Edward Charles Spry

AN ANALYSIS OF THE DEMAND FOR AIR CARGO

Doctor of Philosophy

April, 1974

Summary

The air transport industry spends a great deal of time and resources developing and agreeing pricing policy. Such efforts imply a price responsive market, which may well be justified in the case of passenger traffic. This study attempts to determine how well founded a similar assumption is in respect of cargo traffic.

By weight air cargo is only a minute fraction of total trade. Being largely composed of high value per weight commodities it represents, however, a significantly larger part in terms of value. If value per weight, or rather the proportion of it represented by transport charges, is the dominant criterion in choice of mode, then the assumption of a price elastic market for air cargo seems justified since the quantity of goods traded increases rapidly as average value per weight falls. Most earlier industry studies are based on such reasoning and suggest relatively high elasticity coeffients, ranging from -2.0 to -11.0.

Investigation of distribution management decision-making, deduction from micro-economic theory and analogy to import tariff elasticity, indicate that such estimates are biased upwards. Detailed statistical analysis clearly confirms this.

Commodity or product characteristics, the nature of the market for the product, the existing distribution systems serving that market all appear to be of greater importance in choice of mode than do changes in rate levels.

The demand for transportation is derived and, like a factor of production, its elasticity therefore based on the nature of demand for the goods it helps produce. Inference from studies of import tariff elasticities for manufactured goods indicate an inelastic demand for air cargo.

Statistical analysis confirms this and, by separating out the effects of income and time, offers an explanation for the upward bias in earlier estimates.

TABLE OF CONTENTS

Chapter 1

The role of air cargo in international trade: some figures, forecasts and facts

1.1. Introduction

The aims of the first three chapters of this study are to furnish background information on the part played by air cargo services in international goods transport and to examine the endogenous and external factors determining the scale of that role. The intention is not to provide a precise and complete description of all aspects but merely to sketch in the most important features for the purposes of perspective. It is, perhaps, logical to begin with a broad outline of the main international trade flows and their commodity composition. This will give some general indication of the scale of present air trade and of its potential. This is followed by a more detailed discussion of the scale and nature of present air cargo traffic.

1.2. Patterns of international trade

According to available data (1) the aggregate exports of all countries in the world has been growing on average at about 7% per year and by 1970 had reached a level of more than US$ 280 billion. Table 1 shows the geographical breakdown of this total by main regions. A large part of this trade, approximately 56% in 1970, is in low-value primary commodities which are of little interest from an air transport point of view. The overall magnitude and pattern of exports of higher-value manufactured goods is of more direct relevance. Table 2 gives a broad outline of the geographical breakdown and development of this trade over the period 1960 to 1970.

Compared to the 7% for all commodities, international trade in manufactured goods grew on average at approximately 9% per year during the 1960's. Its proportion of total trade has therefore increased. The largest single trade flow is to and from Western Europe, representing in 1970 some 47% and 27% respectively of world trade in manufactures and totally. The second largest trade region is North America which accounted for 24% of trade in manufactured goods and 20% of the total. Growth of international trade in manufactures averaged a little over 10% per year for both these regions during the period 1960-1970.

Of the West European trade in manufactured goods some 68% is intra-regional, a further 12% is with the United States and Canada and the remainder with the rest of the world. For the United States and Canada 43% of international trade in manufactures is intra-regional and 28% with Western Europe. Over the period 1960 to 1970, growth of European trade in these commodities has been on average 11% per year intra-regionally, 9% per year with North America and 7% with the rest of the world. North American trade in these commodities grew at approximately 12% per year intra-region-

Table 1: Geographical distribution of world exports by value - all commodities 1970

(US$ millions)

From \ To	Western Europe	Eastern x) Europe	North xx) Africa	US and Canada	Rest of World	World Total
Western Europe	76,075	5,538	2,234	13,383	22,167	119,397
Eastern x) Europe	5,715	17,898	564	287	4,934	29,398
North xx) Africa	3,528	470	44	179	307	4,528
US and Canada	15,405	400	60	19,380	19,814	55,059
Rest of World	22,543	2,716	720	17,174	28,557	71,710
World Total	123,266	27,022	3,622	50,403	75,779	280,092

x) including U.S.S.R.

xx) Algeria, Libya, Morocco, Tunisia and U.A.R.

Source: U.N. Monthly Bulletin - various

Table 2: Geographical Distribution of world exports by value - manufactured goods (1960) and 1970

(total SITC groups 6, 7, and 8 except 67 and 68 x) in US$ millions)

To / From	Western Europe	Eastern Europe	North Africa	US and Canada	Rest of World	World Total
Western Europe	40,056 (13,900)	3,245 (930)	1,393 (1,060)	7,667 (3,316)	14,060 (8,384)	66,421 (27,590)
Eastern Europe	1,333 (405)	9,677 (3,860)	187 (58)	144 (29)	2,298 (1,448)	13,639 (5,800)
North Africa	33 (36)	88 (10)	20 (18)	9 (14)	55 (46)	205 (124)
US and Canada	6,220 (2,220)	53 (29)	184 (103)	10,878 (3,331)	9,430 (5,670)	26,765 (11,353)
Rest of World	3,360 (939)	514 (506)	343 (211)	4,925 (1,420)	8,236 (2,982)	17,378 (6,058)
World Total	51,002 (17,500)	13,577 (5,335)	2,127 (1,450)	23,623 (8,110)	34,079 (18,530)	124,408 (50,925)

x) Manufactured goods classified mainly by material; machinery and transport equipment; and miscellaneous manufactured articles but excluding iron and steel and non-ferrous metals

Source: U.N. Monthly Bulletin - various

ally and at 8% per year with the rest of the world.

While the figures above give some basic indications of trade patterns, trade statistics by value are, of course, not as useful in specifying transport requirements as trade flows defined in terms of weight. This is especially true in the case of air cargo. Many items moving by air have extremely high values but create very little in the way of traffic e.g. bullion and other rare metals, precious stones, artwork, antiques, etc.

The geographical distribution and development of trade must be expected to differ in terms of weight from those in terms of value because the commodities involved differ from area to area, influencing the average values per unit weight. No detailed worldwide statistics on trade by weight are published and only fractional data exist on the proportions of internatonal trade moving by air and by surface transport. A sample of such data is shown in Table 3.

It would appear from the table that the total trade by weight, excluding crude materials and mineral oil products, tends to be more heavily concentrated to intra-regional markets than the same trade considered in terms of value. Whereas Table 1 showed that of total West European exports by value some 68% was intra-regional and 12% with the rest of the world, the data in Table 3 suggest that by weight intra-regional trade represents a substantially greater proportion and other trade somewhat less.

The geographical distribution of trade going by air is also included in Table 3. This shows the opposite pattern with a smaller proportion by weight moving intra-regionally than by value and a considerably greater share of North American trade going by air. It is interesting to note that for a centrally located country the typical intra-regional share of airborne trade is 50% to 60% whereas for countries in the periphery of a region, such as Finland, Greece and Sweden, the proportion is around 70% to 80%.

1.3. Present air cargo traffic by weight and value

1.3.1. Air cargo traffic by weight

In 1970 total scheduled international and domestic air traffic including passengers, cargo and mail) amounted to some 48 billion tonne-kilometers[x)]. Compared to 1969 this was an 11% increase, below the 14% per year average for the period 1960-1970. Total international scheduled traffic grew by 17% in 1970 to 22.3 billion tonne-kilometers, an increase

Footnote:

x) Statistics for the U.S.S.R. are not included

Table 3: Examples of regional distribution of international trade by weight

(all commodities except SITC groups 2 and 3, crude materials and mineral oil products)

		Export and Import by all means of transport			Export and Import by air transport		
		Intra-Regional	North America	Rest of World	Intra-Regional	North America	Rest of World
Austria	(1968)	90%	2%	8%	64%	27%	9%
Finland	(1967)	85%	5%	10%	86%	11%	3%
Germany (Fed.Rep.of)	(1968)	88%	6%	6%	50%	39%	11%
Netherlands x)	(1967)	71%	6%	23%	64%	28%	8%
Switzerland	(1968)	93%	3%	4%	58%	27%	15%
Greece	(1968)	...	...	...	76%	13%	11%
Sweden	(1967)	...	...	...	67%	26%	7%

x) Including crude material and mineral oil products

Source: (2)

slightly above the 16% average for the decade. This traffic represented 48% of the total, a proportion which is increasing due to the lower average rate of increase, 7% per year, in domestic traffic. Table 4 gives a complete breakdown by types of traffic for the period 1960 to 1970.

The total volume of air freight traffic carried on scheduled international and domestic services in 1970 amounted to almost 11 billion tonne-kilometers, approximately 23% of total scheduled traffic, and brought in US$ 1,746 million in operating revenues, equal to 10.6% of the total. In contrast to the share of traffic which has increased from 17% in 1960, revenue from cargo activities has remained at around 10% over the same period. This smaller share in due to the lower average yields, i.e. revenue per tonne-kilometer, on freight compared to passenger traffic. It should be noted, however, that the freight share of revenues for some airlines is significantly higher than this world average.

These traffic figures may be given greater meaning if related to surface transport. By comparison, for example, railway merchandize traffic in the same year amounted to almost 5,000 billion tonne-kilometers, i.e. approximately 450 times as much as by air. As for seaborne shipping, some 2.4 billion tonnes of cargo were loaded in that year, dry cargo accounting for almost a half. The average distance factor for sea traffic is not known, but even at a conservative estimate of 2-3,000 kilometers this would mean a traffic scale some 500 times as great as that by air.

The very small market share of goods transport held by air is in stark contrast to the situation in passenger traffic. In competing for the carriage of passengers the air transport industry has been notably successful, having come since World War II to exceed the various forms of surface transport in the number of passengers carried on the majority of longer journeys throughout the world. Already in 1958 more passengers were carried across the North Atlantic by air than by sea. In United States inter-city traffic (excluding commuter services), air services came to exceed motor carriers in 1955 and railways in 1957 and, by 1970, probably accounted for some three-quarters of the total common carrier traffic.

The total of scheduled air freight has been growing at about 17% per year over the period 1960 to 1970, that is slightly above the average for all traffic. This development is shown in Table 5. Growth has been most outstanding in respect of international traffic which, averaging over 20% per year, has consistently exceeded the annual increases in domestic freight movements since 1963. By 1970 international air cargo traffic amounted to some 6.5 billion tonne-kilometers, equal to about one third of all scheduled air traffic and about two thirds of all air freight.

Table 4: Total traffic carried on the scheduled services of all ICAO member state airlines 1960-1970

(million tonne-kilometers)

Year	International Operations				Domestic Operations				Total Operations			
	Total (Passengers, Cargo + Mail)	Total (Cargo + Mail)	Cargo	Mail	Total (Passengers, Cargo + Mail)	Total (Cargo + Mail)	Cargo	Mail	Total (Passengers, Cargo + Mail)	Total (Cargo + Mail)	Cargo	Mail
1960	4.980	1.320	990	330	7.360	1.450	1.170	280	12.340	2.770	2.160	610
1961	5.530	1.560	1.190	370	7.950	1.640	1.290	350	13.480	3.200	2.480	720
1962	6.400	1.850	1.440	410	8.700	1.870	1.470	400	15.100	3.720	2.910	810
1963	7.300	2.120	1.660	460	9.670	2.000	1.600	400	16.970	4.120	3.260	860
1964	8.570	2.450	1.970	480	11.220	2.370	1.940	430	19.790	4.820	3.910	910
1965	10.240	3.170	2.600	570	13.220	2.890	2.360	530	23.460	6.060	4.960	1.100
1966	12.110	3.890	3.130	760	15.410	3.500	2.730	770	27.520	7.390	5.860	1.530
1967	13.870	4.480	3.580	900	18.770	4.110	3.120	990	32.640	8.590	6.700	1.890
1968	15.900	5.550	4.500	1.050	21.800	4.910	3.610	1.300	37.700	10.460	8.110	2.350
1969	19.210	7.150	5.970	1.180	23.960	5.320	3.990	1.330	43.170	12.470	9.960	2.510
1970	22.350	7.910	6.470	1.440	25.740	5.600	4.300	1.300	48.090	13.510	10.770	2.740
1971	23.760	8.230	7.050	1.180	26.930	5.800	4.430	1.370	50.690	14.030	11.480	2.550

Source: ICAO "Traffic 1960-1970". Digest of Statistics, No. 169
Series T-No. 31 Montreal 1972

Table 5: Scheduled world air freight 1960-1970

(million tonne-kilometers)

Year	International Operations		Domestic Operations		Total Operations		International
	tonne-kilo-meters	percent increase	tonne-kilo-meters	percent increase	tonne-kilo-meters	percent increase	in percent of total
1960	990		1,170		2,160		45.8
1961	1,190	20.2	1,290	10.3	2,480	14.8	48.0
1962	1,440	21.0	1,470	14.0	2,910	17.3	49.5
1963	1,660	15.3	1,600	8.8	3,260	12.0	50.9
1964	1,970	18.7	1,940	21.3	3,910	19.9	50.4
1965	2,600	32.0	2,360	21.6	4,960	26.9	52.4
1966	3,130	20.4	2,730	15.7	5,860	18.1	53.4
1967	3,580	14.4	3,120	14.3	6,700	14.3	53.4
1968	4,500	25.7	3,640	16.7	8,140	21.5	55.3
1969	5,970	32.6	3,990	9.9	9,960	22.5	59.9
1970	6,470	8.4	4,300	7.5	10,770	8.0	60.1
1971	7,050	9.0	4,430	3.0	11,480	6.6	61.4

Sources: ICAO, "Traffic 1960-1970/1961-1971". Digest of Statistics No. 159/169 Series T-No. 30/31 Montreal, 1971/1972

Despite the extremely minor role it plays in goods transportation, the air freight market share is increasing. The rate of growth in international air cargo having been, with the exception of 1970, at a level over twice that of the growth in international trade in manufactured goods.

It is frequently assumed that the typical growth patterns for a new product will follow a path somewhat similar to that described by a Gompertz or logistics "S" curve. At first, while the product is still a novelty growth is relatively slow and unstable but, as the product becomes better known, growth accelerates and finally, as the product reaches maturity, tapers off. As FIG. 1 illustrates, there is some evidence from the growth patterns of other transport media for expecting air cargo to follow a similar form of development.

Table 5 strongly suggests that air freight as a whole is still going through an accelerating phase. However, there is an interesting difference in growth rates between international and domestic air cargo, the latter being considerably slower than the former. This may mean that domestic air cargo, over 80% of which is domestic United States, is approaching the upper part of the "S" curve and is therefore growing more slowly. The implication of this being that future growth domestically will depend more primarily on increases in industrial production and improved technology.

The same conclusion does not yet seem to apply in respect of international air cargo although some slowdown is evident in the last two years. Growth appears to be less influenced by changes in the level of trade than for other modes of transport. In fact it may even be possible that air cargo, up to a point, thrives on recession, exporters and importers becoming more cautions about holding inventories overseas as the volume of trade decreases or fails to grow as anticipated. As discussed in chapter 3, air cargo provides a means for reducing stocks without lowering the quality of service to customers and it seems likely may be more used under such "exceptional" circumstances than as a regular means of transport.

In support of this argument it could be noted that while the growth rate of international air cargo is high it has also been erratic. Indeed, it is surprising that even after more than 25 years of serious development it still displays many of the characteristics of an "infant industry" e.g. a rapid but uneven growth, financial instability and considerable and continuous technological change. Compared to industries of a similar "age" and technological nature, such as the computer industry for example, the air cargo business could be said to show a rather disappointing lack of "maturity" in many ways.

Table 6 shows the distribution of air freight by registry of airlines. This gives only an approximation of the actual geographical distribution of international air freight traffic due to the existing system of traffic

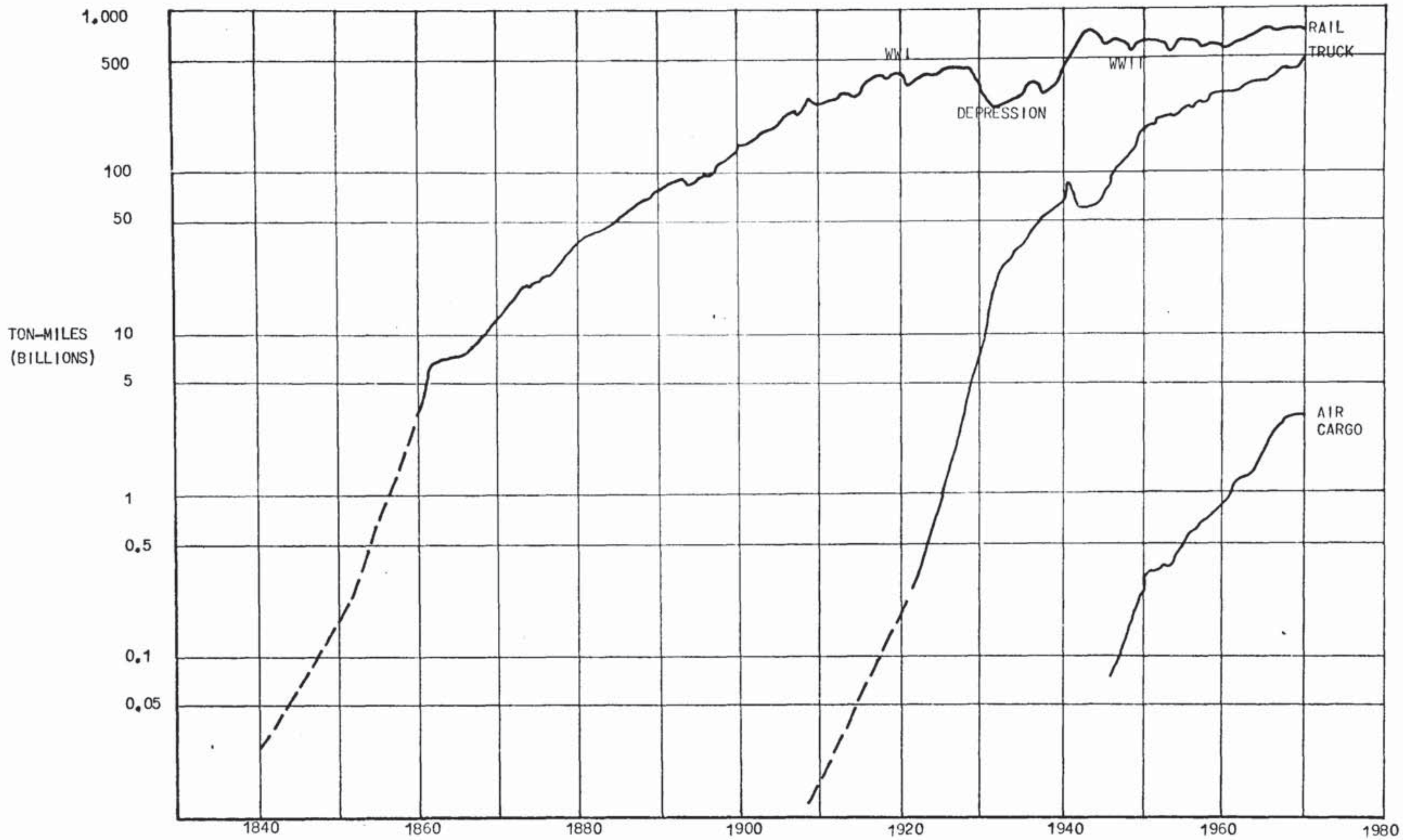


Fig 1: HISTORICAL GROWTH PATTERNS OF RAIL, TRUCK AND AIR IN UNITED STATES DOMESTIC CARGO TRANSPORT

Table 6: Air freight traffic by geographical region - 1970

(million tonne-kilometers)

Airlines of region:	International Operations	Domestic Operations	Total Operations
North America	2,067	3,681	5,748
Europe	2,881	171	3,052
Far East	528	165	693
South America	321	141	462
Oceania	177	97	274
Africa	212	35	247
Middle East	284	10	294
World (120 ICAO States)	6,470	4,300	10,770

Source: ICAO "Traffic 1960-1970" Digest of Statistics, No. 159 Series T-No. 30, Montreal 1971 rights - see chapter 2 - but may be taken as a reasonable expression of where the bulk of the traffic is generated. The table indicates, not unexpectedly, that while it is true that air cargo is global in scope it is nevertheless concentrated most heavily to the industrialised, high income areas. In 1970 European and North American airlines accounted for more than 80% of all air cargo transported. The shares of international and domestic air freight being 76% and 90% respectively.

Over 90% of all scheduled international air cargo traffic transported by European and North American airlines in that year, i.e. almost 70% of the world total, was carried by the airlines of eleven countries, and almost a half of this by the airlines of two countries. A percentage breakdown of the part played by each is shown in Table 7. The most important international route for these carriers was naturally the North Atlantic which in 1971 represented almost 40% of the total international air cargo traffic of IATA carriers (3) .

Although all-cargo services are not new, some were operated before World War II, they only reached a significant scale during the post-war period, this increase being particularly marked after the introduction of highly productive all-cargo jet aircraft. The international industry data for the North Atlantic and Intra-European routes shown in Table 8 illustrates the growing significance and share of freight on all-cargo services compared with freight carried on passenger services. This share must be expected to fall back somewhat during the next few years due to the rapid increase in cargo capacity on passenger flights brought about by the introduction of wide-bodied aircraft.

1.3.2. Air cargo traffic by value

The role of air cargo is both minor and major when it comes to the total transportation market. It is negligible in terms of volume as noted above, but quite significant if the value of goods transported is used as a yardstick.

Table 9 shows the air penetration i.e. the proportion of total traffic moving by air, of United States exports to 17 European countries for 1969. Penetration by value ranged from a low of 12.3% (Norway) to a high of 47.9% (Switzerland), whereas by volume the percentages ranged from 0.07% to 1.57%. Obviously the value of air cargo per unit weight must exceed that of ocean cargo by a factor of several hundred. In 1969, the value of United States imports per kilogram was as follows:

1969	Sea	Air
General imports	US$ 0.01/kg	US$ 2.86/kg
Misc. manufactured goods	US$ 0.45/kg	US$ 3.63/kg

Table 7: Distribution of scheduled international air cargo traffic carried by airlines registered in Europe and North America -1970..

Rank	Country	Tonne-kilometers (millions)	Percentage
1.	United States	1,824	36.9
2.	United Kingdom	500	10.1
3.	Germany, Fed. Rep.	476	9.6
4.	France	457	9.2
5.	Netherlands	383	7.7
6.	Italy	272	5.5
7.	Scandinavia[x)]	216	4.4
8.	Belgium	187	3.8
9.	Switzerland	73	1.5
10.	All others	560	11.3
	Total	4,948	100.0

x) Scandinavia here includes Denmark, Norway and Sweden only.

Source: ICAO "Traffic 1960-1970", Digest of Statistics, No. 159 Series T-No. 30, Montreal 1971

Table 8: Proportion of all-cargo traffic carried on all-cargo aircraft

	1960	1965	1970
North Atlantic routes	43%	46%	60%
Intra-European routes	22%	36%	43%

Sources: "World Transport Statistics 1970" IATA, Montreal 1971

"Review of the economic development of the airlines of E.C.A.C. member states". ICAO, Montreal 1968.

Table 9: Proportion of trade moving by air - United States exports - 1969

Importing country	Percent of exports going by air	
	by value	by volume
Belgium	15.93	0.32
Denmark	25.52	0.43
Finland	15.17	0.62
France	40.36	0.62
Greece	12.41	0.21
Iceland	15.29	0.46
Ireland	40.31	0.86
Israel	13.09	0.13
Italy	22.27	0.16
Netherlands	14.82	0.16
Norway	12.28	0.11
Portugal	14.15	0.16
Spain	12.62	0.07
Sweden	28.41	0.77
Switzerland	47.91	1.57
United Kingdom	36.63	0.90
West Germany	32.91	0.34

Source: "U.S. International Air Cargo Markets"
C.A.B. Washington, 1970

Products shipped by air cover a wide range, from industrial materials, spare parts and machinery to live animals, freshly-cut flowers, and clothing. High value per unit weight is often an important factor, as indicated earlier, but attempts to run regressions of the proportion of traffic going by air against value per kilogram gave for the most part unstable and relatively uninteresting results, confirming the inconclusive findings of earlier research (4) . The reason for the instability in such analyses can be easily seen from FIG. 2. The curves show the relationship between the value and volume of exports for a sample of countries and illustrates clearly the fractional scale of volume involved at high and medium values per unit weight. Such small percentages behave unreliably in regressional calculations.

Table 10 shows the air penetration for the major Standard International Trade Classification (SITC) groupings of westbound North Atlantic trade in 1969. No clear pattern emerges from these highly aggregated data, but there does seem to be some tendency for air penetration to increase in importance as products become more highly processed.

1.4. Air freight traffic potential

A number of techniques for estimating the air freight potential of a given trade flow have been developed employing frequency curves of average value per unit weight such as those shown in FIG. 2. These techniques are based on the fact that average value per unit weight of traffic varies substantially between different modes of transport. By studying the patterns of values per unit weight of commodities traded internationally estimates, it is argued, can be derived of how much more trade could conceivably be transferred to air if, by reducing rates for example, commodities of somewhat reduced values could be taken into account. As can be seen from FIG. 2. such estimates generally indicate a large market potential and high price elasticity. For example, although there are variations between the curves it appears that the volume of trade in goods valued above US$ 2.50 per kg. tends to be about four times as great as that above US$ 4.00 per kg.

This type of estimation is, however, subject to two criticisms. First, it is unreliable from a statistical point of view. Being based on the mean, to be representative such estimates must assume that value per unit weight follows a normal distribution. This is invalid since the pattern for most commodities or trade flows is skewed by large proportions of lower-valued items. Consequently, the modal value would be more representative than the mean but such a measure is not available in published trade statistics or easily obtained. This criticism is particularly valid

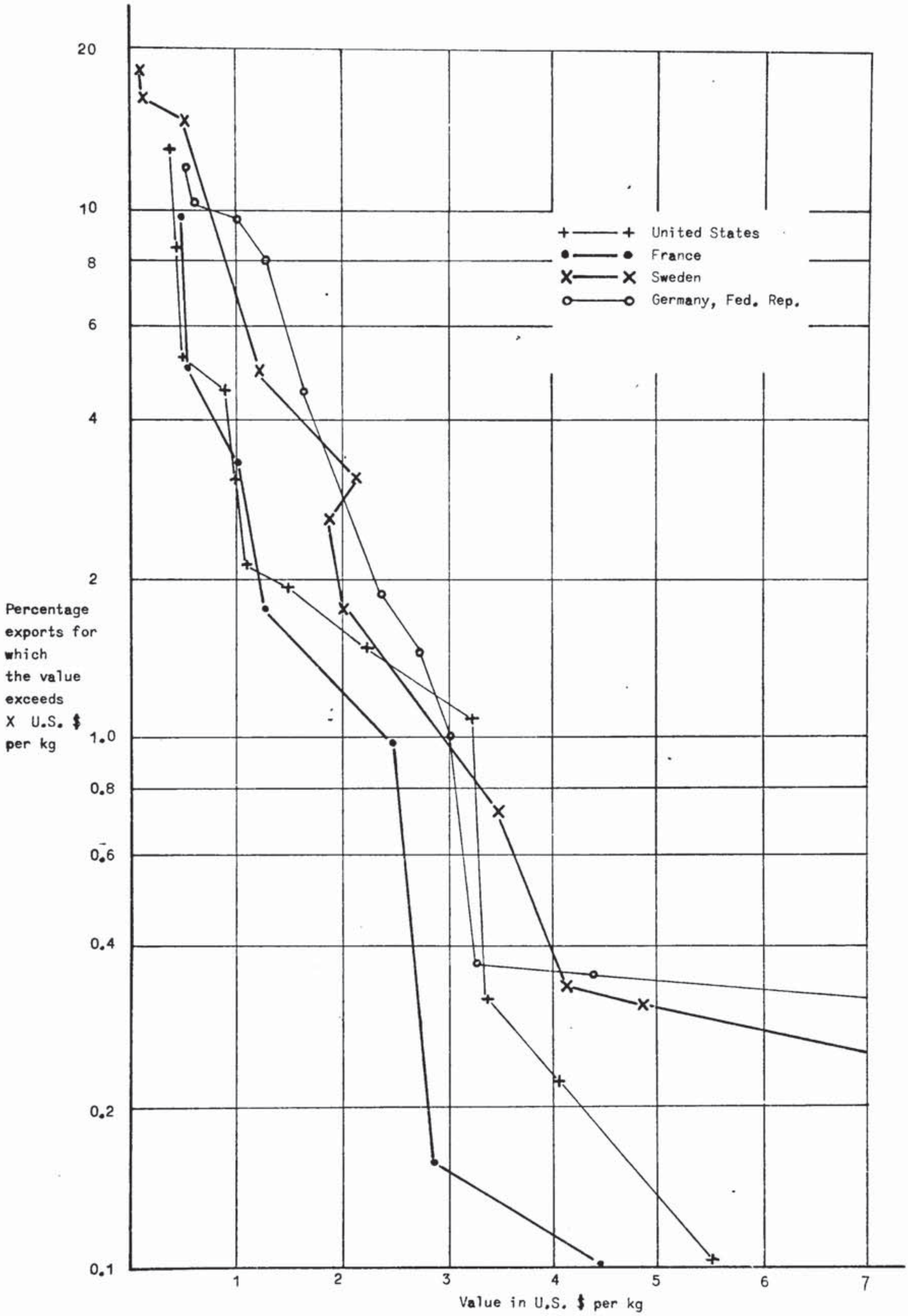


Fig 2: PROPORTIONS OF TOTAL EXPORTS OF VARIOUS COUNTRIES FOR WHICH THE VALUE PER UNIT WEIGHT EXCEEDS ARBITRARY LEVELS

Table 10: Air penetration of European exports to the United States - 1969

Code	Standard International Trade Classification (SITC) Description	Air cargo penetration By value %	By weight %
0.	Food and live animals	0.86	0.07
1.	Beverages and tobacco	0.05	0.02
2.	Crude materials, inedible, except fuels	18.65	0.03
3.	Mineral fuels, lubricants	0.01	0
4.	Oils and fats, animal and vegetable	0.03	0.01
5.	Chemicals	12.53	0.23
6.	Manufactured goods, classified by material	10.16	0.18
7.	Machinery and transport equipment	12.62	1.78
8.	Miscellaneous manufactures, N.E.C.	49.26	12.05
9.	Other, including small packages	48.13	8.64

Source: "U.S. International Air Cargo Markets"
C.A.B. Washington, 1970

when these general or aggregate methods are applied on a specific commodity-by-commodity or route-by-route basis. To be of use these methods must, however, be applied in detail since the vast majority of air cargo traffic moves at rates defined specifically by commodity and route.

Second, such techniques are over-simplifications and fail to take into consideration the fact that choice of transport mode is also influenced and conditioned by a large number of factors other than value per unit weight. The nature of such factors and the extent of their influence on choice of transport is discussed at length in chapter 2.

Other more elaborate techniques have also been developed around the wider concept of total distribution cost (5) . Such methods are based on the assumption that the mode of transport chosen ought to be that which minimises not merely transport cost but the costs of distribution as a whole. Many of the factors involved are those discussed in chapter 2 but as noted there most attempts to quantify their influence and to predict from this the traffic potential for any transport mode have failed to make allowance for the effects of other more qualitative aspects. As a consequence, the resultant estimates of traffic potential have proved to be more arithmetic exercises than realistic or practical forecasts. By the same token that transport cannot be considered in isolation from the total distribution activity of a company, so too, must distribution be viewed as merely one of a number of closely related company functions.

An alternative, circumscribing difficulties in evaluating the influence of such qualitative factors, is to assume that for a given commodity their incidence is of equal effect over all routes composing a trade flow. The share of a commodity traffic carried by a particular transport mode on any one of these component routes might then be adopted as the maximum share attainable in practice on the others. The total potential for a given transport mode can thus be built up on a commodity-by-commodity and route-by-route basis.

Two methods of calculation have been derived from this line of thought[x)] both of which are based on the principle that, within a single region to region trade flow, e.g. the North Atlantic, large differences between participating countries in the proportions of trade carried by air

Footnote:

x) These calculation techniques were originally presented in a report prepared by the author at the request of SAS and presented as a working paper to the KSSU (KLM, Swissair, SAS, and UTA) Cargo Policy Group meeting in September 1971. More detailed computer applications are at present being developed through SAS and with the data processing assistance of the Boeing Company.

on a commodity-by-commodity basis, signify a potential for increase in the lower penetration markets.

