment in a suitable way. It was therefore necessary to add this feature to the package, which again proved fairly easy with the package chosen.

When specifying the networks, it was important to include only that information which provided necessary distinctions in cross-channel route choice. The networks were therefore extremely simplified in areas remote from the crossing, with more detail in the coastal regions of South-East England, Northern France, Belgium and the Netherlands. Two networks were produced, one for car travellers, representing roads and car ferries, and one for other travellers representing rail, air and a few bus routes, and the relevant crossing facilities.

B.1.3 The Choice of Zoning System

When choosing a zoning system, we had to consider several factors; availability of datas, the complexity of the network necessary, and the relevance to route choice. On the data side, IPS were willing to supply us with data broken down to county of UK residence, and country of destination. However, data for individual counties provided extremely inadequte sampling in many cases. It was judged that in areas remote from the crossing, breakdown by county was largely irrelevant to route choice, so counties were aggregated into planning regions. In the regions close to the crossing, it was felt that county of origin was an important factor in route choice (this was borne out by the data) so the South-East and East Anglia and, to a lesser extent, the South-West region were disaggregated to county level.

Choice of a zoning system for Continental Europe was more difficult. IPS could not supply any data broken down beyond country level; however, we felt that the location of the continental destination within countries was likely to be an important, if not dominant, factor in route choice. The only information available to us came from the surveys undertaken for the previous study, in which 132 zones were used. It was felt that to use this zoning system would involve the production of too detailed a network, and that much of the information was irrelevant to route choice. Furthermore, the surveys showed some destination zones to which no travellers were sampled. In the end, the criterion used was that of relevant to route choice; where two or more of the original zones were in the same position with regard to access to the ports, they were amalgamated. The final result was 25 UK zones and 54 Continental zones; these are shown on Figure B.1.

Figure B.1

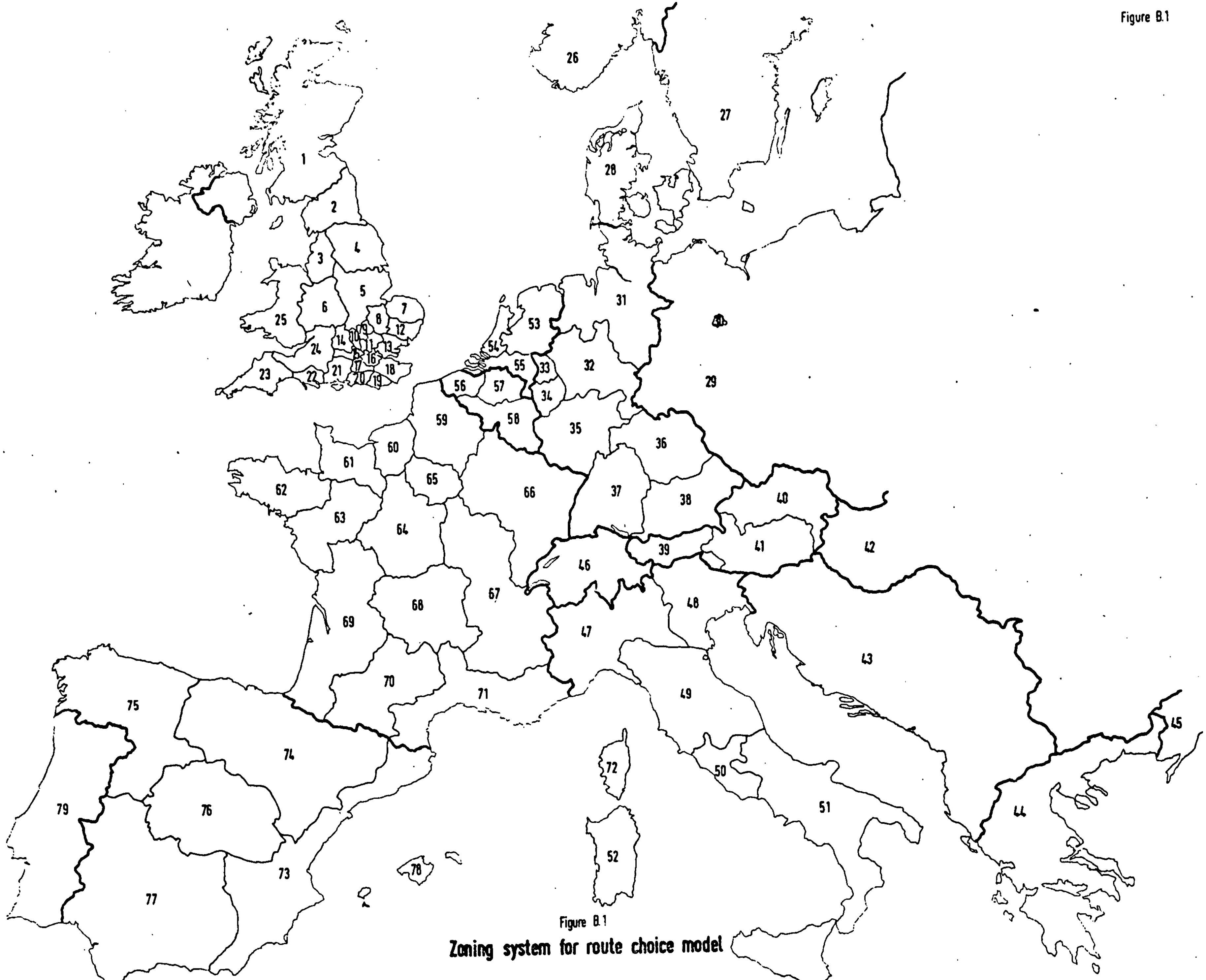


Figure B.1
Zoning system for route choice model

B.2 THE ROUTE CHOICE MODEL FOR CAR TRAVELLERS

B.2.1 The Network

The network used to produce the characteristics of car travellers is shown diagramatically in Figure B.2. Solid lines represent roads and dashed lines ferry routes. Each road link is assigned a distance, and in addition, some information on road type was recorded, to allow us to be flexible in our choice of models. Areas remote from the crossing points, e.g. Spain, Portugal, Greece and Turkey are connected to appropriate points on the network by notional road links, since it was felt that details of roads in these areas were irrelevant to cross-Channel route choice.

This network allows us to calculate, for the traveller from UK zone i to Continental zone j, the characteristics of all the possible routes. These characteristics include:

- mean UK road distance;
- mean Continental road distance;
- mean time taken for crossing;
- mean crossing fare.

B.2.2 The Model Structure

We assume that any individual wishing to drive to the Continent chooses a route by minimising some function of his crossing characteristics. However, his individual values will not be the same as the mean values calculated from the network; furthermore, the form of each individual's impedance function may be different. We attempt to stipulate this in the following way. We postulate a form of an impedance function, into which we insert the mean values calculated as above an example of such a function is:

$$\bar{I}^k_{ij} = a_u D^u_{ip} + a_c D^c_{qj} + a_t T_k + a_f F_k$$

where I^k_{ij} is the mean impedance for travellers from zone i to zone j using crossing k;

- D^u_{ip} is the UK road distance from zone i to the port p at the UK end of crossing k;
- D^c_{qj} is the Continental road distance from the port q at the Continental end of crossing k;

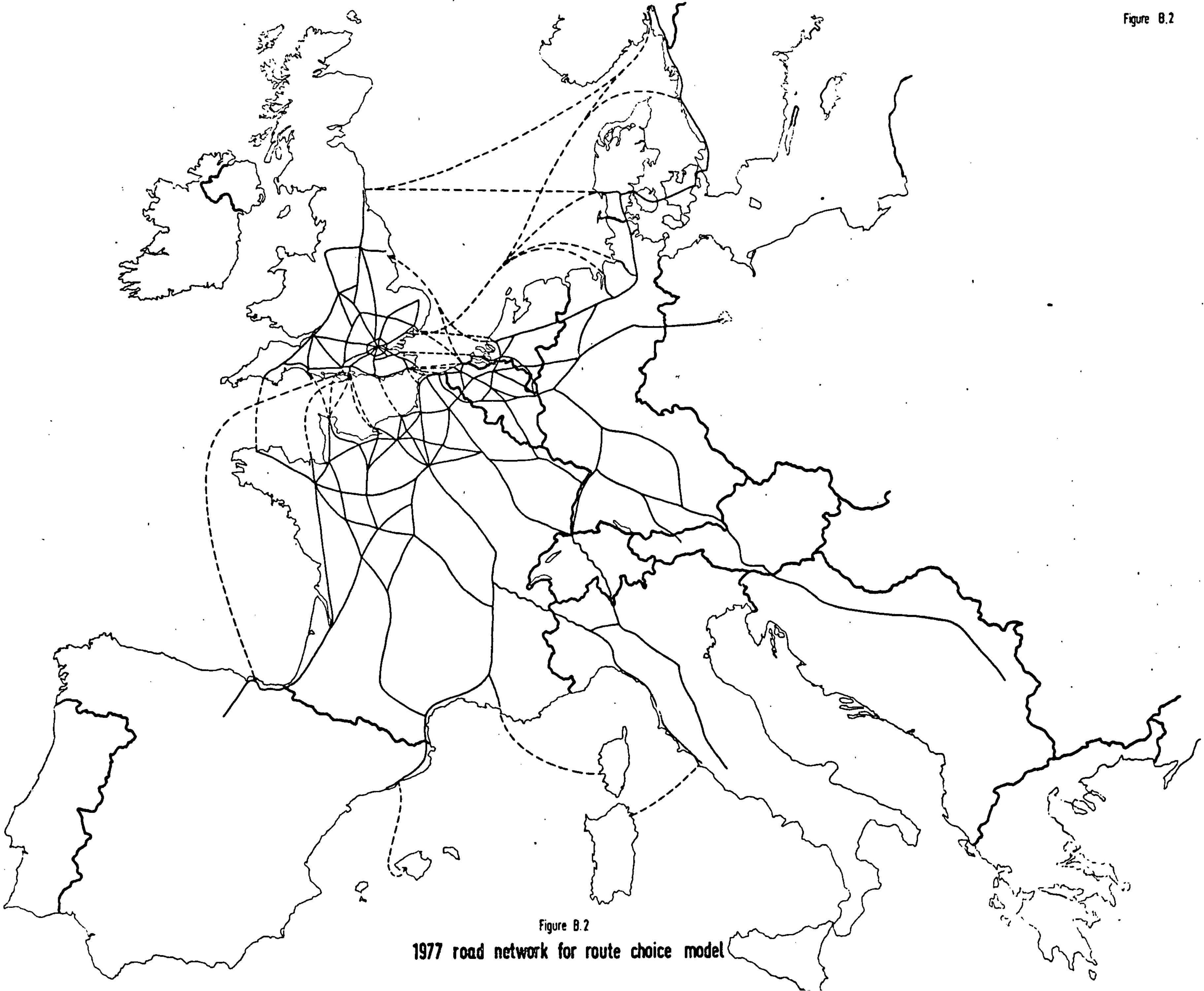


Figure B.2

1977 road network for route choice model

- T_k is the time required for crossing k;
- F_k is a typical fare for crossing k;
- a_u is the impedance per unit of UK road distance;
- a_c is the impedance per unit of Continental road distance;
- a_t is the impedance per unit time;
- a_f is the impedance per unit of typical fare.

Values of D^u, D^c, T_k and F_k may be obtained from the network. The fare we have chosen is that for two adults and two children in a 14-foot car, on a summer weekday. The other variables, a_u, a_c, a_t and a_f are parameters to be determined from the observations. Clearly, they are not all four independent. It is convenient to set the average a_f to unity, so that the impedance is expressed in money units.

Variation in the routes chosen by individuals with common measured characteristics can arise from many sources. The parameters a_u and a_c represent the sum of two effects. They take account of the running costs of the car (which will, of course, vary with the size of the car) and of the perceived disutility of time spent travelling in the car, which will vary with the number in the party, and, subjectively, with their perceptions of time. Similarly, a_t will vary with the size of the party and with their perceptions of time spent on a ferry (for example, a_t will be high for an individual liable to sea-sickness, but low for one to whom it is a pleasure to travel by sea). The value of will be low for an individual in a small car, or a shareholder claiming a concessionary fare, but high for a large party touring in a caravan. As well as parameter values, the values of the observable variables may differ from the mean; an individual in a zone may live nearer or further away from the port than the zone centroid. As an example of how variation in the relative values of the terms in the impedance function will affect the choice of crossing, we consider the journey from London to Koln. The characteristics of the most likely routes are as follows:

Crossing	UK road distance (miles)	Continental road distance (miles)	Crossing time (minutes)	Crossing fare (£)
via Dover- Calais	84	222	90	47
via Dover-Ostend	84	181	210	47
via Sheerness-Vlissingen	60	179	420	52

The "best" routes for individuals of given characteristics are shown in Figure B.3. Individuals with a low disutility of road travel but high disutility of ferry time will choose the shorter Calais route. Individuals with low, a_f (since f is defined for an average party, this might be a single person in a car, or someone taking advantage of a fare concession) and low disutility of ferry time, relative to that for road travel, will choose the more expensive and longer Vlissingen route, which minimises their road distance.

It is clearly not practible to model all the sources of uncertainty described above individually. We have therefore chosen to simulate the uncertainty arising from all possible factors in the following way. The impedance to travel for the individuals in the UK zone i to the Continental zone j are assumed to be distributed about the mean value according to the distribution function $N_k\ (I_{ij})$; that is, the probability of an individual having impedance in the interval I_{ij} to $I_{ij} + dI_{ij}$ for travel from i to j using crossing k is $N_k\ (I_{ij})\ dI_{ij}$. Consider an individual zone whose impedances for this trip by crossing k is I_k (the subscripts i, j being dropped for clarity). The probability of the route by crossing k having lower impedance than that by crossing l is then the cumulative probability of I_l from I_k upwards. That is:

$$\text{probability k preferred to l, given } I_k, = \int_{I_k}^{\infty} N_l(I_l)\, dI_l$$

The probability that k has the lowest impedance of all routes is the product of factors like this:

$$\text{probability k preferred to all other routes, given } I_k, = \prod_{l \neq k} \int_{I_k}^{\infty} N_l(I_l)\, dI_l$$

The probability of any individual choosing crossing k is therefore the average of this probability, weighted by the distribution N_k:

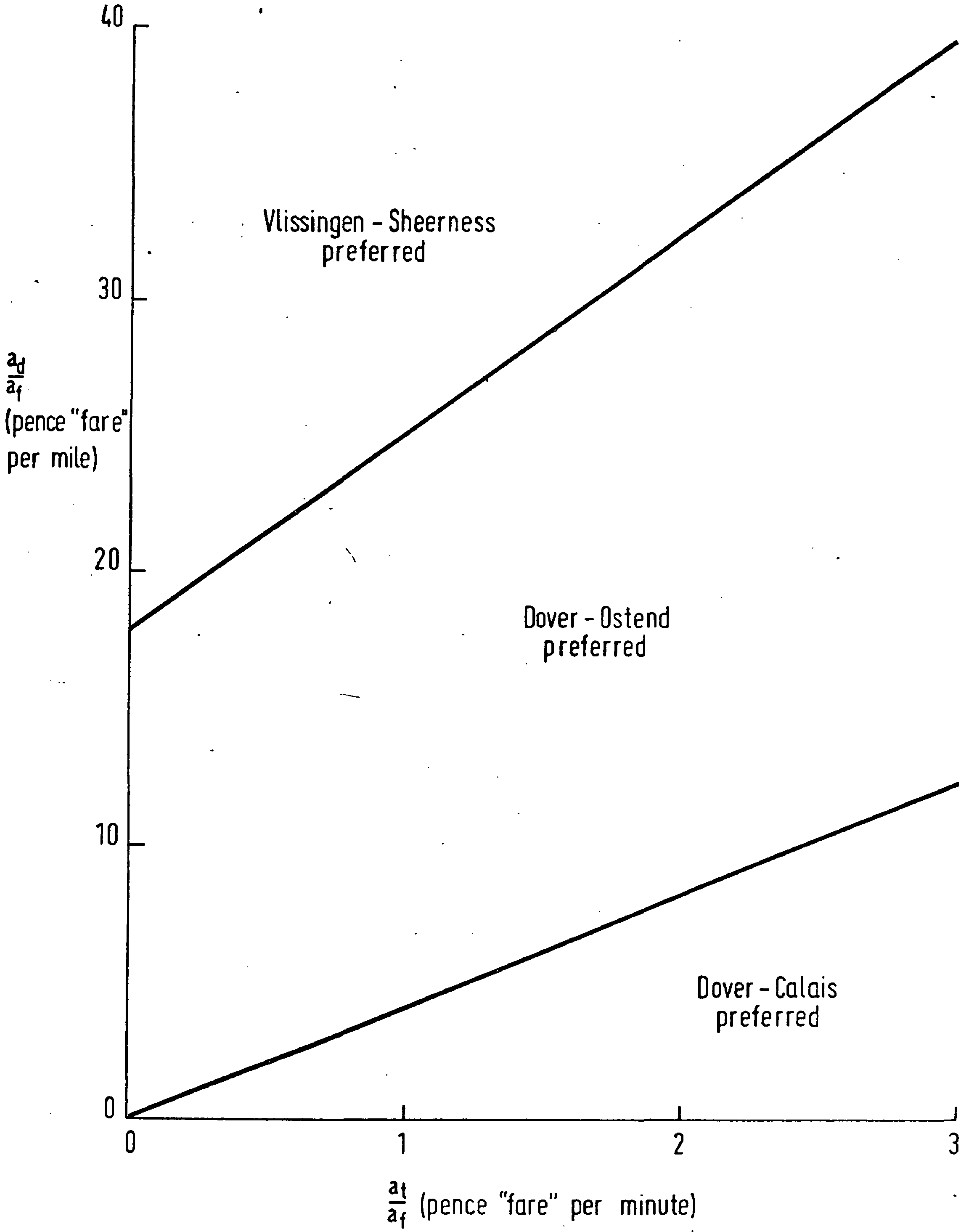
$$\text{probability crossing k chosen} = \int_{-\infty}^{\infty} N_k(I_k) \left[\prod_{l \neq k} \int_{I_k}^{\infty} N_l(I_l)\, dI_l \right] dI_k$$

Two crucial questions now arise:-

- what is the form of the impedance function?
- what is the structure of the distribution N?