1.4.1. Method A - greatest air penetration

The ratio of present air trade to total trade by all modes of transport is calculated on a commodity-by-commodity basis and denoted air market penetration. Each country's total air trade potential is then obtained by multiplying the total weight of its trade in each commodity by the highest air market penetration achieved in that commodity by any other country from which the total trade flow is composed, and summing the results for all commodities.

In equation form this can be expressed as follows for each country participating in the total region to region trade flow:-

$$\text{Total air trade potential} = TC_a \times \left[\frac{AC_a}{TC_a}\right]_{\max \frac{AC_a}{TC_a}} + TC_b \times \left[\frac{AC_b}{TC_b}\right]_{\max \frac{AC_b}{TC_b}} + TC_n \times \left[\frac{AC_n}{TC_n}\right]_{\max \frac{AC_n}{TC_n}}$$

where, TC = total trade in commodity

a...n = range of commodities forming trade flow

AC = present air trade

$\max \frac{AC}{TC}$ = highest air market penetration of all countries participating in trade flow.

1.4.2. Method B - air penetration of largest air trade flow

In this method a more conservative approach is used to accommodate the fact that the highest air market penetration sometimes occurs in the exports of a country representing a very small share of the total trade flow in that commodity and an equivalent penetration is unlikely to be attained in the other countries representing more substantial shares. Therefore, instead of selecting the highest air market penetration as a base for comparison, the air market penetration of the country with the greatest air tonnage in the commodity is used.

In equation form this is a s follows:

$$\text{Total air trade potential} = TC_a \times \left[\frac{AC_a}{TC_a}\right]_{\max AC_a} + TC_b \times \left[\frac{AC_b}{TC_b}\right]_{\max AC_b} + TC_n \times \left[\frac{AC_n}{TC_n}\right]_{\max AC_n}$$

where, max AC = highest air cargo tonnage of all countries participating in the trade flow.

By way of illustration these calculation methods have been applied to the Europe-United States trade statistics for 1970.

The Europe - United States air trade potential 1970

In order to facilitate a manual computation not all commodities found in the total North Atlantic trade flow statistics have been included in the calculation of its air trade potential. Only commodities (defined by a four-digit SITC code) with at least 1,000 tons already moving by air in 1970 have been selected, this again accentuates the conservative nature of the estimate made.

In all 83 commodities were found which fulfilled this requirement, 46 eastbound and 37 westbound. These are listed in Tables (i) and (ii) in Appendix I. The air potential for each of these commodities was then computed on a country-by-country basis by methods A and B. As few as 5 and as many as 9 countries were involved in the data base for each commodity calculation. The detailed results by commodity and by country are shown in Tables (iii), (iv) and (v), (vi) in Appendix I and are summarized in Table 11 below.

Table 11: North Atlantic actual and estimated potential air trade 1970

	Actual air trade- (tonnes)	Potential air trade			
		Method A	Method B	As % of	
				A	B
Eastbound	133,050	94,841	41,503	+ 71	+ 31
Westbound	106,919	168,113	66,930	+157	+ 63
Total	239,969	262,954	108,433	+110	+ 45

It can be seen from the table that even under these extremely conservative conditions the air trade potential is still, at best, only three quarters actualised. Bearing in mind the maturity of the North Atlantic as an air cargo route, it seems unlikely that the transport demands generated by any other trade flow are met more adequately than this.

1.5. Air freight capacity

The total aircraft fleet of all IATA airlines was 3,967 aircraft in 1971. Of these 572 were all-cargo aircraft or aircraft convertible from passenger to all-cargo configuration. This represents some 14% of the total number, a share which has increased slightly from the 11% of 1960. The fleet of all-cargo and convertible aircraft in 1971 is shown in Table 12. It appears from the data that piston engined aircraft now only account for about 9% of the total number of aircraft and 3% of all capacity compared to the corresponding figures of 80% and 65% respectively in 1960. The diminishing share of total all-cargo capacity represented by piston-engined aircraft has been caused by the introduction of more productive jet aircraft, their numbers having increased substantially over the period. The above figures are even possibly an overstatement as the high efficiency jet equipment is likely to be more heavily utilized. These changes in the scale of operation by different aircraft type have significantly reduced costs.

The total amount of air freight capacity available is difficult to establish with any accuracy for two reasons. Firstly, only incomplete data exist on the capacity produced by all-cargo aircraft. Many of the aircraft listed in Table 12 operate in both passenger and all-cargo configurations at different times of the year or day in order to accommodate variations in the level of passenger and cargo demand. Secondly, cargo capacity on passenger flights cannot be calculated directly but must instead be accepted as the residual payload after deduction for other types of traffic carried. Such estimations, being based on payload weight only, are likely to overstate the amount of capacity remaining for cargo since only theoretical consideration can be given to any space constraints which might exist.

Bearing in mind these reservations Table 13 nevertheless gives some indication of the growth and scale of the total cargo capacity offered on scheduled international services and of the part represented by all-cargo operations. Total cargo capacity grew at about 19% per year over the period 1951-1971 compared to just over 16% per year for total available capacity for all forms of traffic. Over the period 1960-1971 this growth was approximately 18% per year compared to the 22% for traffic - see Table 4 above. While capacity growth has been slower than traffic the amount of unutilised cargo capacity in absolute terms has increased some eight-fold over the period and equalled approximately 7 billion tonne-kilometers in 1971 i.e. about half the total cargo capacity offered. This growth in capacity has been due mainly to the increase in number and productivity of all-cargo operations, the capacity offered on these services having increase on average at approximately 27% per year compared to the 14% on passenger aircraft.

Even assuming, as estimated in section 1.4, an accessible air cargo market potential almost twice that of existing traffic levels, the scale of capacity presently offered would still be more than sufficient. Indeed, it might be argued that in 1971, for example, even if the high growth rates of the past were expected to continue (and there were then indications of a slowdown) there was no justification for general capacity increases until at least 1974. Preliminary statistics for 1972, however, indicate a capacity growth. This is due unavoidably to the increasing number of wide-bodied passenger aircraft that are coming into service but less understander also to an increase in capacity on all-cargo aircraft.

Table 12: All-cargo or convertible aircraft fleet of IATA member airlines -

Type of aircraft	Number in operation	Typical payload capacity	Tot capac
		Tonnes	
Turbo-jet:			
Four-engine:			
Boeing 747F	1	100	1
Boeing 707-320	219	44	9,6
Douglas DC-8F/CF	58	43	2,4
H.S. Comet 4	2	18	
B.A.C. VC-10	1	38	
Three-engine:			
Boeing 727QC	99	18	1.7
H.S. Trident	2	18	
Two-engine:			
DC-9F	48	11	5
Boeing 737	8	19	1
Fokker F28	1	7	
Turbo-prop:			
Four-engine:			
B.A.C. Viscount	24	14	3
B.A.C. Vanguard	19	18	3
Lockheed Hecules	5	20	1
Lockheed Electra	9	15	1
Canadair CL-44	1	24	
Two-engines:			
Fokker F-27	14	6	
H.P. Herald	8	5	
Piston engined:			
Four-engines:			
Douglas DC-4	11	6	
Douglas DC-6	18	12	[illegible]
Douglas DC-7	4	15	
Breguet 763	3	12	
Lockheed L1049	1	12	
Two engines:			
Douglas DC-3	15	3	
Convair 440	1	8	
Total	572	-	

Source: ICAO "Fleet - Personnel 1971" Digest of Statistics, No. 172, Series FP-No 25. Montreal 1973

Table 13: Development of total scheduled cargo capacity on international routes 1951-1971

Year	Total tonne-kilometers capacity available (millions)	Actual passenger tonne-kilometers including baggage (millions)	Passenger load-factor (%)	Estimated total passenger tonne-kilometers capacity available (Col. 2/3 x 100) (millions)	Actual mail tonne-kilometers (millions)	Theoretical cargo tonne-kilometers capacity available (Col. 1-5) (millions)	% increase over previous year	Cargo tonne-kilometers capacity available on all-cargo aircraft (millions)	% increase over previous year	Capacity on all-cargo aircraft as proportion of total cargo capacity available
Column	1	2	3	4	5	6	7	8	9	10
1951	2,310	1,060	59.9	1,770	100	430	-	22	-	5.1%
1952	2,640	1,221	61.2	1,995	115	530	23.3	33	50.0	6.3%
1953	2,980	1,370	60.2	2,275	130	575	8.4	47	42.4	8.1%
1954	3,430	1,523	57.7	2,640	160	630	9.6	69	46.8	10.9%
1955	3,955	1,794	60.4	2,970	190	835	32.5	96	39.1	11.5%
1956	4,635	2,110	61.7	3,420	200	1,015	21.5	155	61.4	15.3%
1957	5,500	2,495	61.3	4,070	220	1,210	19.2	200	29.0	16.5%
1958	6,400	2,747	56.7	4,845	250	1,305	7.9	238	19.0	18.2%
1959	7,120	3,180	59.6	5,335	280	1,505	15.3	290	21.8	19.3%
1960	8,950	3,900	57.9	6,736	340	1,874	24.5	362	24.8	19.3%
1961	11,700	4,490	52.5	8,552	430	2,718	45.0	620	71.1	22.8%
1962	13,690	5,170	52.1	9,923	480	3,287	20.9	828	33.5	25.2%
1963	15,680	5,880	51.9	11,329	530	3,821	16.2	1,074	29.7	28.1%
1964	17,960	6,960	54.5	12,771	550	4,639	12.1	1,373	27.8	29.6%
1965	21,250	8,140	54.4	14,963	680	5,607	20.9	1,805	31.5	32.2%
1966	22,440	8,190	53.7	15,251	760	6,429	14.7	2,257	25.0	35.1%
1967	26,800	9,480	53.6	17,686	900	7,306	13.6	2,695	19.4	36,9%
1968	31,120	10,450	51.3	20,370	1,050	8,870	21.4	3,477	29.0	39.2%
1969	37,260	12,160	51.0	23,843	1,180	10,503	11.8	4,317	24.2	41.1%
1970	43,380	14,400	53.1	27,119	1,440	11,279	7.4	4,689	8.6	41.6%
1971	48,620	15,530	50.5	30,752	1,180	14,042	24.5	5,341	14.0	38.3%

Source: ICAO "Traffic 1951 - 1965/1961-1971"
Digest of Statistics No. 127/169
Series T-No. 25/31 Montreal, 1962/1972

1.6. Physical characteristics of air freight traffic

Physical characteristics of the traffic flow also influence the economics of air cargo services both on the ground and in the air. From a revenue standpoint it is the shipment characteristics of weight and density which are of most significance, the IATA cargo tariff applying rate discounts and surcharges on these grounds. With respect to costs both shipment and piece characteristics are important. Since each shipment must be covered by an airwaybill (AWB) the number of shipments per given cargo traffic flow directly affects the level of airline documentation and accounting costs. The number, weight, dimensions and density per piece on the other hand influence the handling efficiency within the cargo terminal and during aircraft loading and unloading. These factors also determine the type of aircraft capable of transporting the cargo and the extent to which maximum payload is achieved, thereby establishing the level of airborne cost per unit of cargo traffic.

Since very little information was found to exist at present about such factors a survey was necessary to establish a data base for reference and analysis. Such a survey was made by the author at Copenhagen Airport on behalf of Scandinavian Airlines System during the three month period September to November 1971. An abstract of the survey report is contained in Appendix II, the findings are summarized and discussed below.

A total of almost 12,000 shipments, together weighing some 1,220 tonnes and covering 210 commodities (as defined by SITC four digit code) were surveyed. This sample represented approximately 4% of the total cargo flow through the Copenhagen terminal during the period of the survey. Mean values of the most important cargo traffic characteristics derived from the survey data are summarized in Table 14 and illustrated in FIGS. 3 to 7. As the Table shows the typical shipment weighs some 100 kgs, is a little less than $0.5m^3$ in cube, giving an average density around 220 kgs/m^3, and is composed of 4 to 5 pieces.

For at least a part of the sample Table 14 also distinguishes between the physical characteristics of traffic carried on different services. Although this sub-sample involves only some 35% by weight of the total survey, it broadly indicates a generally lower weight and cube per shipment and piece for traffic carried below-deck on passenger aircraft. As is shown below the physical characteristics of the traffic flow as a whole do not appear, however, to justify this.

FIGS. 3 and 4 show the cumulative frequency curves of shipment weight and density. Some 80% of all shipments were found to weigh less than 45 kgs, the first weight breakpoint in the IATA air cargo tariff and over 90% less than 100 kgs, the second breakpoint. In terms of the total traffic flow shipments under 45 kgs and under 100 kgs account respectively for about 10%

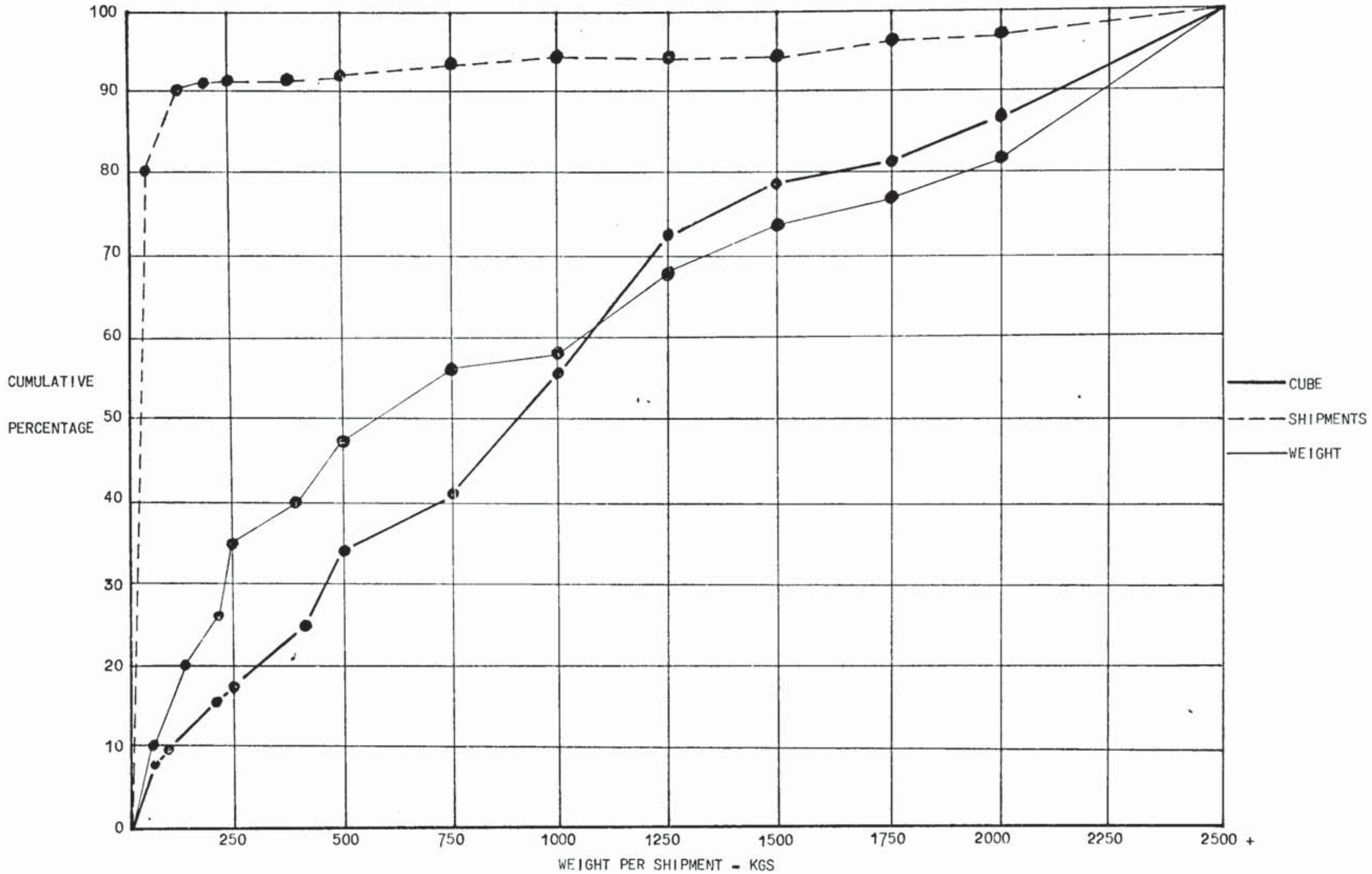


Fig 3: CUMULATIVE FREQUENCY CURVES OF WEIGHT PER SHIPMENT

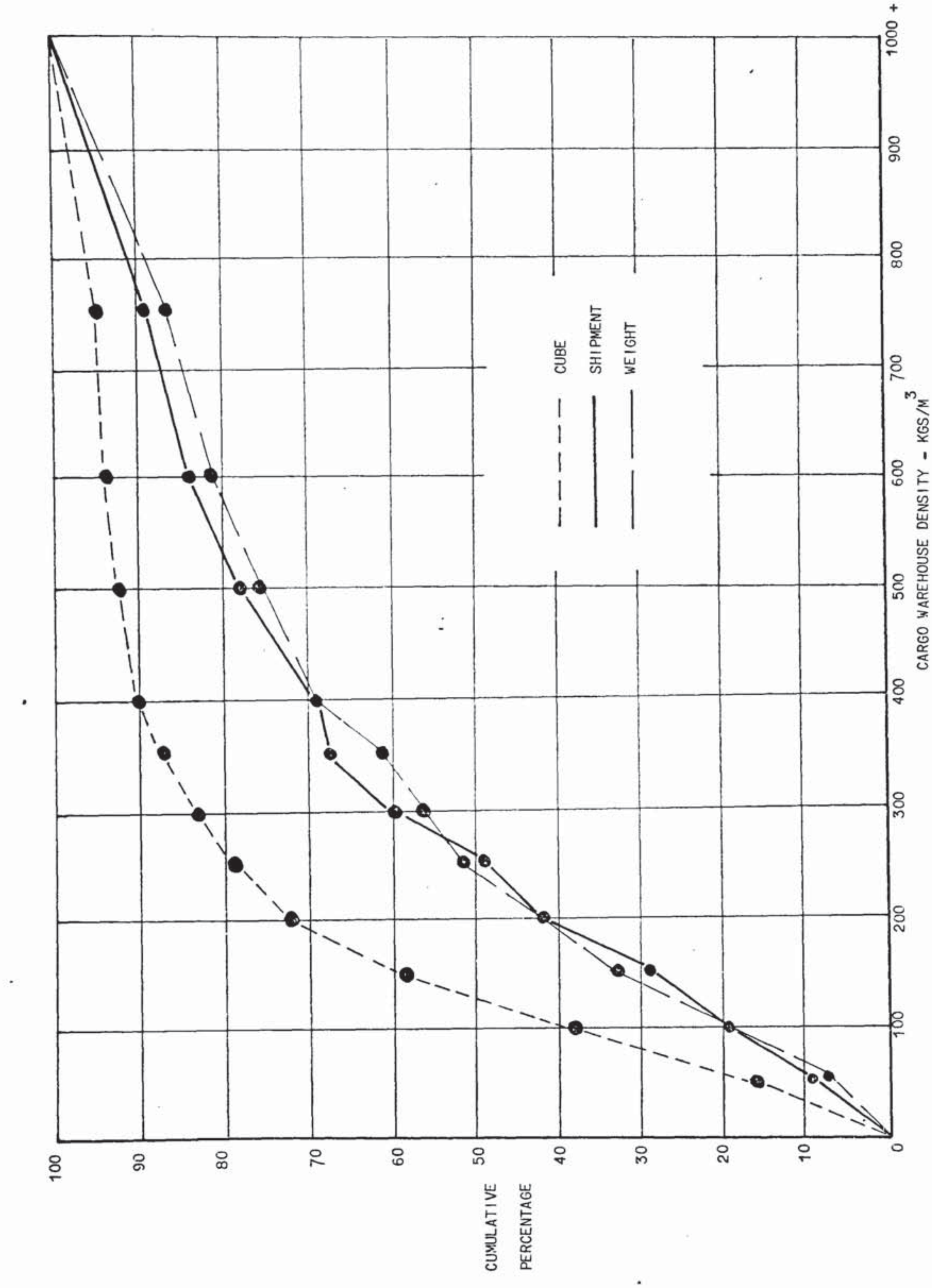


Fig 4: CUMULATIVE FREQUENCY CURVES OF SHIPMENT DENSITY

and 16% by weight and 7% and 10% by cube. To see these measures in a broader perspective comparison can be made to corresponding surface transport parameters. It has been reported, for example, that only some 13% of the number of railway merchandise shipments are of less than 50 kgs. (6) . Considering non-bulk seabourne dry cargo, on average only some 8% of shipments are under 50 kgs (7) .

Table 14: Cargo traffic flow characteristics

Cargo traffic flow average characteristic	Passenger flights	All-cargo flights	Total flights
Weight per shipment (kgs)	44.9	183.6	104.0
Cube per shipment (cubic meters)	0.198	0.898	0.478
Pieces per shipment	2.7	7.5	4.6
Weight per piece (kgs)	16.5	24.6	22.6
Cube per piece (cubic meters)	0.073	0.120	0.104
Density	227.2	204.4	217.5

Since the frequency curve of weight cumulates faster than cube through the range to 300 kgs and more slowly thereafter to 1,250 kgs, it might be argued that shipment weight and density have a broadly inverse relationship, at least over this range of shipment weight. Shipment density increases up to 300 kgs but falls off beyond that point and especially rapidly between 750 kgs and 1,250 kgs. Despite this pattern of declining density the IATA tariff offers the greatest discounts at the highest shipment weight breakpoints of 500 and 1,000 kgs.

FIG. 4 shows the frequency curves for the physical density of cargo traffic[x)]. The IATA rate structure requires that all shipments of a density less than 143 kgs/m^3 shall be charged volumetrically at the equivalent of that density. Thus, for example, a shipment of 100 kgs and 1 m^3 would be charged as it weighed 143 kgs. In previous industry negotiations to increase the density requirement to a level more in line with the 300 kgs/m^3 and 200 kgs/m^3 of shipping and trucking, a number of IATA airlines have stated that only a few percent of shipments are rated by volume. The sample distribution shows, however, some 26% of shipments, representing approximately 30% of the traffic by weight are below the tariff breakpoint. This discrepancy gives support to the general industry opinion that a significant proportion of consignments which should be rated by volume are actually rated by weight.

Footnote

x) All reference here is to "warehouse density" not "on-board density" as no allowance has been made for stacking or stowage inefficiencies.

More stringent control of shipment density at acceptance for transport would increase airline revenues but would also, of course, increase handling costs too.

FIG. 5 illustrates the frequency distribution of the number of pieces per shipment. More than 60% of all shipments, representing about 14% of traffic by weight, consist of a single piece; 10% are of 2 pieces, and 8% of 3 pieces. In all, approximately 80% of all shipments are of 3 pieces or less but represent only just over 25% of the traffic by weight. More than 30% of the traffic by weight is in shipments of 18 or more pieces. The inverse relation between weight and density shown in FIGS. 3 and 4 is again demonstrated here. The weight curve cumulates faster than cube over almost the entire range signifying that density grows, and increasingly so, with the number of pieces per shipment. The implication of this is that while low weight shipments tend to be of higher density and, therefore, offer better possibilities for payload utilization, this is conditional upon the number of pieces per shipment. High weight shipments can be of high density, but this is most likely if split into a large number of small pieces. The number of pieces per shipment on the other hand determines handling costs - see chapter 4 - an important element of total expenses.

The weight and dimensions of individual pieces of cargo are also important, limiting both handling and loading possibilities. FIG. 6 shows the cumulative frequency curve of piece weight for the sample. Taking 50 kgs as the limit for manual handling in the below-deck compartment of a passenger aircraft, approximately 90% of all pieces, accounting for about a half of all traffic in terms of weight, were found to be under this level. FIG. 7 shows the frequency curves of width, height and length of individual pieces. Over 85% of all pieces have a maximum of 80 cms in any one dimension. The maximum piece dimensions acceptable through the below-deck cargo compartment loading door on a DC-9-21, a relatively small passenger aircraft, are by comparison 132 x 80 x 117 cms. In other words, despite the differences in traffic characteristics shown in Table 14 it would appear that some 80-90% of all cargo pieces are of suitable weight and dimensions for loading and carriage on most present day passenger aircraft.

The physical characteristics of the cargo traffic flow can also be distinguished geographically. For example, the average intercontinental shipment appears to be some 30-40% greater in terms of weight than intra-European and to be composed of 2 to 3 times as many pieces. Intra-European traffic, by contrast, has a higher than average warehouse density. North Atlantic traffic has a density some 24% below the average in total but with great variety by direction due to the different natures of the commodity flows involved, being 42% below the average in westbound direction and 18% above eastbound.

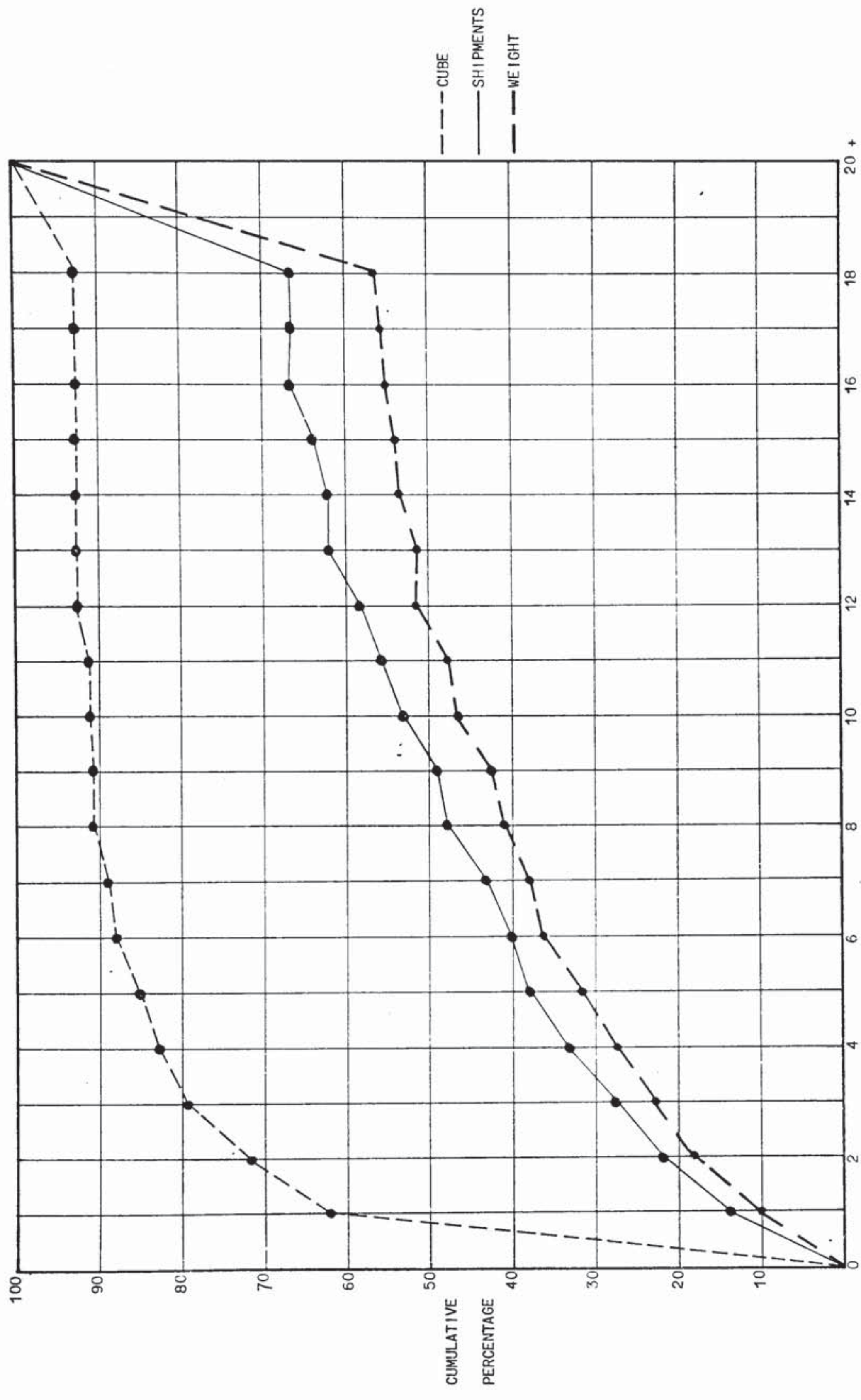


Fig 5: CUMULATIVE FREQUENCY CURVES OF NUMBER OF PIECES PER SHIPMENT

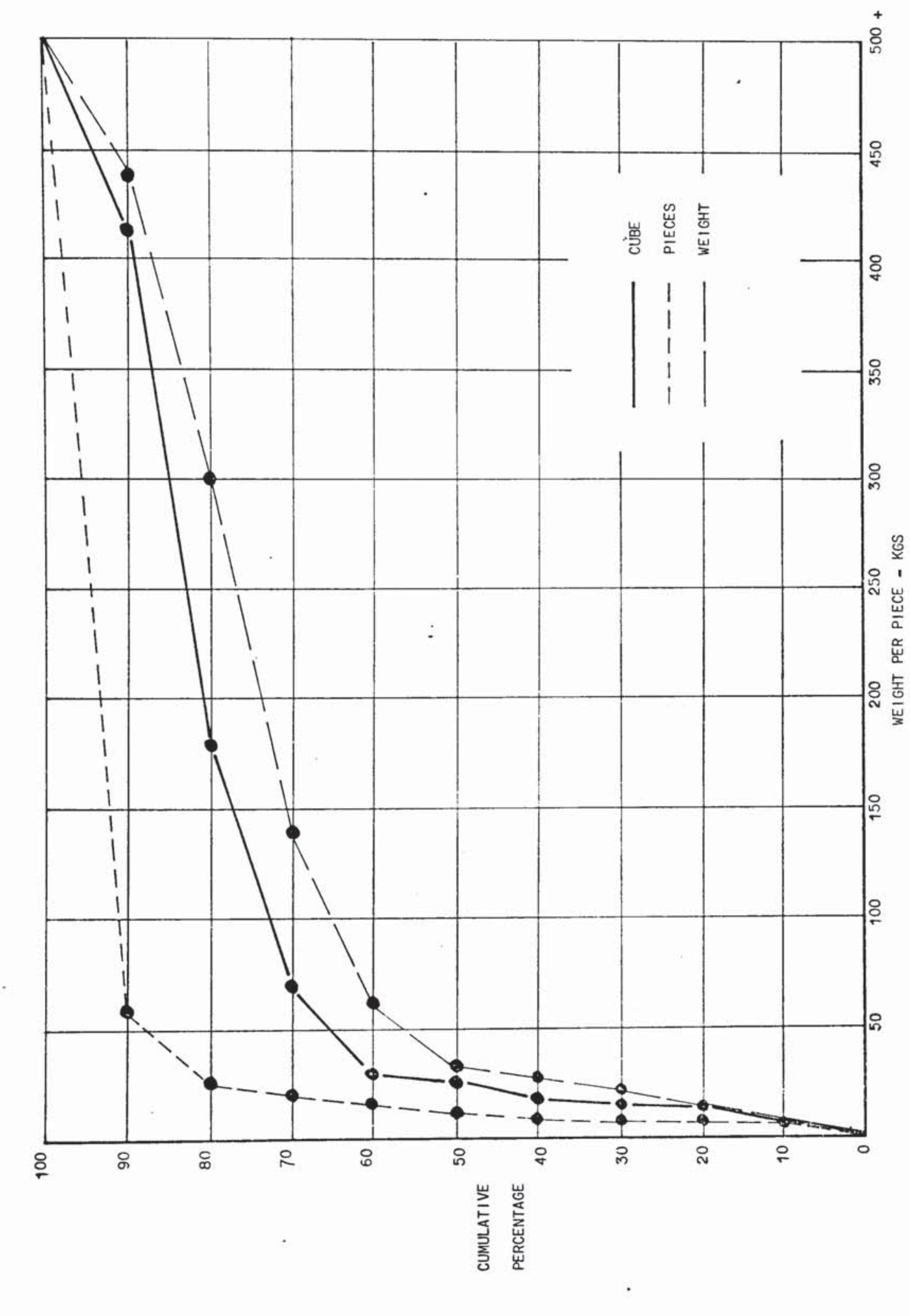


Fig 6: CUMULATIVE FREQUENCY CURVES OF WEIGHT PER PIECE

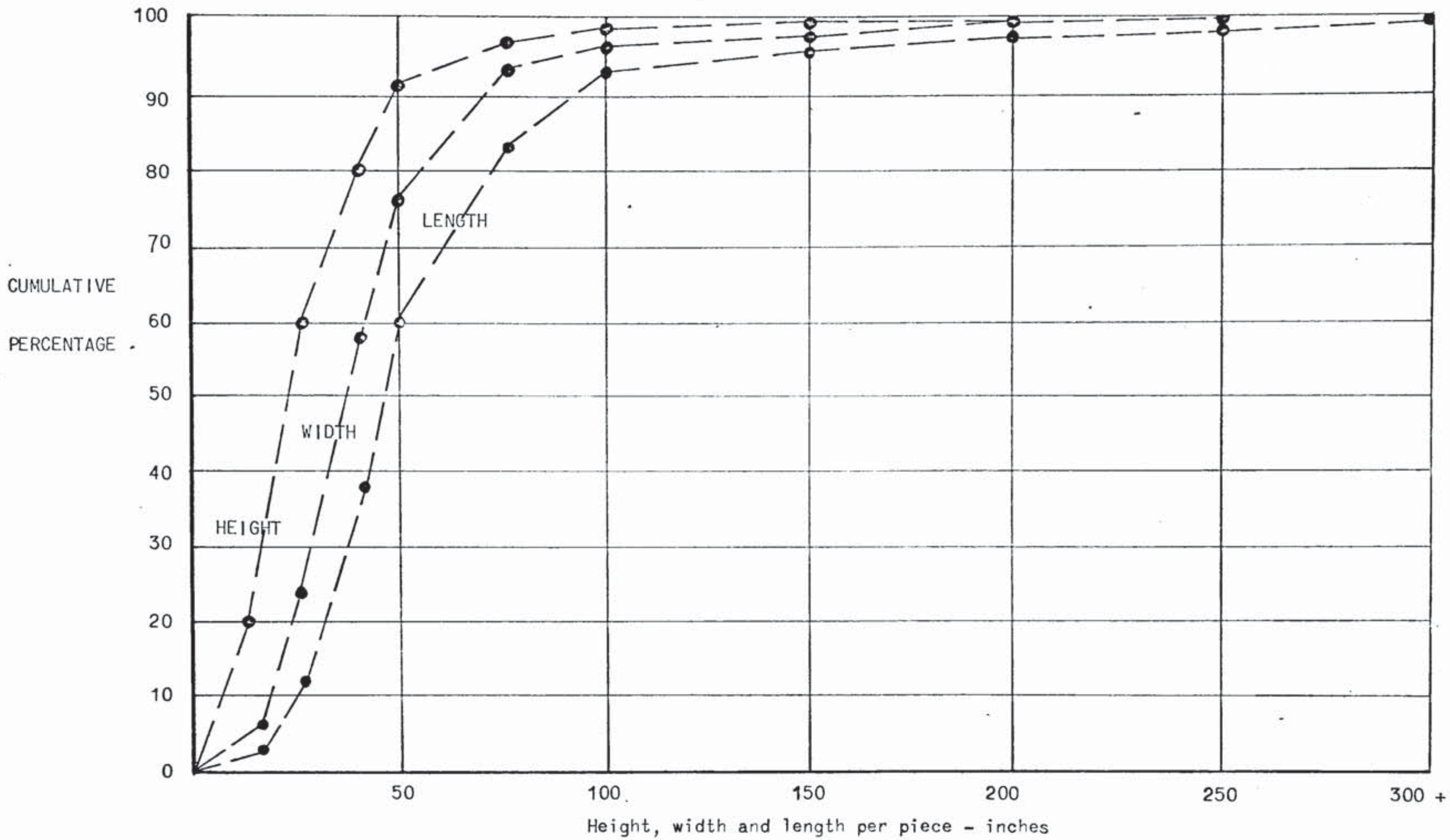


Fig. 7: CUMULATIVE FREQUENCY CURVES OF PIECE HEIGHT, WIDTH AND LENGTH

1.7. Periodic fluctuations in air cargo demand

Fluctuations in the demand for air cargo can in general be broken down into three elements:-

(a) quarterly or seasonal variations;

(b) variations by day of the week; and

(c) variations by hour of the day.

These fluctuations tend to follow cyclical patterns with peaks occurring in:-

(a) the last quarter of the year;

(b) immediately before a weekend; and

(c) in the late evening and night.

The size of the fluctuations can be of considerable economic significance for both revenue and costs. Transport is a service and cannot be stored. This immediacy means that the amount of revenue earned by an airline or even the industry as a whole, will depend very much, therefore, on how well the capacity, frequency and scheduling of services match these variations in traffic demand. From the viewpoint of costs on the other hand, traffic patterns and especially traffic peaks establish the scale of resources required for effective operation, resources which must also be maintained through times other than the peak.

FIG. 8 illustrates the extent of quarterly fluctuations in air cargo demand on the North Atlantic compared to similar variations in passenger traffic. The graph plots the ratio, "A", between the highest and lowest traffic quantities per quarter in each year over the period 1962 to 1971. For cargo traffic the ratio has been in the range 1.1 to 1.5 over the whole period. For passenger traffic, despite the existence of a large number of seasonally differentiated fares, the size of fluctuations has been much greater, around 3.0. In the case of cargo this traffic ratio appears to have increased slightly with time and in passenger to have decreased. With growth in traffic volume the fluctuations have in all cases increased substantially in absolute terms.

Ratio "A" somewhat overstates the significance of demand fluctuations, however, since it takes no account of the effect of the general growth in the quantity of traffic over the period in question. In the case of cargo the peak traffic quantity has occurred almost invariably in the fourth quarter of the year and the lowest in the first quarter. This means that a more accurate comparison would be between the highest traffic quarter in one year and the lowest in the next. Such a ratio, "B", is also shown in FIG. 8 for both cargo and passenger traffic.

With such an adjustment for growth the ratio between highest and lowest quarters has rarely exceeded 1.1 in the case of cargo. In the case of

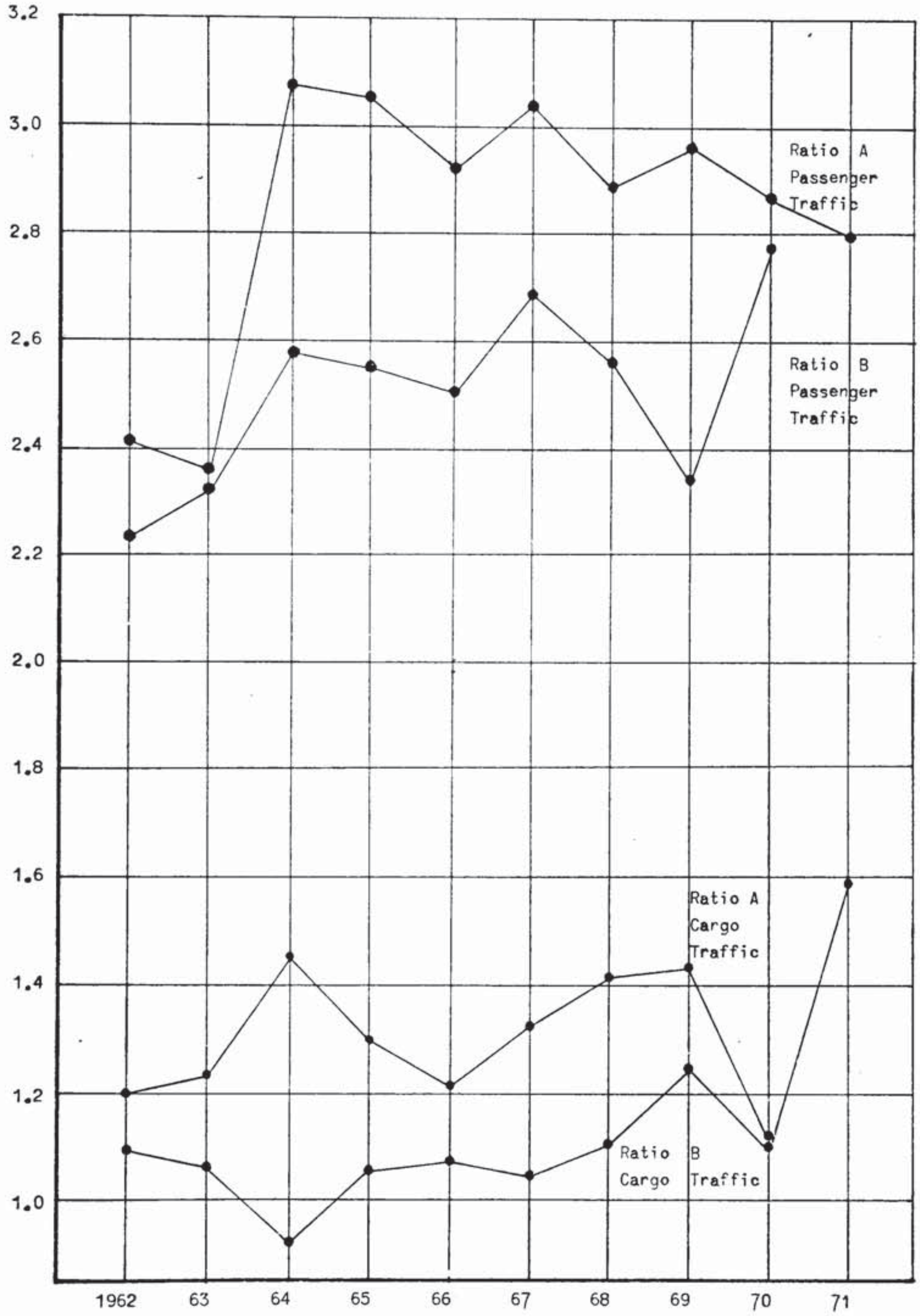


Fig. 8: Ratio of highest to lowest traffic quarter for cargo and passengers

passenger traffic the ratio still remains much higher.

Taking the North Atlantic as being generally representative, it would thus appear that fluctuations of the air cargo demand over seasons of the year are very limited and unlikely to be of any great impact in respect of capacity utilization. In contrast, the pronounced fluctuations in passenger traffic may indicate that the cargo capacity on passenger flights varies considerably during the year.

While the pattern of long-term fluctuations in the cargo flow is of importance to the amount of revenue earned fluctuations from day to day and hour to hour are of more immediate relevance to cost levels. Despite their influence on costs very little information about such fluctuations appears to be available. An indication of how the traffic flow is distributed over these time periods might, however, be gained from the data collected in the sample survey described in Appendix II. The variations that were found in the level of traffic flow by day and hour are illustrated in FIGS. 9 and 10. From FIG. 9 it appears that there is a general increase in the volume of traffic per day from Monday through to Saturday, with a fall-back on Sundays. The average quantities of cargo handled in this instance were in the region of 250 tonnes on Mondays and 410 tonnes on Saturdays, i.e. a peak-to low-day ratio of about 1.6.

The total cargo flow i.e. imports, exports and transfer cargo, by hour of the day was found to follow the very distinct pattern shown in FIG. 10 with almost two thirds of all traffic occuring in the eight hour period from 22.00 to 06.00. Inbound traffic predominates in the first four hours of this peak, with about 70% of the total arriving during that period, and outbound the second half, with 50% of the total in that period. Dividing the 24 hour period into three shifts: 06.00-14.00, 14.00-22.00 and 22.00-06.00, gives the peak-shift 22.00-06.00 a traffic flow ratio of around 1.5 against the total in low-shift.

Combining the ratios of high to low traffic flows in each of the time cycles considered, quarterly, daily and hourly, will give some indication as to the scale of the peak problem present in the air cargo industry (a problem common to all service industries). The quantity of traffic in the peak quarter, day and hour is in the region of:

$1.1 \times 1.6 \times 1.5 = 2.6$ times as great as the quantity in the low quarter, day and hour. Needless to say this creates severe problems in selecting an optimum scale of operation, particularly in respect of ground handling facilities.

1.8. Directional imbalances in the demand for air cargo

An essential difference between passenger and cargo traffic is that the vast majority of passengers fly round-trip while cargo travels one way

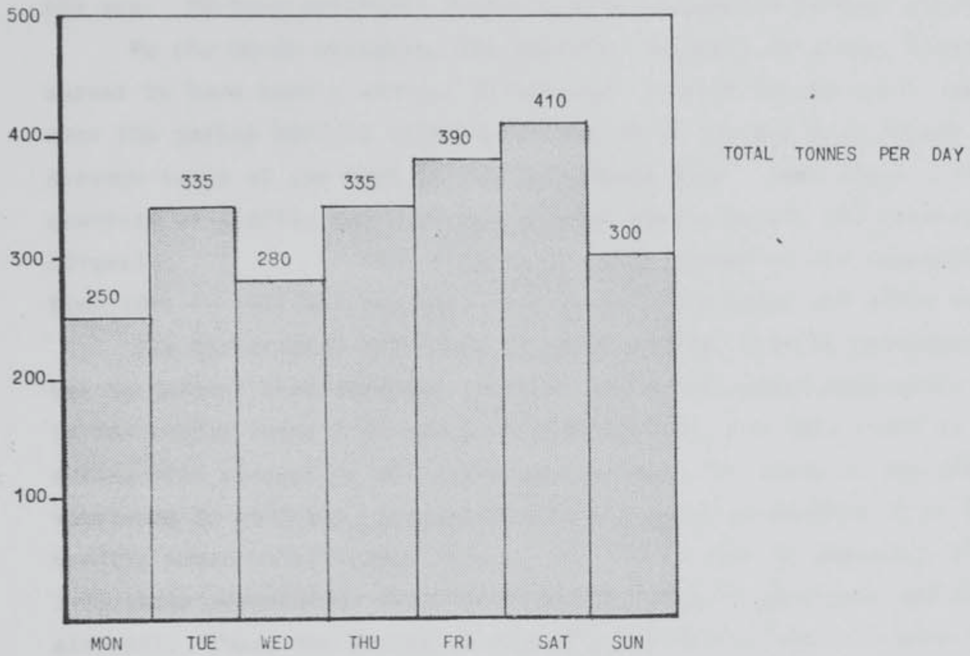


Fig. 9: Daily fluctuations in freight flow

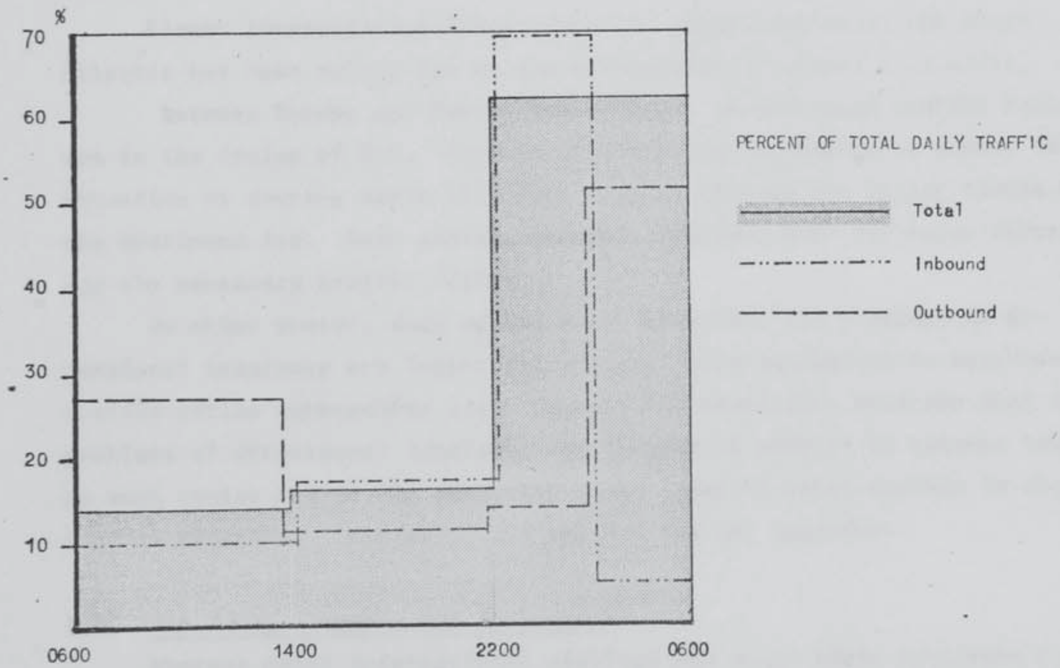


Fig. 10: Hourly fluctuations in freight flow

only. As a result directional imbalances exist in the quantities of cargo traffic on many routes.These present problems to the further expansion of certain routes, especially those connecting industrialised and less developed nations where the nature of the commodities traded makes traffic very much one way. On most important routes a more reasonable balance appears to exist

On the North Atlantic, for example, as Table 15 shows, there does not appear to have been a serious directional problem in the total cargo flow over the period 1960-72 with the exception of the two most recent years. The average ratio of the high to low directions have been about 1.16 i.e. the quantity of traffic has been one average approximately 16% greater in one direction This imbalance was in favour of the eastbound direction from 1961 to 1967 but has been consistently the other way since then.

The directional imbalance in cargo traffic flow on passenger flights has in general been somewhat greater than on all-cargo operations, the high to low ratios being 1.18 and 1.13 respectively, but this trend is deteriorating with respect to all-cargo operations. The scale of the directional imbalance in 1965 was, in absolute terms, equal to roughly 5% of the total traffic moved on all-cargo flights and 12% of that on passenger flights. By 1972 these proportions were equal at 10% for both passenger and all-cargo aircraft. Thus, the degree of capacity utilization on all-cargo flights has declined due to the increasing incidence of directional imbalance in traffic flows.

Closer investigation shows that this deterioration on the North Atlantic has been mainly due to the substantial imbalance in traffic between Europe and Canada where west- to eastbound traffic ratios are in the region of 3:1. Certain carriers have attempted to remedy this situation by routing their all-cargo flights through the United States on the eastbound leg. Such action, however, requires both all-cargo aircraft and the necessary traffic rights.

On other routes, such as the South Atlantic, the problems of directional imbalance are larger and growing, with southbound to northbound traffic ratios approaching 2:1. Recent IATA statistics indicate that these problems of directional imbalance are frequently greater in revenue terms on such routes due to the generally lower level of rates applied in the low traffic direction. Ratios of 3:1 and 4:1 are not uncommon.

1.9. Air cargo agents and forwarders

Whereas major international airlines may count their customers for passenger services in hundreds of thousands, their important customers for air cargo may rather be counted in hundreds. A representative of Pan American World Airways, for example, has claimed that more than 50% of the cargo carried by that airline comes from fewer than 5% of its customers

Table 15: North Atlantic freight flow by direction and aircraft type 1960-1972

YEAR	PASSENGER FLIGHTS				ALL-CARGO FLIGHTS				TOTAL FLIGHTS			
	WEST-BOUND	EAST-BOUND	DIFF. (W-E)	RATIO (HIGH/LOW)	WEST-BOUND	EAST-BOUND	DIFF. (W-E)	RATIO (HIGH/LOW)	WEST-BOUND	EAST-BOUND	DIFF. (W-E)	RATIO (HIGH/LOW)
1960	14.406	12.051	2.355	1.19	10.014	9.589	425	1.04	24.420	21.640	2.780	1.13
1961	17.055	18.129	(1.074)	1.06	11.724	15.943	(4.219)	1.35	28.779	34.072	(5.293)	1.18
1962	21.311	22.846	(1.535)	1.07	12.054	13.611	(1.557)	1.13	33.365	36.457	(3.092)	1.09
1963	24.545	28.398	(3.853)	1.16	13.481	12.745	736	1.06	38.026	41.143	(3.117)	1.08
1964	26.725	34.117	(7.392)	1.28	19.061	19.151	(90)	1.00	45.786	53.268	(7.482)	1.16
1965	38.056	48.463	(10.407)	1.27	28.604	31.801	(3.195)	1.11	66.664	80.264	(13.600)	1.20
1966	44.202	53.881	(9.679)	1.22	39.385	39.109	276	1.01	83.587	92.990	(9.403)	1.11
1967	46.362	54.823	(8.461)	1.18	49.219	50.607	(1.388)	1.03	95.581	105.493	(9.912)	1.10
1968	66.327	59.559	6.768	1.11	72.063	59.970	12.063	1.20	138.390	119.529	18.861	1.16
1969	84.865	75.602	9.263	1.12	102.197	93.581	8.616	1.09	187.062	169.183	17.879	1.11
1970	85.640	77.982	7.658	1.10	98.650	87.328	11.322	1.13	184.290	165.310	18.980	1.11
1971	127.750	92.272	35.478	1.38	94.430	69.241	25.189	1.36	222.180	161.513	60.667	1.38
1972	141.948	115.146	26.802	1.23	133.780	110.582	23.198	1.21	275.729	225.728	50.001	1.22

Source: "World Air Transport Statistics" IATA Montreal 1973.

(8) . In spite of this, however, it has not been very common for shippers and airlines to deal directly with each other but rather through an agent or forwarder.

The existence of agents and forwarders dates back to before the beginning of air transport. They may alternatively act strictly as agents for shippers and consignees, dealing on their behalf with the airlines and other parties involved, or they may act as consolidators whereby they assume separate contractual relationships themselves with the shipper on the one side and the airline on the other. Until the development of containerization in air cargo their activities were mainly as intermediaries, since that time, however, increasing emphasis has come to be placed on their latter role as consolidators.

From the point of view of the shipper the agent performs essential functions such as cartage to and from the airport and the premises of the consignors and consignees, provision of documentation services, including the preparation of airwaybills, clerical services, communication and information facilitates for monitoring the progress of a shipment, and advice on routings, schedules and rates. Such services would be too time consuming and expensive for the majority of shippers to provide themselves and airlines usually only provide such services in the vicinity of airports. The consolidator or forwarder provides all these services to shippers and in addition offers lower rates through groupage i.e. consolidating individual shipper's loads to achieve rebates for higher weights and pallet loads. In the case of imports, both agents and forwarders also provide brokerage and customs clearance facilities.

From the air carrier's viewpoint both agents and forwarders provide services which, except in a few isolated instances, the airlines themselves have never attempted to perform. Most importantly the agents and forwarders provide collectively a distribution network of branch offices and cargo collection depots throughout the industrialized areas of most countries. They provide road transport for local collection and delivery, containerization, breakbulk and warehouse facilities. In addition they issue airwaybills on behalf of airlines and by providing the various services and advice that shippers require, perform a handling function at what should be a lower unit cost than if the competing airlines were each to provide them separately, with the consequent duplication of effort.

IATA has a registration system for cargo agents under which licences are issued dependent upon the applicant first satisfying a local airline of his ability to meet certain criteria of handling, transport, sales and revenue production. The holding of such a licence entitles agents to recieve commission from the airlines at 5% of the rates. In theory the licensing of agents ensures compliance with the IATA resolutions regarding rates and practices, since non-compliance would risk revocation of the licence and therefore loss of commission.

In many countries a significant and increasing proportion of income for the larger agents accrues from the consolidation of cargo. It should be noted that in the United States, while both forwarders and agents are licensed by the CAB, the former are precluded from receiving commission; hence they depend entirely on the income derived from consolidating shipments. This form of groupage has been an implicit feature of the IATA rating philosophy for a very long time by virtue of its "freight-all-kinds" (FAK) quantity breakpoint structure and is perpuated in the relatively new system of bulk unitization charges. The IATA air cargo tariff is described in detail in chapter 5.

A predominant part of air cargo revenue comes to the airlines through agents and forwarders and their role is demonstrably an important one to the industry. Currently they handle from 60 to 90% of the revenue in most countries (9) and it is accepted play an important part in the shipper or consignee's choice of airline. There are good reasons for believing that maintainance and extension of the present general and bulk FAK rate structure can only reinforce this position.

Indeed, the successful development of containerized traffic, and with it the expected ground handling economics for the airlines, depends heavily upon the cooperation of the agents. It has been estimated[x)] that within a few a years the development of containerization could result in 30 to 40% of all traffic by weight being transported in containers of one sort or another. To achieve this will require a substantial commitment by the consolidators in terms of premises and equipment investment.

The underlying rationale of the carrier/agent relationship has historically been founded on the fact that competition between the large number of agents ensured the lowest charges were quoted to the shipper, even though all were based on the IATA "wholesale" tariff. This rationale could be nullified if the number of agents is drastically reduc ed and only a few very large companies remain. The development of such an oligopolistic situation could ultimately lead to a position where consolidators offered traffic by the plane-load to the lowest bidding carrier. To-day's roles would then have been completely reversed, the airlines instead becoming the transport agents of the consolidators.

Footnote

x) By an IATA Working Group of which the author was a member.

1.10. Summary and conclusions

The largest trade flows in manufactures are intra-European and North Atlantic; the growth in these areas being on average about 11 and 9% per annum respectively. Not unnaturally the largest air trade flows are also on these routes but, at 20% per annum, growing considerably faster. It appears from the data that while the value per weight of trade in general tends to increase with distance, the opposite trend occurs in air trade. This is not so suprising, however, since the economic advantages of air transport increase rapidly with distance and, at greater distances, can therefore be of benefit to trade of lower average value per weight.

While air trade is growing faster than the total and in value now represents about 10%, the traffic volumes involved are very small compared to other modes of transport, but are predicted to grow substantially; the pattern of this growth being expected to follow the classical "S" shaped logistics curve. Even the most conservative forecasting techniques indicate traffic potentials some 50% greater than present levels.

Despite the fact that only about a half of the total cargo capacity offered is presently utilized, increasing amounts continue to be provided each year. Over the period 1960 to 1971 capacity growth has been at approximately 18% per annum, i.e. only a little less than traffic. A major part of this growth has been the result of increases in all-cargo operations, even though survey shows that the physical nature of some 80-90% of traffic is suitable for transport in the belly compartments of passenger aircraft.

Two other features of the air cargo industry are also of noteable influence. First the flow of air cargo is subject to periodic fluctuations and directional imbalance which affect both revenue and costs. The fluctuations in traffic level play an especially important part in determing the scale and level of costs for ground handling services.

Second, unlike the passenger market, air cargo is highly concentrated. Some 60-80% of all air cargo moves through the channels of agents and forwarders. The market power this gives them relative to the individual carrier is further enhanced by the growing incentives offered by the rate structure for consolidation of the traffic by agents into larger shipments.

Chapter 2

The regulatory setting of air cargo

2.1 Introduction

It has long been argued and is now generally agreed in most countries, regardless of the ruling political doctrine, that because air transport serves the national interest its provision must in some way be regulated:-

> .... governments have special interests in the development of the air transport industry and some kind of regulation of the airlines is necessary to secure these aims of national policy. (10)

The plentitude of these regulations has made the airlines of most countries de jure or de facto national institutions[x)] and has meant the virtual incorporation of air transport into the public sector of the economy. The extent and consequences for air crago traffic of some of the most important regulations are described below.

2.2 National interest and commercial objectives

The fact that it is a public service and can be used to further national interests has influenced the structure of the air transport industry (12) (13) (14). It has meant particularly that the prime operating objective for most airlines is not solely commercial or financial, but has been made to simultaneously embody political, economic and social purposes. Evidence of this can be found in the policy statements of aviation authorities in a number of countries[xx)].

Politically an airline is an attribute of sovereignty and independence and as a flag carrier serves the national interest by providing a demonstrative means for their assertion. It is also of value to national defence, offering a reserve logistical capability, training and maintaining flight personnel, and ensuring the development of essential ground and navigational facilities. Domestically it can help sustain political cohesion where cultural, linguistic, religious, etc., differences are great, as well as provide an immediate transport infrastructure where no other exists.

Footnotes:

x) Selznik (11) asserts that commercial organizations become institutions through the assimilation of organizational values which relate them to the wider society. This definition seems to fit admirably the present circumstances of most airlines.

xx) For example, in the United States the 1958 Federal Aviation Act enumerates a list of objectives to be pursued by the air transport industry beginning with:-

> "..... the development of an air-transportation system properly adapted to the present and future needs of the foreign and domestic commerce of the United States, the Postal Service, and of national defence."

This theme has since been reiterated in the Presidential International Air Transport Policy statements of 1963 and 1970 (15) (16).

Economically an airline can benefit the industry of its home country by facilitating trade, increasing the scope and frequency of commercial contact and establishing a commercial "presence" in foreign markets. It can also be a direct source of national wealth in itself: a country which is a net "exporter" of air transport receiving payment for its services from the passengers and shippers of countries whose position as secondary air carriers make them net "importers"[x)]. Airline operations also, of course, play an extremely important part in developing and supporting the tourist industry, a significant sector of the economy in many countries. National interests are also served by the contribution that air transport makes to social progress. The speed advantage of air makes possible more frequent and far reaching travel, thereby creating broader opportunities for intellectual and cultural exhange.

The priority given by national aviation authorities to these objectives frequently imposes a heavy financial burden on carriers and often makes route or traffic cross-subsidization, or some form of government subsidy necessary. The receipt of subsidy payment and the frequent emphasis of non-financial aims has created an industry environment in which, subject to modest profitability[xx)] or economic breakeven, maximum growth rather than maximum profit has become the primary operating objective. Indeed, it has even been remarked that:-

> "..... if an airline were to make big profits the agencies in charge of civil aviation with which it had dealings, or the authorities over economic and political affairs generally, would conclude that such profits were excessive, in so far as they contained possibilities for a reduction in fares (or rates) and did not correspond to the more general interest or to public service" (18) .

Footnotes:

x) Straszheim has noted, for example, that:-

> "..... in 1960 KLM earned a net amount of $65 million in foreign exchange from carrying foreign travellers and saved $72 million in foreign exchange by carrying Netherlands nationals abroad. Aircraft purchase abroad left a net plus of $25 million - almost 8% of the Netherlands net goods and services foreign exchange balance. Elsewhere it has been stated that in the first quarters of 1971 alone:- "British airlines contributed a surplus of $85 million to the balance of payments."(13)

xx) "The objective agreed for BEA is an average return over the five-year period of 6% a year on its net assets (after making proper provision for depreciation, but before taking account of interest charges)." Even this commercially modest aim has only occasionally been achieved.(17)

2.3 National interest and an operating monopoly

National interest and public service objectives have also affected the structure of the air transport industry in another way. Most governments have chosen a single national airline as a means in the pursuit of these objectives. By granting this "chosen instrument" a complete or partial monopoly of the scheduled international air services provided by the airlines of that country, the authorities have been able to exercise through it powerful influence over developments in the air transport industry as a whole. The process of these policies has led to the present situation in which most countries have only one airline licensed to operate scheduled international services[x)], and where the right of entry to the international market is strictly controlled.

2.4 International regulation of operation and capacity

In addition to national authorities governments also work together bilaterally and multilaterally through bodies like the International Civil Aviation Organisation (ICAO) and the European Civil Aviation Conference (ECAC) to attain a similar degree of control internationally. The objectives and benefits of such international collaboration are, however, not very clearly defined:-

> "..... any consideration of the extent to which the consequences of the present system of regulation are harmful or beneficial must rest upon an agreed definition of the general public interest. No such agreement has yet been reached, but a great step forward would be made if, instead of disputing both the objectives and the consequences of their present aviation policies ..... governments were able to approach the tremendously difficult problem of reconciling their conflicting national interests for an area of common agreement on the economic effects of the present régime." (19)

Whether to the good or detriment of the industry there can be no doubt that international regulation forms a major environmental factor for all forms of air traffic. An outline of the major components of this regulation follows.

2.4.1. Traffic freedoms

Any airline operation requires the use of air space, the control of which is well recognised in international law:-

> "The contracting States recognise that every State has complete and exclusive sovereignty over the air space above its territory." (20)

Footnote:

x) This can be seen from the fact that in 1970 only 194 airlines were operating scheduled international services from the 120 countries that were then contracting members of ICAO. Of these approximately 40 were very minor operators with small route networks.

The use of this space by an aircraft foreign to the state must, therefore, be considered a privilege:-

> "No scheduled international air service may be operated over or into the territory of a contracting State, except with the special permission or other authorization of that State, and in accordance with the terms of such permission or authorization." (20)

These conditions are very restrictive by contrast to the degree of political control exercised over the operation of some other international transport media.