Leaving the first question open for the moment, we consider the distribution of deviations from the mean. If these are assumed to form a Weibull distribution, and the spread of the deviations is the same for

Figure B.3 Preferred crossings for London - Köln



a_d is the impedance per unit of road distance all choices, an analytical solution is obtained, the parameters of which can be estimated using accepted techniques. This model is the "multinominal logit"' model. The Phase I Channel Tunnel Study examined this model and rejected it for two reasons. The first was the implausibility of the assumption that the error structure was the same for all choices. It was felt likely that the deviations from the mean were likely to be greater for large journeys. The second was the property of the model generaly known as the "independence of irrelevant alternatives" property. It can be shown that, for the multinominal logit model, introduction of a new alternative will take the same proportion of choice-makers from all other choices. This property may be desirable in some situations where the alternatives genuinely are irrelevant. However, in our case, it will lead to extremely implausible conclusions. For example, the introduction of the new link between Kent and the Pas de Calais will attract the same proportion of travellers (from London to Paris) from the Hampshire-Normandy routes as it does from the Dover-Calais routes. This property arises in part from the assumption of a constant error source. However, even if this assumption is relaxed, the property, while not strictly true, still adversely affects the plausibility of the results. The main cause of error is the assumption that the impedances for the different routes are independently distributed. However, it is likely that deviations from the mean for a pair of crossings like Dover-Calais and Dover-Boulogne are highly correlated.

Our approach to this problem has been to split the route choice into more than one stage. At each stage we try to represent choices in which each one genuinely is irrelevant to choices between the others. The stages chosen for our car model are shown diagrammatically in Figure B.4. Furthermore, we find, as was found in the previous study, that a better representation of the observations is obtained when the standard deviation of the distribution is made proportional to the mean value. Unfortunately, this formulation does not lend itself readily to formal estimation. We judged that the cost of formal estimation using statistical techniques would be out of all proportion to the benefit obtained.

In a preliminary analysis an attempt was made to simulate route choice using a "Monte Carlo" approach, in which random individuals

Figure B.4 Route choice stages for car travellers

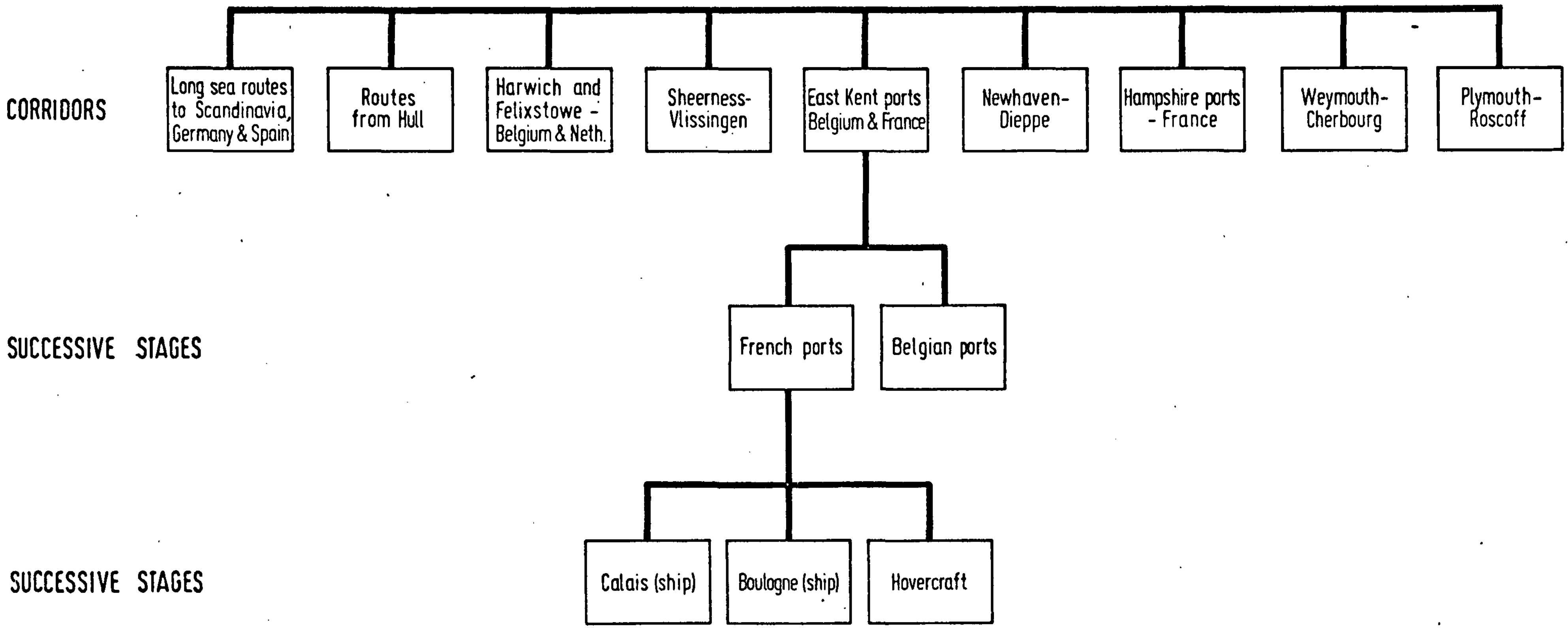


Figure B.4

were sampled from the distribution. However, this was found to be much more costly than straightforward numerical evaluation of the solution, even with far fewer, samples than were necessary to achieve convergance.

B.2.3 The Impedance Function

Two forms of impedance function were examined: that of the previous study, and a more conventional, additive generalised cost formulation. Typical forms of these were:

Previous study: $I = \alpha \log (2D_u + D_c) + \beta \log F + \gamma \log T$

Generalised cost: $I = a_u D_u + a_c D_c + F + vT$

where α, β, γ and a_u, a_c, v are parameters. Normal distributions were assumed, with standard deviations proportional to the mean impedance. The effects of time spent travelling in the car were assumed to be incorporated in the road distance variable.

Our tests suggested that the generalised cost function was preferable, both on the grounds that it provided a better fit to the observations, and because the logarithmic model had some rather surprising and counter-intuitive properties.

The application of generalised costs to the analysis of route choice for holiday travellers is not without problems of its own. Although it provides plausible and widely acceptable explanation of the trip makers' perceived costs, it should be remembered that little is known about holiday travellers' perceptions of the journey costs they incur. Most research in this area has been directed at understanding short trips made in urban areas for trip purposes such as journeys to work. In spite of these drawbacks, it seems reasonable to assume that leisure travellers' perceptions of travel costs are a variant of the conventional costs formulations used in urban or inter-urban studies and do not required a fundamentally new and distinct approach to be adopted.

The use of a conventional additive generalisd cost formulation led to certain problems with under-prediction of traffic on the very long-haul ferries. The eventual solution was the realisation that the money "cost" of these ferries (the ferries direct to Scandanavia, Germany and Spain, and those operating from Hull) used in the impedance function should only include the pure travel component. Where they were providing, in addition, overnight accomodation or meals, allowance should be made for this. When this allowance was made, a satisfactory representation of the observed pattern of route choice could be obtained.

The first stage of the route choice was the split between broadly defined "corridors". Values of the parameters a_u, a_c, v and the coefficient of variation were sought which would reduce the number of trips from a given UK zone to a given Continental country which were assigned to the wrong corridor. Validation at the level of zones within continental countries was not possible as no data were available for 1977. Initially, a function was used in which a_c was equal to a_u, but this proved to be an unsustainable assumption. The final form arrived at was:

$$I = 0.14D_u + 0.10D_c + F + 1.35T$$

where D_u was the road distance in the UK in miles;

- D_c was the road distance on the Continent in miles;
- F was the peak weekday fare for two adults and two children in a 14-foot car;
- T was the crossing time up to a maximum of 12 hours.

The implications of the parameter values found are interesting, especially with regard to people's perceptions of time. The values of a_c and a_u subsume the perceived costs of motoring and the disutility of time on the road. If a plausible average value of 4p per mile for the running costs is assumed, this leaves disutilities of time in the car of 10p per mile in the UK and 6p per mile on the Continent; that is for an average speed of 40 mph, £4 per hour in the UK and £2 on the Continent, for the average car-load. This different perception of driving in the UK and the Continent accords with the findings of previous studies. With an average occupancy of just over three persons, the "values of time" found are higher than those usual in studies of shorter journeys, which is not at all surprising. A much lower disutility of time on the ferry is found, which again is intuitively reasonable.

The impedance distribution is normal with a standard deviation of 0.03 of the mean. This function assigned car travellers to corridors, with about 80% correctly classified at the level of UK zone to Continental country. Illustration of the performance of this model are shown in Figures B.5 and B.6.

FIGURE B.5
OBSERVED AND PREDICTED CAR TRIPS BY CORRIDOR

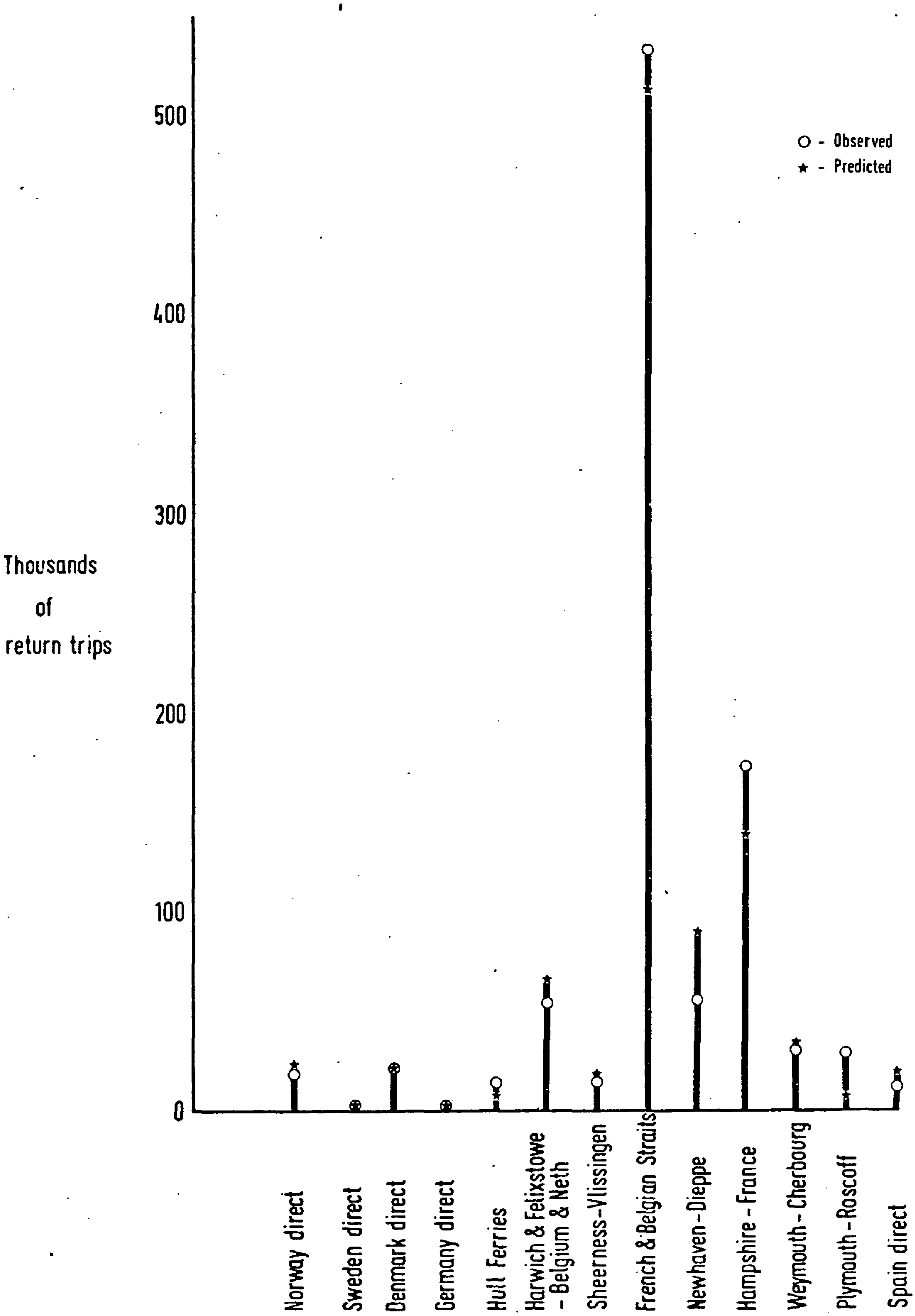
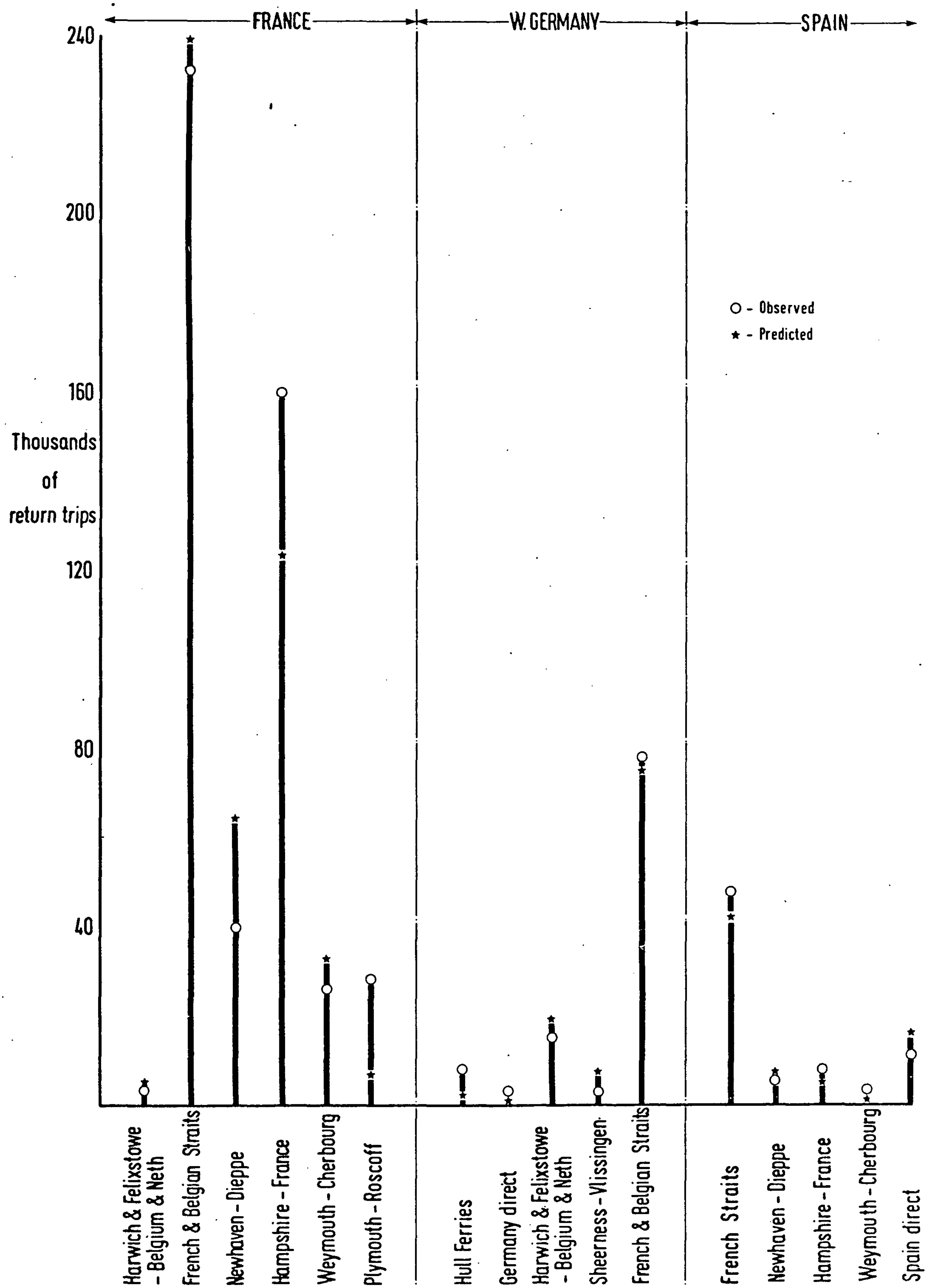


FIGURE B.6
OBSERVED AND PREDICTED CAR TRIPS TO FRANCE, W. GERMANY, SPAIN



B.2.4 The Choice Between French and Belgian Straits

The next stage is the assignment of travellers through the East Kent ports to Belgian and French routes. The proportions of car trips from Dover, Folkestone and Ramsgate going to Ostend and Zeebrugge on one hand, and Calais, Boulogne and Dunkerque on the other, are shown in Table B.1.

Table B.1 Car Trips Through East Kent Ports

Destination	via Belgian port	via French Port	via French Port	Average distance advantage of Belgium (miles)
	(thousands of return trips)		(%)	
France	2	230	99.2	-43
Belgium & Lux.	26	14	34.6	41
Netherlands	13	12	47.4	41
West Germany	47	30	38.6	41
Italy	9	42	83.0	13
Spain	-	47	100	-41
Switzerland	6	18	75.2	32
Austria	5	8	62.2	41

When, as in this case, there are only two alternatives being considered, the probabilistic route choice model described above may be approximated by an analytical expression:

$$\log\frac{p_1}{p_2} = \frac{1.22\ (I_2 - I_1)}{x\bar{I}}$$

where p_1, p_2 are the proportions choosing the two routes;

- I_1 and I_2 are their impedances;
- $\bar{I}$ is the average impedance; and
- x is the ratio of the standard deviation of the impedance distribution to the mean. Plotting $\log p_1/p_2$ against $(I_2-I_1)/\bar{I}$ should therefore give a straight line going through the origin. Figure B.7 shows this plot, where the impedance function used is that inferred from

the best fit for choice of corridor. The points indeed lie on a straight line, but is does not go through the origin. To explain this let us consider the behaviour of a traveller who is genuinely indifferent to the choice between a French and a Belgian port out of Dover. This traveller would be faced with 3.7 sailings to a French port for each one to a Belgian port. It seems reasonable that such travellers would show a French/Belgian ratio of 3.7. The straight line resulting from this hypothesis is shown as a solid line on Figure B.7; it explains 97.4% of the variance of the values of log (p_1/p_2). The "best" straight line is shown dashed, and explains 97.6% of the variance. We are therefore satisfied with the hypothesis, and propose that the choice between Belgian and French crossings out of Dover, Folkestone and Ramsgate be modelled using the same impedance function as for corridor choice, with a standard deviation 1.6% of the mean value, and a factor to allow for the frequency ratio.