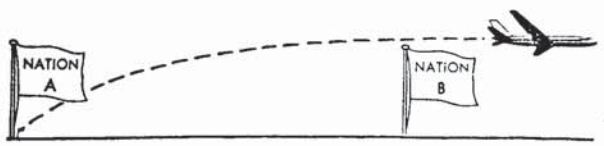
In the case of shipping, for example, while coastal operations are usually heavily protected, international traffic is generally open to vessels of any nationality. Exceptions to this rule are considered flag discrimination and in contravention of a number of international agreements containing resolutions specifically forbidding such action e.g. the Conventions for European Economic Cooperation of 1948 (21) . In practice such discrimination is of minor importance affecting only some 5% of traffic (22) .

The international transport services provided by road and rail are subject to closer regulation than ocean shipping and, with the current efforts of the EEC Transport Commission in Europe and the Interstate Commerce Commission in the United States to divert goods traffic from the former to the latter, this seems likely to become increasingly so. The extent of this control at present is narrow, however, compared to air transport regulation, and applies more to the nature of the vehicles employed than to traffic rights and capacity offered.

The fundamental elements of present international air transport regulation were determined at the 1944 Chicago Convention on International Civil Aviation. Initially 22 nations were party to the Convention, by 1971 there were 120 signatories. Regulation relates primarily to the privilege of operation across states foreign to the nationality of an aircraft and applies to all types of traffic carried. Detailed specification of these privileges or "freedoms" is to be found in the International Air Transport Agreement, briefly they are as follows:-

(a) <u>The first freedom</u>

This allows an airline operator to fly over foreign territory without landing.



(b) The second freedom:

This allows an airline operator to land in a foreign state for purely technical purposes (i.e. for non-traffic purposes).

(c) The third and fourth freedoms:

These freedoms allow an air carrier to operate for traffic purposes between his own and a foreign state. The third freedom is concerned with outgoing traffic and the fourth freedom with the right to carry traffic from the foreign to the home territory.

(d) The fifth freedom:

This introduces the rather more complex concept of traffic between states foreign to the operating airlines home state. These are generally accepted as supplementary freedoms in association with the third and fourth.

(e) The sixth freedom:

The right of an airline of country A to carry traffic from country B through a point in A to country C by combining the fourth and third traffic freedoms held with B anc C respectively. This freedom was not defined under the terms of the International Air Transport Agreement but, as is shown below, its growing importance has led to an informal recongnition over time.

It was the intention of the Agreement that these freedoms be adopted multilaterally, creating an open market similar to that in international shipping. The Convention did not achieve this aim. Due to the overriding competitive advantage of the American carriers in terms of equipment at that time only the non-commercial freedoms could be accepted multilaterally. To ensure "fair and equal opportunity" for all carriers and to protect the national interests they represent, a number of European nations insisted that all commercial freedoms be negotiated bilaterally. Such agreements were not to be binding for all time and have been frequently re-negotiated since.

2.4.2. Bermuda-type agreements

The usual objective of a bilateral agreement is an equitable exchange of opportunities for the capacity offered by the airlines of the countries concerned (23). Most agreements are of the Bermuda-type[x)] and specify the volume of direct inter-parties traffic as the criteria for the level of capacity to be provided and only thereafter permit capacity for fifth freedom traffic (20).

The extent of this supplementary capacity in relation to the primary is not, however, clearly stated in the Bermuda capacity clauses but must be periodically justified by "ex post facto review".

In practice, and particularly in areas where air transport is well developed, the granting of fifth freedom traffic rights is usually strictly limited and permitted only on a closely bargained and reciprocal basis. A noticeable effect of this restrictiveness is the distinctive "hub and spoke" pattern that it gives to the international route networks of most airlines in contrast to the more random disposition of domestic routings. Examples of this are shown in FIGS. 1 and 2 respectively.

The question of shape of network can be of particular economic significance to cargo operations because, unlike passenger movements, traffic is one-way. The economic viability of any flight depends greatly on round-trip load-factor. Most important all-cargo routes have a directional imbalance in traffic flow - see chaper 1 - and where traffic rights only permit operations out to a destination(s) and back over the same route, the capacity supplied in response to the largest traffic demand must also be offered in the other direction. If alternative destinations (or series of destinations) were permitted (i.e. by making routes triangular or polygonal) a traffic demand more appropriate to this level of capacity might be found and a better overall load-factor and economic result achieved.

Footnote:

x) In January 1946, after protracted negotiation, Great Britain and the United States concluded an air services agreement in Bermuda. This has since frequently been used as a model for other bilateral agreements.

Another indication of the general restrictiveness in granting the fifth freedom is the limited competition on many routes from carriers providing capacity under this traffic right. Table 1 shows that on a selection of the most important European routes fifth freedom capacity represented only about 17% of the total on average in 1970.

Whilst the sixth freedom is not normally dealt with explicitly in bilateral agreements, its extensive employment can constitute a serious "leak" to the otherwise closely controlled system of traffic rights. However, any airline concentrating too heavily (or too openly) on this type of traffic risks objection from others or their governments on the grounds that it is distorting the primary capacity criteria; but control is difficult. Without detailed information on the origin, destination and routing[x)] of all movements over a route sixth freedom traffic cannot be distinguished and may simply be substituted for genuine inter-parties traffic. Such practice becomes particularly attractive in situations where a fourth freedom sector is unprofitable in isolation e.g. short-haul all-cargo routes, but can be used to feed traffic to a more than compensatorily profitable on-going third freedom sector e.g. cargo on a long-haul passenger flight. Because of the difficulties in regulation it is, perhaps, not surprising to find that this is an area in which competition between carriers is hard.

The extent of such competition is limited in the passenger market by the "20% deviation rule". Sixth freedom traffic involves a deviation from the direct routing and thereby increases the transport distance. If this increase is greater than 20% then a proportionally higher fare must be charged. Such a constraint is not imposed on the routing of cargo shipments, the through rate being applicable over any route.

Until the early 1960's the impact of traffic right agreements on the provision of cargo capacity was almost entirely incidental to the conditions imposed on passenger traffic. Basically this was so for three reasons. First, capacity negotiations were naturally most concerned with the largest market sector. Although, as noted in chapter 1, cargo represents on average around 30% of all international air traffic, it generates only about 10% of airline revenues. Second, the aerodynamic shape of passenger aircraft automatically makes available varying amounts of space below the floor in excess of the requirements for carriage of baggage and mail. Since the majority of routes are operated by passenger aircraft, passenger and cargo

---

Footnote:

x) At present the CAB is planning to implement a compulsory statistical reporting system of origin, destination and participating carrier information on all cargo shipments entering or leaving the United States by air (24) . This will make public for the first time the extent to which various carriers depend on sixth freedom traffic to achieve an economic result on certain of their routes.

Table 1. The extent of fifth freedom capacity on main European routes

Rank	Route x	Weekly average number of flights in one direction	Number of flights performed under 5th freedom rights	Column 1 as a percentage of Column 2
Column		1	2	3
1.	LON-PAR	241	35	14%
2.	AMS-LON	157	17	11%
3.	CPH-STO	123	43	35%
4.	DUB-LON	111	0	0%
5.	CPH-OSL	96	19	20%
6.	MAD-ROM	64	11	17%
7.	BRU-LON	63	1	2%
8.	HEL-STO	62	14	23%
9.	(ATH-ROM	61	28	46%
	(FRA-PAR	61	13	21%
11.	ROM-ZRH	59	17	29%
12.	MAD-ZRH	54	6	11%
13.	MIL-PAR	51	2	4%
14.	AMS-FRA	50	5	10%
15.	AMS-BRU	49	21	43%
16.	PAR-ZRH	48	6	13%
17.	AMS-CPH	47	6	13%
18.	OSL-STO	46	11	24%
19.	(FRA-VIE	42	14	33%
	(FRA-ZRH	42	2	5%
21.	(CPH-LON	41	0	0%
	(MAD-PAR	41	11	27%
23.	BRU-PAR	38	4	11%
24.	(BRU-FRA	37	8	22%
	(VIE-ZRH	37	2	5%
	(LIS-MAD	35	7	20%
26.	(MAD-MIL	35	1	3%
	(MIL-ZRH	35	0	0%
29.	LON-MAD	34	6	18%
30.	CPH-FRA	32	5	16%
31.	MIL-VIE	22	14	64%
32.	LON-OSL	18	0	0%
33.	ATH-IST	16	11	69%
34.	ROM-VIE	10	0	0%
	Total	1958	340	17%

x = Origin/Destination placed in alphabetical order

AMS = Amsterdam
AHT = Athens
BRU = Brussels
CPH = Copenhagen
DUB = Dublin
FRA = Frankfurt
HEL = Helsinki
IST = Istanbul
LIS = Lisbon
LON = London
MAD = Madrid
MIL = Milan
OSL = Oslo
PAR = Paris
ROM = Rome
STO = Stockholm
VIE = Vienna
ZRH = Zurich

capacity are, therefore, joint products and cannot be considered in isolation. Third, where all-cargo services did exist they represented only a minor part of the total cargo service offered (less than 15%[x]) and were considered of so slight significance in most cases as not to warrant individual examination in traffic rights negotiation.

This generally liberal attitude to cargo is now changing. While in revenue terms cargo traffic still only represents around 10-12% of total, it is this contribution which, given present passenger fare levels, keeps the operation of many routes viable on a year-round basis. Awareness of this fact has increased interest in the granting of cargo traffic rights. The substantial amounts of belly-cargo capacity generated by the advent of wide-bodied aircraft[xx] and their capability to accept containerised and palletised loads, formerly transportable only on all-cargo aircraft, has also further stimulated this interest.

On routes like the North Atlantic where, because of freighter operations, large amounts of cargo capacity have existed for a long time the principle of separate consideration of cargo traffic is now well established. This has led to a number of intergovernmental disputes[xxx] and to the inclusion of cargo traffic in ex post facto reviews. These reviews have continued to be on a bilateral basis on the North Atlantic but a more open multilateral policy has now been adopted in Europe (25) .

2.5 Industry regulation of operation and capacity

Superimposed on this inter-governmental system of capacity regulation are the individual operating agreements concluded between airlines; the most common form of which is the "route pool".

Such pools are mostly between two carriers and reflect in practice the principles, explicit or implicit, of the bilateral agreement between

Footnotes:

x) Complete statistics on cargo capacity and traffic by passenger and freighter aircraft are not readily available or easily calculated with any accuracy. Cargo capacity on passenger flights, for example, not being calculated directly but instead taken as the residual of total capacity after theoretical allowance for other types of load. The above figure is an estimate based on ICAO traffic statistics.

xx) E.g. the cargo capacity of the passenger version of the Boeing 747 is roughly triple that of the passenger version of the 707 or put another way as much as that of an all-cargo 707.

xxx) The most controversial disputes were between the United States and Italy in 1963-65, and the United States and France in 1965-66. The involvement of the United States in both of these, and in other less publicised disputes, was primarily due again to the temporary equipment advantage enjoyed by the American carriers in being the first to possess all-cargo jet equipment.

their respective countries, regulating capacity, frequency of operation and traffic quotas on the routes covered[x]. The main purpose of these arrangements is to assure both pool partners of enough revenue to attain a satisfactory economic route result by limiting capacity. Such practice is expressly permitted by the terms of the Chicago Convention and is found in widespread use almost everywhere in the world except the United States where it is prohibited by anti-trust legislation.

There are two basic types of pool cooperation:-

(a) production pools in which the parties share the revenue earned from pooled operations in proportion to their share of capacity production; and

(b) cost/revenue pools in which the parties share both costs and revenue originating from pooled operations in proportions agreed in advance.

In practice production pools are the most common and most restrictive of the level of capacity and quality of service offered. The fact that no airline would permit too great an imbalance in the revenue shares received from a pooled route ensures that in most cases the level of capacity is principally determined by the carrier predisposed to the most conservative estimate of traffic demand. The level of quality of service is affected in a similar way. Where revenue is shared in proportion to the capacity provided, profitability will be determined solely by the level of cost at which that provision can be made. Costs can be reduced, and hence the gain from the pool increased, by lowering the quality of service offered to a level below that of the other partner but just above that at which it would be called into question e.g. by giving a flight a commercially unattractive schedule but one which nevertheless marginally improves the overall utilization of an aircraft. In such a duopolistic situation the process of action and reaction can only lead to a minimisation of the quality of service offered. This disadvantage is avoided in a cost/revenue pool.

The details of pool agreements are confidential and the extent to which they affect operations is difficult to estimate, the variation between carriers depending greatly on the areas covered by their route networks. In Europe, for example, almost all routes are subject to such agreements, whereas on the North Atlantic hardly any are.

Footnote:

x) "To a large extent pooling introduces Bermude-type capacity predetermination where the bilateral provides none, through a backdoor on a non-governmental level. Since, however, such interline pool agreements cannot be concluded without the blessing, or at least the acquiescence of the governments concerned, the difference between the two types of capacity predetermination become relatively insignificant." (20))

There can be little doubt, however, that pool agreements also affect competition on routes where no agreement exists. This is well illustrated on the North Atlantic where the extensive pool arrangements existing within Europe between European airlines enable and encourage them to exercise a strong control over the routing of traffic. If, for some reason, the North Atlantic services offered by one European carrier are not competitive against those of a North American carrier, there is still the possibility for that airline to obtain a bigger share of the route revenue by channeling traffic along one of the revenue pooled European routes to the "gateway" airport of another European carrier offering a more competitive service. In this way certain European carriers (e.g. KLM Dutch Airlines and Lufthansa) have been able to turn the benefit of a liberal bilateral agreement with the United States into a competitive advantage all over the Europe- North America market.

It has already been noted that the extent of such sixth freedom competition cannot easily be determined for lack of data. However, it appears to be growing:-

> "There is some evidence that the incidence of air service by foreign air carriers from points behind their home countries may continue to increase." (16)

As well as creating official concern and stimulating attempts by the authorities, particularly in the United States, at more stringent control, the scale of this traffic and the marketing efforts of some carriers in promoting it have also been the cause of disharmony between a number of pool partners themselves.

2.6 IATA and industry price regulation

IATA was founded in 1945 by the airlines of a number of countries to meet the problems created by the rapid expansion of air transport foreseen after World War II. Membership is automatically open to any operating company licensed to provide scheduled air services by a government eligible for membership in ICAO. The work of the Association deals with the non-political aspects of air transport operation and is organizationally administered by five permanent committees: Financial, Legal, Technical, Traffic Advisory, and Medical.

The jurisdiction of the Traffic Advisory Committee includes matters such as the analysis of operating costs, operating procedures, schedules, conditions of carriage, etc. The policy and authority of this committee stems from decisions made at the biennial Traffic Conferences.

The primary function of the Traffic Conference is price-setting. Conference decisions are taken only by unanimous vote, each member airline holding one vote regardless of size. Once adopted and approved such resolutions are considered binding contracts on all members. In the performance of its duties the Conference may accept advice and counsel from other parts of the Association but within its terms of reference is responsible only to the governments of the carriers represented.

Cargo rate decisions are generally considered more complex than those for passenger traffic because of the larger number of variables which should be considered e.g. packaging, perishability, size of shipment, value, shape, density, handling requirements, directional imbalance in traffic etc., and the varying significance each can have in different markets. The extent of this complexity and the general increase in importance of cargo traffic have been recognised by the establishment of a number of separate Commodity Rate Boards, These Boards have been delegated the authority to reach agreement on the introduction of lower rates for specific commodities moving between particular points. As noted in Chapter 5 the vast majority of cargo traffic now moves at such rates.

There are strong justifications for the regulation of pricing in international air transport. As described above, entry into the market is strictly controlled and the level of capacity provided restricted both by the governments and carriers concerned. If such a situation is not to be nationalistically or commercially exploited some form of multilateral control must be imposed on the price at which this capacity is offered. Although a large number of airlines are publicly owned and have other objectives than profit maximisation, a certain level of profitability is still an aim for most. The level and priority given to this aim, however, varies between carriers and without joint price control there could be no guarantee that its pursuit by one or more would not be at the expense of the others and of the public and national interests they represent.

Whilst the justifications for price control are evident, its practical application and the attainment of an economically optional and unanimously acceptable price compromise is made extremely difficult by the variation in operating conditions between different carriers. Most carriers seek to maximise the economic performance of their total operation and in so doing are often prepared to accept cross-subsidization between routes and between different types of traffic on the same route. Some carriers, for instance, operate no freighter aircraft and consider cargo marginal traffic only and to be priced accordingly. Other carriers operating freighters are prepared to subsidize their costs with revenue from cargo carried on passenger flights. Others again argue that all-cargo operations must be self-supporting and cargo rates set at a level to cover the average costs of such operations.

In addition, any pricing compromise must take into consideration the different scale and competitive structure of the markets in which carriers operate. The economic significance of a traffic flow between two points can vary greatly between operating carriers. Consequently, so too can their views on the rates to be applied. This is of particular importance where carriers have their operation centre at airports which enjoy a geographical advantage in being the natural "gateway" to a large hinterland e.g. Copenhagen to Scandinavia, Amsterdam to Northern Europe, Frankfurt to Central Europe, etc. and can consequently easily divert traffic from other points.

The situation is, therefore, one in which price regulation is generally accepted as necessary. Such regulation is, however, a matter of compromise and opinions vary as to the efficiency of the present IATA Conference machinery and the logicality of the rate structure it has produced. With respect to efficiency assessment is difficult since meetings are closed and all agreements reached without written record being kept of the factors considered or the emphasis given to them. Certain aspects of tariff rationale are examined in detail in chapter 5 but there seems to be little doubt that in general the level of rates would be higher if decisions were by majority vote (26). Under the present system an airline or minority group of airlines wishing to reduce fares is in a strong bargaining position since it always holds the threat of vetoing any other agreement. In the ensuing "open" situation all carriers would be free to apply whichever rate they chose. To stay competitive this would mean in practice that all were forced to adopt the low rate originally sought. The success of this tactic has been demonstrated many times on the North Atlantic. The question now is whether or not this process has been so successful that rate levels no longer cover costs. This discussion is also taken up in chapter 5.

2.7 Summary and conclusions

Air cargo is one of the products of the air transport industry and as such is subject to the various national, international and inter-company regulations that have been built up around it. These regulations apply, in general, to three major areas:-

(a) entry to the market and financial operating objectives;

(b) the right and scale of route operation; and

(c) pricing.

The regulation of (a) is normally the prerogative of single national governments and whilst there is variation between countries in the degree exercised, the necessity of some form of control is widely accepted. In most countries a part of this control is directed at the integration of non-financial objectives into the commercial aims of the national carrier.

The control of (b) involves by definition another state authority and its national airline and must, consequently, be conducted bilaterally at both intergovernmental and inter-compay levels.

Tariff regulation (c), by contrast, requires multilateral agreement since transport rates between any two points can have important indirect effects for the pricing and traffic on services to, from and between other points, some of which may be located in different states. The fact that cargo tariffs are unaffected by the length of the routing actually adopted gives this point particular significance and makes multilateral involvement essential. Because of its complexity and direct implications for the economic performance of carriers, price regulation is administered at an inter-company level but subject to the ultimate approval of individual governments.

The rapid growth in air cargo over the last decade has drawn more attention to cargo traffic rights and their capacity conditions than heretofore. Effective control is difficult, however, due to the existence of supplemental traffic rights. National interest arguments have made maximum revenue or market share rather than maximum profit the operating goal for most carriers and thereby given added incentive to the exploitation of these rights. The extent of such traffic cannot be accurately assessed with present data but there are indications that it will be more carefully monitored by national authorities in the future.

It is possible with such a development that the granting of cargo traffic rights may become more restrictive and perhaps more integrated with rate regulation. Whilst the IATA rate-setting machinery is multilateral and requires unanimity it, nevertheless, seems to work more in favour of those proposing to lower rates than the converse. Whether present rate levels cover a particular carrier's cargo costs will depend very much on the mix of passenger and all-cargo aircraft operated. This varies greatly between routes and carriers and is frequently the cause of conflict in determining the appropriate rate level. Carriers operating no all-cargo aircraft tend to consider cargo traffic as purely marginal and advocate to price accordingly; those operating freighters must consider a fuller cost allocation. In the future carriers in the latter category may well use traffic rights and capacity criteria to bargain against the low marginal rates proposed by carriers with passenger aircraft only. Such an attitude will make it more difficult to break away from the relatively inefficient "hub and spoke" network patterns.

Chapter 3

An examination of the advantages of air cargo to the user

3.1 Introduction

The purpose of this chapter is to identify those circumstances under which companies can benefit from air transport and which, therefore, influence their choice of transport mode. The discussion is based on information derived from interviews and contacts with Scandinavian companies using air cargo, as well as from the findings of previous research[x)].

While previous research has concentrated mainly on the advantages of the high quality of transport service provided by air, the results of this investigation indicate that the significance of such qualities is conditional to the existence of one or a number of certain conditions in the shipping or receiving company.

The advantages of air transport derive primarily from its speed. Speed reduces time in transit, time waiting for goods, and the size of safety stocks required during the time that replenishments are being shipped. Advantages are also derived from the superior conditions of carriage by air and the reduced costs and improved service this offers. Companies are able to use air cargo advantageously when its speed or conditions of carriage permit them to increase sales, reduce costs, or improve service resulting in a net improvement in profits.

While a multitude of factors affect the operating decisions of any company only a few such characteristics are of significance in the selection of a means of transport. These characteristics relate particularly to procurement and distribution and to certain production activities. Others may be important in determining a company's competitive position or financial success but are insignificant in the choice of transport.

3.2 Characteristics influencing the choice of transport mode

In general the characteristics influencing the choice of transport mode may be grouped under four main headings:

1. Characteristics of the commodities produced;
2. Characteristics of the market demand and supply;
3. Characteristics of procurement and distribution practices; and
4. Characteristics of company expansion which can affect transport and inventory parctices.

3.2.1. Characteristics of the commodities produced

Such characteristics fall into four main groups:

x) Footnote: Much of this chapter was prepared as part of a market research project undertaken by the author on behalf of and in conjunction with Scandinavian Airlines System in 1970-71.

(i) Length of useful life;
  (a) Physical perishability;
  (b) Style or technical obsolescence; and
  (c) Date or time period limitations.
(ii) Value relative to weight;
(iii) Variety of size or style within commodity; and
(iv) Storage or handling requirements.

(i) Length of useful life

The useful life of a commodity or product is that period of time during which it can be used for its original, intended purpose, or held or sold for such a purpose. The length of this period can influence the choice of transport employed. If usable life is relatively short then the time required for transport during the procurement or distribution process may occupy a considerable part of the period during which a product can be used or sold. If the commodity requires special care or protection to maintain its usefulness, which is either difficult to perform or adversely affected by the type of transport, the conditions of carriage may also affect its useful life.

a) Physical perishability: Useful life may be limited because a commodity is perishable; that is, it deteriorates physically so that its usefulness diminishes or disappears over a period of time. In some cases, the preservation of the usefulness of a perishable commodity may require special handling, such as feeding of livestock, moisture or temperature control, or protection against bruising, etc., Fragile items, whose physical deterioration over time is not a consideration, are subject to injury or damage while being transported which may destroy their usefulness. Commodities susceptible to spoilage or deterioration while being transported may have their usefulness curtailed by the mode of transport or may entail special expense during transport in order to avoid such developments. In such cases, the conditions of carriage and the time required for transport are generally important either in determining the time available for sale or use or the cost of preserving or extending the useful time period.

Some commodities which are not perishable under oridinary climatic conditions do deteriorate under the extremes of temperature or humidity sometimes experienced in international trade. In climates with extremes of heat, cold, dryness, or humidity, commodities may require humidity or temperature control or protection in storage which is not ordinarily required. These commodities, therefore, would be considered perishable under such conditions, and their useful lives chould be extended or the cost of protecting their usefulness reduced by using faster transport to reduce local stocks of such commodities.

With respect to perishable items whose deterioration is fairly rapid, the time required for transport may substantially affect the length of time that they can be offered for sale or use or the geographic distance over which they can be marketed. In either case, potential sales volume will be affected by the time required for transport.

b) Style or technological obsolescence: In some cases, the usefulness of a commodity may disappear without physical impairment. This happens with two groups of items: those affected by style and those affected by technological obsolescence. The usefulness of such commodities is dependent on consumer demand for either the commodity itself or for another commodity which includes its use in the production process. Commodities which are subject to technological obsolescence have their usefulness destroyed or diminished if demand is displaced by the development of another commodity which is believed to be better.

(c) Date or time period limitations: Some commodities must be used within a specific period of time; or they are only useful up to a specific date; or they are useful only if available by a specific date. In some cases, this may be due to legal or contractual obligations, to customer requirements which must be met to maintain a competitive sales position, or to the appearance of competitive products (like next week's magazine) which destroy demand for a commodity at or after a specific date. Transport time can be an essential factor in such instances, and such time may affect not only a portion of the useful life of the commodity but whether it is offered for sale or use at all.

(ii) Value per unit weight

The intrinsic value of a commodity is important whenever the question of investment is involved. Commodities in transport or in storage are not productive, and investment in them returns no value to the owner. If the commodities are relatively valuable, the investment cost during transport or time in storage represents an important part of the cost of sale or use.

Value per unit weight, however, does not appear to be as critical in determining the ability of a commodity to "absorb the costs of transportation" as once thought. More important it seems is whether the spread between cost at point of origin and the selling price at destination provides a sufficiently wide margin to cover what level of costs might be involved.

(iii) Variety of size or style within commodity

The problems of procurement and distribution are aggravated when the commodities which a company uses or sells are offered in a wide variety of shapes, sizes, colours, of other variations, or where a commodity group is composed of a large number of different types of the same product or product lines. Unless the demand for each particular size or style can be determined accurately, a large total inventory (and inventory storage and servicing facilities) needs to be maintained to serve the unpredictable demand.

If, in addition, the commodity has a high value, the investment problems are also aggravated. Even a medium priced item held in substantial variety exposes a company to greater investment and obsolescence risks and more complex service and marketing problems than a high priced item available in only one or a few styles. This investment in a varied commodity can be reduced by shortening the transport time.

Variety in style may also aggravate supply or distribution problems and contribute to the danger of shortage. A company which uses speed to reduce time in transit for procurement purposes can reduce safety stocks and re-order only those items for which there is a known demand. Sales are thus serviced and the danger of being left with an unsold inventory is lessened. Conversely, by using high-speed transport a company can reduce the stock of any one variety or style to a narrow minimum without risking an out-of-stock situation. A company is therefore able to carry a much wider range of styles or varieties, and thus increase its probable sales volume, with the same investment.

(iv) Storage or handling requirements

Some commodities require special servicing or protection in storage. Perishable commodities may require refrigeration or temperature control; valuable commodities require protection against theft; some commodities require special handling or servicing to preserve their value, etc. Such storage and handling services and facilities add to the cost and investment required to hold the commodity in inventory. A company which can use high-speed transport to reduce the volume of inventory will, of course, reduce the costs of maintaining the inventory as well. A reduction in the time required to transport goods would also permit some companies to achieve economies of scale by centralizing inventory and relying on rapid transport rather than local warehouses to meet local requirements.

3.2.2. Characteristics of the market demand and supply

The predictability and urgency of demand or supply appear to be critical factors in the choice of transport mode. Their effects may be classified as follows:

(i) Short-run predictability of demand or supply
  (a) Beginning or termination;
  (b) Geographic limitations and timing; and
  (c) Distribution of demand between size and style variations of product.
(ii) Seasonality of demand or supply;
(iii) Frequency of demand;
(iv) Urgency of demand or supply;
  (a) Sensitivity of sales volume to product availability;
  (b) Availability of premium-price markets;
  (c) Dependence of production volume on availability of parts or materials;
  (d) Mobility of production facilities; and
  (e) Investment turnover and transport time.
(v) Unexpected demand or supply shortage.

(i) Short-run predictability of demand or supply

Companies vary widely in their ability to predict customer requirements and their own needs for materials and supplies. These variations depend on demand and supply situations; on the markets in which a company buys and sells; on the commodities used or sold, or the use to which such commodities are put; and on the individual characteristics of a company. Short-run variations in demand, such as daily or weekly fluctuations, are particularly difficult to anticipate. Unpredictability as to the time of occurrence or location of the short-run requirement may necessitate stocking commodities in inventory. The size of such inventories will depend in part on the transport time required for replenishment. Whether unpredictability is due to style difference or to the inability of customers to estimate their requirements, the maintenance of inventories entails substantial risks, and a saving in transport time may affect the volume of sales or inventory requirement. In either case, the company is concerned with the time the goods spend in transit, since rapid transport permits production and supply to adjust more closely to demand.

(a) <u>Beginning or termination</u>: The beginning or termination of a demand or supply requirement, and hence its duration, may be difficult or impossible to predict with any degree of accuracy. Unpredictability of demand for products may result in a company or its customers not being able to accurately estimate the requirement for supplies and materials. Holding commodities locally in inventory makes it possible to respond quickly to demand or supply requirements; however, high-speed transport can be used to accomplish such response without excessive, and perhaps unneeded, supplies of stocks.

(b) <u>Geographic limitations and timing</u>: In some situations, the demand for a commodity may first appear at one location and later at others. The relative timing of the requirement at different locations may be difficult to estimate with any degree of accuracy. If a substantial amount of time is required to transport the commodity to the point of sale or use when these points become known, this may seriously limit the ability of the company to respond to demand requirements.

(c) <u>Distribution of demand between size and style variations of product</u>: Even where the total requirement for a commodity can be estimated, a company may not be able to determine the requirement for particular sizes or styles. This problem will, of course, be aggravated if the commodity is bought or produced in a substantial variety of sizes or styles. Again, fast transport makes it possible to respond quickly to consumer preference, once declared, without jeopardizing investment by establishing local inventories which may not be used.

(ii) <u>Seasonality of demand or supply</u>

Seasonality may be due to weather conditions; it may be traditional, occuring at a particular time each year, e.g. national holidays; or it may be created by business custom e.g. the annual introduction of new motor car models. In order to achieve the best adjustment of production to sales producers attempt to supply "in season". The time required to transport products to the point of sale or use may, therefore, affect the total volume which can be marketed, particularly as noted above at the beginning or near the end of a season.

Some items having a seasonal demand requirement can be held in stock for sale the following year, although this entails both storage and investment costs. Commodities subject to either physical or style perishability cannot ordinarily be carried over without at least some impairment in value. This is especially important in the light of the substantial element of style in all three types of seasonal demand and particularly so for commodities e.g. clothing, where for competitive reasons innovations must be timed for the opening of a new season.

(iii) Frequency of demand

For some products demand is occasional and infrequent but, nevertheless, urgent. The infrequency of the demand may make it difficult to maintain adequate stocks at the point of use to satisfy demand when it does arise. This will be particularly true if the commodity is of any significant value and if the geographic location or timing of the demand is uncertain.

Many companies have solved this problem by maintaining central inventories serving a wide geographic area from a single stock. Since the requirement for a product may be critical when it does arise, the time for transport from central inventory to the point of sale or use is important both to the user and to the supplier.

(iv) Urgency of demand or supply

In considering the urgency of demand or supply and the consequent importance of transport time, a company is concerned with the pressure to have a commodity at a given place at a given time to serve production or sales. The degree of this concern will differ substantially between companies and between individual situations affecting a given company, and will depend on the individual circumstances of the market or production situation. A particular company's willingness to use premium means of transport such as air cargo to move a commodity faster depends on whether it can realize sales or cost advantages which justify the added expense.

(a) Sensitivity of sales volume to product availability: In some instances requirements can be anticipated sufficiently to schedule the movement of goods to the point of sale or use so that they will be available when needed. In other situations, the need may be such that considerable transport time (or even the time required to produce the item) can be tolerated.

Sensitivity of sales volume to the availability of a product is most evident in a time-limited market, when the quantity which can be used or sold may be sensitive to the supply available for the duration of the demand. This is particularly true, for example, with fad items, for which demand is extremely strong but of short duration. If the period of demand is sufficiently uncertain the time required for transport may be extremely critical. If goods are not available during the duration of the demand, they may not be sold; and if the time in transport is so long that the demand has disappeared in the meantime, the goods not only cannot be sold, but the transport costs may also be wasted.