B.2.5 The Choice Between Calais and Boulogne

The final stage of the route choice model applies to the choice between French ports. As noticed in previous studies, the choice between the Dover-Calais and Dover-Boulogne ship routes shows a high degree of discrimination on the part of the car traveller. Table B.2 shows the proportions using the Dover-Calais and Dover-Boulogne ship routes, for the most important destinations.

Table B.2 Car Travellers' Choice Between Calais and Boulogne

Destination	Thousands of return trips		Calais/Boulogne ratio	Average distance advantage of Calais
	Dover-Calais ship	Dover-Boulogne ship		
France	97	46	2.1	-20 miles
Belgium & Lux.	7	1	12.1	21 "
Netherlands	9	1	9.4	21 "
West Germany	17	0		21 "
Italy	24	6	4.1	1 "
Spain	19	13	1.4	-21 "
Switzerland	10	2	6.8	21 "
Austria	5	1	8.8	21 "

Figure B.7 The choice between Belgian and French ports

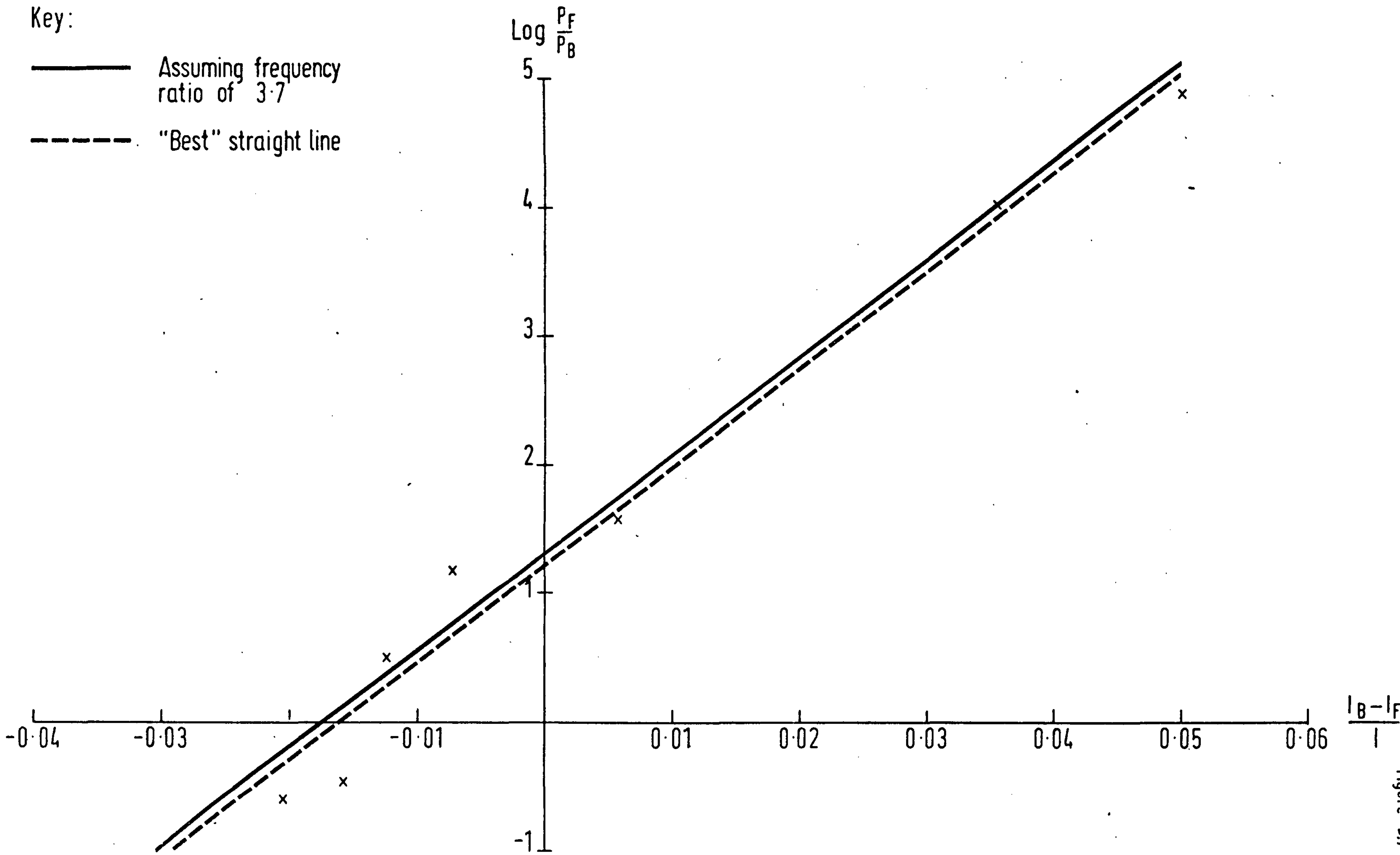


Figure B.7

If, as for the French/Belgian choice, we plot the log of the Calais/Boulogne ratio against $\Delta I/\bar{I}$, a straight line is obtained with an intercept implying a 3.4-fold advantage of Calais at the point of indifference, which is much greater than can be explained by frequency. However, it should be noticed that our impedance function allows for the disutility of road travel as a function of distance only; it does not allow for different types of road. However, the roads giving access to Calais are of motorway standard, whereas those to Boulogne are not. If we assume that this advantage can be represented by an increase in speed from 40 mph to 50 mph over a stretch of road equivalent to that from Calais to Paris, the Calais route will acquire a additional advantage of £1.80. If this term is included in the impedance function, and a factor of 2.1 in favour of Calais incorporated to take account of the frequency difference, the solid line in Figure B.8 is obtained. This hypothesis expains 91.8% of the variance of log (p_1/p_2), compared with the "best" straight line (dotted in Figure B.8) which explains 96.3%. We therefore propose to adopt a model analogous to that for the split betwen French and Belgian ports. The value of $\dot{x}$ inferred from the graphs is 0.031, which, interestingly, is greater than that for the Belgian/French split. This may reflect the lack of information people have on the relative advantages of Calais and Boulogne, whereas those of the Belgian ports vis-a-vis the French ports are comparatively more obvious.

B.2.6 The Choice Between Ship and Hovercraft

Unfortunately, the only detailed data we possess on the patterns of use of the hovercraft and ships out of East Kent ports are for 1977, a year in which the Seaspeed hovercraft services were severely curtailed. No consistent pattern of choice of hovercraft or ship could be discerned in the data. If the choice of hovercraft or ship were determined by the same impedance function we have used hitherto, the hovercraft could potentially attract a large share - perhaps 60% - of the short-sea market. This may indeed be the case, and the factor constraining hovercraft shares may simply be their capacity. On the other hand, the disutility of time spent on a hovercraft may well be different from that spent on a ship for reasons of discomfort, or reliability. The data we have gave no way of determining this.

Figure B.8 The choice between French ports out of Dover

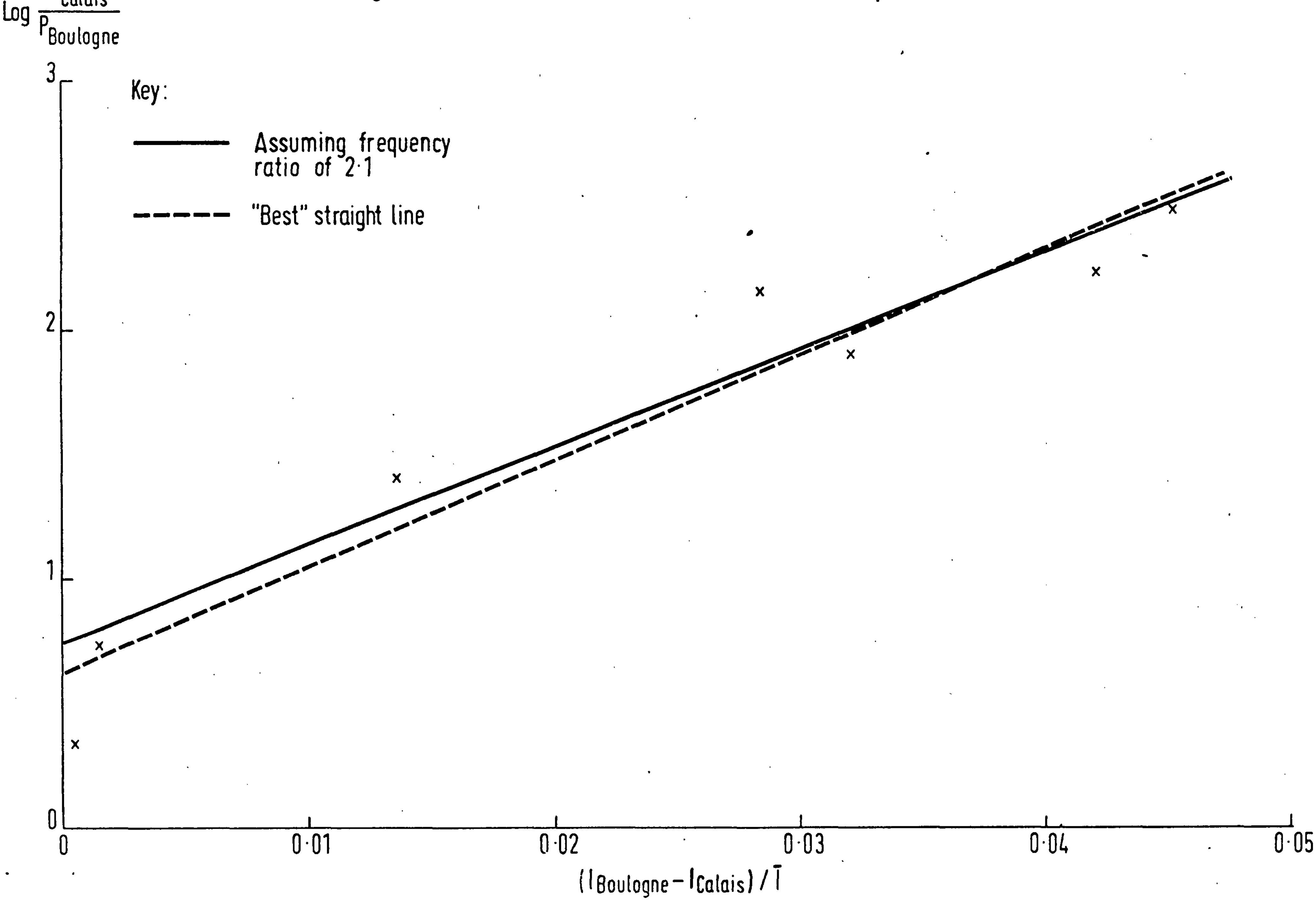


Figure B8

B.3 THE ROUTE CHOICE MODEL FOR NON-CAR TRAVELLERS

B.3.1 The Network

For this category of travellers, we have adopted a model of the same form as that described for car travellers. Data were again assembled and stored as a transport network, and processed using a widely available computer package.

The network used is shown in Figure B.9; the diamonds represent airports considered. Where a zone is served by more than one relevant airport, a composite frequency, fare and journey time was used. Of UK airports, only those with frequent (more than daily), scheduled flights to Continental destinations were included. UK airports considered were therefore as follows:-

Composite Scotland (Glasgow, Edinburgh, Aberdeen)
Newcastle
Manchester
Birmingham (including a few East Midlands services)
Heathrow
Gatwick

For these travellers, our formulation of travel impedance was based on only two variables, travel cost or fare, and travel time. These were calculated as follows.

Air fares, frequencies, and times were obtained from published time-tables. Summer weekday frequencies were used. Ferry fares, times and frequencies were likewise obtained; again, the summer weekday fare for a single adult were used. For the surface modes, rail was chosen as the representative mode of this class of traveller (with the addition of the connecting bus services for the Dover-Calais and Ramsgate-Calais hovercraft). Times and frequencies of trains were taken from published time-tables. For rail fares, a representative figure of 4p per mile was taken throughout the network. Our representation of the network allowed us to include the effect of having to change train or aeroplane where no through route existed; we constrained waiting times to a maximum of two hours, even for very infrequent services, on the grounds that the traveller would arrange his journey so as to make connections with such services. For air services and for the ferries, a minimum wait of one hour was imposed, to allow for checking in and clearance.

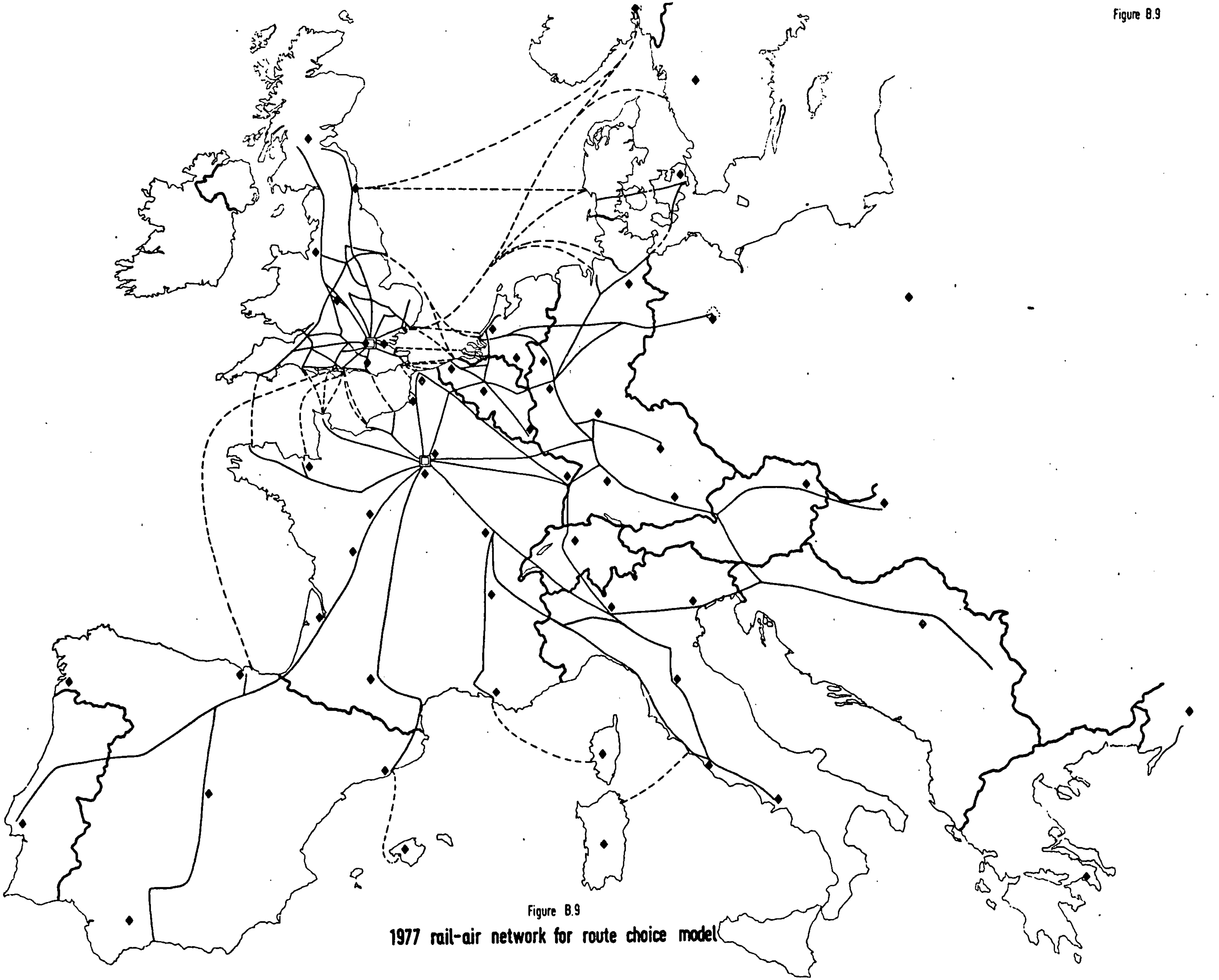


Figure B.9
1977 rail-air network for route choice model

B.3.2 The Impedance Function for Independent Travellers

The impedance functions used was was follows:

$$I = T + \frac{C}{V}$$

where T is the through time calculated as described above, including rail time, air or ferry time, time for access to railhead or airport, and waiting time; C is the through cost, including rail, air and ferry fares; and V is a parameter, the "value of time". In principle, this impedance function could be formulated to allow V to be different for different types of time, e.g. time in train, time in ship, time in flight, waiting time. However, we found no necessity for this complication.

The parameters of the model were V and the coefficient of variance (the standard deviations of the impedance distributions were assumed proportional to the means throughout). The best values of these parameters were found by searching for those which minimised the trips recorded in the 1977 IPS tabulation which were wrongly allocated to corridor (as defined for the car route choice model, but extended so that each UK airport was considered to constitute a corridor, with the exception of the London airports, which were grouped together).

An initial difficulty arose because the model consistently tended to overpredict the use of Heathrow and underpredict that of other airports. The reason for this was recognised to be the fact that the scheduled air fares were being used, whereas at these other airports a high proportion of travellers were using low-cost charter flights. To overcome this, a factor was applied to fares from each airport to reflect the proportion of charter flights using that airport. These factors could of course be modified for forecasting purposes to take account of likely future changes in the pattern of charter flights. Another, related, difficulty arose because IPS recorded travellers on routes where no scheduled services existed, presumably because of the existence of charter routes, for which no fares, times, or frequencies could be obtained. The factors found necessary were 0.8 for Manchester and Scotland, 0.9 for Newcastle and Birmingham, and 0.95 for the Heathrow-Gatwick corridor.

and thus it is likely that the proportion of travellers to France going to this zone was much lower then than it was in 1977. The underprediction on Hull routes (even after allowance has been made for meals and accommodation) suggests that we have understated the accessibility of Hull by treating Yorkshire and Humberside as a single zone. It may also reflect the different nature of the service; these ferries are presented in their promotional materials as being akin to a luxury cruise (as are those direct to Denmark, Sweden and Spain). The absolute errors here are negligible in the context of diversion to a fixed link.

As for car travellers, there is overprediction on the Newhaven-Dieppe crossing and underprediction on those from Southampton and Portsmouth. This could be because we have overstated the accessibility of Newhaven by rail.

Table B.3: Predicted and Observed Route Choice of UK Non-Car Leisure Travellers, 1977

(% of total travellers in category)

Crossing	Independent		Package		Total	
	Observed	Predicted	Observed	Predicted	Observed	Predicted
Sweden direct	0.1	0.0	0.1	0.0	0.1	0.0
Denmark direct	1.0	0.5	0.4	0.1	0.7	0.3
Germany direct	0.5	0.2	0.0	0.0	0.2	0.1
Hull routes	0.9	0.2	1.0	0.0	1.0	0.1
Haven- Belg, Neth.	4.6	5.0	1.3	0.9	2.7	2.7
Sheerness-Vlissingen	0.5	0.3	0.2	0.1	0.3	0.2
Belgian Straits	8.1	7.6	4.1	2.1	5.9	4.6
French Straits	31.2	33.2	5.7	8.8	17.1	19.7
Newhaven-Dieppe	2.2	4.1	0.8	1.7	1.4	2.8
South Coast-Normandy	2.9	2.4	2.1	1.2	2.4	1.8
Brittany direct	1.2	0.3	0.3	0.1	0.7	0.2
Spain direct	0.1	0.0	0.0	0.0	0.1	0.0
Total surface	53.3	54.0	15.8	15.0	32.5	32.4
Air via London	38.7	40.2	51.5	73.2	45.8	58.5
Air not via London	8.0	5.7	32.7	11.8	21.6	9.1
Total Air	46.7	460	84.2	85.0	67.5	67.6
Total (thousands of return trips)	2419	2419	3012	3012	5431	5431

Total includes traffic to all Continental Europe except Norway.

Numbers may not sum to totals because of rounding.

It should be noted that the model includes no non-measurable route-specific factors.

B.3.3 The Impedance Function for Package Travellers

The behaviour of this category of traveller is more difficult to model than that of the independent traveller because, by definition, the information about fare paid is not available. The characteristics of the package traveller are:-

- he tends to travel more by air;
- he tends to use regional airports rather than Heathrow;
- when travelling by sea, he tends to use the longer sea crossings to a greater extent than the independent traveller, at the expense of the French and Belgian straits routes.

These characteristics have interesting implications. If they were paying the same fares as independent travellers they would suggest a higher value of time parameter. A more likely explanation is that there is, in fact a substantial reduction in the fares actually or implicitly paid, which would have the same effect. Another factor working in the same direction is the fact that a much larger proportion of package travellers use coach, a slower, cheaper mode than rail. These implicit reductions in fare would tend to shift travellers from sea to air, and, for those using sea crossings, away from the cheaper crossings (the French and Belgian straits).

We have chosen to model this behaviour using the same network and the same functional form as for the independent non-car travellers, but with the relative importance of fare reduced.

The best parameter values found are £2.10 per hour for the value of time, and 0.1 for the coefficient of variation; again, of course, this is relative to scheduled fares, and the "real" value of time required for evaluating benefits will be considerably lower.

The predicted and observed distribution of traffic are again compared in Table B.3.1; the quality of the fit suffers from the same defects as that for independent travellers. In addition, there is a large underprediction of the Belgian Straits traffic; the observed ratio of Belgian Straits to French Straits traffic for package travellers is much higher than for independent travellers. We believe that this is because coach operators in Belgium are subject to much less administrative restriction than in France.

B.4 THE ROUTE CHOICE MODEL FOR FREIGHT

For freight, the same model structure was used as for leisure passengers. The relevant journey characteristics were taken to be time and cost, and, as shown in the main report, time and cost for the land portions were both found to be linear with distance.

Distances from the zones to the ports were again abstracted from a network. As most unitised freight carriage was road-hauled, road distances were taken as representative. The network used was that for the car travellers, with modifications to include additional ports: Immingham, Great Yarmouth, Tilbury and Poole.

The impedance function used is described in the main report.

B.5 THE EVALUATION OF USER BENEFITS

B.5.1 Method

The benefits to transport users from an improvement in a transport network may be inferred directly from our formulation of route choice, since our impedance function is a direct measure of the disutility of transport. Thus, the benefits to transport users as a whole are simply the difference in total impedance between the two situations (for example, with and without a fixed Channel crossing).

For a given zone-zone flow, as shown in B.2.2 above, the probability, P_k, that crossing k is chosen is

$$P_k = \int_{-\infty}^{\infty} N_k(I_k) \left[\prod_{l \neq k} \int_{I_k}^{\infty} N_l(I_l)\, dI_l \right] dI_k$$

where I_k, I_l are the impedances for crossings k and l, and may take any value; they are sampled from the distributions N_k, N_l.

Suppose there are M users going from a given origin zone to a given destination zone. The number of these users having a given impedance I_k for the route via crossing k is $MN_k(I_k)$ and the probability that these users will choose crossing k, that is, that the impedance I_k is lower than all the others others is:

$$\prod_{l \neq k} \int_{I_k}^{\infty} N_l(I_l)\, dI_l$$

Thus the total impedance for those users using crossing k with a given impedance I_k is:

$$MI_k\, N_k(I_k) \prod_{l \neq k} \int_{I_k}^{\infty} N_l(I_l)\, dI_l$$

and the total impedance for all users using crossing k is therefore:

$$M \int_{-\infty}^{\infty} I_k N_k(I_k) \left[\prod_{l \neq k} \int_{I_k}^{\infty} N_l(I_l)\, dI_l \right] dI_k$$

The average impedance for travellers using all crossings is thus the sum of terms like this, divided by M:

$$\text{mean impedance} = \sum_k \int_{-\infty}^{\infty} I_k N_k(I_k) \left[\prod_{l \neq k} \int_{I_k}^{\infty} N_l(I_l)\, dI_l \right] dI_k$$

B.5.2 Units

As described above, the units of our impedance functions are undefined with respect to a multiplying factor; that is, if all parameters were multiplied by the same factor, the same results would be obtained. To evaluate user benefits, we must express these disutilities in money terms. The impedances were initially expressed for convenience in terms of some standard fare; we obtained, from ferry operators, the ratio of this fare to average receipts per passenger. For non-car travellers, this ratio was assumed to be applicable to all portions of the journey.

Table B.5 sets out the values or disutilities of time thereby obtained.

Table B.5 Values of Time for UK Leisure Travellers (1979 £ per person per hour)

		LOW		HIGH	
	1977	1985	2000	1985	2000
Car travellers					
- in a car, UK road*	0.88	0.94	1.23	1.02	1.58
- in a car, Continental road	0.53	0.56	0.74	0.61	0.95
- waiting	0.88	0.94	1.23	1.02	1.58
- on a ferry or in a tunnel	0.30	0.32	0.41	0.34	0.54
Non-car travellers					
- independent	0.90	0.97	1.26	1.05	1.63
- package	0.65	0.70	0.91	0.76	1.18

* Travel on a Channel bridge is assumed to incur the same disutility as that on a UK road.

RECONCILIATION BETWEEN HM CUSTOMS AND NPC DATA

1. HM Customs and Excise trade data provided the most complete source of information on the initial origin and final destination of trade and on the port used. In contrast, the destination and origin in NPC data was found to be principally expressed in terms of the country of initial dis-or-embarkation. We therefore decided to use HM Customs data to obtain the pattern of trade.

2. However, HM Customs data excluded a number of traffics which we wished to consider, and had a number of other limitations. The principal characteristics and limitation of HM Customs data are:-

(a) expression on a net tonne basis, i.e. exclusive of packaging;

(b) exclusion of Irish traffic to the Primary and Secondary Zone which used the UK as a land bridge;

(c) exclusion of entrepot traffic to or from countries beyond the Primary and Secondard Zones;

(d) exclusion of import/export vehicles;

(e) exclusion of the NPC category "other goods carried on ro-ro services", i.e. those goods carried on by trailers limited to ship or port use only;

(f) rail wagons were categorised as "containers";

(g) the container category included all other containers, not just those that were "lift-on lift-off".

3. NPC data did not have the above limitations. We therefore decided to use NPC data for estimating the total level of unitised trade to the Study Zone. The data would then also be expressed in tonnage terms reconcilable with our tariff data collection exercise, i.e. inclusive of packaging. A problem with NPC data was the a breakdown of trade was not given for all the countries of our study zone. Therefore, it was necessary to make a number of approximations in deriving total flows. Imports and Exports to our study zone, by country of dis- or embarkation are shown in Table C.1.

TABLE C1: NPC UNITISED FREIGHT FLOWS. BY COUNTRY OF DIS- OR EMBARKATION

('000 Tonnes)

			BELGIUM - LUXEM	DENMARK	FRANCE	ITALY 3)	NETHERLANDS	WEST GERMANY	TOTAL EEC 1)	AUSTRIA -SWIT.	SPAIN 4)	TOTAL PRIMARY	SECONDARY ZONE 2)	TOTAL STUDY ZONE	IRISH TRAFFIC 4)
IMPORT	1	RGV	1609	500	1907	0	1387	130	5533	0	0	5533	200	5733	
	2	ROLLED ON CONTAINER	62	100	162	150	223	70	767	0	29	796	188	984	
	3	TOTAL ROLLED - ON - SERVICES	1671	600	2069	150	1610	200	6300	0	29	6329	388	6717	269
	4	CONTAINER	510	116	153	150	1206	201	2320	0	279	2599	263	2862	
	5	RAIL-WAGONS	204	10	417	0	0	0	621	0	0	621	0	621	
	6	CONTAINER + RAIL WAGONS	698	116	570	150	1206	201	2941	0	279	3220	263	3483	
	7	CONTAINER + RAIL + ROLLED ON CONTAINERS	760	216	732	150	1429	271	3558	0	308	3866	456	4322	
	8	IMPORT-EXPORT VEHICLES 5)	155	128	237	0	251	54	825	0	0	825	50	875	
	9	TOTAL IMPORT	2541	828	2878	300	3067	455	10069	0	306	10377	651	11097	
	10	TOTAL RO-RO + I/E VEHICLES 5)												7614	
EXPORT	1	RGV	1390	156	1567	0	1152	45	4309	0	0	4309	100	4409	
	2	ROLLED ON CONTAINERS	37	171	97	100	146	30	581	0	7	589	72	661	
	3	TOTAL ROLLED ON SERVICES	1427	327	1664	100	1298	75	4791	0	7	4798	172	4970	219
	4	CONTAINER	409	50	134	320	1007	90	2010	0	194	2204	295	2499	
	5	RAIL-WAGONS	135	0	133	0	0	0	268	0	0	268	0	268	
	6	CONTAINER + RAIL-WAGONS	544	50	267	320	1007	90	2278	0	194	2472	295	2767	
	7	CONTAINER + RAIL + ROLLED ON CONTAINERS	581	221	364	420	1153	120	2749	0	203	3161	267	3528	
	8	IMPORT-EXPORT VEHICLES	151	63	67	0	177	50	508	0	0	508	0	508	
	9	TOTAL EXPORT	2122	413	1988	420	2466	225	7597	0	203	7778	467	8245	
	10	TOTAL RO-RO + I/E VEHICLES 5)												5478	

NOTES:
1) Including unallocated category
2) Zone is from NPC Short Sea: 30% of Mediterranean category minus Iberia, plus 50% of other Baltic.
3) Category breakdown is estimated.
4) Estimated.
5) Includes other general cargo that is rolled on.

Source: NPC Statistics 1977.

4. We then carried out the following transformations on HM Customs statistics:-

(a) reclassified HM Customs traffic to be consistent with the NPC definition of ro-ro and container. A proportion of container traffic, representing that which was rolled on by ships' vehicles, was subtracted and added to the ro-ro total. These proportions (21% for import, and 11% for export) were deducted from the corresponding division observed in NPC data between rolled-on containers and total containers;

(b) multiplied by a factor for packaging. An average all-commodity figure was arrived at after consultation with NPC and HM Customs;

(c) import-export vehicles were added as ro-ro. These figures were obtained from NPC data (see Table C.1);

(d) Irish traffic through the UK was added. Using data on Irish registered vehicles through the UK, it was taken as being 5% of total study zone flows, as derived in Table C.1. It was assumed to be entirely ro-ro; direct Irish - Continental sea services exist for container;

(e) the total transformed data was compared with NPC figures for ro-ro and containers.

Transformations carried out on this basis are shown in Table C.2.

5. The different between the NPC total derived in Table C.1 and HM Customs figures (i.e. columns 7 and 8 in Table C.2) assuming that the correct reconciliation procedure has been carried out, gave an estimate of the level of entrepot trade. This was the only factor not yet allowed for. Definitional uncertainties with ro-ro and container categories as used by HM Customs in 1977 meant that the difference also included the error from our reclassification procedure. Therefore we took the sum of the net difference for ro-ro and container as the entrepot traffic.

TABLE C.2: COMPARISON OF HM CUSTOMS AND NPC DATA FOR UNITISED TRAFFIC ('000 TONNES)

	1	2	3	4	5	6	7	8	9	10
CATEGORY	HM CUSTOMS	HM CUSTOMS REDEFINED	PACKAGING FACTOR	IMPORT-EXPORT VEHICLES & OTHER ROLLED-ON CARGO	TOTAL	IRISH TRAFFIC	TOTAL	NPC	DIFFERENCE	% OF TOTAL TRADE
IMPORT										
Ro-Ro	5,654	6,306	6,620	825	7,445	296	7,741	7,614	+127	
Container & Railwagons	3,102	2,450	2,695	0	2,695	0	2,695	3,483	-788	
Total	8,756	8,756	9,315	825	10,140	296	10,436	11,097	-661	6
EXPORT										
Ro-Ro	4,246	4,524	4,976	508	5,484	219	5,703	5,478	+225	
Container & Railwagons	1,543	1,265	1,392	0	1,392	0	1,392	2,767	-1,375	
Total	5,789	5,789	6,368	508	6,876	219	7,095	8,245	-1,150	14

TABLE C.3: ESTIMATE OF UNITISED UK EXPORT ENTREPOT TRADE 1975

('000 tonnes)

FROM:	ORIGINATED FROM PORTS	DOMESTIC	PRIMARY AND SECONDARY ZONE	ENTREPOT	% ENTREPOT OF ORIGINATED FROM PORTS	% TOTAL ENTREPOT TRADE	TOTAL TRADE WITH COUNTRY
Netherlands	2,749	1,323	1,053	373	13%	62%	1,420
W. Germany	309	309	0	0	0%	0%	1,477
Belgium	1,776	942	690	143	8%	24%	1,057
France	2,273	1,335	909	29	1%	5%	1,457
Spain	329	294	0	35	10%	6%	556
Italy	103	100	3	0	0%	0%	646
Denmark	810	733	45	27	3%	5%	383
TOTAL	8,349	5,041	2,700	607	7%	100%	6,996

Source: NPC Bulletin No. 11. GB Non-Fuel Port Traffic: 1977

TABLE C.4: ESTIMATE OF UNITISED UK EXPORT ENTREPOT TRADE 1975

('000 tonnes)

TO:	LANDED AT PORTS	DOMESTIC	PRIMARY AND SECONDARY ZONE	ENTREPOT	% ENTREPOT OF LANDINGS	% OF TOTAL ENTREPOT TRADE	TOTAL TRADE WITH COUNTRY
Netherlands	2,076	774	982	320	15%	44%	851
W. Germany	177	165	5	7	4%	0%	1,036
Belgium	1,514	713	623	178	12%	25%	820
France	1,378	808	375	195	18%	27%	851
Spain	232	203	12	17	7%	2%	229
Italy	105	105	-	0	0%	0%	558
Denmark	316	271	33	12	4%	2%	331
TOTAL	5,798	3,039	2,030	729	12.5%	100%	4,675

Source: NPC Bulletin No. 11. GB Non-Fuel Traffic: 1977

6. To verify our reconciliation procedure, separate estimates were gained from NPC on entrepot trade (see Tables C.3 and C.4). The percentage of final trade estimated as entrepot by our reconciliation (see Table C.2) was closely comparable to the NPC estimate (i.e. 7% compared to 6% for imports, and 14% compared to 12.5% for exports).

7. It was assumed that all entrepot (being principally long distance trade) was by container. The entrepot trade as derived was divided by country, on the basis of the country distribution estimated by NPC in 1975 (see Tables C.3 and C.4), as shown in Table C.5.

TABLE C.5: DIVISION OF ENTREPOT TRADE BY COUNTRY

('000 Tonnes)

COUNTRY	IMPORTS		EXPORTS		TOTAL TRADE FLOWS	
	% OF TOTAL	ASSUMED DIVISION OF ENTREPOT TRAFFIC	% OF TOTAL	ASSUMED DIVISION OF ENTREPOT TRAFFIC	% OF TOTAL	ASSUMED DIVISION OF ENTREPOT TRAFFIC
Netherlands	62	410	44	506	50	916
W. Germany	0	0	0	0	0	0
Belgium	24	159	25	289	25	448
France	5	33	27	311	19	344
Spain	6	40	2	23	3	63
Italy	0	0	0	0	0	0
Denmark	5	33	2	23	3	56
TOTAL	100	661	100	1,150	100	1,827

8. On the basis of information shown in Tables C.1-5, total scale up factors from HM Customs to NPC were adopted as following:

(a) all country multiplication factors to allow for:-

(i) redefinition of modes;
(ii) inclusion of packaging;
(iii) inclusion of import-export vehicles;
(iv) inclusion of other 'rolled-on' cargo.

These are shown in Table C.6.