Similar situations arise with respect to high-value, high-style items where the local inventory is deliberately restricted to avoid risks of inventory losses. A company's ability to pursue such control policies without losing sales depends on the rapid response to demand made possible by fast transport. Due to their novelty there is frequently a high demand for new models or products during the early period of their introduction. Until the demand is established, however, there is no certainty as to whether the new products will gain acceptance and, if so, what the scale and location of demand will be. Fast transport permits a better coordination of supply to demand during this introduction period.

(b) Availability of premium-price markets: As noted above the demand for some commodities is so strong that, if scarcities arise, premium prices are offered. While such situations may occur as the result of catastrophies or other emergencies, they frequently arise in the normal course of production and marketing. If an item suddenly becomes popular, demand may far exceed expectations or supply provisioning, thus creating a temporary premium-price situation. A supplier's ability to profit from a premium-price situation depends on his putting commodities on the market before the scarcity which created the situation is cured and the premium price disappears. This frequently depends on transport time. Where production time must also be considered, transport time takes on added importance.

(c) Dependence of production volume on availability of parts or materials: The production volume of a company, or that of its customers, is dependent to a considerable extent on the availability of supplies of materials and parts. Where production requirements are uncertain or impredictable, or where limitations exist on the supplies of needed parts or materials, it may be difficult to have commodities available when and where they are needed. Where the commodities can be held in inventory, this may make it possible to smooth out production. However, if the requirement for production is particularly difficult to predict, or if the limitations on supply, investment requirements, or other considerations make the maintenance of adequate inventories expensive, then the utilization of productive facilities may be decreased while waiting for parts or materials to be made available. In such cases, any reduction in the time required for transport will increase company productivity.

(d) Mobility of production facilities: Companies which perform production functions at more than one location often find it necessary to duplicate at least part of their investment equipment and facilities at different production points. Some companies have found it possible to reduce their total investment requirements by the use of mobile facilities or equipment. Where scheduling the use of these facilities at various locations requires unproductive transport time between points of use, the total investment in production facilities may be reduced if a form of transport is used which minimizes the unproductive transit time and the time thus saved can be used productively.

(e) Investment turnover and transport time: The cost of investment in commodities being transported is determined by the length of time it takes and by the value of the commodities themselves. If there is also a risk of loss in value, due to the demand diminishing before they can be brought to the point of sale or use, reduction in transport time will limit this risk. Stocks of commodities are also affected by the time required to transport them; the level of safety stocks and the quantitiy ordered at any time being dependent on the transport time required.

Investment costs are a factor of both time and value. While commodities are being transported to points of sale or use, they produce nothing for shipper or consignee and the investment in them yields no return. The unproductive time in transport is increased if production or distribution facilities are substantially remote from market or supply sources. When commodities are used soon after being received, reducing unproductive transport time will speed up the flow of commodities through the production or distribution system, thus increasing the rate of investment turnover which is most important where commodities are valuable or the company is limited in its supply of capital.

(v) Unexpected demand or supply shortages

In the course of most business activities, unexpected or emergency requirements occur which are characterized by their irregularity, infrequency, and nonpredictability. Such requirements constitute true emergencies and, in these circumstances, the deficiency causing a demand or supply shortage must be eliminated as rapidly as possible. The type of transport which will relieve these shortages in the quickest possible time will generally be the most rewarding. These situations must be distinguished from market and supply situations containing elements of unpredictability (which may characterize them as urgent) but which are not true emergencies since they are the product of normal business activity and can be expected i.e. planned emergencies, even if not predicted accurately. Also, it should be recognized that a situation may be an emergency from the standpoint of a user but not from the standpoint of a supplier, and that some emergencies result from the fact that providing for all contingencies is economically unwarranted.

3.2.3. Characteristics of procurement and distribution practices

The most important characteristics relate naturally to the transport and inventory practices of a company. These may be grouped as follows:

(i) Transport practices;
- (a) Control over selection of transport mode;
- (b) Transit times;
- (c) Transport schedules and connections;
- (d) Geographic dispersal and connections;
- (e) Incidence of loss, damage or deterioration;
- (f) Cost of protecting goods in transit;
- (g) Control of goods in transit;
- (h) Gross weight as basis for assessment of import duties; and
- (j) Shipment sizes relative to tariff weight breakpoints.

(ii) Inventory practices;
- (a) Purpose and function of holding inventory;
- (b) Location of inventory;
- (c) Effect of inventory practices on facilities required; and
- (d) Dependence on wholesalers to perform inventory function.

(i) Transport practices

(a) Control over selection of transport mode: Reductions in the time commodities spend in transit and improvements in the conditions of carriage are not always of equal benefit to shippers and consignees. To have any real effect on the selection of transport mode such factors must affect directly or indirectly the company which is in the position to make this choice. Frequently, however, a company which does not directly control the choice of transport may be in a position to influence it. Even when buying goods prepaid, for example, a consignee can usually affect the choice since he ultimately pays the transport cost either directly or indirectly. Any company, whether shipper or consignee, willing to absorb a difference in transport charges, or willing to share the cost can also normally determine the mode to be employed.

(b) Transit time: Where a company is concerned with the time commodities spend in transit, it is concerned with the total elapsed time from shipper to consignee i.e. including time for packaging, loading, unloading, and transfer in transit, and surface transport to the port of departure. What constitutes a significant reduction in transit time will depend on the individual circumstances of the company situation involved. Sometimes a few hours are important and, in some situations, air can achieve such time reductions. Ordinarily, where a shipment involves any substantial time or distance, air transport will substantially reduce the total time involved.

(c) Transport schedules and connections: The availability of schedules offering adequate capacity at desirable departure and arrival times at desired points of origin or destination, and the availability of direct service as opposed to connecting service, affect the time advantage of one form of transport as opposed to another and, therefore, the choice of transport means.

(d) Geographic dispersal of production and distribution facilities: Companies with production or distribution facilities at a number of locations are often more concerned with transport time than those with such facilities at only one location. This is particularly true if any of these locations are remote from either supply sources or markets. Such a company will be concerned with transport time if it moves commodities between these points and, since it is both shipper and consignee, is in a good position to judge the advantage of reducing transit time and to control the choice of transport means.

(e) Incidence of loss, damage or deterioration: All means of transport involve certain risks to the commodities being moved, but some commodities are more sensitive to such hazards. Also, some forms of transport expose commodities to greater risks than others. Where one mode of transport is characterized by a high incidence of such risks an alternative offering a higher quality of carriage such as air cargo may permit their reduction or elimination.

(f) Costs of protecting goods in transit: Companies seeking to avoid the losses which result from the risks discussed above may attempt to safeguard their shipments by special forms of packing. For transport of lower quality of carriage than that offered by air such packaging must be more adequate and consequently more expensive.

Perishable commodities subject to spillage and some commodities such as drugs and biologicals may require temperature or moisture control in transport. Air transport can reduce the need for and cost of such control by reducing the time during which it is required. Similarly, shipments requiring special service or handling in transit, such as feeding, may not need such service, or need it for a shorter time, if transport time is sufficiently reduced.

Companies frequently also protect themselves against the cost of loss or damage in transit by insurance, the costs of which are passed on directly or indirectly to the shippers or consignees. Forms of transport which subject commodities to less risk permit lower insurance cost by reducing the time over which it must be provided.

(g) Control of goods in transit: Expedition and coordination of commodity movements present problems in control of shipments and entail subsidiary costs for documentation. Companies shipping internationally where both land and sea movements are involved require the integration of different forms of transport; alternate more direct forms of transport such as air cargo may permit simpler management, tracing of shipments, and documentation.

(h) Gross weight as the basis for import duty assessment: In some cases duties are assessed on a gross-weight basis. In international movements where air cargo services permit a reduction in the packaging requirement, this may also reduce the gross weight and hence the duty for which the shipment is liable.

(j) Shipment size relative to tariff weight breakpoints: Most transport rate structures provide lower rates for larger shipments.

The point at which the rate changes is called the weight breakpoint. These breaks occur at different points for different forms of transport. Because of the typically smaller capacity of all-cargo aircraft, rate breaks or quantity discounts are available for smaller quantities in air transport than in regular rail, sea or truck rate schedules. A company whose shipments are too small to take advantage of surface rate breaks may still be able to ship in lots large enough to take advantage of the air tariff. In some instances this permits commodities to be transported cheaper by air than by surface and, in other cases, narrows the rate differential.

(ii) <u>Inventory practices</u>

Companies find it necessary to establish inventories to service production or sales when requirements are difficult to predict on a day-to-day basis and the users cannot wait for commodities to be transported. Where commodities can be made available at the time and place needed by use of air transport such inventory can be reduced or eliminated.

The dependence of inventory levels on transport and the ability of a company to reduce or eliminate inventory by reducing transport time, with corresponding savings in total procurement or distribution costs, have been explored extensively in previous research (5) (9). There are various costs associated with the inventory function, and companies seek to reduce or alter their inventory practices to reduce or eliminate these costs.

Any function which ties up investment in goods and storage facilities incurs costs. Where there is any substantial element of uncertainty in the timing or duration of demand this will affect the ultimate sale or usable life of goods held in inventory, and entail risks which may result in costs. The costs involved in holding goods in inventory include:

<u>Investment in goods held in inventory</u>. Cost of inventory in stocks is the major cost of holding goods in inventory and is determined by the value, volume and variety of commodities which must be maintained to service a given demand as well as the opportunity cost of such investment.

<u>Investment in storage facilities or the cost of renting such</u>. The ownership costs of storage facilities will be affected by the size of the investment they represent and its opportunity cost. Also, costs recognised in normal accounting, such as depreciation, maintenance, licenses, insurance, taxes, and so forth, must be considered. If a facility is rented, the rental charge rather than the facility

investment needs to be considered.

Cost of servicing and protecting inventory. Some types of goods in storage require special protection or servicing, such as protection against theft (if extremely valuable), refrigeration or humidity control (if subject to spoilage), and, in some cases, periodic servicing or similar handling (as for batteries or living things).

Losses due to obsolescence if inventory diminishes in sales value. If a commodity is subject to physical perishability or deterioration, changes in style, or technological obsolescence which displace it with a more effective substitute, holding inventory entails some degree of risk in that stocks may become unsaleable or may have to be sold at a loss.

Costs resulting from inadequate inventory provision. Some companies try to reduce investment cost in inventory or the risk of investment loss due to obsolescence by holding the level of inventory down. If this results in loss of sales or interruptions of production because of being out of stock, such practice entails a definite cost which is the result of this inventory policy and attributable to it. Similarly, if extraordinary expenses are entailed in ordering in uneconomical lots or at uneconomical times, or through the use of premium transport in order to avoid an out-of-stock situation, these costs are also attributable to this inventory policy.

The ability of a company to reduce or avoid any of these costs by using faster transport is dependent on its ability to reduce the investment in inventory and storage facilities by reducing transit time. This, in turn, depends on the purposes of inventory.

(a) Purposes and functions of inventory holding: Inventory in maintained for a variety of purposes, some of which are not related to or dependent on transport time. Companies produce for inventory, when demand cannot be accurately anticipated, if holding the commodities permits production in lot sizes that are economical and smooths the production flow. Other companies hold stocks of commodities in order to buy in economical lots or in anticipation of price increases. In the latter case, companies may seek either to avoid the consequences of price increases or to speculate on such increases. Companies may also accumulate inventories to take advantage of quantity rate breaks in transport or, as the result of buying in excess of immediate needs, in order to ship in economical lot sizes. Reductions in transport time will not necessarily permit reductions in inventory held for these reasons.

Inventories of commodities which are maintained for the purpose of having goods where and when they are needed, however, are related to transport time. Because of these local stocks, the production or sales function need not wait on the transport of a commodity, and the size of the safety stock required while goods are being reordered and transported is controlled by the length of the reorder cycle, including the transport time involved. Where the function of having commodities available when and where needed can be performed by using air transport, reduction in transit time will permit a reduction in inventory.

(b) Location of inventory: The location of inventory is determined, in part, by the transport time required to move commodities to point of use or sale and, in part, by the nature of the procurement or distribution requirements and practices of the company involved. A company may maintain an inventory of supply items at the point of use as well as central inventories of products at the factory. Some companies maintain only central or regional warehouses to supply their territories, while others maintain local warehouses as well.

The location of inventory and the purpose served by maintaining it at each particular type of location have a very important bearing on the importance of transport time and its ability to reduce costs of carrying inventory. If the same total inventory investment is going to be maintained, a reduction in transport time will not permit a reduction in inventory investment. Changes in inventory and transport practice, however, will sometimes permit comparable service of the market or production requirement with a smaller centralized total inventory, and often will permit a reduction in total warehouse or service costs.

(c) Effect of inventory practices on facilities required: Where inventory practice includes the use of air transport to make commodities available where and when needed, such use may also make it possible to reduce or completely eliminate inventory facilities at particular locations. A company's ability to eliminate an inventory facility by using high-speed transport for a particular commodity will depend on factors such as whether the facility must be maintained for inventory of other commodities, and, if this is the case, whether the space released by the elimination of or reduction in inventory of one commodity can be used for other purposes, thus reducing total warehousing costs. If the inventory space is not owned, reducing the facility's cost by releasing the rented space may be more possible than if the space is owned.

In cases where substantial costs are involved in servicing or protecting inventory, the reduction in inventory levels for commodities requiring such service may permit a reduction in such costs even if the cost of facilities themselves cannot be reduced.

For some companies it has been possible to eliminate warehousing and servicing expenses at particular locations with a consequent reduction in total warehousing and servicing expense by centralizing inventory on a regional or a national basis. Even if no reduction in total inventory occurs, savings can be achieved in this manner. Any of these reductions in inventory facilities or service costs will influence the choice of transport means when they can be achieved by using a faster means of transport to give comparable service.

(d) Dependence on wholesalers to perform inventory function: Some companies depend in whole or in part on wholesalers to perform inventory functions. In some cases, the commissions charged for such services are high. In other cases the terms of the agreement between a company and its distributors may make a company directly or indirectly responsible for the inventory; the company is then subject to potential loss in sales or investment return just as much as if it owned the inventory. Where the organization of a company and its procurement and distribution processes permit it to perform the inventory function without a direct increase in total cost, it may wish to by-pass wholesalers for such reasons.

3.2.4. Characteristics of company expansion which can affect transport and inventory practices

A company's procurement, production, and distribution systems do not remain static. If production, marketing, or procurement activities change, these changes may affect the characteristics of the company and create new conditions which, in turn, may affect the choice of transport. It is necessary, therefore, to consider these implications of expansion:

(i) The relationship of transport to the development of expansion opportunities;

(a) Effect of transport on availability of markets;

(b) Effect of transport on supply sources; and

(c) Effect of transport on the ability to utilize new distant production locations.

(ii) The relationship of sales or supply requirements at existing or new locations to the development of expansion opportunities;

(a) Expansion which could require increases in inventory; and

(b) Expansion which could require the establishment of inventories at new locations.

(i) The relationship of transport to the development of expansion opportunities

The time required to transport commodities affects any expansion opportunity involving more transport than that currently used.

(a) Effect of transport on availability of markets: The marketing of some commodities is extremely competitive and demands prompt service. The time required for surface transport may limit a manufacturer's ability to penetrate a particular distant market or make penetration possible only by establishing a local inventory. If this is not possible due to the expense or risk involved the market will continue to be limited or unavailable to the producer from present location unless a faster means of transport is used. The use of high-speed transport to eliminate local inventories will also permit a company to test market without commitment of inventory as well as to routinely service the market with little or no local inventory.

(b) Effect of transport on supply sources: The utilization of a company's productive facilities or the total amount of a product which it can produce and sell may sometimes be limited by the availability of local supplies and the time required to reach other supply areas by surface transport. In some cases, supplies from distant sources may be cheaper because of lower labour costs or more ready access to raw materials, or they may be superior. If transport time is considerable, however, the length of time that commodities are tied up in transit may necessitate investment costs sufficient to offset the advantage of the cheaper or superior material. Reduction in the transport time may make it possible to use such sources economically.

(c) Effect of transport on the ability to utilize new but distant production locations: Some companies find it desirable to change the location of all or part of their facilities to secure more ready access to either a supplier or to markets or to cheaper labour. If such locations are substantially distant from supply or market sources, the use of surface transport, particularly sea transport, may entail a length of time that can weaken the company's competitive position and make the use of such locations uneconomical. If the time commodities are in transit is kept to competitive proportions by the use of high-speed transport, such location changes can be economically possible.

(ii) The relationship of sales or supply requirements at existing or new locations to the development of expansion opportunities

Companies contemplating expansion, either in existing areas or in areas not presently served, or contemplating the introduction of new products must consider the effect of such growth on inventory. In some situations, the investment requirement for the expansion of inventories or the creation of new inventory locations may limit the timing or scope of the expansion or, perhaps, prevent it altogether. In establishing new market areas or introducing new products, the company faces the added risk that its products or service may not be accepted, thus making any inventory investment difficult and costly to liquidate. The costs of procurement or distribution through wholesalers, or other intermediaries, may also prohibit expansion.

(a) Expansion which could require increases in inventory: For a company considering an expansion which will result in increased inventory requirements the main concern is often with alternatives which would make this increase unnecessary. Companies who support their production or sales efforts with supply or market inventories frequently find that the expansion of sales will result in a requirement for the expansion of inventories of products, and sometimes of supplies as well. If such growth is substantial, it may exceed the available capacity of warehouse facilities and require the establishment of new facilities. Where the inventory requires any form of service or protection, additional expenses will also be involved. All of these requirements increase the investment necessary to support the expansion and increase the level of profits which will be required to justify the expansion activity. If the expanded production or sales effort can be served without increasing inventory, or with a smaller increase in inventory by using high-speed transport, the investment requirement for expansion and, consequently, the profit opportunity necessary to justify it will be less.

(b) Expansion which could require the establishment of inventories at new locations: Where a company has an opportunity to expand its markets by penetrating new areas, it may find it necessary to establish inventory facilities at the new locations. This will require an investment in the inventory and in the facilities. In addition to the normal risks of inventory investment, including the risk of inventory obsolescence, the special risk of nonacceptance in a new territory must be considered. If the transport time involved for the new location is substantial, the inventory requirement may also be substantial. All these factors add to the investment required to finance expansion and tend to limit the expansion opportunities. If using faster transport makes it unnecessary to establish substantial inventories, expansion opportunities will be enhanced and the risks reduced.

3.3 Summary and Conclusion

The above discussion attempts to show that the decision to employ one or another transport mode is determined not only by the relative qualities and costs of the modes in question but also by a wide range of company characteristics. This complexity makes it difficult to generally evaluate the influence of any single factor since this will vary over time and from company situation to situation. It is, perhaps, such quantification problems which explain why despite the time and effort spent by a large number of air carriers, the "total distribution cost concept" has not been as extensively adopted by companies as at first appeared likely.

Another important reason for this lack of success is that to implement the findings of a distribution cost analysis would in many cases require revolutionary changes in a company's organization and operating structure as well as its channels of procurement and distribution. Such changes will generate opposition not only from those directly concerned with the procurement and distribution functions but also on a much broader front since they will conflict with established job and organizational relationships.

Because of such resistance changes in transport means or in company procurement or distribution practices have frequently been found to be more matters of principle than of calculation. In a number of cases such changes had been long considered but were only instigated in the course of far broader company reorganizations. The overriding influence of these exogenous factors makes it seem very unlikely that relatively minor changes in rate levels between transport modes can be of much significance in determining the volumes of traffic they carry.

Chapter 4

An economic analysis of the demand for air cargo

4.1 Introduction

At present relatively little is known of the demand characteristics of air cargo, or for that matter about the demand for goods transportation in genereal (27) . The price sensitivity of traffic volumes is fundamental to such an understanding. The intention of this and the next two chapters is to examine some of these characteristics and in particular to try to estimate the price and income elasticities of the demand for air cargo. Some such estimates already exist, but it will be argued most are unrealistically high.

For the airlines a clear understanding of demand characteristics and especially price elasticity, is a prerequisite of any attempt to optimise their role in the overall spectrum of goods transport.

Government bodies, too, need more knowledge in this respect. If, for instance, demand is found to be inelastic it will tend to stabilise rates at a relatively high level and encourage collusion between carriers to raise them higher. In such a case the need for public supervision and control will be greater than if demand were elastic. Under this condition, where competitive rate-setting is more likely, the regulatory problem is simpler. In the short-run its main objective will be to prevent rate cutting to below marginal cost levels, and in the long-run to ensuring that revenues are sufficient to cover average costs.

4.2 The need for a methodology

Up to the present time relatively little has been done to develop an adequate methodology for analysing the demand for air cargo. This particularly striking compared to the abundance of material on passenger traffic. As was pointed out at the M.I.T. Transportation Workshop:-

"The technique used to project cargo appear to be

> much more primitive than those used for passenger traffic. Perhaps the main reason for their crudity is that until recently there has been no clearly stated and empirically tested theory of demand for alternative modes of transport." (28)

This deficiency has also been unintentionally highlighted elsewhere. A recent ICAO publication on air traffic forecasting (29)) for example, found only one model of air cargo traffic (30) compared to eight relating to passenger traffic.

Some interesting attempts have been made recently to approach the estimation of demand curves for goods transport from the viewpoint of microeconomic theory. Such procedures have been received with considerable scepticism within the industry, where it appears not unusual to feel that questions of demand characteristics can be best analysed in terms of existing data only, without reference to theory. This kind of "measurement versus theory" argument is classical and likely to recur in any applied research.

A well known contribution to this debate is Koopman's article "Measurement without theory" (31) . Although referring to the particular case of business cycles, his comments are also of general relevance:-

> "Fuller utilisation of the concepts and hypotheses of economic theory....as a part of the processes of observation and measurement promises to be a shorter road, perhaps even the only possible road, to (the) understanding (of business cycles)."

There are two important counter-arguments here to the pragmatist claims that microeconomic analysis is to "theoretical" and fails to recognise the limitations imposed by data availability. First, even if one starts out simply to observe and describe, the mere collection of data will perforce be related to some theoretical preconceptions. Measurement without theory is hardly possible, although the theoretical content need not be explicit. Second, without a reliance on theory it will be difficult, perhaps even impossible to relate findings to policy-making in any consistent manner.

Economic theory attempts to explain as well as predict. The reasons for going beyond naïve , non-explanatory statistical forecasting techniques such as exponential smoothing, etc., to models which have an economic behavioural content, as is done in chapter 6 , lies in the assumption that only to the extent that it is possible to identify the determinants of an economic phenomenon can it be possible to reach conclusions relevant to the policy decisions affecting that phenomenon.

There is a wide range of models that have been or could have been applied in analysing goods transport demand. Most have been adopted on a one-time basis only due to the diversity and frequent incompleteness of statistical information, something which makes the use of any generalised model difficult (32). When faced with a particular problem the normal industry practice seems to have been first to study what data is available and then to apply whatever approach this makes practicable. Such a "forced" choice will also eventually have to be made in this study but it is of interest to consider what others might be adopted if unconstrained by data availability.

4.3 The derived demand for transport

Cargo services have no utility independent of the goods transported. In this sense they are analogous to factors of production such as labour and capital, and a typical neoclassical analysis would therefore treat their demand as being derived from the goods which they help to produce. Marshall has shown (33) that the elasticity of demand for such inputs is determined by:-

(a) the elasticity of substitution with other inputs used in the production process,
(b) the elasticity of demand for the final product,
(c) the fraction of total costs accounted for by the input in question, and
(d) the elasticity of supply of the other inputs used in the production process, and through this the elasticity of supply of the final product.

The elasticity of input demand will vary in the same direction as these four factors: e.g. the smaller the elasticity of demand for the final product and the smaller the transport charges relative to the final price of the goods shipped, the smaller will be the elasticity of demand for transportation.

Whether transport is considered an essential input will depend on market conditions for the final product. If the local market is able to absorb the entire production at a price sufficient to cover all costs, then the demand for transport is likely to be considerably more elastic then when "exports" are necessary due to saturation of the local market. Usually transport is not a substitute for other factors of production, although it could be considered to be so if relocation of plant is a possibility.

Demand for a particular mode of transport will depend on the possibility of substituting other modes for it. Air cargo, for example, is a substitute in many situations for rail or truck transport. As discussed in chapter 3, under certain circumstances the nature of the goods being shipped is such that no realistic substitute exists. This applies to many highly perishable products e.g. fresh-cut flowers, newspapers, fashionwear, etc. In these cases, ceteris paribus, the demand for air transport would be expected to be less elastic than when alternative modes are more readily acceptable.

An expression for the elasticity of transport demand that incorporates the last three of Marshall's four points has been derived by Bennathan and Waters (34). Let demand for goods shipped be:

$$P_d = P_d(X) \qquad /1/$$

where P_d is the demand price expressed in C.I.F. (cost, insurance and freight) terms and X the quantity shipped. Similarly, let the supply function be:

$$P_s = P_s(X) \qquad /2/$$

where P_s is expressed in F.O.B. (free on board) terms. For equilibrium then:

$$P_d(X) = P_s(X) + T \qquad /3/$$

where T is the transport charge. Differentiating /3/ with respect to T gives:

$$\frac{dP_d(X)}{dX} \cdot \frac{dX}{dT} = \frac{dP_s(X)}{dX} \cdot \frac{dX}{dT} + 1 \qquad /4/$$

which can be rewritten as:

$$\frac{dP_d(X)}{dX} \cdot \frac{dX}{dT} - \frac{dP_s(X)}{dX} \cdot \frac{dX}{dT} = 1 \qquad /5/$$

or:

$$\frac{dX}{dT} = \left[\frac{dP_d(X)}{dX} - \frac{dP_s(X)}{dX}\right]^{-1} \qquad /6/$$

Let E_{trans} denote the elasticity of transportation. Then:

$$E_{trans} = \frac{dX}{dT} \cdot \frac{T}{X} = \frac{T}{X} \cdot \frac{P_d}{P_d} \cdot \left[\frac{dP_d(X)}{dX} - \frac{dP_s(X)}{dX}\right]^{-1} \qquad /7/$$

But since $P_d = P_s + T$

$$E_{trans} = \frac{T}{P_d}\left[\frac{X}{P_d} \cdot \frac{dP_d(X)}{dX} - \frac{X}{(P_s + T)} \cdot \frac{dP_s(X)}{dX}\right]^{-1} \qquad /8/$$

or

$$E_{trans} = \frac{T}{P_d}\left[\frac{X}{P_d} \cdot \frac{dP_d}{dX} - \frac{X}{P_s\left[1 + \frac{T}{P_s}\right]} \cdot \frac{dP_s}{dX}\right]^{-1} \qquad /9/$$

$$= \frac{T}{P_d}\left[\frac{1}{E_d} - \frac{1}{\left[1 + \frac{T}{P_s}\right]} \cdot \frac{1}{E_s}\right]^{-1} \qquad /10/$$

where E_d is the demand elasticity for the goods shipped and E_s the elasticity of supply for the same goods.

But:

$$1 + \frac{T}{P_s} = 1 + T(P_d - T)^{-1} = \frac{(P_d - T) + T}{(P_d - T)} = \frac{P_d}{(P_d - T)} \qquad /11/$$

Therefore:

$$\left[1 + \frac{T}{P_s}\right]^{-1} = -(1 - f) \text{ where } f = \frac{T}{P_d} \qquad /12/$$

E_{trans} can now be written as:

$$E_{trans} = f\left[\frac{1}{E_d} - (1 - f)\frac{1}{E_s}\right]^{-1} \qquad /13/$$

$$= f\left[\frac{E_s \cdot E_d}{E_s - (1 - f)E_d}\right] \qquad /14/$$

where $f = \frac{T}{P}$, i.e. the fraction of the final price which is spent on transpordation, and where E_s and E_d are supply and demand elasticities for the goods shipped. E_{trans} is the rate elasticity of goods transport. If the limit of /14/ above is taken as the supply elasticity approaches infinity it gives:

$$E_{trans} = f \cdot E_d \qquad /15/$$

By comparing /14/ and /15/ it can be seen that whenever $E_d < 0$ $E_s > 0$, the normal conditions in a competitive market, and E_s is finite, E_{trans} will be smaller than when $E_s = \infty$.

$$= \frac{E_s \cdot E_d}{E_s E_d - (1 - f) E_d^2} \quad 1 \qquad /16/ = \frac{/14/}{/15/}$$

Therefore, if /15/ is used to estimate E_{trans}, the estimates will be exaggerated when the supply elasticity is less than infinite. It should be noted that the elasticity of demand for transport will be negative whenever $E_s > 0$ and $E_d < 0$.

4.4 The demand for air cargo as a derived demand

Summarising the above, demand has been shown to be determined by:

(a) the demand for the goods shipped,

(b) the supply of the goods shipped,

(c) the ratio of transport charges to final price of the goods,

and (d) the degree of substitution possible between transport modes,

and is expected to be negative under normal competitive market conditions. These results assume a constant state of technology between the different modes of transport, stability in demand, supply and income functions and no expectations or uncertainty.

Assuming that the elasticity of demand for the goods shipped and the proportion of their final price represented by transport charges are known, then the relationships established in /14/ and /15/ provide a method for estimating the price elasticity of air cargo. As less numerical information is available on the elasticity of supply than of demand, /15/ or $E_{trans} = fE_d$ will be used, where f is the ratio of the transport charge over final price. It should be noted that as stated above, this procedure will give a higher estimate of E_{trans} in absolute terms than the true value.

As an example, a rough estimate of f can be derived for North Atlantic traffic. The average value of U.S. imports by air from Europe in 1971 was approximately $12,200 per tonne (35). This figure refers to the market value in the exporting country and, therefore, is in most cases less than the final price. For the same year the average rate per tonne-kilometer for Pan American Airways on that route was 12.31 U.S. cents, a figure closely resembling the industry average (-- see Appendix III). The average North Atlantic flight distance is about 5,500 kilometers, giving an average cargo charge per tonne of about $680. Adding this to the value for imports raises it to $12,880. This is probably less than the final market price in the United States since customs duties, insurance, profits, etc., have not been taken into account. The resulting ratio of transport charges to price is 0.053. This is suprisingly low at first sight, but is clearly due to the extremely high value of goods shipped by air. Case studies by ICAO (2)) yield ratios ranging from 0.128 to 0.054.

As rates on the North Atlantic tend to be lower than on most other routes, a conservative estimate of this ratio generally would be nearer o.1,even though this may be a slight exaggeration in the case of especially high value trade flows e.g. South Africa to Europe. It is interesting to note on this point that Kindleberger (36) has estimated,in a quite different respect,that as a rule-of-thumb the difference between export F.O.B. and import C.I.F. prices can be taken to be about 10 per cent for intercontinental trade.

If the ratio of air transport charges to final product price is around 0.1, it follows from / 15/ that the demand elasticity of of the goods shipped would have to be at least -10 for air transport demand to have unit elasticity. If the product price elasticity is less then the demand for air transport can be expected to be inelastic. This, however, ignores the possibility of substitution with other modes. To consider the effects of this possibility it is first necessary to establish what relationship there is between transport price and transport quality on the one hand, and the level of goods production cost and market price on the other. In many cases a decrease in the former will result in an increase of the latter, the influence on the level of demand for an individual transport mode being determined by the ratio between these changes.

Demand elasticities have been estimated for a number of commodity groups, particularly with reference to imports. Early estimates of price elasticity in international trade frequently found demand to be inelastic. By contrast, more recent studies have concluded that such demand is elastic, particularly with reference to finished manufactures. Orcutt (37) has shown that the earlier estimates were biased, largely due to erroneous statistical techniques, and that the demand for imports is indeed highly elastic. Ball and Marwah (38) obtained the following estimates of price elasticity for imports into the United States:

crude material	0.26
semi-manufactures	-1.38
finished products	-3.5

DeVries (39) arrived at similar results: 0.39 for crude materials, -1.36 for semi-manufactures and -4.12 for finished manufactures. Shinkai (40) has similarly estimated the price elasticities for Japanese exports. His results are defined in terms of the two-digit SITC code and range from a low of -0.77 to a high of -1.73.

As manufactured goods are far more important to air transport than crude materials and semi-manufactured goods, the highest of the above estiames, -4.12 will be adopted for this example. Assuming that the air transport charges amount to 10 per cent of the final price, this yields a demand elasticity for air cargo of -0.412. Even in such a case air transport charges would have to represent at least 25 percent of final price before transport demand was of unit elasticity.