(b) entrepot traffic (as shown in Table C.2) was directly added to the three main entrepot countries (i.e. Netherlands, Belgium, France). It was included because we felt it desirable to consider total unitisable trade flows; however research eventually indicated that the potential for diversion was lower than average.

TABLE C.6: MULTIPLICATION FACTORS FOR REDEFINITION PACKAGING AND ROLLED-ON CARGO

CATEGORY	REDEFINITION BETWEEN RO-RO AND CONTAINER	PACKAGING	IMPORT-EXPORT VEHICLES, AND OTHER ROLLED-ON CARGO	TOTAL
Import				
Ro-Ro	1.115	1.050	1.125	1.317
Container	0.790	1.100	1.000	0.869
Export				
Ro-Ro	1.065	1.100	1.102	1.291
Container	0.820	1.100	1.000	0.901

9. In our modelling of origins and destinations, entrepot traffic was treated as follows:-

(a) for exports, the UK origins were spread as the non-entrepot traffic. The continental destinations were port zones in the appropriate countries (i.e. Rotterdam, Antwerp and Le Havre) for which independent entrepot zones were created in the freight model, so that this trade could be treated separately;

(b) for imports, the origins were the three continental entrepot port zones. The UK destinations were distributed across the UK zones, as the non-entrepot traffic.

The entrepot zones were given network link characteristics compatible with their use for long distance traffic.

10. Irish traffic in the UK was taken as originating or destinating equally in the North West and Welsh UK zones which contain the main UK-Irish trade ports of Liverpool, Holyhead and Fishguard. It was assumed that the continental origins and destinations of such traffic had the same pattern as UK trade.

INLAND HAULAGE AND SEA-CROSSING TARIFFS

Ro-ro

1. A survey was made of road haulage rates for a 12 metre tilt trailer to a number of principal continental destinations. Using regression analysis the following formula was fitted to the data:-

Total haulage charges:-

G.B. - C_{RR1} = £38 + 0.55 per vehicle mile

Continent C_{RR2} = £68 + 0.64 per vehicle mile.

Assuming that the average load of a 12 metre tilt trailer is 12.4 tonnes (from NPC statistics), then the average haulage costs per tonne were (1979):-

G.B. - C_{RR1} = £3.06 + 0.044 per mile

Continent - C_{RR2} = £5.48 + 0.0516 per mile.

Reducing these to 1977 figures gave:-

G.B. - C_{RR1} = £2.23 + 0.032 per mile

Continent - C_{RR2} = £4.01 + 0.037 per mile.

2. Published sea-crossing tariff rates by routes were supplied by ferry operators. These are shown in Table D.1. From the ferry operators questionnaire we were in many cases supplied with the confidential information as to the actual tariffs charged. Comparison with the published tariffs indicated the level of discounts granted and the levying of fuel and currency surcharges. For other routes, an estimate of the actual tariffs was made on the basis of known ratios of actual to published tariffs.

Container

3. We decided in the present study to treat lo-lo container land haulage as one mode. Therefore, we found it necessary to adopt an inland haulage formula which reflected a weighted average of road and rail haulage rates. The derivation of ro-ro haulage rates is described in the preceding section. Rail haulage rates are analysed in the next section.

TABLE D1: EXAMPLES OF RO-RO SEA-CROSSING TARIFFS

SEA CROSSING		PUBLISHED FERRY TARIFF Ro-Ro £. Vehicle (1979)		
U.K. Port	Continental Port	Accompanied	Unaccompanied	Average
Hull	Hamburg	385	310	348
	Rotterdam	335	275	310
Gt. Yarmouth	Scheveningen	315	150	282
Felixstowe	Zeebrugge	240	220	230
	Esbjerg	435	435	435
Harwich	Hook of Holland	260	240	250
	Antwerp	270	255	263
Sheerness	Vlissingen	210	170	190
Dover	Zeebrugge	270	265	268
	Calais	245	240	243
Portsmouth	Cherbourg	285	285	285
Southampton	Le Havre	285	285	285
Poole	Cherbourg	255	270	262

4. Data on container sea-crossing tariffs was assembled in a similar fashion as that for ro-ro. Examples of published data on container sea-crossing tariffs are shown in Table D 2.

TABLE D2: CONTAINER SEA-CROSSING TARIFFS

U.K. Port	Continental Port	1979 Charge per Container
Hull	Hamburg	230
	Rotterdam	155
Felixstowe	Zeebrugge	110
	Esbjerg	230
Harwich	Hook of Holland	125
	Antwerp	155
Southampton	Le Havre	140
	Cherbourg	

Railwagon

5. Rail haulage tariff books were analysed. There are no published tariffs at present for Italy or Spain. Large quantities of agricultural products are imported to the UK from these countries by rail so it was important to assume tariff rates for them.

6. Separate average charge rates were sought for the UK and continental sections of rail haulage. This proved difficult to discern, because of the variability in the form of the tariff negotiated between the UK and other countries, and the fact that the data was not readily reconcilable with those produced from other sources. As a result we decided to use a simple country specific P+Qd total cost formula from the UK to the continent.

7. A one-stage 'P+Qd' formula was not available for Austria. Instead a three stage formula existed, i.e., British Section charges, intermediate country charges, and Austrian charges. We fitted a P+Qd formula to this by 'point sampling', using a number of alternative possible distances. A similar process was undertaken for Germany, which had a two-stage tariff.

8. We were then in a position to express total through P+Qd relationships for 2-axle wagons by the six continental countries for which we had tariffs:-

(1)	France	C_{RW} = £222 + 0.30 per Km.	Published in BR tariff 1979
(2)	Belgium	C_{RW} = £261 + 0.20 per Km.	
(3)	Holland	C_{RW} = £318 + 0.20 per Km.	
(4)	Swiss	C_{RW} = £501 + 0.36 per Km.	Derived from BR tariff 1979
(5)	Germany	C_{RW} = £391 + 0.21 per Km.	
(6)	Austria	C_{RW} = £570 + 0.11 per Km.	

9. Converted to a 1977 charge per tonne-mile rate, minus sea-crossing and discount, the formula were:-

(1)	France	C_{RW} = £5.54 + 0.0236 per mile
(2)	Belgium	C_{RW} = £7.44 + 0.0151 per mile
(3)	Holland	C_{RW} = £11.74 + 0.0151 per mile
(4)	Swiss	C_{RW} = £25.57 + 0.0273 per mile
(5)	Germany	C_{RW} = £17.26 + 0.0160 per mile
(6)	Austria	C_{RW} = £21.20 + 0.009 per mile

10. The introduction of fixed tariff rates has been a recent innovation,and they are currently awaited for other countries. In the absence of published tariffs for the more distant countries in our study zone it was necessary to assume tariff rates. After discussions with railway agencies a number of assumptions were made on rail haulage tariff rates. Secondary zone countries were generally given the same haulage tariff rate as Germany. Spain and Italy were given haulage tariff rates similar to France.

11. Attempt was made to verify the above figures. Limitations on data availability and the generally conflicting information from varying sources led to difficulties with this. However, agreement was found for the general form of the above formulae.

12. Confidential data was gained from BR on receipts by sea-crossing route in 1977. These were analysed and input to the model on a per tonne basis.

FREIGHT TRANSIT TIME OF ALTERNATIVE MODES

1. We made initial surveys of transit time between UK and continental destinations using timetabled information from freight forwarders. However, data collected from other sources showed that transit times by railwagon and lo-lo container, were in pratice, much longer. We therefore sought data on actual transit times.

Ro-ro

2. Various studies were consulted to gain information on ro-ro transit times. However, these were either poorly documented in terms of their data base, or not appropriate for use in the present study. As a result, new surveys were carried out. The times gained were inclusive from London through to continental destinations. Delivery schedules were generally met. There are fairly frequent scheduled departures to most 'near-sea' destinations for ro-ro freight. A limited amount of information was also gained on import ro-ro times. This showed import and export times to be broadly comparable. Regression analysis of the data for travel time gave the following formulation for inland transit time:-

$$t_{RR} = 16.0 + 0.058 \text{ hrs. per mile.}$$

3. Port times vary by port; however an average port time 1.5 hours was deduced for each port. Information was also gained on sea-crossing times and frequency of service from each port. These are shown in Appendix A. For the near-sea countries, sea-crossing times vary by route from under 2 hours (Dover-Calais) to over 20 hours (Harwich-Hamburg). Sea-crossing times to Scandinavia are generally of the order of 30 hours. The frequency ranged for ro-ro sea-crossing routes from 1 per day on the Immingham-Rotterdam route, to about 32 per day on the Dover-Calais route. The treatment of frequency is discussed in Appendix H.

Container

4. Information was gained from freight operators and various published sources on lo-lo container transit times. Again wide discrepancies between published sources and actual times were found. As a result, and since we treated lo-lo container as a composite mode, we fitted a formulae from the weighted average of the formulae we derived for ro-ro (70%) and railwagon (30%), reflecting the study zone modal split.

5. Our review of transit times showed that delivery times to more rural or distant destinations were much longer. In particular, sources agreed that delivery times to the Iberian peninsula were much longer compared to other destinations of similar distance in the study zone. An additional time of 96.00 hours fixed time to our general formula was derived for container traffics to the Iberian peninsula.

6. Container lo-lo port times were found to be closely similar to railwagon, largely due to comparable movement operations. Data from the BR Operational Research Division showed that, on average, container port times were slightly longer than railwagon. Our estimate of average port time in 1977 was 66.0 hours. It was noted that there were a number of possibilities for greatly reducing these, some of which are currently being put into effect.

Railwagon

7. Information was gained from the BR International Shipping Division on timetabled inland haulage times to 51 continental destinations. These are summarised in Table E.1. It was estimated that the average journey time from the UK origin to Zeebrugge was 48 hours.

8. However, contact with freight forwarders, analysis of confidential survey data, and information from the British Rail Operational Research Division showed that though the mode (i.e., most common) transit time was close to the timetabled time, mean transit times were much longer. This was due to:-

(1) delays in marshalling;
(2) traffics being lost in transit;
(3) customs delays;
(4) inflexible timetabling arrangements, leading to long wait times due to missed connections;
(5) other delays due to equipment and administration difficulties.

9. By combining data from a number of sources, the inland haulage transit time rail haulage formula we finally adopted was:-

TABLE E1: TIMETABLED CONTINENTAL RAIL WAGON FREIGHT & DISTANCES

From Dunkirk or Zeebrugge

	TO	COUNTRY	TOTAL HOURS	DISTANCE (ROAD MILES)
1.	Amiens	France	29	86
2.	Bordeaux	"	43	537
3.	Clermont Ferrand	"	51	427
4.	Dijon	"	46	378
5.	Limoges	"	43	424
6.	Lille	"	23	50
7.	Lyon	"	46	469
8.	Marseilles	"	49	664
9.	Nancy	"	37	329
10.	Nantes	"	45	370
11.	Orleans	"	40	262
12.	Paris	"	31	182
13.	Reims	"	34	176
14.	Rennes	"	46	323
15.	Rouen	"	48	135
16.	Toulouse	"	47	621
17.	Tours	"	45	330
18.	Basel	Switzerland	35	480
19.	Berne	"	43	470
20.	Luzern	"	48	540
21.	Zurich	"	46	534
22.	Bologna	Italy	63	828
23.	Florence	"	82	881
24.	Milan	"	61	700
25.	Naples	"	113	1184
26.	Rome	"	82	1053
27.	Turin	"	87	661
28.	Barcelona	Spain	107	865
29.	Madrid	"	134	972
30.	Seville	"	158	1276
31.	Lisbon	Portugal	177	1296
32.	Antwerp	Belgium	30	126
33.	Bruselles	"	25	122
34.	Rotterdam	Netherlands	47	187
35.	Bremen	Germany	50	415
36.	Dortmund	"	54	285
37.	Hamburg	"	52	475
38.	Cologne	"	32	253
39.	Munich	"	53	614
40.	Munster	"	54	297
41.	Osnabruck	"	46	334
42.	Berlin	"	77	574
43.	Dresden	East Germany	92	615
44.	Leipzig	"	117	563
45.	Prague	Czechoslavakia	67	687
46.	Poznan	Poland	128	702
47.	Warsaw	"	142	1058
48.	Vienna	Austria	90	820
49.	Belgrade	Yugoslavia	108	1229
50.	Budapest	Hungary	63	971
51.	Zagreb	Yugoslavia	120	994

Source: B.R. Railfreight Ferry Train Services : A Guide to Continental Arrival Times For Export Traffic via Dover and Huwich.

$Trw = 48.0 + 0.288$ hours per mile.

The average railwagon time per port derived was 56.0 hours.

POTENTIAL FOR LINK-INDUCED UNITISATION

Overall Situation

1. We carried out an investigation into whether a new channel link facility would induce further unitisation. The present level of unitisation and forecasts of the change in unitisation rates, which would occur in any case over the study period, are analysed in Appendix G.

2. Consideration of haulage rates showed that through whole train load haulage, or semi-train load haulage, would be the most likely to attract traffics currently going by bulk mode. We therefore first sought to investigate this possibility. Movement by individual wagon-load, RGV container, or ro-ro on the bridge was a less likely possibility for the type of traffics not yet unitised.

3. We were able to base our work on the extensive studies carried out by Coopers & Lybrand in the previous Channel Tunnel studies. These concentrated on a group of commodities (referred to as the "Special Commodities") which were initially thought would be most likely to convert from bulk or semi-bulk mode, to unitised mode across the link. The 1970 situation for the "Special Commodities" is shown in Table F1. The conclusion of these studies was that there would be little or no potential for induced unitisation with the installation of a Channel Tunnel. There were two main reasons for this:-

(a) the comparatively long low value/volume relationship of the goods meant that they could be attracted only by the cheapest forms of transport;

(b) the large investment in existing facilities for these goods.

TABLE F1: UNITISATION OF "SPECIAL COMMODITIES" 1970

1,000 tonnes

COMMODITY	IMPORTS			EXPORTS		
	Total	non-unitised	Unitised	Total	non-unitised	Unitised
1. Chemicals[1]	1234	799	435	727	460	397
2. Transport Equip[2]	3531	110	243	514	148	496
3. Iron and Steel	1029	1029	-	1097	1097	-
4. Other Bulk Commodities						
(i) Coal	122	122	-	2948	2948	-
(ii) Ores & Scrap	1665	1665	-	419	419	-
(iii) Crude Fertilisers & Minerals	1162	1162	-	2433	2433	-
(iv) Cereals & Cereal Preps	1530	1530	-	241	241	-
(v) Sugar & Sugar Preps	169	169	-	61	61	-
(vi) Wood, Lumber, Cork	38	38	-	7	7	-
(vii) Manufactured Fertilizers	754	754	-	26	26	-
TOTAL	8056	7378	678	8473	7840	885

Notes

1. Including chemical elements and miscellaneous chemicals
2. Consists of (a) assembled vehicles
   (b) unassembled vehicles,
   (c) vehicle spares and replacement parts.

4. We carried out a review of the current situation with regard to these commodities. This work has led to a similar conclusion. We have therefore assumed there will be no induced unitisation following the construction of either a road or a rail fixed link. This is more fully reviewed in the next section which summarises our findings by commodity.

Review by Commodity

5. In the previous Channel Tunnel studies, an extensive set of interviews were carried out to determine the nature of movement of commodities, with potential for unitisation, with the installation of a fixed Channel Link. It was not felt necessary to fully repeat that exercise here, since the general pattern and nature of movement of these goods has on the whole remained similar. As noted, many of these commodities have had large capital investments in transport facilities, which act against rapid change in movement patterns.

6. Two possible types of non-unitised goods were initially distinguished for each commodity:

(a) bulk flows of generally a very low value/volume ratio, often currently using charter ships, which would probably have little attraction to a new link facility.

(b) bulk flows, of higher value and smaller consignment size, often with an origin or destination further inland, which it was initially thought might use a new link if offered competitive pricing by the use of company trains or wagon load trains.

Chemical Commodities

7. A sizeable component of these traffics is already unitised. We considered the non-unitised component as follows:

(a) movements by bulk liquid charter ships to port-orientated activities, such as refineries. Since raw materials and final product usually have a portside origin and destination (often being moved ashore by pipeline) the movements are not considered as potentially divertable.

(b) large volume shipments, using bulk charter shipping, but with inland origins or destinations. These are not considered as potentially divertable, due to the fact that a short inland haulage with transhipment, and bulk charter shipping, typically to or from continental portside origins or destinations, is generally cheaper than long onland haulage.

Transport Equipment

8. This category consists of ships, railway equipment, aircraft, import-export vehicles and car components. The previous Channel Tunnel studies noted a strong potential for the unitisation of import-export vehicles, due to the large volume of fairly regular flows of these high value goods between the U.K. and the EEC countries. It was found since then that these traffics have moved from being principally carried on bulk charter vessels to using spare capacity on scheduled ferry services. The potential for further unitisation is now fairly small. Regarding the remainder of this category, the movement of ships, railway equipment and aircraft in any case only makes up a small volume of trade, and is already highly unitised.

Iron and Steel

9. Generally speed, reliability and freedom from loss or damage are comparatively unimportant with these products. Since the raw materials are often imported by bulk shipping, many plants have coastal or riverside locations. For further unitisation to occur - for example, for movement of finished steel products inland - we felt that considerable grouping at central rail yards or at ports would be required for it to be economical. This would be unlikely to occur without further major expenditure on the necessary facilities.

Other Bulk Commodities

10. The products in this group (see Table F1) made up about 50% of the base year bulk flows by weight. Their comparatively very low value to weight ratio had led many activities associated with them to be also port-orientated, including the principal points for collection and use in production processes. These facilities have often had large investments in transport infrastructure, i.e. bulk berths and dock handling facilities.

11. In addition, we noted that rail sidings do not exist at a number of points of production or consumption for this group of commodities, often having been removed in relatively recent years (e.g. at scrap-yards in UK, and at wheat silos in France).

12. Rail transport via a new link for these commodities could not compete with cheap charter shipping, except where the original destination or the final distribution centre was inland, and transfer to rail was necessary. Two possible cases we thought worth investigating in detail were exports of coal from the Yorkshire and Midland coalfields, currently going via a large terminal at Immingham, and coal exports from Kent.