Given the correctness of the import demand elasticity estimates, analysis in terms of derived demand appears to strongly suggest that the demand for air cargo is inelastic. A result which contrasts starkly with the findings of earlier studies of the air cargo market.

4.5 Previous studies of air cargo rate elasticity

Previous studies indicate that air cargo traffic volumes are highly price elastic, at least with respect to decreases in rate levels. The ICAO has summarised some of these findings (41) This list, supplemented by results from subsequent studies, is presented in Table 1.

For rate reductions of 10 per cent or less rate elasticity is estimated to vary between -1.5 and -3.0, the higher figure having been derived from research undertaken by aircraft manufacturers (42) (43) The lower figure was reported by Sealy and Herdson (44), and refers only to short- and medium-haul intra-European traffic. ICAO's own assessment was in the range -2.0 to -2.3. For rate reductions greater than 10 per cent elasticity was found to be considerably greater than the figures quoted above, estimates as high as -11.0 for a 50 per cent reduction in rates were suggested by Boeing for example (42).

Two kinds of evidence are frequently presented in support of high elasticity estimations. First that the volume of goods moving by the main types of surface transport increases rapidly at rate levels lower than those of the current air cargo tariff. The figures in Table 2, although somewhat dated, might nevertheless be considered representative of a trend.

Table 1. A summary of previous estimations of the rate elasticity of air cargo demand

Study title, date and description (in chronological order	Estimated air cargo rate elasticity Per cent decrease in rate level: Not specified	10%	30%	50%
Short Bros. air cargo study (1958) Estimates for U.K. overseas air trade. Based on traffic of and above a given value per weight		-2.C	-4.0	-7.0
Boeing "Forecasts of free world passenger and cargo air traffic (1958) Based on estimates in various markets		-3.0	-9.0	-11.0
Sealy and Herdson "Air freight and Anglo-Europe trade" (1961) Based on air and suitable surface traffic		-1.5	-2.2	-4.4
ICAO "Air freight study (1962) Based on trends in total international traffic	-2.0 to -2.3			
Björkman study (1965) (a) intra-European (b) intercontinental	 -1.8 -1.5			
Lockheed "Air cargo growth study 1968-1986 (1970) Various market estimates	-3.0			

Table 2. Rate profile of U.S. domestic surface cargo market

Range of cargo rates (U.S. cents per ton-mile)	Volume and percentage of road and rail cargo being transported over 400 miles in 1952	
	million ton-miles	percent
over 18	1,227	2.7
16 to 18	393	0.7
14 " 16	888	1.9
12 " 14	1,528	3.3
10 " 12	11,346	24.3
8 " 10	11,172	23.9
6 " 8	20,174	43.2
	46,728	100.0

Source: ICAO "Air freight, trends and developments in the world air freight industry".

In this market, at this time, the average level of air cargo rates made it competitive only in the demand range over 18 U.S. cents per ton-mile. At this rate level air cargo accounted for approximately 500 million ton-miles, equal to about a quarter of the total surface traffic moving at that rate. It is clear from the percentage distribution shown in the table that if air cargo rates were reduced the traffic volume of the market in which air cargo became competitive would have increased exponentionally. The weakness of this reasoning lies, of course, in its assumption that the rates of all other modes remain unchanged.

A second line of argument is frequently relates to the average value per weight factor discussed in chapter 2. In all modes of transport the volume of low value-per-weight goods is greater than that of high value items. As has been shown in section 4.4, most goods are unlikely to be transported by a particular means unless its cost is reasonably low in comparison with their value. Thus, if the relatively high level of air cargo rates was reduced, air transport would become practical for a larger variety of goods, as well as to more distant destinations. The shortcoming of this kind of reasoning concerns the fact that it is the average value per consignment, not per commodity, which is the significant parameter. The assumption that the latter reflects the former is highly contentious.

It may also be of interest, by way of comparison, briefly to look at some estimates of demand elasticity for other modes of transport. Benishay and Whitaker (45) have estimated demand elastcities for rail, motor and water transportation in the United States over the period 1946 - 1961. The results are all considerably lower than previously estimated for air transport, being:

rail	-0.84
motor truck	-1.87
water	-0.26

However, only the figure for rail transport is statistically significant.

4.6 Import tariff elasticities - an approach by analogy

Smithies (46) has stated that the imposition of a cargo rate is "precisely analogous to the imposition of an excise tax per unit of commodity". Analysis of the influence of import duties on international trade is normally described in terms of simple geometery (47) the familiar result demonstrating that the effect of a given import duty is dependent on the relative slopes of the demand and supply functions of the commodity being taxed. A similar form of analysis can perhaps be used to estimate the elasticity of the demand for transport.

In connection with the import tarriff reductions that followed the "Kennedy Round", several studies were undertaken to evaluate the elasticity of trade with respect to import duites. Following Smithies analogy some inferences can be drawn from these studies that are relevant to the discussion in hand here.

Before the Kennedy Round tariffs on manufactured goods ranged from 17.1 per cent in Japan to 9.1 for EFTA (48), or somewhat higher than the estimated proportion of final price represented by air transport charges. The Kennedy Round led to cuts in the tariff of 50 per cent. An estimate of the tariff elasticities, defined here as the per cent change in trade volume over the percent change in tariff, should give an indication of what effect a similar major reduction in the cargo rates might have.

Balassa and Kreinin (48) have estimated such elasticities for various countries. Their results have been recomputed in Table 3 to give estimates of the tariff elasticity as just defined. It should be pointed out that the Balassa and Kreinin estimates are not based on actual observations, but have been derived from demand elasticitiesin a similar fashion to that demonstrated for air cargo in section 4.4. The estimates presented here are based on the assumption that the entire tariff reduction accrues to the importer. If the exporter decides to raise his prices somewhat subsequent to a tariff reduction, the estimated tariff elasticities would be lower.

Table 3. Import tariff elasticities

Importing country	Industrial material		Manufactured goods		Average tariffs	
					Industrial materials	Manufactured goods
	e_p	e_t	e_p	e_t	per cent	
United States	-1.18	-0.03	-3.07	-0.358	2.6	13.2
Canada	-0.38	-0.006	-1.62	-0.206	1.6	14.6
EEC	-1.71	-0.022	-2.61	-0.284	1.3	12.2
U.K.	-0.75	-0.024	-2.71	-0.308	3.3	16.5
Other EFTA	-0.81	-0.008	-2.01	-0.168	1.0	9.1
Japan	-0.45	-0.018	-2.53	-0.37	4.2	17.1

e_p = import elasticity
e_t = tariff elasticity as defined in text

The results in Table 3 yield extremely low values for the tariff elasticities of industrial materials, and inelastic values for manufactured goods, the estimated elasticities being in the range -0.2 to -0.37. These results tend to confirm the suggestion made in section 4.4 that the demand for air cargo will also be inelastic.

4.7 Summary and conclusions

The main determinants of transport demand elasticity have been identified for the static case. Existing evidence on air cargo elasticity covers a wide range from highly elastic, in the case of studies undertaken by the air transport industry, to highly inelastic. The latter results, except for that obtained by Allen and Moses (9), are based not on estimated demand functions, but on inferences from microeconomic theory. On the balance of the above, it appears reasonable to draw the preliminary conclusion that demand for air cargo is inelastic, and that most existing estimates are biased upwards. This conclusion refers to the aggregate demand for air cargo, and it should not be suprising if instances of high elasticity are found in certain markets or commodity flows.

Chapter 5

Some correlational estimations of the elasticity of the demand for air cargo

5.1 The basic demand equation

The customary procedure in most previous studies of the rate elasticity of air cargo demand has been to set demand up as a direct function of cargo rates alone, and to make regressional estimates of the relationship between these two variables only. As the demand for goods transport is a derived demand, based on the demand for the goods carried, it might be more correctly expressed if, as is conventional, an income variable were also included:

$$X_t = f(P_t, Y_t)$$

where X_t refers to the demand for air cargo, P_t to the cargo rate and Y_t to the income level in the market concerned. Ruling out special cases such as inferior goods, it is generally expected that X_t will be decreasing function of P_t and increasing in respect of Y_t.

Such a demand formula is static, however, in that it includes no expectations or uncertainty, assumes transport technology constant and the prices of competing modes unchanged. These assumptions are rather drastic, and some will be removed later, but since they are implicit in most earlier studies, it is of interest to maintain them for the present to enable comparable results to be obtained.

5.2 The identification problem in demand analysis

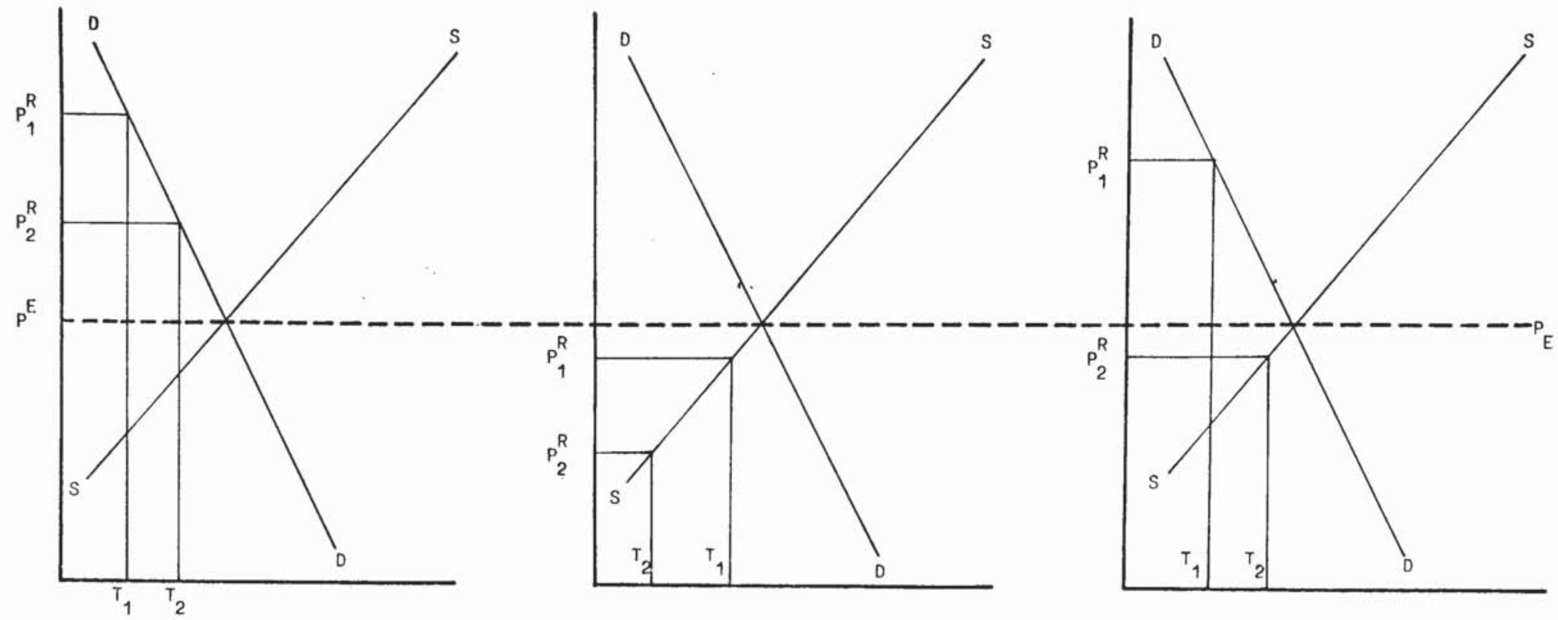
Single equation formulae are used for demand estimation throughout this chapter. This requires some justification in view of the familiar problem of identification in demand analysis (49) i.e. can unbiased and consistent estimates of demand and supply functions be obtained independently of each other or must demand and supply curves be estimated simultaneously?

There are numerous examples where the demand function for transport has been estimated by using a single least squares regression equation. This is acceptable if the problem of identification can be ignored. In most cases concerning public transport this is the case since the level of prices and supply are usually set exogenously by regulatory agencies. The volume of traffic therefore being solely and independently determined by demand.

A similar condition might also be argued to apply in respect of international scheduled air services. As has been described in chapter 3, price policy is established within IATA, and therefore largely outside the control of any one individual carrier, and the amount of capacity available determined by inter-governmental air traffic agreements. The exogenous nature of this latter factor being particularly reinforced in the case of cargo because of the generally by-product way in which it is treated. The amount of cargo capacity offered has been, and on most routes still is, incidental to the level of passenger capacity agreed. This situation is changing however. With the growing significance of all-cargo operations and the large cargo capacity of the wide-bodied passenger aircraft, the provision of cargo capacity is now becoming increasingly subject to separate intergovernmental agreement.

While such justifications for ignoring the problem of identification are attractive, there is a further condition which must also be fulfilled. Such justifications only apply if the price set by the regulatory agency is higher than the equilibrium price for the industry. If set below, any attempt to estimate the effect on traffic of a change in price will produce a supply not a demand function. This is illustrated by the three situations shown in FIG.1.

In Case 1 the regulated price in both periods 1 and 2, P_1^R and P_2^R, is set above the industry equilibrium price, P^E, and



Case 1: Regulated price above industry equilibrium price

Case 2: Regulated price below industry equilibrium price

Case 3: Regulated price above and below equilibrium price

Fig. 1: Identification in Regulated Industries

the change in traffic volume recorded $T_2 - T_1$, is a measure of demand price elasticity.

In Case 2 the regulated price is set below the equilibrium in both periods and, since demand exceeds supply, the change in traffic volume recorded is a measure of supply price elasticity.

In Case 3 the regulated price is set above the equilibrium in the first period and below in the second. The change in traffic volume recorded is thus a combination of demand and supply price elasticities.

A single equation model might therefore be considered appropriate in the case of the air cargo market if the rate structure established by the IATA Traffic Conferences can be shown to be consistently above the equilibrium price level for the industry.

There are strong grounds for believing this to be the case in that, as described in chapter 1, the situation is one of persistent and substantial over-capacity. In total the supply of capacity appears to have been increased always in anticipation of demand levels, with continuous excess capacity as the result. In view of the consequent surplus, aggregate supply might for all practical purposes therefore be considered as, and as having been, perfectly elastic. Even though temporary peaking problems may have arisen on certain routes or during certain periods, the extensive possibilities for sixth-freedom re-routing have enabled most such bottle-necks to be by-passed. Under these conditions, unless demand is also perfectly elastic, which it clearly is not, the supply and demand functions will be independent.

Thus, while identification does not appear to be a problem in this instance, certain other qualifications should be noted before proceeding with the analysis. First any elasticity formula of this kind can only give a broad indication of the order of traffic increases to be expected from any overall reduction in rates. Because of the number and variety of rates applying in any one market it is necessary to measure price changes by changes in some average rate. In most large markets such an average must represent a wide range of actual rate levels and, consequently, it must be assumed that when the average rises or falls the whole range of rates it represents also rises or falls correspondingly. While this may be acceptable in the case of across-the-board increases or decreases in the tariff, it is unlikely to be very representative of situations in which rates are being intrroduced or adjusted selectively.

Second, any formula that may be found suitable for assessing increases in demand due to reductions in cargo rates is not necessarily applicable in the reverse direction, i.e. for assessing reductions in demand due to increases in cargo rates. Such reductions (or failures to expand as much as expected) might normally be anticipated when rate levels are raised, but may be slower to take effect and may not be as large as the increases in demand created by comparable rate reductions, since they receive less publicity than the latter.

5.3 Functional forms of expression for the demand equation

A demand equation in the general terms specified in section 5.1 gives no indication a priori as to the best form for its expression. It is necessary, therefore, to experiment with different forms in order to find the most appropriate. The forms examined here are those that have been commonly used in demand studies (50). There are , as already noted, certain a priori expectations as to the signs to be taken by the independent variables. Assuming rational consumer behaviour, the relationships between demand and income are expected to be inverse and direct respectively. The choice of a equational form for this analysis will be based on the fulfillment of these expectations and on the level of statitical qualification achieved.

The following forms were tried as an experiment:

1. Linear: $X_t = a + bP_t + cY_t$
2. Inverse: $X_t = a + b/P_t + c/Y_t$
3. Double-log: $\log X_t = a + b \log P_t + c \log Y_t$
4. Semi-log: $X_t = a + b \log P_t + c \log Y_t$
5. Log-inverse: $\log X_t = a + b/P_t + c/Y_t$

5.4 Data and variables

The data used here are extracted from published ICAO statistics, in particular Series F (financial data) and Series T (Traffic data) and are reproduced in Appendix III.

Since no distinction is made in ICAO financial statistics between revenue arising from international cargo traffic and that from domestic, the initial estimates of demand elasticity made here must, of necessity, also be in the same aggregate terms. How representative such estimates are of the results that would have been obtained using revenue data for international traffic alone can only judged qualitatively.

Estimates relating to combined international and domestic traffic might be expected to yield generally higher elasticity values than for international traffic alone since the more ready availability of substitute means of transport domestically will give the results an upward bias. Some idea of the extent of this exaggeration can be gained from the separate demand elasticity estimates made in section 4.10 for the United States domestic and North Atlantic markets.

The units of measurement used for the dependent variable are tonne-kilometers and the yield or revenue per tonne-kilometer (in U.S. cents) as the independent price variable. In addition, the United States Production Index has been used as a proxy variable for income. The justification for using this index as an income variable is the heavy reliance of air cargo on industrial products and, as has been shown in chapter 1, the general predominance of the United States in the air cargo market.

The data used in this estimates are annual only, and limited to the post-war period. As a result the number of observations is quite limited and only simple demand functions have been possible if an acceptable number of degrees of freedom was to be retained. The paucity of data, by econometric standards, has led some writers to conclude that estimation of air cargo demand elasticity is impossible by this means (51) This seems unduly pessimistic. There are many examples of industry studies where data problems have been equally serious, but where demand functions have successfully been derived (13)) (58).

5.5 Choice of demand equation

The equations referred to above were used to fit the ICAO data for the years 1950-1971. Although observations are available from 1945 they represent highly unusual circumstances, with severe constraints on civilian traffic. For this reason they were excluded. Data for the year 1949 was kept in reserve to allow first differencing of the variables at a later stage. The results derived are given in Table 1.

An undeflated price variable has also been used. Although this violates the conventional assumption that demand should be homogenous of degree zero with respect to prices and income, it might be of interest to include such a variable for purposes of comparison, since it appears that the undeflated price may have been used in some earlier studies.

Table 1. The demand for air cargo on all scheduled services of ICAO member carriers 1950 - 1971

Equation form	Dependent variable X_t = million tonne-kilometers (TKM)					
	RTKM	DRTKM	INDP	CONS	R^2 / S.E.	D.W. / D.F.
1. Linear	12.88	-	78.23	-6,126	0.8992	0.44
	(0.14)	-	(7.035)	(1.914)	801.1	19
2. Linear	-	76.68	88.66	-8.768	0.9044	0.60
		(1.026)	(7.004)	(2.861)	780.2	19
3. Inverse	225,100	-	-165,800	-723,600	0.8391	0.59
	(4.494)		(1.036)	(1.793)	1,012	19
4. Inverse	-	267,600	157,900	-1088000	0.9066	0.75
		(6.964)	(1.059)	(3.469)	771.5	19
5. Double-log.	-1.108	-	2.466	-0.5033	0.9906	1.64
	(4.541)		(17.01)	(0.36)	0.0839	19
6. Double-log.	-	-1.218	2.117	1.488	0.9921	1.64
		(5.345)	(11.43)	(0.957)	0.0766	19
7. Semi-log.	-5,268	-	5,831	-5,975	0.8272	0.34
	(1.726)		(2.968)	(0.342)	1,049	19
8. Semi-log.	-	-5,206	4,173	-425.5	0.8254	0.30
		(1.659)	(1.635)	(0.02)	1,055	19
9. Log-inverse	43.67	-	-205.2	758.1	0.9849	1.17
	(7.339)		(12.23)	(17.92)	0.1061	19
10. Log-inverse	-	40.84	-167.4	735.4	0.9896	1.41
		(9.303)	(9.828)	(20.52)	0.0882	19

Where TKM = cargo tonne-kilometers
RTKM = yield or average revenue per TKM (U.S.cents) current
DRTKM = RTKM deflated by U.S. wholesale price index
INDP = U.S. industrial production index
CONS = constant term
R^2 = coefficient of determination
S.E. = standard error of estimate
D.W. = Durbin-Watson value
D.F. = degrees of freedom
( ) = t ratio

Data source Appendix III.

The main purpose of the estimations made in Table 1 is to facilitate choice of the equation form most consistent with observed data. Two general criteria are commonly used as the basis for such a decision. First the equation should yield a good fit to observed data. And second, the variations or residuals of observed data around the regression line of the equation should be randomly distributed. Other statistical values demonstrating the acceptability and significance of small samples, the standard error of the estimate and the "t" test, have also been calculated here and are included in the Table.

Goodness of fit can be evaluated from the coefficient of determination i.e. the ratio of variation around the observed data mean that is explained by the regression line compared to the total variation around the mean, or by its square root, the coefficient of correlation. The former is used here and is shown in Table 1 by R^2. It is computed as:-

$$R^2 = \frac{\sum_{t=1}^{n} (X_t^{est} - \bar{X}_t)^2}{\sum_{t=1}^{n} (X_t - \bar{X}_t)^2}$$

where X_t^{est} is the regression point and X_t and $\bar{X}_t$ are the observed data and observed data mean.

The randomness of these observed data variations around the regression line is commonly measured by the Durbin-Watson value (53), designated D.W. in Table 1 and computed as:-

$$D.W. = \frac{\sum_{t=1}^{n} (Z_t - Z_{t-1})^2}{\sum_{t=1}^{n} Z_t^2}$$

where Z is the vertical distance from the observed results to the regression line. Exact critical values for D.W. cannot be derived, but as a practical rule normally the values 1.6 and 2.4 are treated as critical limits. Values of less than 1.6 indicate positive autocorrelation and above 2.4 negative autocorrelation.

The presence of autocorrelation can be interpreted as a warning that the equation form is misspecified, that a variable is missing or that some adjustment process is taking place and that, as a consequence, a dynamic approach is required. FIG.2 gives some illustration of how a misspecified equation may give rise to autocorrelation.

While the regression between Y and X results in a fairly high correlation coefficient, there is a strong autocorrelation with negative residuals tending to follow negative residuals and positive residuals by positive. This produces a low D.W. value. The problem illustrated is one where a non-linear relationship has been estimated as a linear function and demonstartes how a high degree of correlation by itself is not an adequate criterion for choosing a particular demand equation form.

When applying the combined criteria of acceptable D.W. and goodness of fit values to the equations in Table 1 the double logarithmic form (equations 5 and6) fares far better than the others, with D.W. values of 1.64 and R^2's of0.99. The log-inverse form (equations 9 and 10) also does reasonably well, but shows some signs of positive autocorrelation. The signs are correct for both price and income, and their [illegible] coefficients highly significant.

Since what the signs of the independent variables should be is known from economic theory, a one-tail "t" test is appropriate. With 19 degrees of freedom this means that the t-values should exceed 1.725 to be significant at the 5 per cent level, and be greater than 2.528 to be significant at

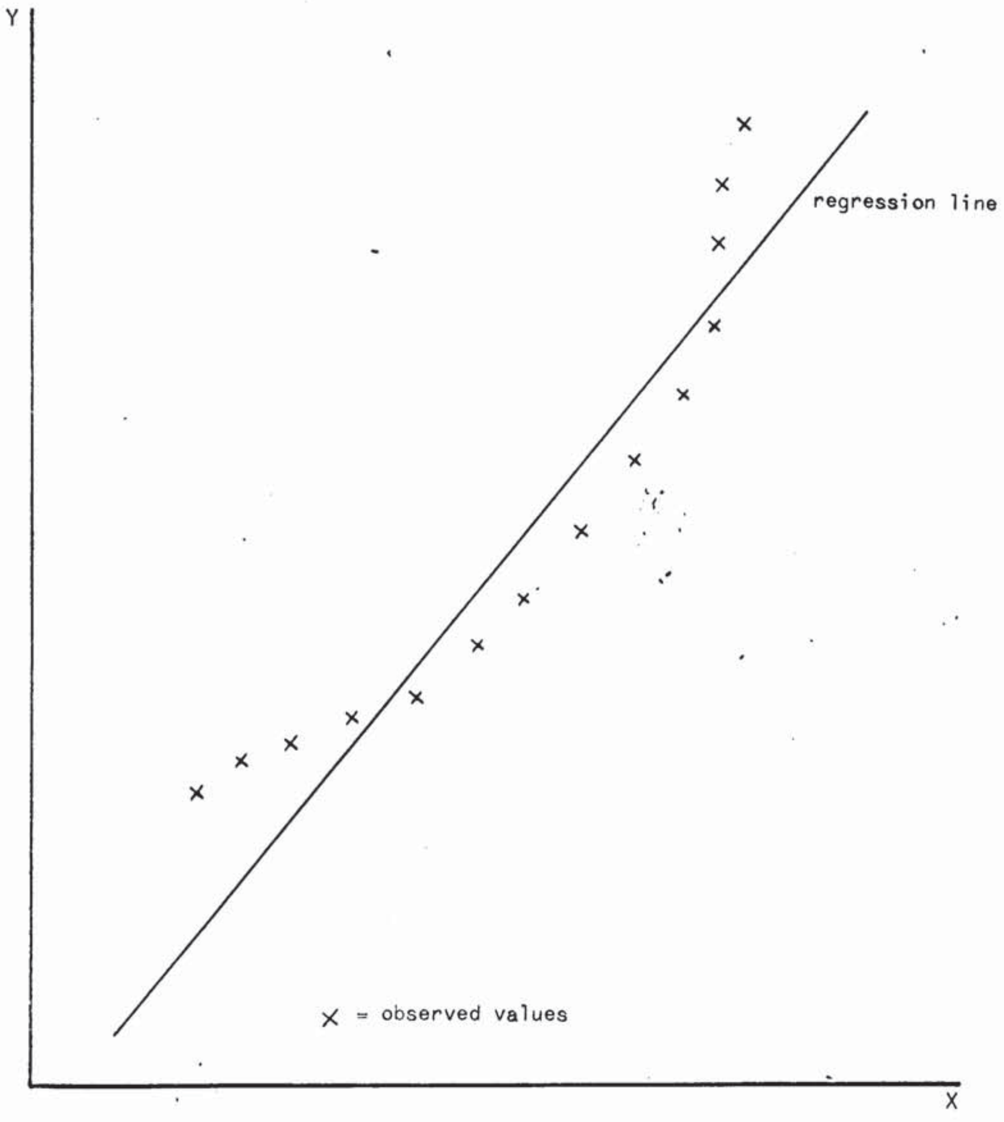


Fig. 2: Autocorrelation

the one percent level. The log-inverse form gives somewhat higher t-values for the price variable than does the double-log form but this may partly be due to positive autocorrelation which produces an upward bias in t-values.

One tentative conclusion that may be drawn from the above estimate is that equations of the demand for air cargo, at least when defined under static conditions as assumed here, should be based on a logarithmic form of the dependent variable, and possibly also of the independent variables. This is not a very suprising result when it is recalled that, as shown in chapter 2, air cargo has been growing at a rapid exponential rate over the period in question, averaging something like 13.5 per cent per annum.

Besides yielding a better fit, the logarithmic form may also have an added advantage over raw data in that it may reduce the presence of heteroscedasticity. Ordinary least squares estimation assumes a constant variance, i.e. the scale of the disturbance terms around a regression line are assumed independent of the value of the dependent variable. When observing a service such as air cargo which has been growing rapidly over time, this assumption becomes unrealistic. As the numerical magnitude of the regression line grows with time it is to be expected that so too will the absolute values of the deviations of actual observations from it. It may, therefore, be more realistic to assume that the percentage deviations over time will be closer to constant. The double-logarithmic form tends to reduce these effects, transforming the raw data into a more homoscedastic condition, and thereby improving the statistical properties of the estimates.

5.6 Estimated price and income elastcities

The price and income elasticities of the double-logarithmic equations are simply the coefficients of the respective variables. This assumes implicitly that elasticities are constant over the entire length of the fitted demand curve. To see this the equations can be written as:-

$$X = A \cdot P^b \cdot I^c$$

where A, b and c are constants. The price elasticity is then defined as:-

$$e_p = \frac{dX}{dP} \cdot \frac{P}{X} = b \cdot A \cdot P^{b-1} \cdot I^c \cdot \frac{P}{X} = b$$

Similarly, the income elasticity equals c.

For the log-inverse cases we get the following equation forms when taking anti-logs:-

$$X = A \cdot e^{(b/P + c/I)}$$

The price elasticity in this case being b/P and the income elasticity c/I. The computed elasticities are shown in Table 2:-

Table 2. The price and income elasticities of the demand for air cargo on all scheduled services of ICAO member carriers 1950 - 1971

Equation form	Undeflated price (RTKM)	Deflated price (DRTKM)	Income (INDP)
5. Double-log	-1.11	-	2.47
6. Double-log	-	-1.22	2.12
9. Log-inverse	-1.88	-	1.86
10. Log-inverse	-	-1.82	1.51

In general the results obtained are considerably below those reported in the earlier industry studies noted in chapter 4. They are nevertheless higher than expected from the a priori reasoning of chapter4. These discrepancies were investigated further.

An attempt was made to estimate price elasticities with price as the only independent variable. The results, presented in Table 3, are of interest since they closely resemble those suggested in earlier studies and offer some explanation of the different, comparatively lower estimates, being reported here in Table 2.

Table 3. The price elasticity of the demand for air cargo on all scheduled services of ICAO member carriers 1950 - 1971 with price as the only independent variable

Equation form	Dependent variable X_t = million tonne-kilometers				
	RTKM	DRTKM	CONS	R^2 / S.E.	D.W. / D.F.
5. Double-log	-4.836 (11.46)	-	22.56 (17.23)	0.8547 0.3295	0.74 20
6. Double-log	-	-3.670 (18.83)	19.08 (31.14)	0.9413 0.2094	0.76 20

For explanation of symbols see Table 1.

The coefficients of determination shown in the Table are high, indicating an equally good fit to the data as that of the same equation form specified in Table 2. The low D.W. values strongly suggest, however, that the equation is misspecified in some way despite the fact that that the signs are correct and the t-ratios apparently highly satisfactory.

5.7 The influence of time

Whilst previous studies may have been at fault in relying on one explanatory variable only, it seems equally unrealistic to argue here that the demand for air cargo is a function of only price and income. An indeterminate number of factors could be incorporated into the demand equation. To maintain sufficient degrees of freedom for the results to be statistically significant, however, the number of factors must be limited and only the most important included. The rapid growth of air cargo traffic makes time a noteable influence.

Air cargo is a fairly new means of goods transport. New products are usually accepted slowly at first and thereafter increasingly more readily as they become better known. Some kind of similar "demonstration effect" may also have been operative in the market demand for air cargo. Moreover there have been substantial technological changes in the nature of the services offered over the period of observation which may have also affected demand. Because of such influences static models of demand frequently include a time trend or "autonomous growth rate" as an estimate of the growth in demand not accounted for by explicitly included variables (54). This time trend is an estimate of the rate at which demand would grow if prices and income remained constant i.e. the partial correlation coefficient. From an economic point of view such a catch-all variable is very unsatisfactory, but for planning purposes within the industry it may be of some value.

As demonstration effects and technological change are probably amongst the most important of its components, the time trend can be expected to be positive. If this is the case, then it seems likely that the influence of such an autonomous growth factor will have helped to create the general impression that air cargo is more price elastic than it actually is. It is clear from the data that the volume of air cargo traffic has grown as rates have fallen. Not all this growth, however, should be attributed to the fall in rate levels.

There are a number of simple models of technological change where a time trend is included as a residual measure of the growth in output which cannot be directly attributed to increases in factors of production (55). Such a technique mightalso be adopted here. The effects of including a time trend are shown in Table 4.

Table 4. The price and income elasticities and autonomous growth rate of the demand for air cargo on all scheduled services of ICAO member carriers 1950-1971

Equation form	Dependent variable X_t = million tonne-kilometers					
	DRTKM	INDP	TIME	CONS	R^2	D.W.
					S.E.	D.F.
Double-log	-1.109 (8.777)	1.010 (5.197)	0.535 (6.696)	5.541 (5.289)	0.9976 0.0018	1.07 18

The equation form used is:-

$$\log X_t = a + b \log P_t + c \log I_t + d \text{ TIME}$$

where TIME is an integer 1,2...22.
For explanation of other symbols see Table 1.