13. The previous Channel Tunnel studies noted that continental destinations for coal were principally to coastal power stations for exports to Germany (Hamburg, Bremen, Farge and Lubeck) and briquetting plants for anthracite from South Wales at Rouen, Nantes and Caen in France. Traffic was unlikely to be diverted to Rail-hauled mode. It was noted that 38,000 tonnes were exported from Kent in 1970, which it was previously thought might experience some diversion.

Of the 3 million tonnes exported, we estimated then that potential diversion was only of the order of 30,000 tonnes per annum (i.e. approximately a train-load per week).

14. The pattern of the principal movements of coal has changed markedly between 1970 and 1977. The relevant principal movements of coal between UK regions and ports and main EEC countries are shown in Table F2. The table shows that British exports to Germany have disappeared, as well as exports from the Kent coalfield. The South-East region has now become a net importer of coal, to a similar level of exports in 1970. The principal exports of coal are via the NCB terminal at Immingham, and the west coast ports.

15. The figures indicate that in the short term, the market for the diversion of coal to unitised mode is likely to be a marginal operation of the order of 1% of the total trade in the commodities. We therefore consider that the previous estimate of 30,000 tonnes per annum for the total to be the level of potential diversion, though this is likely to be for imports, not exports.

16. The other bulk non-fuel Special Commodities traffics, which were considered to have most potential for diversion were:-

(a) china clay exports to France;

(b) grain imports from France;

(c) scrap shipments to Belgium.

17. However, it was found that similar considerations as apply to coal, were important in determining transport movements of these commodities. We felt that the economics of transport operation could allow small regular trainload shipments of china clay (exports) and wheat (imports) to operate with France. These would amount to 30,000 tonnes of china clay, and 90,000 tonnes of wheat, in 1985. This could be made possible by the use of the same hopper wagons, which would be cleaned between the outward and inward trip to the UK.

Conclusion

18. Our studies of the commodity groups that have the most potential for induced unitisation with a fixed link indicate that in fact only a very limited potential exists for diversion to trainload services. Therefore diversion to a bridge would be negligible since rail offers the most attractive alternative. Unitisation rates are already very high, and those traffics still not unitised have preference for bulk shipping modes due to their weight and volume. The level of traffic that might become unitised, for example in the 1985 case, was of the order of 0.2 million tonnes, out of a total average level of forecast trade then of approximately 26 million tonnes. We therefore decided, in common with the previous studies, that from a conservative viewpoint link induced unitisation would be small enough to be considered as zero for our modelling purposes.

TABLE F2 PRINCIPAL MOVEMENTS OF COAL, COKE, BRIQUETTES BETWEEN U.K. PORTS AND EEC BLOCK' THOUSANDS TONNES NET 1977

U.K. PORT \ COUNTRY	IMPORTS				EXPORTS			
	NETHERLAND	WEST GERMANY	BELGIUM & LUXEMBURG	FRANCE	NETHERLANDS	WEST GERMANY	BELGIUM & LUXEMBURG	FRANCE
South-East								
London and Colchester	51	33	56	8	2	-	-	-
Rochester	177	7	78	5	-	1	-	-
Dover, Folkestone, Other	-	-	1	12	2	-	-	-
Bristol Channel								
Newport	-	145	-	-	31	-	14	-
Cardiff	36	-	36	-	7	-	10	16
Port Talbot	-	-	-	-	56	-	65	7
Swansea and Other	-	2	-	-	16	14	32	365
North-East								
Blyth	-	-	-	-	-	30	-	-
Tyne, and Other	-	1	-	-	-	103	0	6
Humber								
Immingham, and Other	1	6	1	-	-	296	10	421
TOTAL FOR PORTS LISTED	265	194	172	25	114	558	140	815

Source: NPC 1977.

FREIGHT CONVERSION FACTOR AND UNITISATION RATE

1. SETEC were responsible for producing trade forecasts over the study period using the high and low economic senarios. They used OECD statistics as their base data source, and a base year of 1976. The trade flows forecast by SETEC were total trade flows, divided into 14 main commodity groups.

2. C & L were responsible for forecasting freight route choice. This was made up of two main stages:

(a) applying unitisation rates to SETEC total trade flows over the study period, to derive the level of potentially divertable traffic

(b) development and appliction of a freight route choice model.

3. It was necessary to determine the base year unitisation rate of SETEC trade flows, as a basis for estimating the level of unitised traffic over the study period. There were four main differences in data sources to be reconciled:

(a) SETEC had used 1976 as a base year, and C & L 1977

(b) SETEC flows were derived from OECD data, and C & L on HM Customs/NPC. Flows by commodity from these sources were compared and discrepancies found particularly in basic commodities, notably to the Netherlands and Belgium, and also in certain total country trade flows, such as Austria and Switzerland, to which a similar discrepancy had been noted in the previous Channel Tunnel Studies. The example of the discrepancy in flows in basic materials to the Primary Zone (minus Denmark) is shown by comparison of total trade in this commodity group in Table G.1

TABLE G1 COMPARISON OF OECD AND HM CUSTOMS 1976
('000 tonnes)

Imports		Exports	
OECD	HM Customs	OECD	HM Customs
1924	3061	7930	4542

When this discrepancy was traced to an individual commodity level, the major variation appeared for sand and gravel. We believe that offshore aggregates which would only pass through ports of the country of destination, may be partial explanation for this discrepancy. Flows in these materials would be greatest for those countries with the widest discrepancy noted above.

(c) SETEC commodity groupings did not readily reconcile with those from other sources.

(d) SETEC data did not include packaging.

4. To reconcile these differences, the following was carried out:

(a) we converted our 1977 unitised trade flows to the 1976 level, by using conversion factors based on total trade flows by country for these years.

(b) SETEC adjusted their value/volume commodity ratios for 1976 so that the total levels reconciled with the total trade flows given by HM Customs for this year. (see Table G.2.) No adjustment was made for the basic commodity sector. It was necessary for C & L to reconcile the two data sources in the adoption of the unitisation rate.

(c) SETEC commodity groupings were mapped into those defined by HM customs for food, manufacturing and basic commodities.

(d) SETEC total trade flows were compared with total packaged unitised trade flows, so the assumption of a unitisation rate included a packaging factor.

5. The 1976 unitisation rate, including packaging and reconciliation factors, was then deduced by country at the three commodity levels (see Table G.3) Though available data on unitisation rates by commodity base year is somewhat uncomprehensive, unitisation rates were checked at a more disaggregate level by comparing with data from HM Customs on individual commodities. When account was taken of the data source reconciliation and packaging factors, the level of the unitisation rates was broadly verified.

6. Analysis was made of NPC work on future levels of unitisation,[1] and further discussions were held with NPC personnel. Their knowledge of unitisation trends of particular commodities and in developments in handling facilities was used in estimating future unitisation rates. This was also in part supplemented by information on possible developments in goods handling from freight forwarders and operators, and other published sources on possible developments in freight traffic.

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1. NPC Report No.11 : GB Non-Fuel Traffic: Forecasts for 1980 and 1985 (Nov.1977)

TABLE G2 1976 and 1977 H.M. CUSTOMS TOTAL NON FUEL TRADE INCLUSIVE OF I/E VEHICLES

Country	IMPORT				EXPORT			
	1. H.M. Customs (1) 1976	2. H.M. Customs (1) 1977	3. 1976/1977	4. Cars 1976	5. H.M. Customs 1976	6. H.M. Customs 1977	7. 1976/1977	8. Cars 1976
Denmark	1155	1223	0.94	0	626	763	0.82	104
Germany	3497	3835	0.91	329	2634	3086	0.85	75
Italy	1685	1900	0.89	161	1290	1290	0.94	87
Netherlands	6670	5097	1.30	11	3212	1741	1.17	135
Belgium	2769	2475	1.12	103	1834	1988	0.92	75
France	4450	5017	0.89	274	1796	1993	0.90	94
Switzerland) Austria)	999	515	0.99	0	0	564	0.80	70
Spain	1478	1555	0.95	3	822	1162	0.71	5
TOTAL	22203	21617	1.03	881	12665	13668	0.93	

(1) Fuel element deducted

TABLE G.3 : ESTIMATION OF UNITISATION SETEC TRADE FROM TOTAL TRADE DATA 1976

Includes correction factor between data sources

Excludes Entrepot and Irish Traffic

COMMODITY SECTOR	GERMANY			ITALY			NETHERLANDS			BELGIUM & LUXEMBOURG			FRANCE		
	TOTAL TRADE	% UNITISED	UNITISED TRADE	TOTAL TRADE	% UNITISED	UNITISED TRADE	TOTAL TRADE	% UNITISED	UNITISED TRADE	TOTAL TRADE	% UNITISED	UNITISED TRADE	TOTAL TRADE	% UNITISED	UNITISED TRADE
IMPORT															
1. Foodstuffs	523	61	319	316	92	291	2538	35	881	869	38	332	2482	33	819
2. Manufactured Goods	1982	78	1539	732	88	644	2991	38	1145	1792	56	998	1597	62	302
3. Basic Materials	210	60	125	119	28	33	391	19	82	212	22	46	657	21	138
4. Coal	187	0	0	0	0	0	131	0	0	82	0	0	71	0	0
TOTAL	2906	70	2014	1167	83	968	6051	35	2010	2955	47	1376	4807	41	1950
EXPORT															
1. Foodstuffs	295	58	171	46	74	43	317	45	143	211	32	67	178	71	127
2. Manufactured Goods	1000	79	790	478	80	383	2016	40	800	1169	51	598	870	81	704
3. Basic Materials	1255	13	158	632	28	171	1805	21	371	2106	10	211	1680	22	365
4. Coal	318	0	0	9	0	0	275	0	0	295	0	0	480	0	0
TOTAL	2873	39	1118	1156	52	598	4419	30	1315	3781	23	876	3208	37	1197

IMPORT	AUSTRIA & SWITZERLAND			SPAIN			DENMARK		
	TOTAL TRADE	% UNITISED	UNITISED TRADE	TOTAL TRADE	% UNITISED	UNITISED TRADE	TOTAL TRADE	% UNITISED	UNITISED TRADE
1. Foodstuffs	11			697	48	336	821	61	493
2. Manufactured Goods	302			439	27	118	213	60	128
3. Basic Materials	14			325	5	15	121	61	74
4. Coal	0			0	0	0	0	0	0
TOTAL	327	141	406	1475	32	469	1155	60	693
EXPORT									
1. Foodstuffs	63			114	39	45	71	32	23
2. Manufactured Goods	329			377	25	95	443	80	397
3. Basic Materials	70			382	5	19	112	18	20
4. Coal	0			28	0	0	0	0	0
TOTAL	461	57	360	901	70	158	626	64	395

Notes 1) Commodity breakdown not available

7. Sources agreed that U.K. - Study Zone traffic at least in terms of value, was already highly unitised. After marked increases in unitisation rates for certain commodities, a general levelling of this process has occurred. Though a small increase was conceivable for some commodities to certain destinations (e.g. fruit and vegetables to the Netherlands) conversely for other commodities a decrease in the unitisation rate might occur if there were large changes in the level of demand, or the movement of origins and destinations to portside locations (eg. possibly chemical traffic with France).

8. We estimated from NPC data that the net overall increase in unitisation to 1985 would be of the order of 2%. It was difficult to assign changes with any real significance to individual commodity groups. Individual commodities have often shown rapid changes in their unitisation rate - for example trade in sugar moved from being largely not unitised in 1970 to being principally unitised in 1977. The trend in overall unitisation rates has however shown less fluctuation.

9. As a result of these considerations, we decided to adopt the following changes in unitisation rates from the base year:

(a) an increase of two percentage poinsts for each commodity group by 1985

(b) a further increase of two percentage points for each commodity group by 2000.

FREQUENCY OF FREIGHT VESSEL SERVICE

1. The port times we adopted included allowance for:
   (a) movement in port areas
   (b) customs clearance
   (c) loading onto vessel
   (d) port-associated waiting time.

Our development of a freight route choice model indicated that waiting time related to vessel route crossing frequency was also a determinant of route choice . We therefore decided to include an additional time factor for waiting related to service frequency.

2. We gave consideration to various weights to be used to incorporate a factor for the perception of this possible waiting time. We adopted the assumption that vehicle arrivals at port were on average random, and that the average waiting time was the average intership time divided by two. The frequency of service by route is included in Appendix A.

3. We made initial assumptions on future likely service levels, based on
   (a) the increase in demand
   (b) the anticipated diversion by route with the introduction of various link schemes.
   (c) changes in vessel size over the study period.
   (d) the differential service characteristics of each route

The initial assumptions as agreed with SETEC are shown in Table H.1. The results of our route choice forecasting (see Appendix P) gained with these initial estimates, showed them on the whole to be reasonable. The results indicated that we possibly underestimated the likely future level of service offered on the Dover Straits by ferry operators in competition with a link. However our estimates may be justified by the future use of particularly large capacity ferries on these routes. Ideally the route choice models should have been reiterated after initial estimates of diversion were gained.

TABLE H.1: FORECAST FREIGHT FREQUENCIES

LINK SCENARIO / ROUTE / Case			NO LINK	SINGLE TRACK	DOUBLE TRACK	BRIDGE	BRIDGE PLUS SINGLE
FRENCH STRAITS							
	1985	High	130	110	40	25	20
		Low	115	95	35	25	20
	2000	High	215	195	66	35	30
		Low	150	130	46	30	25
NEWHAVEN-DIEPPE							
	1985	H	130	125	48	45	40
		L	115	110	43	40	35
	2000	H	215	195	80	60	55
		L	150	150	56	50	45
LE-HAVRE-SOUTHAMPTON							
	1985	H	130	120	74	55	50
		L	115	105	66	50	45
	2000	H	215	195	123	85	80
		L	150	150	86	65	60
CHERBOURG-SOUTHAMPTON							
	1985	H	130	120	108	80	175
		L	115	105	96	170	65
	2000	H	215	195	179	125	120
		L	150	150	125	90	85
BELGIAN STRAITS							
	1985	H	130	110	48	45	40
		L	115	95	43	40	35
	2000	H	215	195	80	60	55
		L	150	130	56	50	45
HARWICH-HOOK							
	1985	H	130	120	62	50	45
		L	115	105	53	45	40
	2000	H	215	210	146	175	170
		L	150	145	80	55	50
FELIXSTOWE-ZEEBRUGGE							
	1985	H	130	120	108	50	45
		L	115	105	93	45	40
	2000	H	215	210	181	175	170
		L	150	140	127	55	50
LONGER DISTANCE ROUTES							
		H	130	120	108	50	45
		L	115	105	93	45	40
		H	215	210	181	175	70
		L	150	145	127	55	50

THE BRITISH CONSULTANTS' ROUTE CHOICE RESULTS

Details of the changes in the patterns of route choice are summarised in the following tables. Table I.1 shows the effect of the links on UK leisure travellers with cars. Tables I.2 and I.3 show similar information for non-car travellers. Details of the changes in freight route choice are summarised in Table I.4 (low growth scenario) and Table I.5 (high growth scenario).

TABLE I.1 UK LEISURE PASSENGERS' ROUTE CHOICE : CAR TRAVELLERS (THOUSANDS OF RETURN TRIPS)

Crossing Group	Low growth scenario						High growth scenario					
	1985			2000			1985			2000		
	No link (thousands)	Tunnel (percentage change)	Bridge (percentage change)	No link (thousands)	Tunnel (percentage change)	Bridge (percentage change)	No link (thousands)	Tunnel (percentage change)	Bridge (percentage change)	No link (thousands)	Tunnel (percentage change)	Bridge (percentage change)
Norway & Sweden direct	24	-	-	48	-	-	32	-	-	81	-	-
Denmark direct	24	-1	-1	47	-	-	31	-	-1	79	-	-
Germany direct	8	-19	-25	23	-5	-7	9	-23	-31	31	-16	-35
Hull-Belgium & Netherlands	28	-21	-27	114	-12	-16	37	-25	-32	175	-16	-29
Haven-Belgium & Netherlands	83	-34	-40	149	-28	-34	110	-33	-41	261	-31	-48
Sheerness-Vlissingen	18	-42	-50	44	-37	-45	26	-40	-52	59	-42	-70
Belgian Straits	88	-7	-36	161	-10	-37	114	-13	-46	208	-29	-76
French Straits - ship	230	-42	-62	355	-46	-64	332	-51	-71	694	-60	-82
French Straits - hover	47	*	*	28	*	*	19	*	*	73	*	*
Newhaven-Dieppe	128	-21	-34	308	-15	-27	182	-32	-40	543	-24	-48
South Coast-Normandy	156	-8	-14	288	-5	-9	205	-10	-17	557	-8	-19
Ferries to Brittany	70	-35	-37	187	-23	-25	87	-37	-40	234	-29	-34
Spain direct	16	-11	-12	43	-6	-7	18	-12	-14	60	-9	-11
Total Ferries	921	-28	-40	1795	-22	-31	1200	-31	-44	3054	-31	-48
Traffic on the Link	-	342	465	-	527	766	-	467	654	-	1168	1835

Notes: (a) hovercraft services are assumed to disappear in the presence of a car-carrying link

(b) these changes in route choice patterns result not only from the presence of the Link, but also from the complicated pattern of tariff reactions described in Section 5.2 of the main report.