The inclusion of a simple time trend leads to a small reduction in the price elasticity, from -1.22 to -1.11, and a drastic reduction in income elasticity, from 2.12 to 1.01. The autonomous rate of growth is estimated at 5.35 per cent per annum.

Acceptance of these estimates also has some interesting implications concerning the accuracy of previous industry study results. For example, if cargo rates are reduced by 5 per cent then, <u>ceteris paribus</u>, this should result in a 5.55 per cent increase in traffic volume within one year. To this must be added 5.35 per cent in autonomous traffic growth.

Observing the level traffic nearly one year after a rate reduction might, therefore, lead to the conclusion that air cargo demand has a price elasticity of around -2.0. Conversely, if rates are increased by 5 per cent at the beginning of a year, the misleading conclusion might be drawn by estimations of elasticity at the end of the year that demand is perfectly inelastic.

Unfortunately the estimates in Table 4 are not very satisfactory statistically. The D.W. value suggests auto-correlation, a warning that the equation is probably misspecified in some way. Also, the great change in income elasticity may indicate multicollinearity, i.e. correlation within the set of explanatory variables. Before investigating this any further one more estimation procedure will be tried.

5.8 First differences

A common estimating procedure when dealing with time series is to use first differences. In the case of the double-log equation this yields:-

$$\log X_t - \log X_{t-1} = a - a + b \log P_t - b \log P_{t-1} + c \log I_t - c \log I_{t-1} + dT_t - dT_{t-1}$$

or $$\Delta \log X_t = b \Delta \log P_t + c \Delta \log I_t + d$$

The constant term a is eliminated when taking first differences and the new constant term d is the coefficient of time from the original double-log function.

First differences can help reduce serial correlation, yielding less biased t-ratios and thereby giving a more correct picture of the significance of the results. It may also reduce multicollinearity between independent variables. The first differencing procedure has a disadvantage, however, in that correlations tend to be lower , so a reduced coefficient of determination can be expected. Table 5 shows the first difference estimates, as well as other previous results for the purposes of comparison.

Table 5 The price and income elasticities of the demand for air cargo on the scheduled services of ICAO member airlines 1950 - 1971

Equation form	Dependent variable X_t = million tonne-kilometers						
	DRTKM	INDP	TIME	CONS	R^2 / S.E.	D.W. / D.F.	P / P_2
1.Double-log	-1.218 (5.345)	2.117 (11.43)	-	1.488 (0.957)	0.9921 0.0766	1.64 19	-
2.Double-log	-1.110 (8.909)	1.010 (5.26)	0.0535 (6.777)	5.600 (5.387)	0.9978 0.0415	1.00 18	-
3.First diff. of logs	-1.154 (4.899)	0.6188 (2.398)	-	0.085 (3.823)	0.5285 0.068	1.30 19	-
4.Double-log **	-1.061 (7.852)	0.955 (5.036)	0.0571 (6.933)	5.656 (5.480)	0.9979 0.040	1.04 18	0.1648 0.1653
5.First diff. of logs**	-0.358 (3.988)	0.568 (5.96)	-	0.098 (5.872)	0.8922 0.033	1.67 19	0.5618 0.5625

** These equations are equations 2 and 3 re-run using the Cochrane-Orcutt search procedure with first order autoregressive scheme (56).
For explanation of other symbols see Table 1.

When comparing the first three equations in Table 5 it can be seen that all give roughly the same price elasticity, but that the first difference estimate gives rise to a further reduction in income elasticity and an increase in the level of autonomous growth, from 5.35 per cent per annum to 8.5 per cent. As expected there is also a considerable reduction in the t-ratios when using first differences, although all coefficients remain highly significant. The coefficient of determination has also decreased as was expected.

As equations 2 and 3 both show signs of positive autocorrelation they were recalculated using the Cochrane-Orcutt first order autocorrelation procedure (56). This procedure is based on the assumption that the autoregressive scheme is of the first order:-

$$z_t = r\, z_{t-1} + e_t$$

where z are the autocorrelated residuals, r a constant and e a disturbance term. An estimate of r can be obtained from the residuals of actual results from the regression lines of the double-log with time and first difference equations. This estimate can then be used to compute the transformed variables $(X_t - rX_{t-1})$, $(P_t - rP_{t-1})$, etc., with which the regressions can be recalculated. If the residuals from the regression lines obtained using the transformed variables still show signs of autocorrelation the procedure is repeated and a new estimate of r obtained. This procedure continues until the coefficient of determination has been maximised. P and P_2 in Table 5 represent the last two estimates of r that result from this iterative process.

Equations 4 and 5 in Table 5 give the equation estimates following the Cochrane-Orcutt adjustment process just described. Equation 4 is not very different from equation 2, but in the case of the first differences (equations 3 and 5) the change in price and income coefficients is considerable and the coefficient of determination has improved noteably, from 0.5285 to 0.8922. The price elasticity in equation 5 is -0.36 and the income elasticity 0.57. This equation also produces the highest autonomous growth rate, 9.8 per cent per annum.

The D.W. values of equations 1 and 5 indicate no serious autocorrelation. Unfortunately they yield very different estimates of elasticity. The choice between them again brings up the question of multicollinearity.

5.9 Multicollinearity

Multicollinearity can be said to exist if there is a high degree of interdependence among a set of explanatory variables,their correlation matrix approaching singularity.

> "Attempts to apply regression techniques to highly multicollinear independent variables generally result in parameter estimates that are markedly sensitive to changes in model specicification and to sample coverage." This is due to the fact that stability "would require not only the perpetuation of a stable dependency between the dependent and independent variables, but also the perpetuation of a stable interdependency between the sets of independent data." (57)

In this light the erratic jumps in the estimates of income elasticity in Table 5 can perhaps be taken as an indication of multicollinearity between the independent variables adopted here.

Farrar and Glauber (57) have developed a test for multicollinearity which attempts :-

> "to define multicollinearity in terms of departures from a hypothesised statistical condition" and which provides " a series of heirarchical measures - at each of three levels of detail - for its presence, severity and location in a set of data." (57)

They define multicollinearity as a departure from orthogonality in a set of independent variables i.e. the existence of some degree of interdependence between the sets of explanatory variables.

> "Such a definition has two advantages. First, it distinguishes clearly between the problem's essential nature - which consists of a lack of independence among the explanatory variables - and the symptoms or effects on the dependency relationship that it produces. Second, orthogonality lends itself easily formulation as a statistical hypothesis and, as such, leads directly to the development of test statistics, adjusted for numbers of variables and observations, against which the severity of departures can be calibrated.
>
> By transforming" the zero correlational matrix between the sets of independent variables "into an approximate Chi-square distribution with $v = \frac{1}{2}n(n-1)$ degrees of freedom, where n is the number of independent variables, a meaningful scale is provided against which departures from orthogonality, and hence the gradient between singularity and orthogonality, can be calibrated." (57)

This statistic is used as a measure of interdependence between sets of independent variables. Where there are more than two such variables, multiple correlations and associated F-values are used to measure each explanatory variable's dependence on each of the other members of the independent set of variables, so as to permit location of the multicollinearity problems.

Since two of the first three equations in Table 5 only deal with two explanatory variables a Chi-square value as defined by Farrar and Glauber will suffice as a test for multicollinearity. The values found were as follows:-

Equation form	Chi-square value	Degrees of freedom
Double-log	47.05	1
Double-log with time	115.53	3
First diff. of logs	0.21	1

These results indicate that there is a severe departure from orthogonality in the first two cases and, therefore, a substantial degree of multicollinearity within those equations. The last equation form does not show any significant deviation from orthogonality however, and it might be concluded that multicollinearity is not present in sufficient degree to disturb the results obtained in this case.

It may also be of interest to examine the double-log with time equation somewhat more closely as to the pattern of interdependence. The F-values are:-

	F (2, 19)
INDP (log)	339.97
DRTKM (log)	88.23
TIME	293.48

These values are all highly significant, and suggest that income and time are the primary sources of interdependence.

It has been argued earlier that due to the nature of the demand for air cargo some kind of time trend has to be allowed for. Yet, as these results indicate, to include time explicitly leads to problems of multicollinearity and possibly arbitrary estimations. On the basis of this it appears reasonable to conclude that the first difference of logarithms constitutes the most acceptable functional form for an aggregate demand equation. Further, it seems reasonable to attach more importance to the results of equation 5 in Table 5 than to the others because of its superior statistical characteristics.

5.10 Regional estimates

The previous estimates were all on a worldwide basis, covering both international and domestic traffic. If such estimates are to be of direct relevance and use to rate-setting decisions, however, they should relate specifically to the market areas over which the rate regulatory agencies, principally IATA and the Civil Aeronautics Board of the United States, have jurisdiction and around which the machinery of this authority is organised. Ideally market specification should be point-to-point, since this is the level at which the individual rates composing the air cargo tariff must in practice be determined. Unfortunately, as already noted, the data necessary for estimates of this sort are not available. More general estimates, but however still useful to a certain extent can be made at intermediate levels of aggregation for which data are available.

Such estimates have been made for four market areas:-

North Atlantic
Pacific
Latin America
Domestic United States

which together accounted for approximately two thirds of the world total air cargo traffic in 1971/2.

5.11 The North Atlantic Market

Certain data are available for the North Atlantic, covering traffic between Europe and North America, including Canada. IATA publishes annual statistics on the tonnage of cargo moving by air over the North Atlantic routes, and makes available to its members - but does not permit publication of- data on the average yield per cargo tonne-kilometer on the route as a whole. The C.A.B. publishes data on the cargo yields of the North Atlantic Division of PANAM. As this closely resembles the overall industry yields for the route it has been adopted as a proxy for that confidential data. Estimates employing actual IATA data have been made in parallel with all of the estimations shown below and no critical bias arising from use of this proxy was found in any case.

As has been shown in chapter 2, the North Atlantic market is one of the most important. In 1971 scheduled air cargo on the North Atlantic (including Canadian traffic) amounted to almost half a million tonnes. The average flight distance for the route is approximately 5,500 kilometers. Combining this data gives an estimate for North Atlantic traffic of around 2,800 million tonne-kilometers, equal to about one third of the ICAO world total.

One a priori grounds one might expect the demand for air cargo on the North Atlantic to be somewhat less elastic than the aggregate world-wide traffic.The main reason for believing this is the absence of high-speed surface transportation, a situation which reduces the possibilities for substitution for the shipper. In fact, many products which are at present shipped by air over the North Atlantic, particularly perishables and novelty or fashion items, might not be shipped at all if air transport was not available. A spectacular, but far from exceptional, example of such trade are the regular shipments of lettuce and strawberries from the West coast of the United States to Scandinavia during the winter months.

The substantial difference in transit time between air and surface transport also gives rise to the important savings on on inventory and alike discussed in chapter 3. Similarly, products that are frequently provided on a rental basis, e.g. computers, copiers, printers, etc., can start earning an income sooner if shipped by air. As a result of these influences air cargo on long-haul routes like this may be of great economic value to shippers, despite its apparently high level of rates compared to surface transport.

The rates on the North Atlantic are at present lower than for most other important market areas . Table 6 gives a summary of the average yield per tonne-kilometer for various markets and carriers. The remarkably low figure for Seaboard World Airlines is due to its all-cargo operations and its deliberate attempts at encouraging large volume traffic.

Table 6. Average yield per cargo tonne-kilometer (U.S. cents) for major market areas 1968

North Atlantic		Seaboard	U.S. Domestic	Intra-European	ICAO Worldwide
European carriers	PAA N.A. Division				
11.0 (a)	13.5 (b)	8.9 (b)	13.9 (b)	30.9 (a)	16.7 (c)

Sources: (a) ICAO "Air Freight Europe-Mediterranean Region" Circular 97-AT/18. Montreal, 1970. p.129

(b) Computed from various tables in CAB "Handbook of Airline Statistics" 1970 edition, Washington 1971.

(c) ICAO "Financial data" Digest of Statistics, No.154 Series F-No.24 Montreal 1971. p.27.

The generally lower rates for the North Atlantic might lead to the expectation that the rate elasticity will be lower, *ceteris paribus*, in this market than in others where the rates are higher. However, the basic equation forms that have been found most appropriate for this study - the double-logartithmic form or variation thereof - yield constant elasticities throughout the entire price range. The *a priori* argument for lower price elasticities on the North Atlantic than for worldwide ICAO traffic must therefore be based on the substitution argument outlined above and explored in detail in chapter 2. In fact, the subsequent results for United States domestic traffic strongly suggest that the availability of substitutes plays a far more important role in determing the level of elasticity than does the actual rate level.

Table 7 gives a summary of the results of the North Atlantic estimates:-

Table 7. The price and income elasticities and autonomous growth in the demand for air cargo on scheduled North Atlantic services of IATA carriers 1950 -1971

Equation form	Dependent variable X_t = Million tonne-miles					
	DRTM	INDP	TIME	CONS	R^2 S.E.	D.W. D.F.
1. Double-log	-1.5337 (3.049)	2.4926 (3.685)	-	-2.627 (0.538)	0.9785 0.1593	0.89 16
2. Double-log	-1.2764 (6.724)	-0.0305 (0.085)	0.1234 (9.973)	6.463 (3.167)	0.9987 0.0596	1.24 17
3. First diff. of logs	-1.3865 (4.712)	-0-4019 (1.130)	-	0.1226 (4.593)	0.5324 0.0808	1.86 18

For explanation of symbols see Table 1.

The results in Table 7 clearly point out the problem of multicollinearity associated with limited sample time series observations. The first regression yields an implausibly high estimate of the income coefficient. The Farrar-Glauber test produces a Chi-square value of 50.4 (one degree of freedom) which is highly significant, confirming the presence of severe multicollinearity.

It has previously been argued that a time trend should be included because of the infant nature of the air cargo market gives rise to a strong autuonomous growth rate. When this is done there is a drastic change in the estimated income elasticity which is now insignificant and takes the wrong sign as well.

The first differences of logarithms do not fare much better as far as the income variable is concerned. However, in this case the associated Chi-square value is as low as 2.22, which suggests there is no significant dependence left in the set of explanatory variables. It would thus appear that for the North Atlantic market, income is not an important determinant of demand. On theoretical grounds this is not very convincing, and it may be more appropriate to leave this question open till more data become available, something which may facilitate a separation of the effect of income from the autonomous growth rate.

The price elasticity appears to be somewhat above unity, which is contrary to our a priori expectations and above the aggregate ICAO results which ranged from -1.2 to 0.36. The autonomous growth rate is found to be 12.26 per cent, based on the first differences of logarithms, compared to a total growth rate of 19.2 per cent. The latter figure is probably too high, as it fails to separate the income effeect from that of autonomous growth.

For this particular market, some figures are available on the rates alternative modes of transport in the form of dry cargo indicies*. Such indicies can at best give only a very approximate picture of the true rates, but an attempt to use these data was considered worth while, although without any expectations with regard to statistical significance. It was hoped, however, that the sign would be correct and that some insight might be gained as to the possible magnitude of the cross-price elasticity. The results are shown in Table 8.

Statistically, the results in Table 8 are somewhat disappointing, but not without interest. Using the one-tail test the air cargo rate and the autonomous growth rate are

---

* Liner indicies were unfortunately not available for the entire period of observation. The index used is prepared by the Italian Ministry of the Merchant Marine, and has been extracted from OECD "Maritime Transport" Paris. Annual.

Table 8. Cross-price elasticities for air and surface cargo moving over the North Atlantic routes 1950 - 1971

Equation form	Dependent variable X_t = million ton-miles						
	DRTM	DOR	INDP	TIME	CONS	R^2 S.E.	D.W. D.F.
1. Double-log	-1.2711 (6.623)	0.0609 (0.831)	-0.1722 (0.431)	0.1320 (8.134)	6.631 (3.20)	0.9969 0.0602	1.22 14
2. First diff. of logs.	-1.2392 (3.933)	0.0990 (1.201)	-0.5188 (1.411)	-	0.1377 (4.72)	0.5450 0.0797	1.84 15

Where DOR = deflated ocean rate index
For explanation of other symbols see Table 1.

highly significant, but the income variable still has the wrong sign, and is not significantly different from zero. The coefficient for ocean rates has the right sign but is insignificant. However, this is not suprising given the inadequacy of the data on ocean rates. In particular, these data cover a wide variety of products that never move by air and that probably never will. It appears that own price elasticity shown in Table 8 may have been biased upwards as the implicit assumption of constant prices for competing modes was violated. Note, however, the very high autonomous growth rate. This means, in fact, that we have explained very little of what caused the rapid growth on the North Atlantic.

Multicollinearity is strongly present in the case of the double-log equation , but only to a moderate degree when first differences of logarithms are used. The Chi-square value is 7.49 (three degrees of freedom) in the latter case, which is not statistically significant.

The above results, combined with a priori expectations, suggest that the rate elasticity for air cargo on the North Atlantic is possibly as high as -1.271. The cross-price elasticity between air and ocean cargo is probably very low, the estimate obtained here being not significantly different from zero. This suggest very little substitution takes place between the two modes of transport. No conclusions could be drawn with respect to income elasticity in this market, as estimates had the wrong sign in most cases. In no case, however, were the estimates significantly different from zero.

5.12 The Pacific and Latin American markets

The C.A.B. also publishes PANAM data for the Pacific (including Alaska) and Latin America route areas. These data were again used as a proxy for industry data. A similar analysis was undertaken to that made on the North Atlantic data. The results of this exercise are shown in Table 9.

It is interesting to note that the price variables alone produce quite good results. A similar attempt was made to use the income variable alone. The elasticities obtained were around o.3 but insignificant, and the corrected R^2 was negative both for the Pacific and Latin America. Hence it appears that price is a major factor in these markets. It should be noted that the autonomous growth rate is found to be 4.9 per cent per annum for Latin America and 8.7 per cent for the Pacific when the price variable alone is used. The actual growth rates recorded in these areas over the period of observation were 9.3 and 17.4 per cent per annum respectively. Thus, it appears that about half the growth in these markets is accounted for by reductions in rates.

The price elasticities obtained for Latin America and the Pacific are higher than a priori expectations. It has been assumed that the same lack of adequate substitute means of transport exists as does on the North Atlantic route, and would

Table 9. The price and income elasticities and autonomous growth in the demand for air cargo on scheduled Pacific and Latin American services of IATA carriers 1950 - 1971

Equation form	Dependent variable X_t = million tonne-kilometers					
	DRTKM	INDP	TIME	CONS	R^2 S.E.	D.W. D.F.
	Pacific Market					
1. Double-log	-1.586 (13.41)	0.5128 (1.345)	0.0855 (6.573)	5.363 (2.804)	0.9967 0.0586	1.59 15
2. Double-log	-1.720 (5.209)	-0.4273 (0.9727)	-	0.1032 (3.259)	0.5672 0.0998	1.85 16
3. First diff. of logs	-1.609 (5.200)	-	-	0.0870 (3.238)	0.5686 0.0997	1.68 17
	Latin American Market					
1. Double-log	-1.614 (4.808)	0.6557 (1.588)	0.0152 (0.7307)	5.934 (2.838)	0.9738 0.0873	1.27 15
2. Double-log	-1.296 (4.399)	-0.1700 (0.5039)	-	0.055 (2.174)	0.4791 0.0782	1.57 16
3. First diff. of logs	-1.254 (4.542)	-	-	0.0483 (2.294)	0.4951 0.0765	1.68 17

For expanation of symbols see Table 1

have similarly produced relatively low price elasticities for Latin America and the Pacific. One possible explanation of the difference is suggested by the low autonomous growth rates. On the North Atlantic, this rate was found to be around 13 per cent per annum. The difference suggests that air cargo is far less developed on the international routes of the Western Hemisphere than over the North Atlantic, and hence has not created traffic exclusive to itself in those markets.

If this is indeed the case, then it may be expected that in the future the Latin American and Pacific markets for air cargo will gradually come to resemble more the North Atlantic market, and that price elasticities for these markets will then decline. Whether this happens, of course, depends on the development of ocean transport, in particular the advent of fast container ships. The introduction of such services may contribute to increased substitutability between ocean and air cargo over all major international trade routes, with increased cross-price elasticities as a result.

5.13 Domestic air cargo traffic in the United States

The domestic air cargo market in the United States is far more developed than any other country's. This is due to several factors which have been of direct benefit to this form of transport. Geographical and demographical considerations have played a large part, the great distances that exist between the major population centres being especially suitable to the efficient use of jet equipment. Equally important, of course, has been the high level of income and industrial activity.

Another factor which may have played an important role is that shippers in the United States appear to be more sophisticated in their approach to physical distribution problems than their counterparts elsewhere in the world. Many large manufacturing companies in the United States have redesigned their whole distribution systems in order to be able to use air cargo to the optimum e.g. UNIVAC, Litton, Raytheon, etc. Some shippers use air cargo exclusively for long-haul shipments, and have come to rely on air transport in a way rarely found elsewhere in the world. It is probably justified to say that whereas air cargo is still an "exceptional" mode of transport in most countries, in the United States it is a "regular" one. As a consequence greater substitution between air and other modes of transport can be expected in this market than is found on average overall.

Another indication of the maturity of this market is the relative slowing down of its rate of growth - see Table 5 and FIG.1 in chapter 1. In the light of these conditions this market might be expected to be more price elastic than the others discussed above.

The results of the demand elasticity estimations made for the domestic United States air cargo market are shown in Table 10. Similar estimates have also been made for the total of U.S. intercity goods transportation performed by common (public) rail, truck and air carriers, and for traffic moving by air express service. (Air express consists primarily of small shipments that move at a premium rate and have priority over regular cargo traffic.)

The results for total intercity goods transport are consistent with <u>a priori</u> expectations and it may be of interest to compare them with those of Benishay and Whitaker's study of goods transport demand within the United States over the period 1946 - 1961 (46). The elasticity estimates in that study were:-

Table 10. The price and income elasticities of the demand for inter-city goods transport in the United States 1950 - 1971

Equation form	DRTM*	INDP	TIME	CONS	R^2 / S.E.	D.W. / D.F.
	Dependent variable X_t = million ton-miles					
Total cargo (rail - truck - air)						
1. First diff. of logs	-0.3762 (4.251)	0.8343 (9.145)	-	-0.0098 (1.411)	0.9009 0.0211	2.09 18
Air Cargo						
2. First diff of logs	-1.815 (4.729)	0.002 (0.004)	-	0.1409 (4.509)	0.5504 0.1136	2.06 18
3. Double-log	-1.433 (2.824)	0.7930 (1.395)	0.0897 (3.978)	5.381 (1.513)	0.9860 0.0998	1.46 17
Air Express						
4. First diff. of logs	0.1164 (0.517)	1.329 (5.610)	-	0.0036 (0.204)	0.6018 0.0626	2.62 18
5. Double-log	0.1269 (0.7203)	1.367 (6.399)	0.0014 (0.1645)	-2.817 (2.787)	0.9846 0.0457	2.00 17

* In the case of total cargo, the rate variable is a weighted index of the deflated yields of the three modes in question.

explanation of other symbols see Table 1.

Price elasticity	Income elasticity
Rail...........-0.842	0.976
Inland water...-0.264 (not significant)	1.305
Truck..........-1.873 (not significant)	0.342 (not significant)

Benishay and Whitaker expressed suprise at the low elasticity estimated for water transportation, but given the discussions of derived demand in chapter 4, their result seems quite reasonable, whereas the other two results seem on the high side. As rail transport is the dominant mode in terms of traffic volume, it is also perhaps the most relevant mode against which to assess the estimates made here of air cargo demand elasticity. In terms of income elasticity the estimates for rail and air are close, but in price elasticity there is a wide discrepancy. The explanation for this is not immediately apparent.

The results shown in Table 10 become distinctly more puzzling when air cargo and air express are considered. The usual equation form, the first difference of logarithms, yields a relatively high price elasticity coefficient for air cargo, -1.815, which does not appear unreasonable considering the degree of inter-modal competition in this market. More disturbing, however, is the fact that income elasticity is found to be practically zero and totally insignificant. The statistical test, including the Farrar-Glauber test for multicollinearity, give little or no indication as to what the reasons may be for this unexpected result. It is worth noting, however, that the constant term is highly significant. As this term represents the autonomous growth rate in this instance, it was decided to return to the double-logarithmic form with time as an explicitly included variable. The results appear more plausible, but are still far from satisfactory from a statistical point of view. Demand remains price elastic, -1.433, and the estimate for income elasticity, 0.7930, has the right sign. The time variable shows as highly significant. As might be expected there is substantial overall multicollinearity in this case, as demonstrated by a Chi-square value of 81.9 for three degrees of freedom.

The Farrar-Glauber test further reveals that the existence of multicollinearity can be traced to the highly significant correlations between time and income. An attempt also was made (not shown in the Table) with a double-logarithmic equation using only price and income as explanatory variables. The resulting price elasticity was not much different from the previous result, -1.967, but the income elasticity was unrealistically high at 2.82. Although both elasticities were found to be statistically significant, the results were rejected as implausible.

Thus, the situation in the domestic U.S. air cargo market appears analogous to that indicated by the results for the North Atlantic. The price elasticity estimate remains relatively stable over a limited range of values but the income elasticity estimate is extremely unstable.* It seems reasonable therefore to limit any conclusions concerning the numerical values to the price elasticity. As expected, air cargo appears to be relatively price elastic in the domestic U.S. market, the values ranging from -1.433 to -1.816, the latter figure being more significant in the statistical sense. These elasticity values are higher than those found in any other market area examined here.

When it comes to income elasticity or more correctly the elasticity in respect to industrial production, the double logarithmic form with time as an explanatory variable yields the most plausible results, around 0.8. This is quite close

*Benishay and Whitaker (46) encountered the same kind of difficulties in the case of trucking price and income elasticities.

to the results obtained from the ICAO data, and only slightly lower then the highly significant income elasticity coefficient, 0.8343, found for the total U.S. inter-city goods transport demand. It had been expected that the elasticity for air cargo would be somewhat higher than that for total cargo traffic, but the results do not apparently support this assumption.

Air express, as might be expected, presents a quite different picture to that of air cargo. The estimates for air express price elasticity that appear in Table 10 are all positive, which suggest air express is an "inferior" good in the economic sense of the term. Clearly it is not. Air express might be more appropriately classified as a "necessity". It is used primarily where speed is essential; and usually where there is no practical alternative available. This situation appears to have influenced the rate-setting policies for air express, and it is interesting to note the substantial difference in yield between air cargo and air express. In the case of the former the yield declined from 29.03 U.S. cents in 1950 to 19.97 U.S. cents in 1971 at current prices. The corresponding figures for air express are 39.13 U.S. cents 36.33 U.S. cents. This difference can hardly be explained in terms of cost difference alone, and the airline have apparently assumed air express to be highly price inelastic and have not adjusted rates in attempts to increase traffic.It might be argued that the practically constant rates over the entire period of observation make it difficult to measure the influence of price. However, as deflated prices were used in the regression, there was after all a reasonable change in rates, with a drop at constant prices from 45.74 U.S. cents in 1950 to 33.42 U.S. cents in 1971.

The estimates of price elasticity for air express given in Table 10 are without exception not significantly different from zero and it appears reasonable to conclude that the demand for air express is highly inelastic.

The income elasticity estimate also yields very different results in the case of air express compared to air cargo. The estimated income elasticities are close to 1.3 in all cases and highly significant statistically. Although previously termed a necessity, and therefore unlikely to be as highly income elastic as the resulting estimates for air express imply, the term and the estimates are amenable in one sense. The income variable here is represented by a proxy, the industrial production index. As industrial production increases, it can be expected that the need for spare parts will rise even faster. Such items are frequently moved by air express.

An attempt was also made to estimate the cross-price elasticities between air cargo and trucking services, and between air express and trucking services. The resulting estimates are shown in Table 11.

Table 11. The cross-price elasticities of air cargo and air express to trucking in the United States domestic inter-city goods transportation market 1950 - 1971

Dependent variable X_t = million ton-miles

Air Cargo

Equation form	DRTM	TRUCK	INDP	CONS	R^2 / S.E.	D.W. / D.F.
1. First diff of log	-2.235 (5.996)	1.563 (2.572)	0.3398 (0.794)	0.1114 (3.764)	0.6573 0.0991	1.85 17

Air Express

Equation form	DERTM*	TRUCK	DRTM	INDP	CONS	R^2 / S.E.	D.W. / D.F
2. First diff. of log	0.6125 (1.998)	-0.7508 (2.059)	-0.3180 (1.153)	0.8852 (3.125)	0.0257 (i.401)	0.6770 0.0564	2.76 16

*DERTM = deflated air express rate per ton-mile

For explanation of other symbols see Table 1

The reason for excluding rail is that railway traffic and the corresponding rates and yields are greatly influenced by bulk shipments of commodities such as coal and grain, which for obvious reasons do not move by air. The cross-price elasticity between air and trucking (see equation 1) is, however, significant. The own price elasticity was found to increase from -1.8 to -2.2, showing that own price elasticity as previously estimated was biased downwards. The reason for this being that the deflated truck rates showed an upward trend during the period of observation, namely from 5.86 U.S. cents per ton-mile in 1950 to 6.38 U.S. cents in 1970. The income elasticity has the right sign, but is statistically insignificant. The autonomous growth rate has been reduced from 14 per cent to 11 per cent per annum.

The results for air express in Table 11 (equation 2) are at first suprising. The sign suggests that air express may be complementary to truck and air cargo services, a finding which is consistent with the previous suggestion of air express as a necessity,being based on emergency shipments. Such shipments would be expected to be roughly proportional to the total air cargo and truck traffic, rather than competitive with such traffic. The own price elasticity is however still positive. The Farrar-Glauber test values show that there is considerable multicollinearity present (unlike equation 1) which may result in arbitrary estimates. The results for air express should therefore be considered only tentative.

Chapter 6

A dynamic competitive model for estimating the elasticity of demand for air cargo

6.1 A dynamic competitive model

The demand model developed in chapter 5, although yielding significant and plausible results, has a basic weakness. In all cases, it leaves a substantial amd highly significant time trend or autonomous growth rate. Such a model is therefore inadequate in fully explaining the development of air cargo demand unless someway can be found to identify the phenomenon underlying this time trend. The following is an attempt to eliminate the time trend by developing a dynamic form of analysis, incorporating into the model a concept defining the competitive relationship of air cargo to other forms of goods transport.

Balestra (57)) in his study of demand for natural gas in the United States has used a model which analyses the incremental demand for energy rather than total demand. The rationale for this is the assumption of a certain rigidity in existing demand. Users of electricity, for instance, will not switch to gas right away even if gas becomes considerably cheaper per energy unit, as their existing investment in electrical appliances would entail a considerable cost in changing from electricity to gas. Only when these appliances are ready for replacement will electricity users consider alternative forms of energy.

It is frequently argued that users of transportation may similarly be reluctant to make frequent switches between different modes. As has been shown in detail in chapter 2, the mode of transport used is not independent of warehouse facilities, inventory policies or information systems. Thus, it may reasonably be expected that shippers also will review their choice of transport only at considerable intervals of time. Hence, the market split between competing modes at any particular point in time is not freely determined by demand for and supply of transportation. Only when planning new distribution systems, or when planning changes in existing systems can the principles of demand theory be expected to be fully relevant.

New demand for the transport services of a particular mode is derived not only from the increase in goods traffic, but also from the effects of changes in distribution systems. Some of the new increase in traffic may not, in fact, be "free" with respect to the choice of transport mode, since existing distribution systems may have adequate capacity to take up this marginal demand. Nevertheless, for the sake of simplicity, it is assumed here that any increase in goods traffic is uncommitted as to mode.

Because of data limitations on competing modes, the following analysis is limited to the United States domestic market. The most directly competitive mode to air cargo in that market is trucking, and the analysis will consequently be limited to these two modes. The basic postulate underlying the following is that competition takes place primarily over "new" or incremental demand for transportation facing the two modes.