TABLE I.2 UK LEISURE PASSENGERS' ROUTE CHOICE: INDEPENDENT NON-CAR (THOUSANDS OF RETURN TRIPS)

Crossing Group	Low growth scenario								High growth scenario							
	1985				2000				1985				2000			
	No link (thousands)	1-track (percentage change)	2-track	Bridge	No link (thousands)	1-track (percentage change)	2-track	Bridge	No link (thousands)	1-track (percentage change)	2-track	Bridge	No link (thousands)	1-track (percentage change)	2-track	Bridge
Haven - Belgium & Netherlands	95	-20	-17	-1	56	-23	-25	-2	61	-21	-22	-1	12	-23	-30	+5
Belgian Straits	195	-35	-37	-4	181	-46	-49	-6	166	-40	-43	-5	105	-54	-58	-8
French Straits	837	-39	-66	-40	903	-47	-76	-47	759	-43	-72	-44	450	-59	-85	-59
Newhaven - Dieppe	94	-37	-31	+11	72	-42	-37	+13	72	-40	-34	+13	22	-48	-46	+11
South Coast - Normandy	49	-34	-32	-2	39	-35	-35	+1	37	-33	-33	+1	19	-28	-31	-1
Total ferry	1303	-36	-53	-26	1266	-45	-66	-34	1116	-40	-60	-30	612	-56	-76	-46
Air via London	1018	-1	+1	+1	1662	+1	+3	+3	1346	+2	+4	+2	2725	+5	+4	+2
Air not via London	222	-7	-6	+2	359	-11	-11	+3	290	-10	-9	+3	604	-13	-13	+2
Total Air	1240	-2	-1	+1	2021	-1	-	+3	1636	-	+1	+2	3328	+1	+1	+2
Traffic on the link	-	645	835	294	-	823	1056	306	-	625	807	244	-	860	893	514

Notes: (a) The increases in air traffic via London are attributable to the assumed fare cuts (see section 5.2 of the main report)

(b) The increases in certain ferry traffic in the presence of the bridge are attributable to the demise of the hovercraft

(c) Only those services are shown which carry an appreciable propertion of this category of traffic

TABLE I.3 UK LEISURE PASSENGERS' ROUTE CHOICE: PACKAGE NON-CAR (THOUSANDS OF RETURN TRIPS)

Crossing Group	Low growth scenario								High growth scenario							
		1985				2000				1985				2000		
	No link (thousands)	1-track (percentage change)	2-track	Bridge	No link (thousands)	1-track (percentage change)	2-track	Bridge	No link (thousands)	1-track (percentage change)	2-track	Bridge	No link (thousands)	1-track (percentage change)	2-track	Bridge
Haven - Belgium & Netherlands	35	-23	-24	-3	30	-28	-28	-4	21	-25	-25	-3	8	-36	-37	-5
Belgian Straits	90	-33	-34	-9	98	-40	-41	-11	73	-37	-39	-10	55	-49	-52	-22
French Straits	399	-34	-57	-40	487	-37	-62	-41	318	-35	-60	-42	229	-42	-70	-52
Newhaven - Dieppe	87	-32	-28	-4	88	-34	-30	-4	58	-31	-27	-2	24	-32	-30	-1
South Coast - Normandy	61	-34	-40	-21	61	-32	-42	-22	40	-42	-38	-20	18	-30	-37	-25
Total ferry	693	-33	-47	-27	776	-36	-52	-31	518	-35	-50	-29	334	-41	-62	-38
Air via London	2443	-2	-1	-	3267	-2	-1	-	2835	-1	-1	-	4404	-	-	-
Air not via London	379	-5	-5	+5	504	-7	-6	-1	450	-6	-6	-	725	-6	-7	-
Total air	2883	-2	-2	-	3771	-2	-2	-	3285	-2	-1	-	5129	-1	-1	-
Traffic on the link	-	410	486	198	-	555	663	253	-	350	418	158	-	353	430	125

Notes: Only those services are shown which carry an appreciable proportion of this category of traffic.

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TABLE I.4 FREIGHT ROUTE CHOICE : LOW GROWTH SCENARIO

YEAR		1985					2000				
TONNAGES BY CORRIDOR / CROSSING SCHEMES	MODE	NO LINK	SINGLE TRACK	DOUBLE TRACK	BRIDGE	BRIDGE PLUS SINGLE TRACK	NO LINK	SINGLE TRACK	DOUBLE TRACK	BRIDGE	BRIDGE PLUS SINGLE TRACK
1. Hull-Hamburg	Ro-Ro	401	395	388	385	389	515	506	490	491	492
2. Hull-Rotterdam	"	1520	1491	1302	1288	1306	2345	2289	1948	1948	1955
3. Haven-Hook	"	2758	2673	2607	2469	2460	4230	4064	4161	3930	3874
4. Haven-Zeebrugge, Dunkirk	"	1278	1177	924	879	779	1894	1603	1284	1327	1137
5. Harwich-Hamburg	"	547	530	489	479	488	639	614	537	531	534
6. Belgian Straits	"	2444	2183	2540	2272	2228	3503	3055	3532	3150	2967
7. French Straits	"	2376	1746	1788	1808	1495	2875	2009	2019	2030	1593
8. Newhaven-Dieppe	"	734	384	366	464	302	655	251	307	494	249
9. Soton-Le Havre, Cherbourg	"	1598	1146	942	1126	873	1773	1117	972	1317	919
10. Hull-Hamburg	Lo-Lo	241	235	236	235	237	348	340	334	338	336
11. Hull-Rotterdam	"	750	664	643	665	650	1117	1013	921	972	931
12. Haven-Zeebrugge, Dunkirk	"	1800	1598	1368	1683	1260	1094	1970	1854	1930	1690
13. Haven-Rotterdam	"	1121	1159	935	1036	860	1653	1762	1653	1478	1488
14. Harwich-Hamburg	"	1104	1071	1062	1055	1065	2018	1960	1897	1912	1903
15. Tilbury-Rotterdam	"	1251	1311	965	1115	963	1890	1088	1440	1624	1401
16. Soton-Cherbourg	"	400	393	391	399	392	553	549	548	552	548
17. Dover-Dunkirk	Railwagon	3076	-	-	2148	-	7793	-	-	6022	-
18. Harwich-Zeebrugge	"	1341	1092	876	987	864	3314	2573	2300	2709	2254
19. Harwich-Dunkirk	"	0	-	-	0	-	0	-	-	0	-
20. Link	Railwagon	-	4850	3917	-	3781	-	10814	9352	-	9928
21. "	Lo-Lo	-	740	644	-	644	-	615	450	-	441
22. "	Ro-Ro	-	-	2447	4356	3802	-	-	3104	6445	5461
TONNAGES BY MODE											
1.	Ro-Ro	13756	11724	13801	15515	14122	18438	15507	18453	21663	19180
2.	Lo-Lo	6665	9172	6243	6187	6071	9656	10277	9095	8806	8739
3.	Railwagon	4417	5942	4793	3135	4645	11107	13417	11653	8732	11282
TOTAL TONNAGES											
Link		0	5590	7008	4356	8227	0	11458	12906	6445	14930
Non-Link		24837	19247	17829	20481	16610	39201	27742	26295	32756	14271
TOTAL		24837	24837	24837	24837	24837	39201	39201	39201	39201	39201

Notes (a) Units are thousands of tonnes, imports and exports combined.
(b) It was assumed that the Dover-Dunkirk and Harwich-Dunkirk railwagon services are withdrawn in the presence of a rail link.

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TABLE I.5: FREIGHT ROUTE CHOICE: HIGH GROWTH SCENARIO

YEAR / CROSSING SCHEME / TONNAGES BY CORRIDOR	MODE	1985 NO LINK	1985 SINGLE TRACK	1985 DOUBLE TRACK	1985 BRIDGE	1985 BRIDGE PLUS SINGLE TRACK	2000 NO LINK	2000 SINGLE TRACK	2000 DOUBLE TRACK	2000 BRIDGE	2000 BRIDGE PLUS SINGLE TRACK
1. Hull-Hamburg	Ro-Ro	495	487	475	471	475	885	870	847	839	847
2. Hull-Rotterdam	"	1783	1746	1469	1447	1465	3668	3574	3005	2939	2970
3. Haven-Hook	"	3239	3140	3181	2978	2964	6469	6218	6364	5733	5724
4. Haven-Zeebrugge, Dunkirk	"	1792	1540	1251	1146	1033	3652	3103	2649	2276	2083
5. Harwich-Hamburg	"	681	659	598	583	591	1131	1087	950	912	923
6. Belgian-Straits	"	3038	2740	3046	2598	2554	6282	5585	6265	4906	4707
7. French Straits	"	3120	2389	2316	2151	1818	5559	4090	4001	3430	2793
8. Newhaven-Dieppe	"	1037	612	612	643	499	1513	708	819	1015	618
9. Soton-Le Havre, Cherbourg	"	2103	1596	1241	1392	1136	3442	2405	1968	2280	1789
10. Hull-Hamburg	Lo-Lo	247	240	240	239	241	431	420	418	418	411
11. Hull-Rotterdam	"	845	733	704	727	707	1748	1522	1438	1482	1399
12. Haven-Zeebrugge, Dunkirk	"	2157	1931	1644	2008	1521	4031	3666	3106	3723	2869
13. Haven-Rotterdam	"	1243	1301	1044	1156	967	2487	2682	2086	2231	1914
14. Harwich-Hamburg	"	1234	1195	1180	1171	1180	2979	2894	2828	2805	2819
15. Tilbury-Rotterdam	"	1380	1469	1077	1242	1079	2846	3129	2225	2426	2140
16. Soton-Cherbourg	"	448	437	434	445	435	798	786	785	795	786
17. Dover-Dunkirk	Railwagon	2672	-	-	1671	-	8515	-	-	5660	-
18. Harwich-Zeebrugge	"	1184	1073	752	780	732	3789	3305	2519	2676	2327
19. Harwich-Dunkirk	"	0	-	-	0	-	0	-	-	0	-
TONNAGES ON LINK											
20.	Railwagon	-	4445	3381	-	3188	-	12626	10234	-	9586
21.	Lo-Lo	-	963	836	-	823	-	1550	1315	-	1284
22.	Ro-Ro	-	-	3215	5846	5290	-	-	6401	13678	12233
TONNAGES BY MODE											
1.	Ro-Ro	17287	14909	17404	19256	17825	32601	27642	33269	38007	34689
2.	Lo-Lo	7553	8269	7159	6989	6952	15320	16650	14202	13880	13621
3.	Railwagon	3856	5518	4133	2451	3920	12303	15931	12753	8336	11912
TOTAL TONNAGES											
Link		-	5408	7432	5846	9301	-	14176	17950	13678	23103
Non-Link		28696	23288	21264	22850	19395	60224	46048	42274	46566	37121
TOTAL		28696	28696	28696	28696	28696	60224	60224	60224	60224	60224

Notes (a) Units are thousands of tonnes, imports and exports combined.
(b) It was assumed that the Dover-Dunkirk and Harwich-Dunkirk railwagon services are withdrawn in the presence of a rail link.

Mathematical Formulation of the Multiplier Model

Let f_i^q = final demand for commodity i in the q^{th} EEC member country, where i = 1, ..., 10.

Final demand will include investment but will exclude private consumption expenditures and exports to other EEC member countries.

Let f_{11}^q = transfer payments to households; i.e. it will include all income receipts, other than wages and salaries, which are directly received by households from production sectors.

Let a_{ij}^q = I - O coefficient for the q^{th} country, where this represents the total (i.e. domestic plus imports) requirements of the i^{th} goods in the j^{th} sector.

Note that i, j = 1, ..., 11, since A = a_{ij} includes household expenditure coefficients as the last column, and household income generation coefficients (wages and salaries only) as the last row.

Let g_j^q = gross output (i.e. intermediate plus final output) of the j^{th} sector in the q^{th} country, where j = 1, ..., 10.

Let g_{11}^q = total household income.

Note that q = 1, ..., 8, since Belgium and Luxembourg are combined into one country for model purposes.

The total demand for good i in country q will be

$$d_i^q = \sum_{j=1}^{11} a_{ij}^q \; g_j^q + f_i^q \qquad (1)$$

Note that d_{11}^q will simply be total household income generated in the q[th] country.

Let x_i^{pq} = amount of commodity i shipped from country p to country q.

Therefore the proportion of total demand for commodity i in country q which is imported from country p is θ_i^{pq}, where

$$x_i^{pq} = \theta_i^{pq} \; d_i^q \qquad (2)$$

Note the θ's sum to one because part of country q's demand is likely to be supplied by itself (i.e. $\theta_i^{qq} \geqslant 0$)

$$d_i^q = \sum_{p=1}^{11} x_i^{pq}$$

$$\sum_{p=1}^{11} \theta_i^{pq} = 1$$

Finally, we know that

$$g_i^p = \sum_q x_i^{pq}$$

$$= \sum_q \theta_i^{pq} \; d_i^q$$

$$= \sum_q \theta_i^{pq} \; (\sum_j a_{ij}^q \, g_i^q + f_i^q) \qquad (3)$$

In matrix form this becomes

$$g^p = \hat{\theta}^{pq} \; (A^q \, g^q + f^q) \qquad (4)$$

and for the entire regional system

$$g = \theta \; (\hat{A} \; g + f) \qquad (5)$$

$$= (I - \theta \; A)^{-1} \; \theta f \qquad (5)$$

where

$$A = \begin{bmatrix} A^1 & O & \cdots & O \\ O & A^2 & \cdots & O \\ \vdots & & & \\ O & & & O \end{bmatrix}$$

and

$$\theta = \begin{bmatrix} \hat{\theta}^{11} & \hat{\theta}^{12} & \cdots & \hat{\theta}^{18} \\ \hat{\theta}^{21} & \hat{\theta}^{22} & \cdots & \hat{\theta}^{28} \\ \vdots & & & \\ \hat{\theta}^{81} & & \cdots & \hat{\theta}^{88} \end{bmatrix}$$

and where g and f are stacked vectors of country gross outputs and final demands.

Note $\hat{t}$ is just notation for a diagonal matrix whose diagonal elements are those of the vector t.

Equation (5) is the basix Leontief-type solution to the multicountry multiplier system. It shows the differential supply response (in terms of gross sectoral output changes) on a country by country basis for changes in final demands in each country.

Multiplier Analysis — Sectoring Scheme — Appendix K

Model sectors	R25 Code	NACE - CLIO (R44)	R44 Code
1. Agriculture, forestry fishing.	01	Agriculture, forestry and fishing products.	10
2. Fuel and power products.	06	Coal, lignite (brown coal) and briquettes.	03
		Products of coking.	05
		Crude petroleum, natural gas and petroleum products.	07
		Electric power, gas, steam and water.	09
		Production and processing of radioactive materials and ores.	11
3. Ferrous and non-ferrous ores and metals.	13	Ferrous and non-ferrous ores and metals other than radioactive.	13
4. Non-metalic mineral products.	15	Non-metalic mineral products.	15
5. Transport equipment.	28	Motor vehicles.	27
		Other transport equipment.	29
6. Food, beverages, tobacco.	36	Meats, meat preparations, etc.	31
		Milk and dairy products.	33
		Other food products.	35
		Beverages.	37
		Tobacco products.	39
7. Textiles and clothing, leather and footwear.	42	Textile and clothing.	41
		Leathers, footwear.	43
8. Other manufacturing.	17	Chemical products.	17
	19	Metal products except machinery and transport equipment.	19
	21	Agricultural and industrial machinery.	21
	23	Office and data processing machines.	23
	25	Electrical goods.	25
	47	Paper and printing products.	47
	49	Rubber and plastic products.	49
	48	Other manufacturing products.	51
		Timber, wooden products and furniture.	45
9. Building and construction.	53	Building and construction.	53

Model sectors	R25 Code	NACE - CLIO (R44)	R44 Code
10. Services.	68	Recovery and repair service.	55
		Wholesale and retail trade.	57
		Lodging and catering service.	59
		Inland transport services.	61
		Maritime and air transport services.	63
		Auxiliary transport service.	65
		Communication services.	67
		Services of credit and insurance institutions.	69
		Business services provided to enterprises.	71
		Services of renting of immovable goods.	73
		Market services of education and research.	75
		Market services of health.	77
		Recreational and cultural services, etc.	79
	86	General public service.	81
		Non-market services of education and research.	85
		Non-market services of health.	89
		Domestic services.	93

Trade (Supply) Coefficients, 1976

Country of Supply	Sector	D	F	I	N	B-L	UK	IRL	DK
D	1	0.7787	0.0016	0.0108	0.0166	0.0106	0.0051	0.0006	0.0068
	2	0.7143	0.0182	0.0097	0.0117	0.0577	0.0021	0.0010	0.0175
	3	0.8742	0.0534	0.0394	0.1814	0.0693	0.0218	0.0418	0.2282
	4	0.9025	0.0327	0.0234	0.1125	0.0660	0.0091	0.0055	0.0565
	5	0.8377	0.0579	0.0731	0.1272	0.3445	0.0484	0.0260	0.2990
	6	0.9171	0.0095	0.0295	0.0304	0.0216	0.0057	0.0014	0.0256
	7	0.7843	0.0240	0.0134	0.1654	0.0864	0.0075	0.0151	0.0593
	8	0.8766	0.0532	0.0616	0.1350	0.1439	0.0303	0.0503	0.1195
	9	0.9951	0.0008	0.0097	0.0035	0.0067	0.0008	0.0000	0.0004
	10	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
F	1	0.0191	0.8843	0.0337	0.0333	0.0938	0.0322	0.0139	0.0075
	2	0.0074	0.5880	0.0052	0.0048	0.0134	0.0053	0.0002	0.0060
	3	0.0135	0.7539	0.0412	0.0404	0.0645	0.0101	0.0328	0.0749
	4	0.0123	0.8764	0.0196	0.0192	0.0509	0.0086	0.0038	0.0082
	5	0.0488	0.8256	0.0836	0.0715	0.1624	0.0391	0.0327	0.0425
	6	0.0112	0.9184	0.0288	0.0128	0.0422	0.0083	0.0050	0.0052
	7	0.0223	0.8471	0.0209	0.0262	0.1377	0.0078	0.0071	0.0174
	8	0.0167	0.8219	0.0278	0.0296	0.0814	0.0145	0.0144	0.0162
	9	0.0006	0.9974	0.0104	0.0006	0.0034	0.0029	0.0000	0.0003
	10	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
I	1	0.0178	0.0085	0.7912	0.0064	0.0089	0.0055	0.0007	0.0078
	2	0.0031	0.0043	0.4768	0.0027	0.0030	0.0068	0.0010	0.0050
	3	0.0062	0.0152	0.7120	0.0054	0.0055	0.0049	0.0109	0.0071
	4	0.0191	0.0241	0.8929	0.0127	0.0192	0.0055	0.0032	0.0128
	5	0.0176	0.0241	0.7523	0.0208	0.0259	0.0128	0.0208	0.0248
	6	0.0044	0.0045	0.8641	0.0030	0.0052	0.0039	0.0018	0.0021
	7	0.0497	0.0362	0.8939	0.0458	0.0602	0.0190	0.0133	0.0299
	8	0.0108	0.0202	0.8023	0.0162	0.0242	0.0088	0.0121	0.0139
	9	0.0022	0.0001	0.9713	0.0001	0.0003	0.0007	0.0000	0.0000
	10	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
N	1	0.0304	0.0084	0.0067	0.6303	0.0652	0.0159	0.0013	0.0064
	2	0.0392	0.0162	0.0088	0.5363	0.1230	0.0172	0.0069	0.0814
	3	0.0077	0.0092	0.0077	0.4582	0.0583	0.0176	0.0228	0.0367
	4	0.0089	0.0044	0.0016	0.6771	0.0628	0.0034	0.0018	0.0035
	5	0.0100	0.0064	0.0047	0.5421	0.0360	0.0054	0.0045	0.0207
	6	0.0228	0.0127	0.0221	0.8351	0.0652	0.0034	0.0051	0.0166
	7	0.0148	0.0047	0.0024	0.5167	0.0995	0.0034	0.0051	0.0166
	8	0.0154	0.0129	0.0125	0.6000	0.0913	0.0105	0.0170	0.0226
	9	0.0012	0.0001	0.0003	0.9911	0.0031	0.0009	0.0001	0.0001
	10	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
B-L	1	0.0056	0.0049	0.0024	0.0189	0.6198	0.0020	0.0003	0.0011
	2	0.0075	0.0040	0.0020	0.0135	0.4596	0.0059	0.0013	0.0514
	3	0.0209	0.0618	0.0216	0.1238	0.5334	0.0111	0.0400	0.0863
	4	0.0085	0.0160	0.0080	0.0833	0.7172	0.0054	0.0037	0.0108
	5	0.0405	0.0153	0.0221	0.1128	0.2654	0.0136	0.0012	0.0231
	6	0.0065	0.0092	0.0054	0.0334	0.8046	0.0026	0.0008	0.0010
	7	0.0163	0.0276	0.0056	0.0994	0.5019	0.0062	0.0066	0.0153
	8	0.0104	0.0180	0.0094	0.0560	0.4600	0.0064	0.0115	0.0124
	9	0.0004	0.0005	0.0003	0.0014	0.9828	0.0005	0.0000	0.0000
	10	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000
UK	1	0.0014	0.0018	0.0024	0.0043	0.0076	0.6581	0.0105	0.0016
	2	0.0050	0.0050	0.0034	0.0125	0.0161	0.6813	0.2542	0.1014
	3	0.0051	0.0115	0.0105	0.0368	0.0136	0.6939	0.3612	0.0603
	4	0.0048	0.0049	0.0084	0.0165	0.0112	0.9122	0.0765	0.0226
	5	0.0118	0.0151	0.0130	0.0361	0.0623	0.7997	0.1206	0.0737
	6	0.0021	0.0049	0.0028	0.0104	0.0090	0.8462	0.0366	0.0070
	7	0.0050	0.0060	0.0062	0.0181	0.0136	0.8114	0.2355	0.0717
	8	0.0071	0.0126	0.0124	0.0348	0.0579	0.7752	0.2213	0.0473
	9	0.0008	0.0004	0.0011	0.0017	0.0019	0.9852	0.0027	0.0007
	10	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000	0.0000
IRA	1	0.0002	0.0003	0.0006	0.0006	0.0020	0.0127	0.9355	0.0001
	2	0.0000	0.0000	0.0000	0.0001	0.0000	0.0004	0.5844	0.0000
	3	0.0003	0.0005	0.0004	0.0012	0.0008	0.0015	0.4025	0.0002
	4	0.0003	0.0001	0.0003	0.0003	0.0002	0.0044	0.8758	0.0006
	5	0.0005	0.0001	0.0001	0.0001	0.0000	0.0014	0.7424	0.0001
	6	0.0012	0.0014	0.0014	0.0047	0.0048	0.0149	0.9183	0.0010
	7	0.0005	0.0003	0.0002	0.0012	0.0005	0.0146	0.6467	0-0013
	8	0.0005	0.0005	0.0004	0.0013	0.0023	0.0041	0.5193	0.0008
	9	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002	0.9970	0.0000
	10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
DK	1	0.0065	0.0014	0.0014	0.0025	0.0042	0.0040	0.0003	0.8051
	2	0.0033	0.0000	0.0003	0.0001	0.0000	0.0006	0.0015	0.3026
	3	0.0006	0.0002	0.0001	0.0010	0.0006	0.0006	0.0021	0.1675
	4	0.0023	0.0002	0.0006	0.0017	0.0006	0.0012	0.0004	0.7600
	5	0.0007	0.0002	0.0011	0.0017	0.0012	0.0010	0.0005	0.1948
	6	0.0039	0.0018	0.0082	0.0030	0.0032	0.0191	0.0010	0.8910
	7	0.0011	0.0002	0.0002	0.0019	0.0006	0.0022	0.0011	0.5280
	8	0.0021	0.0016	0.0012	0.0046	0.0029	0.0033	0.0062	0.5430
	9	0.0001	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.9975
	10	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	1.0000

A Comparison of Gross Output Estimates

Sector/Country		g*	g**	g
D	1	25645	30170	34566
	2	42681	37568	34532
	3	50262	59682	57695
	4	16006	16797	16733
	5	28809	33112	33062
	6	57547	68019	69634
	7	26380	32458	34196
	8	267833	211106	194575
	9	57178	59100	58332
	10	291503	276650	268580
F	1	26147	35987	38750
	2	23485	19627	19594
	3	14065	19458	21416
	4	8510	9602	9526
	5	34085	26279	25253
	6	46429	46194	47429
	7	19889	21986	22900
	8	102860	106620	106767
	9	54152	51432	51512
	10	235791	239519	241614
I	1	19093	18256	20827
	2	12671	9574	9322
	3	8825	10366	10712
	4	5916	6005	6145
	5	10144	9060	9010
	6	18950	24137	25053
	7	19176	19566	20066
	8	53891	53226	53260
	9	20891	21493	21567
	10	105922	110453	112200
N	1	7644	7743	9828
	2	16065	12347	11461
	3	2483	3616	4222
	4	1656	2255	2352
	5	2853	3967	4028
	6	13359	17719	19164
	7	3074	4573	5120
	8	25154	29569	30940
	9	11655	10789	10980
	10	64938	66650	61376
B-L	1	3951	4498	5179
	2	6817	4889	4610
	3	5018	7491	8749
	4	2080	2444	2467
	5	4384	4323	4295
	6	9054	10244	10753
	7	4040	4540	4842
	8	16552	17827	18117
	9	9392	8743	8714
	10	45180	42608	42969
UK	1	9711	8713	9191
	2	29026	20896	19295
	3	13211	12704	13422
	4	5302	6402	6272
	5	12457	14379	14301
	6	27945	30820	31135
	7	12871	13997	14392
	8	66804	73507	74808
	9	24653	22252	22098
	10	162776	156707	157013
IRL	1	2739	3663	3152
	2	985	721	655
	3	238	194	229
	4	729	587	536
	5	490	764	882
	6	5368	4215	4151
	7	915	982	1071
	8	1316	2610	2750
	9	2049	1779	1705
	10	7712	6693	6515
DK	1	3204	3393	3396
	2	1444	828	725
	3	117	212	194
	4	729	832	852
	5	837	380	343
	6	5711	6733	7018
	7	892	1111	1149
	8	6626	6821	6802
	9	5682	6127	6008
	10	26356	24724	24624

ASSESSMENT OF AIRCRAFT NOISE IMPACT: PARAMETER VALUES

(a) Passengers per Aircraft

Year		London Airports Passengers/Aircraft	Source
1972		78	Actual
1973		85	Actual
1974		83	Actual
1975		86	Actual
1978		96	Estimated Actual
1980		120	Airport strategy for Great Britain (HMSO 1975)
1985		150	Airport strategy for Great Britain (HMSO 1975)
1990	High	200	Airport strategy for Great Britain (HMSO 1975)
	Low	180	Airport strategy for Great Britain (HMSO 1975)

Proposal: For 1990 and beyond, adopt 1990 low values.

(b) Residents Affected by Air Traffic Movements (ATMs)

This is based on the comparison of the projected populations within the NNI bands in 1990, comparing the low growth case (i.e. low growth of aircraft size) with the high growth case. (Source: Airport Strategy for Great Britain)

Heathrow

	1990 (i) Low	(ii) High	(iii)	(iv)
ATMs (000s)	242	311	69	1
Population (000s)				
35+ NNI	227	289	62	0.899
45+ NNI	41	59	18	0.261
55+ NNI	3	4	1	0.014

Other London Airports

	(i) Low	(ii) High	(iii)	(iv)
ATMs (000s)	143	258	115	2
Population (000s)				
35+ NNI	3	8		0.043
45+ NNI	1	2	1	0.009
55+ NNI	0	0	0	0.0

Sources: (i), (ii) Airport Strategy for Great Britain
(iii) (ii) - (i)
(iv) (iii) expressed per ATM

Proposal: Adopt the Heathrow values for Heathrow, the other London airport values for the rest of the U.K.

(c) Household Size

See Main Report (Section 2.25).

(d) Depreciation Factors for Residential Property

	Heathrow (%)	Gatwick (%)
Property bought within 35 NNI	2.7	9.0
Property bought within 45 NNI	3.6	7.2

Source: Roskill Commission

Proposal: Adopt the Heathrow values for Heathrow, the Gatwick values for the rest of the U.K.

(e) Average Values of Residential Property

	Average Value of Residential Property (1st Quarter 1979)
All U.K.	17,500
Outer South East	19,000
Outer Metropolitan area	23,200
Greater London	22,100

Source: Nationwide Building Society : Housing Trends

Proposal: Adopt the Greater London value for residents around Heathrow, Outer South East value for all other U.K. residents affected.

(f) <u>Scale up factor to Cover Public Building</u>

Ratio of total noise costs to residential noise costs: 1.75

Source: Roskill Commission average value for the four sites examined.

Proposal: Adopt the same value for both Heathrow and other U.K. airports.

Appendix O

FERRY OPERATORS COSTS

The operating costs for each route are made up of the following demands:-

(a) maintenance;
(b) crew costs;
(c) fuel;
(d) terminal costs;
(e) commission, booking charges, and insurance;
(f) general publicity;
(h) port charges;

(a) Maintenance

The breakdown of maintenance costs, and the values of the parameters in January 1979 prices are shown below:-

	Ro-Ro Vessels			Container Vessels
	Short Routes	Routes Long	Freight	
Fixed Annual Cost (per vessel)	£84,750	£152,550	£67,800	£67,800
Variable cost (per crossing)	£28.25	£56.50	£28.25	£28.25
Variable cost (per mile)	£0.68	£0.68	£0.68	£0.68

(b) Crew Costs

	Ro-Ro Vessels		
	Multipurpose	Freight	Container Vessels
Average cost per vessel Per "trip hour" (where the trip time includes loading and unloading)	£169.50	£99.44	£88.93
Fixed cost (per vessel p.a.)	£32,800	£32,800	£32,800

(c) Fuel and Lubricants

Costs are expressed per mile.

	1985 LOW	1985 HIGH	2000 LOW	2000 HIGH
All vessels	£11.85	£9.64	£14.82	£9.44

(d) Terminal Costs

All costs are per trip.

	Ro-Ro Vessels		
Route	Multipurpose	Freight	Container Vessels
French Straits	£271.20	£135.60	n.a.
Belgian Straits } Newhaven-Dieppe	£440.70	£169.50	n.a.
Haven-Netherlands	£1,017.00	£169.50	£91.50
Other routes	£1,423.80	£271.20	£91.50

(e) Commission, Booking and Insurance Costs

For all vessels, this was taken as 10.35% of receipts, net of landing dues.

(f) Publicity

	Ro-Ro Vessels		
	Multipurpose	Freight	Container Vessels
Costs per fleet	£164,750	£154,750	-
Plus			
Costs per vessel	£96,050	£7,910	£50,850

(g) General Administration

	Ro-Ro Vessels		
	Multipurpose	Freight	Container Vessels
Costs per fleet	£56,500	£56,500	-
Plus			
Costs per vessel	£135,600	£135,600	£64,410

(h) Port Charges

		Ro-Ro Vessels		Container Vessels
Route	Per Passenger	Per Accompanied Car	Per Ro-Ro Vehicle	Per Ship Trip
French Straits	£1.77	£2.29	£17.05	n.a.
Belgian Straits	£1.46	£2.11	£17.36	n.a.
Newhaven-Dieppe	£2.11	£3.71	£27,38	n.a.
Other routes	£1.65	£3.15	£22.85	£1,492

Hovercraft

A similar operating cost structure was used for hovercraft. The values of the parameters were derived from information supplied confidentially by Seaspeed.

British Rail Passenger Receipts

Appendix P

(a) Average Revenue per Passenger Mile - all Passengers

	(i) 1977	(ii) January 1979
Full Fares	4.24	4.88
Reduced Fares	2.77	3.19
Season Tickets	2.69	3.09
All fares	3.22	3.70

:-

(i) HMSO: Transport Statistics

(ii) Estimated

(b) Average Revenue per Passenger Mile - Independent Leisure Travellers

The average of all fares, excluding season tickets was taken. This gave a value, in January 1979 prices, of:-

4.08 p/mile

(c) Average Revenue per Passenger Mile - Business Travellers

On the assumption that the ratio of fares paid by business and independent passengers is approximately. 100 : 60, this gives a value in January 1979 prices of :-

6.80p/mile

This is about mid way between the full first and second class fares, and therefore is a reasonable value.

(d) Average Revenue per Passenger Mile - Package Travellers

It was assumed that the ratio of fare paid by independent and package travellers was 100 : 54. This gives a value in January 1979 prices of:-

2.18 p/mile

Appendix Q

Effects of Pollutants

Carbon Monoxide

Carbon Monoxide when inhaled combines with the haemoglobin in the blood to produce carboxy-haemoglobin. Since the affinity of carbon monoxide for haemoglobin is 240 times that of oxygen, it is preferentially absorbed even at very low concentrations. The result is to decrease the capacity of the blood to transport-oxygen. The degree of absorption depends on the concentration of carbon monoxide in the air, the periods of exposure and the activity of the individual.

There is some disagreement as to what are safe concentration levels. Some say the maximum should be 50ppm (parts per million), others 30ppm or even 10ppm. A survey of busy streets in Great Britain over a 15 month period showed that the proportion of time when the concentration of more than 50ppm was exceeded only on very isolated occasions. Professor Lawther of the British Medical Research Council claims that a cigarette smoker with every puff inhales seven times as much carbon monoxide as the highest concentration found in heavy traffic. In some smokers levels as high as 15% concentration in the blood have been found. Continuous exposure to 25ppm will lead only to 4% concentration. It is generally agreed that people should be protected from an atmosphere which would lead to the 4% level. The survey of busy streets referred to above suggests that traffic alone is unlikely to give rise to such a condition.

The above seems to indicate that carbon monoxide emissions are not likely to leave any permanent effects or cause any acute physical discomfort. However, the effects cannot be entirely discounted. It can cause temporary physical discomfort for particularly susceptible people, and there is evidence to show that quite small amounts of carboxy-haemoglobin in the blood may impair temporarily mental ability.

Hydrocarbons

Hydrocarbons emitted react with nitrogen oxides in sunlight, producing ozone, peroxyacyl nitrates, aldehydes, and other complex chemical products. These pollutants seem to produce eye, nose and throat irritations, but it has been difficult to establish relationships. Most of the studies have been carried out in Los Angeles. It appears that these pollutants are only likely to cause problems in combination with particular meteorological conditions. Such conditions are not reckoned to exist in Great Britain.

Oxides of Nitrogen

These react with hydrocarbon to form the petrochemical oxidents discussed above. It can also be a primary pollutant. Studies in the USA of children in different pollution areas found that the incidence of acute respiratory illness was significantly greater in the 'high' (greater than 0.10ppm) pollution areas. The World Heath Organisation claim there is insufficient information upon which to base specific air quality guides. It seems unlikely that the intermittent exposure to the nitrogen oxide emitted from vehicles is a real danger to health. However, the effect is clearly adverse and more permanent that the effects of carbon monoxide, and therefore the long term effects remain a worry.

Sulphur Dioxide

The World Health Organisation have found it very difficult to measure the effects of sulphur dioxide, since it very rarely occurs alone. In addition, the Warren Springs laboratory in the U.K. have found that they cannot measure the traffic contribution to the levels of sulphur dioxide even on very busy streets in West London.

Lead

Lead pollution is of two forms - particulates, resulting from combustion, and volatile compounds, resulting from unburnt petrol. The pollution levels tend to be very localised. Pollution tends to be much higher in urban areas, and heaviest in streets with heavy traffic. The highest levels recorded by the WHO were during rush hours on highways, giving readings of 14-25μmg/m^3. Even the average for Los Angeles in near traffic areas was only 6.4μmg/m^3. The general average of concentration of lead in the air for city streets is about 2-4μmg/m^3.

Although studies have been carried out on the effects of lead on workers subject to a high degree of exposure (0.15μmg/m^3), no adequate studies on the effects on the general adult population have been carried out.

All reactions to lead are calibrated against the level of lead in the blood. However, it gets there in various ways: mainly from food, but also from water and from the air. Even on the WHO's extreme assumption that continouse exposure to concentrations of 1μmg/m^3 in the ambient air lead to concentration of 2.0μmg/m^3 in the blood, an ambient air value of 4.0μmg/m^3 (top end of the general average for a city, see above), will only lead to a contribution of 9.0μmg/100ml concentration in the blood. Food on the other hand leads to general lead levels of 25μmg/100ml.

Thus, though the effects of lead are adverse, the impact of lead pollution from cars is only a contributory factor. However, the increase above the natural level may give rise ultimately to toxic doses.

Smoke

Smoke consists mainly of very fine particles of carbon. It is not considered to be a health hazard in itself but carbon particles may act as nuclei both for haze formation and for the absoprtion of gases such as sulphur dioxide and nitrogen oxides. The latter are likely to cause damage to the lungs, but little is known about this phenomenon.