Let F_t be total demand for air cargo and trucking combined, at time t. At any given time, the demand for F_t is determined by the cost of transportation to the shipper, income (expressed here in terms of industrial production), population size, and other factors. This relationship can be expressed as:-

$$F_t = f(P_t, N_t, I_t) \qquad /1/$$

where P_t = cargo rate deflated by wholesale price index,
N_t = population size, and
I_t = industrial production (index)

It is further assumed that this relationship can be adequately expressed as a linear equation. Also, if F_t satisfies basic needs, it may be permissable to drop the price variable from the equation. In this particular case, this appears quite reasonable, as attempts to estimate the price elasticity have yielded results that are not significantly different from zero in the case of trucking, and also for trucking and air cargo combined. The estimates of the price elasticity for trucking and air cargo combined made in the last chapter yielded a value of -0.06 with a t-value of only 0.13. It seems justified therefore to drop the price variable and to rewrite /1/ as:-

$$F_t = a_0 + a_1 N_t + a_2 I_t \qquad /2/$$

The increment in demand between the two periods is:-

$$\Delta F_t = F_t - F_{t-1} \qquad /3/$$

To get total new demand the amount of existing cargo which is "released" during the previous year must be added to this i..e cargo that, as a result of changes in the distribution system, becomes uncommited to mode. Let W_{t-1} be the average "stock" of distribution systems in year (t-1). This stock may be partly physical, consisting of warehouse facilities, packaging equipment, etc., but it may also cover a psychological commitment to a particular form of distribution. In the latter sense, the stock concept is analogous to Houthakker and Taylor's psychological stock variable (50) asociated with certain non-durable consumer goods, and where the stock variable essentially refers to habit and habit formation. Habit formation or inertia appears to play a considerable role in distribution (58) and the Houthakker-Taylor formulation seems quite realistic in the case of modal choice.

If the stock variable is interpreted primarily as a psychological commitment to a particular mode or to a given modal mix, we may approximate this stock variable by the level of usage of a mode at the beginning of time period:-

$$W_{t-1} = F_{t-1} \qquad /4/$$

This stock will be depreciated over time, and it is assumed that this takes place at a constant rate, r. Thus, at the end of period t, what remains of the original stock will be:-

$$W_t = (1 - r)W_{t-1} = (1 - r)F_{t-1} \qquad /5/$$

Hence, at the end of period t, $(1 - r)F_{t-1}$ represents the amount of transportation demand that remains commited with respect to mode. It follows that total new demand can be expressed as:-

$$F_t^* = \Delta F_t + rF_{t-1} = F_t - (1 - r)F_{t-1} \qquad /6/$$

By analogy, the new demand for air cargo, AF_t^*, will be:-

$$AF_t^* = AF_t - (1 - r_A)AF_{t-1} \qquad /7/$$

where r_A is the depreciation rate of the stock of air cargo(which will include the desertion of air cargo by disenchanted air transport users).

The increase in demand for air cargo will have to come from F_t^* rather than from the total market of air and truck cargo, as a large portion $((1 - r)F_{t-1})$ of that market is already committed either to air transport or trucking. The demand equation for new air cargo can therefore be written as:-

$$AF_t^* = b_0 + b_1P_{At} + b_2P_{Tt} + b_3F_t^* \qquad /8/$$

where P_A and P_T refer to the deflated air and truck rates respectively. Using /6/ and /7/,equation /8/ can be rewritten

$$AF_t = b_0 + b_1P_{At} + b_2P_{Tt} + b_3(F_t-(1-r7F_{t-1}) + (1-r_A)AF_{t-1} \qquad /9/$$
$$= b_0 + b_1P_{At} + b_2P_{Tt} + b_3F_t-b_3(1-r)F_t-1 + (1-r_A)AF_{t-1}$$

Equation /9/ can be estimated by a two stage proecedure. First the unknown F_t in /2/ is estimated:-

$$\hat{F}_t = a_0 + a_1N_t + a_2I_t \qquad /10/$$

The estimated values, $\hat{F}_t$, are then substituted for the actual values of F_t in /9/ which for the purposes of estimation can be rewritten as:-

$$AF_t = b_0 + b_1P_{At} + b_2P_{Tt} + b_3\Delta F_t + b_4F_{t-1} + b_5AF_{t-1} \qquad /11/$$

where ΔF_t is the difference between the estimated values of F_t from /10/ and the actual F_{t-1}. The reason for computing the first difference this way is forecasting considerations. When forecasting one would not know the actual values of F_t, whereas F_t-1 would be known. However, for purposes of comparison, the differencing was also done for actual values. The resulting regression results were far better when the first difference between estimated F_t's and actual F_{t-1}'s were used, than when both series were actual values. The results of the estimations were as follows:-

First stage:

$$F_t = -364900 + 3005N_t + 1007I_t$$
$$(7.633) \quad (7.375) \quad (4.306)$$

R^2 corrected: 0.9887; Std. error of estimate : 8320

D.W.: 1.65; Degrees of freedom: 17

Second stage:

$$AF_t = \underset{(0.558)}{-90.63} - \underset{(3.069)}{31.798}P_{At} + \underset{(3.007)}{132.}P_{Tt} + \underset{(1.840)}{0.0012}\,F_t$$
$$\underset{(0.457)}{-0.00001}F_{t-1} + \underset{(18.546)}{1.0903}AF_{t-1}$$

R^2 corrected: 0.9965; Std. error of estimate: 26.36

D.W:2.08: Degrees of freedom 14

Own price elasticity: -1.23; Cross-price elasticity: 1.54

(Data sources - Appendix III)

The numbers in parentheses are t-ratios. All signs are correct,and all coefficients, except F_{t-1}, are highly significant, as the one-tail test applies. The price elasticities have been estimated from the arithmetic means of the dependent variable and the price variables.

Note that the coefficient of AF_{t-1} is greater than one (= 1.09). This implies a value of r_A, the depreciation coefficient associated with the stock of AF, equal to -0.09, i.e. a negative rate of depreciation. The value 1.09 is well within less than two standard deviations of 1.00, so a more reasonable interpretation of the result is that the rate of depreciation of the stock of air cargo commitment is not significantly different from zero. This implies that air cargo users on the whole are not likely to abandon the use of air cargo once they have started using it. It is a fact, however, that some users do abandon air cargo after a trial period. This may have been counterbalanced by a "demonstration effect" that appears to play an important role in the demand for any product that is relatively new in the market. If this demonstration effect is strong enough, it may outweigh the depreciation effect and the coefficient of AF_{t-1} would then be larger than one.

Balestra got similar results in the case of demand for gas, and accounted for the coefficient being larger than one (but not significantly different from zero) by four possible reasons:-

(1) low depreciation where product is relatively new;
(2) when product is a superior good, replacement will tend to be for the same product;
(3) demonstration effect counteracting the depreciation effect; and
(4) if the market grows fast enough the depreciation rate may become quite small.

In the case of air cargo, all these factors can be expected to be at work to some extent. The value of the AF_{t-1} coefficient therefore appears reasonable.

The coefficient of F_t is somewhat larger than the coefficient (in absolute terms) of F_{t-1} and far more significant. This supports the underlying assumption of this model that the growth of air cargo depends more on the increase in total cargo than on the actual level of total cargo.

In order to permit comparison between price elasticities over time , the above equations were fitted for two different periods of time, namely, 1950-1960 and 1961-1971. The resulting own price elasticities are: -0.75 for the period 1950-1960 and -1.35 for the period 1961-1971, whereas the price elasticity for the entire period 1950-1971 was -1.24. All figures refer to estimates of /11/. Because of small sample sizes, the standard errors are very large, and, as a result, the differences between the various periods are not statistically significant. Thus, there is only tentative evidence that demand for air cargo has become more elastic over time. On intuitive grounds, such a conclusion appears reasonable, however. During the 1950-1960 period air cargo was much more limited in scope. It did not have its present ability to handle large consignments, and was primarily used as an emergency measure. Today it is far more common to see air cargo used on a regular basis. It is therefore likely that shippers have become more responsive to changes in air cargo rates during recent years. At the same time, surface transportation has been substantially improved over the period of observation, thereby increasing the options available to the shipper. It therefore appears that demand for air cargo may have become more elastic over time due to increased substitutability between various modes.

The depreciation rate for air cargo was found to be close to zero. It may be of interest to evaluate the depreciation rate for the total market for cargo, as this is of importance to the potential market for air cargo. The greater this rate of depreciation, the larger will be the portion of the total cargo market that is uncommitted to mode of transport in any one year. In order to do this /9/ above can be rewritten substituting /2/ for F_t:-

$$AF_t = b_0 + b_1P_{At} + b_2P_{Tt} + b_3(N_t-(1-r)N_{t-1}) \qquad /12/$$
$$+b_4(I_t-(1-r)I_{t-1}) + b_5AF_{t-1}$$

We can estimate r, by varying r between 0.00 and 1.00, and then choose the value of r which maximises the F-statistic associated with R^2 (which is the same as maximising R^2) We define two new variables:-

$$N_t^* = N_t - (1 - r)N_{t-1}$$
$$I_t^* = I_t - (1 - r)I_{t-1}$$

and compute these for varying values of r. We then estimate /12/ after substituting N_t^* and I_t^* for the terms in the parentheses in that equation. The results are shown in Table 1.

Table 1: Estimation of mode choice "depreciation" in the domestic United States air and truck cargo market 1950-1971

P_{At}	P_{Tt}	N_t^*	I_t^*	AF_{t-1}	r	R^2 F(5,14)	D.W. D.F.
-24.65 (2.289)	132.10 (3.093)	-9.79 (-1.72)	3.17 (2.5)	1.09 (22.44)	0.15 -	0.9967 1152.485	1.55 14
-24.36 (2.264)	133.56 (3.141)	-8.91 (1.926)	3.27 (2.519)	1.09 (22.02)	0.20 -	0.9967 1162.487	1.54 14
- 24.32 (2.259)	133.73 (3.146)	-8.74 (1.957)	3.29 (2.518)	1.09 (22.943)	0.21 -	0.9967 1162.891	1.54 14
-24.28 (2.254)	133.88 (3.15)	-8.57 (1.986)	3.30 (2.156)	1.09 (21.867)	0.22 -	0.9967 1162.718	1.53 14
-24.19 (2.239)	134.19 (3.154)	-8.12 (2.06)	3.34 (2.06)	1.09 (21.639)	0.25 -	0.9967 1160.063	1.52 14

where r = rate of depreciation of air cargo

Although r was permitted to vary for the entire range 0.00 to 1.00 results are shown for five values of r only to save space. The maximimum value of r was found to be 0.21. This implies that on average, physical distribution systems are changed or reviewed about every four years. This relatively high depreciation rate does not seem unrealistic, as we are largely dealing with a psychological stock or committment to particular modes.

The results shown in Table 1 suggest that air cargo should have a large potential market not only in terms of the overall increase of demand for cargo but also by being able to attract business which is presently going by truck.

6.2 Summary and conclusions

In summary, it may be concluded that the dynamic competitive model appears well suited to explain the demand for air cargo in the United States, and that it generally confirms the results of the static model, but also that it provides insights that go beyond those of the static model. The time variable used in the latter has been eliminated. Instead, demand for air cargo is explained in terms of competition for incremental demand. Demand for total air cargo is found to be somewhat less elastic than was the case for the static model. In the light of the results from the dynamic model, the time trend in the static model may, in the case of the domestic market for air cargo in the United States, represent an outward shift of the demand curve due to the continuing increase in demand for total transportation and to a strong demonstration effect.

Appendix 1

Table (i): United States exports to OECD Europe by air - 1970

(Commodities involving 1,000 tonnes or more)

RANK	SITC CODE	DESCRIPTION	TONNES AIR	TONNES SEA	% AIR
1.	714.9	Office machines n.e.s.	15.348	5.146	75
2.	714.2	Electronic computers	7.028	2.531	74
3.	891.2	Phonographic records and other sound media	6.185	6.408	49
4.	734.9	Aircraft parts and accessories	5.786	2.864	67
5.	732.8	Motorvehicle & tractor parts & accessories	5.378	96.935	5
6.	719.9	Machinery parts and accessories	5.117	22.227	19
7.	729.3	Electronic tubes	4.962	9.454	34
8.	861.9	Measuring, Control, etc. instruments	4.463	4.233	51
9.	729.5	Electrical measuring & controlling apparatus	4.402	2.171	67
10.	719.2	Pumps and centrifuges	3.867	32.509	11
11.	724.9	Telecommunications equipment n.e.s.	3.743	4.500	45
12.	722.2	Electrical apparatus for making etc., electrical circuits	3.720	3.954	48
13.	678.5	Iron and steel tube and pipe fittings	3.685	5.338	41
14.	892.9	Printed matter n.e.s.	3.561	2.965	55
15.	719.8	Machinery and mechanical appliances n.e.s.	2.913	15.100	16
16.	711.5	Internal combustion engines excl. aircraft	2.816	80.183	3
17.	729.9	Electrical machinery & apparatus n.e.s.	2.792	66.378	4
18.	719.3	Mechanical handling equipment	2.431	83.301	3
19.	512.0	Organic chemicals	2.377	2.399.096	-
20.	719.5	Powered tools n.e.s.	2.306	11.592	17
21.	722.1	Electrical power machinery and parts	2.164	8.747	20
22.	718.4	Construction and mining machinery	2.117	62.962	3
23.	653.7	Knitted or crocheted fabric	2.101	1.076	66
24.	861.6	Photographic equipment	1.988	4.682	30
25.	711.4	Aircraft engines	1.984	1.199	62
26.	719.1	Heating and cooling machinery	1.913	40.277	5
27.	719.6	Non-electrical machines n.e.s.	1.903	10.289	16
28.	581.2	Polymer and copolymer materials	1.860	223.114	-
29.	581.1	Polymer and copolymer products	1.731	103.656	1
30.	893.0	Plastic articles n.e.s.	1.721	9.981	17
31.	054.5	Fresh vegetables n.e.s.	1.534	21.648	7
32.	717.1	Textile machinery	1.520	19.400	7
33.	051.9	Fresh fruits n.e.s.	1.486	653	[illegible]
34.	653.5	Woven fabric of non-cellulosic fibre	1.439	4.035	[illegible]
35.	899.6	Orthopaedic appliances, articles, etc.	1.416	54	[illegible]
36.	862.4	Photographic film and plates	1.380	10.104	[illegible]
37.	662.3	Bricks and other refractory construction materials	1.316	92.216	
38.	861.7	Medical instruments	1.308	1.611	[illegible]
39.	642.9	Art paper	1.281	11.282	
40.	664.7	Safety glass	1.277	3.545	[illegible]
41.	655.4	Coated or impregnated textiles	1.231	5.245	[illegible]
42.	718.2	Printing and bookbinding machinery	1.194	4.943	[illegible]
43.	891.1	Tape recorders, record players, etc.	1.145	3.862	[illegible]
44.	684.2	Aluminium and aluminium alloys	1.069	31.448	
45.	695.2	Tools n.e.s.	1.048	7.710	
46.	698.9	Articles of base metal n.e.s.	1.044	7.582	
		TOTAL	133.050	4.548.506	
		GRAND TOTAL OF EXPORTS TO EUROPE	210.728	76.346.000	

Table (ii): OECD Europe exports to the United States by air - 1970

(Commodities involving 1,000 tonnes or more)

RANK	SITC CODE	DESCRIPTION	TONNES AIR	TONNES SEA	% AIR
1.	851.0	Footwear	24,854	69,811	26
2.	841.4	Clothing, accessories, etc. knitted or crocheted	6,847	3,725	65
3.	717.1	Textile machinery	6,256	54,742	10
4.	651.0	Yarn and thread	4,699	68,783	6
5.	841.1	Clothing of woven textiles	4,440	3,962	53
6.	653.7	Knitted or crocheted fabric	3,375	2,132	61
7.	725.0	Electrical household equipment	3,342	57,539	5
8.	732.8	Motor vehicle and tractor parts n.e.s.	3,290	154,963	2
9.	831.0	Travel goods, handbags, etc.	3,256	3,056	52
10.	711.5	Internal combustion engines excluding aircraft	3,042	96,757	3
11.	714.9	Office machines n.e.s.	2,921	5,529	35
12.	893.1	Rubber and plastic manufactures	2,515	24,976	9
13.	714.2	Calculating and adding machines	2,371	7,953	23
14.	724.9	Telecommunications equipment n.e.s.	2,304	6,591	26
15.	719.8	Machinery and mechanical appliances	2,197	27,112	7
16.	892.9	Printed matter n.e.s.	2,081	7,124	23
17.	695.2	Tools n.e.s.	1,928	27,446	7
18.	719.2	Pumps, centrifuges, etc.	1,895	104,058	2
19.	719.9	Machinery parts and accessories n.e.s.	1,751	16,387	10
20.	861.2	Spectacles and frames	1,708	837	67
21.	653.5	Woven fabric of non-cellulosic fibre	1,650	1,362	55
22.	722.1	Electric power machinery	1,592	32,771	5
23.	892.1	Maps, charts, books, pamphlets, etc.	1,533	39,453	4
24	841.3	Clothing and accessories of leather	1,446	259	85
25.	891.1	Tape recorders, record players, etc.	1,447	16,017	8
26.	729.5	Electrical measuring and controlling apparatus n.e.s.	1,405	1,691	45
27.	719.5	Powered tools n.e.s.	1,364	39,804	3
28.	652.2	Cotton fabrics n.e.s.	1,292	15,077	8
29.	655.4	Coated or impregnated textiles	1,235	6,418	16
30.	722.3	Electrical apparatus for making, etc., electrical circuits	1,212	7,142	[illegible]
31.	894.4	Fishing, hunting, sports equipment etc.	1,164	10,563	[illegible]
32.	512.0	Organic chemicals	1,138	634,072	
33.	862.4	Photographic film and plates	1,131	13,235	
34.	861.9	Measuring, control, etc. instruments n.e.s.	1,079	2,917	[illegible]
35.	611.3	Leather - calf	1,058	2,426	[illegible]
36.	653.6	Woven fabrics of manmade fibre n.e.s.	1,953	5,236	[illegible]
37.	611.9	Leather n.e.s.	1,038	1,792	
		TOTAL	106,919	1.573,718	
		GRAND TOTAL OF EXPORTS TO UNITED STATES	175,372	28.204,002	0.

Table (iii): United States potential air exports to Europe - 1970

(Commodities involving 1,000 tonnes or more air exports presently)

RANK	SITC CODE	DESCRIPTION	POTENTIAL TONNES METHOD A	POTENTIAL TONNES METHOD B
1.	512.0	Organic chemicals	11,174	-
2.	729.9	Electrical machinery n.e.s.	10,695	1,995
3.	051.9	Fresh fruits n.e.s.	5,164	2,943
4.	581.2	Polymer and copolymer materials	4,630	1,011
5.	862.4	Photographic film and plates	3,796	1,728
6.	719.9	Machinery parts and accessories	3,429	236
7.	664.7	Safety glass	3,427	1,591
8.	678.5	Iron and steel tube and pipe fittings	3,424	853
9.	719.3	Mechanical handling equipment	3,404	3,404
10.	729.3	Electronic tubes	3,342	-
11.	891.2	Phonographic records and other sound media	3,099.	107
12.	662.3	Bricks and other refractory construction materials	2,513	2,513
13.	684.2	Aluminium and aluminium alloys	2,462	216
14.	719.2	Pumps, centrifuges, etc.	2,337	2,337
15.	054.5	Fresh vegetables n.e.s.	2,239	1,384
16.	724.9	Telecommunications equipment	1,820	1,820
17.	653.5	Woven fabrics of non-cellulosic fibres	1,777	1,777
18.	891.1	Tape recorders, record players, etc.	1,674	125
19.	892.9	Printed matter n.e.s.	1,647	11
20.	719.8	Machinery and mechanical appliances n.e.x.	1,526	1,526
21.	714.9	Office machines n.e.s.	1,481	278
22.	711.5	Internal combustion engines excluding aircraft	1,460	1,460
23.	722.2	Electrical apparatus for making, etc , electrical circuits	1,444	913
24.	717.1	Textile machinery	1,407	1,407
25.	719.1	Heating and cooling machinery	1,148	594
26.	893.0	Plastic articles n.e.s.	1,088	997
27.	732.8	Motor vehicle and tractor parts n.e.s.	1,056	481
28.	719.5	Powered tools n.e.s.	1,046	1,046
29.	722.1	Electrical power machinery	958	958
30.	719.6	Non-electrical machines n.e.s.	939	843
31.	861.9	Measuring, control, etc., instruments n.e.s.	885	665
32.	655.4	Coated or impregnated textiles	855	855
33.	653.7	Knitted or crocheted fabric	812	785
34.	861.7	Medical instruments	788	51
35.	734.9	Aircraft parts and accessories	781	781
36.	711.4	Aircraft engines	730	730
37.	718.2	Printing and bookbinding machinery	668	312
38.	642.9	Art paper	618	166
39.	861.6	Photographic equipment	587	587
40.	698.9	Articles of base metal n.e.s.	497	497
41.	695.2	Tools n.e.s.	496	152
42.	718.4	Construction and mining machinery	444	444
43.	729.5	Electrical measuring and controlling apparatus	411	411
44.	581.1	Polymer and copolymer products	370	370
45.	714.2	Electronic computers	276	136
46.	899.6	Orthopaedic appliances	17	7
		TOTAL	94,841	41,503

Table (iv): European potential air exports to United States - 1970

(Commodities involving 1,000 tonnes or more air export presently)

RANK	SITC CODE	DESCRIPTION	POTENTIAL TONNES	
			METHOD A	METHOD B
1.	512.0	Organic chemicals	37,362	37,362
2.	851.0	Footwear	27,522	1,375
3.	711.5	Internal combustion engines excluding aircraft	18,743	503
4.	891.1	Tape recorders, record players, etc.	9,920	-
5.	719.5	Powered tools	8,983	7
6.	695.2	Tools n.e.s.	4,962	197
7.	725.0	Electrical household equipment	4,770	2,626
8.	722.1	Electrical power machinery	3,770	3,770
9.	655.4	Coated or impregnated textiles	3,682	507
10.	652.2	Cotton fabric n.e.s.	3,541	103
11.	732.8	Motor vehicle and tractor parts n.e.s.	3,120	3,120
12.	651.0	Yarn and thread	2,985	464
13.	714.2	Electronic computers	2,678	638
14.	717.1	Textile machinery	2,606	941
15.	841.1	Clothing of woven textiles	2,565	623
16.	722.3	Electrical apparatus for making, etc., electrical circuits	2,523	20
17.	719.9	Machinery parts and accessories n.e.s.	2,494	2,494
18.	862.4	Photographic film and plates	2,295	1,112
19.	653.7	Knitted or crocheted fabrics	2,068	2,068
20.	714.9	Office machines n.e.s.	1,928	738
21.	719.8	Machinery and mechanical appliances n.e.s.	1,926	104
22.	653.6	Woven fabrics of manmade fibres n.e.s.	1,783	1,556
23.	729.5	Electrical measuring and controlling apparatus n.e.s.	1,610	694
24.	611.3	Leather - calf	1,557	141
25.	831.0	Travel goods, handbags, etc.	1,538	1,538
26.	724.9	Telecommunications equipment n.e.s.	1,364	530
27.	611.9	Leather n.e.s.	1,325	219
28.	841.4	Clothing accessories	1,314	1,314
29.	894.4	Fishing, hunting, sports equipment	1,306	908
30.	719.2	Pumps, centrifuges, etc.	1,142	343
31.	893.1	Rubber and plastic manufactures n.e.s.	1,056	65
32.	861.9	Measuring, control, etc. instruments n.e.s.	1,019	-
33.	892.1	Maps, charts, books, pamphlets, etc.	989	-
34.	653.5	Woven fabrics of non-cellulosic fibres	604	604
35.	861.2	Spectacles and frames	563	-
36.	892.9	Printed matter n.e.s.	342	195
37.	841.3	Clothing and accessories of leather	158	51
		TOTAL	168,113	66,930

Table (v) : Potential air trade - United States exports to Europe - 1970

(Commodities involving 1,000 tonnes or more air exports presently)

COUNTRY	TOTAL TONNES	AIR TONNES	% AIR	POTENTIAL AIR TONNES	
				METHOD A	METHOD B
AUSTRIA	-	-	-	-	-
BELGIUM/LUX.	637,547	9,265	1.5	13,018	6,348
DENMARK	10,038	576	5.7	371	193
FINLAND	7,908	11	0.1	237	79
FRANCE	180,255	18,161	10.1	3,517	2,102
GERMANY, FED. REP.	398,353	25,168	6.3	19,084	8,457
GREECE	4,773	61	1.3	362	316
IRELAND	579	412	71.2	46	46
ITALY	219,431	8,441	3.8	7,030	4,395
NETHERLANDS	1.306,066	10,494	0.8	22,308	8,583
NORWAY	2,264	44	1.9	1,805	1,184
PORTUGAL	827	151	18.3	455	455
SPAIN	118,385	1,658	1.4	3,952	2,485
SWEDEN	57,511	3,141	5.5	8,306	4,001
SWITZERLAND	6,759	1,500	22.2	1,489	893
UNITED KINGDOM	410,867	35,888	8.7	12,861	1,966
TOTAL	3.361,563	114,971	3.4	94,841	41,503

Table (vi) : Potential air trade - Europe exports to United States - 1970

(Commodities involving 1,000 tonnes or more air exports presently)

COUNTRY	TOTAL TONNES	AIR TONNES	% AIR	POTENTIAL AIR TONNES	
				METHOD A	METHOD B
AUSTRIA	8,212	1,093	13.3	1,999	827
BELGIUM/LUX.	95,334	1,191	1.3	8,925	5,840
DENMARK	12,551	2,503	19.9	1,636	318
FINLAND	-	-	-	-	-
FRANCE	90,795	7,224	7.9	7,969	4,247
GERMANY, FED. REP.	424,434	20,613	4.9	47,155	12,793
GREECE	-	-	-	-	-
IRELAND	3,606	2,143	59.4	253	-
ITALY	502,220	30,664	6.1	49,916	23,761
NETHERLANDS	99,667	2,245	2.3	7,591	7,228
NORWAY	547	22	4.0	129	70
PORTUGAL	4,025	274	6.8	1,142	586
SPAIN	73,328	7,096	9.7	11,758	4,530
SWEDEN	25,505	2,993	11.7	2,427	697
SWITZERLAND	17,117	3,059	17.9	1,406	793
UNITED KINGDOM	242,423	17,214	7.1	25,807	5,240
TOTAL	1.599,764	98,334	6.1	168,113	66,930

Appendix II

Summary of Cargo Traffic Flow Survey

The study consisted of a survey and analysis of the cargo traffic flow at Copenhagen airport.

1. Survey

The survey involved three basic phases: data collection, commodity coding and data processing.

1.1. Data collection

The data collection phase involved a physical survey and airwaybill (AWB) review.

The physical survey activity was conducted intermittently over a period of three months, September-November 1971. A balanced and representative mix of cargo was sought by sampling on various days of the week and times of day. From shipment labelling items of information such as AWB number, shipment weight, number of pieces and origin - destination were recorded on data sheets - see example shown in FIG. 1. The external measurements of each piece in a shipment were also registered along with its nature and handling characteristics as defined in Table 1.

The completed data sheets were matched against shipment documents in an AWB review and other information concerning commodity description, declared value and flight information added where available.

1.2. Commodity coding

The cargo traffic flow sample was also coded according to the Standard International Trade Classification (SITC). The assigned commodity codes represent the most detailed category or classification consistent with the description obtained from the AWB and package labels. A general commodity description on the AWB results in a general code on the data sheet, i.e. one ending in one or two zeros.

For example, a shipment identified only as "Electrical Machinery" would be coded 7200, whereas the same shipment described as "Telecommunications Equipment"would be coded 7240, and, if more precisely defined, as "Televisions" the SITC code would be 7241.

The SITC system was found to be inapplicable for classifying certain sample shipments and additional codes were fabricated. The most·used of such codes was 9319. This was constructed for shipments described only as "General Cargo", for shipments of multiple commodities without specific weight and commodity assignments per piece and for shipments not located during the AWB review. Other artifical codes used were:

Table 1: Cargo traffic flow handling characteristics

PKG - Packaging characteristics

1 Carton (Cardboard container closed on six sides, plus cardboard mailing tubes and heavy envelopes.)

2. Box (Wood, metal or plastic container closed on six sides, including trunks and suitcases.)

3. Crate (Partially enclosed containers, including kennels.)

4. Pallet (Cargo mounted on forkliftable type base regardless of top or side covering.)

5. Vessel (Barrel, drum and specialized cylindrical containers.)

6. Bag (Flexible container of plastic, fabric, etc.)

7. Banded (Two or more packages banded or tied together to form one piece without any pallet base.)

8. Container (IATA registered containers.)

9. Other (No protective cover or other packaging method.)

HDL - Handling characteristics

1. General (No special handling restrictions.)

2. Environmental (Temperature, pressure, humidity restrictions.)

3. Fragile

4. Dangerous (Flammable, explosive, radioactive, etc.)

5. Fragile and dangerous

6. Fragile and environmental

7. Dangerous and environmental

STK - Stackability characteristics

0. Unstackable (Cargo cannot be stacked on top of the piece without incurring damage.)

1. Stackable

UNT - Unitization characteristics

0. Unitized (Two or more packages or items physically constrained to form one shipment piece as frequently occurs in banded, palletized and containerized packaging.)

1. Single piece

DATE

AWB No.	COMMODITY	SITC CODE

COMMENTS:

SHIPMENT DATA			
ITEMS	WEIGHT-KGS		
ORIG	DEST	A/C	

DECLARED VALUE U.S. $

No. OF ITEMS	WEIGHT EACH KGS	LENGTH CMS	WIDTH CMS	HEIGHT CMS	PKG	HDL	STK	UNT

A/C	PKG	HDL	STK	UNT
0 = PAX 1 = FRT	1. Carton 2. Box 3. Crate 4. Pallet 5. Vessel 6. Bag 7. Banded 8. Container 9. Other	1. General 2. Environ-mental 3. Fragile 4. Dangerous 5. Fragile - Danger 6. Fragile - Environ. 7. Dangerous - Environ.	0 = Unstackable 1 = Stackable	0 = Unitized pieces 1 = Single piece

Fig 1: CARGO TRAFFIC FLOW SURVEY DATA SHEET

9110 Postal packages and diplomatic material;
9310 Personal effects;
9311 Human remains; and
9710 Coin and legal tender

1.3. Data processing

The information contained on the data sheets was keypunched and certain sample statistics derived by computer processing. The mean values of sample characteristics generally represent the quotient obtained by dividing the total number of the sample (pieces or shipments) into the sum of the applicable characteristic such as cube or weight. Mean density was computed as the quotient of the summations of weight and cube for a specific sample segment. Mean value per kg was also to be calculated per sample shipment but this was not possible due to poor sample data in this respect.

2. Analysis

2.1. Physical characteristics of the cargo flow

A total of 11,734 shipments representing approximately 1,200 tonnes and covering 210 SITC commodity codes are included in the survey. In total the sample represents about 4% of the total cargo flow through Copenhagen airport during the period over which it was taken. The cargo traffic characteristics derived from the sample are summarised in Table 2 and illustrated in FIGS. 2 to 11. In addition, Table 2 identifies some 41% of the shipments by the type of aircraft used for transportation. Although including only 34 to 37% of the weight, cube and number of pieces in the total sample, certain variations in characteristics were found which indicate that generally smaller shipments are carried on passenger aircraft, presumeably because of the limitations imposed by belly loading.

The 227 kgs/m^3 density of cargo carried on passenger aircraft is surprisingly low, being only slightly greater than the density mean for the sample as a whole. In the analysis of weight characteristics per piece - see FIG. 5 - an inverse relationship was found between piece weight and density in the lower piece weight range, the frequency curve of traffic flow by cube cumulating increasingly faster than that by weight as piece weight rises. Due to the generally lower average weight per piece of cargo carried on passenger flights this traffic was, therefore, expected to exhibit a higher than average density. Conversely, freighter cargo was generally expected to be of lower than average density because of its higher average piece weight. The sample evidence does not support this, however, possibly due to the fact that distinction between aircraft type used could only be made with respect to certain routes.

Table 2. Cargo traffic flow characteristics - survey results

Sample characteristic	Passenger flights	All-cargo flights	Total flights
Shipments	3.372	1.469	11.734
Pieces	9.185	10.978	53.976
Cube (cu. meters)	667	1.319	5.632
Weight (kgs)	151.530	269.645	1.220.052
Cube per shipment (cu. meters)	0.198	0.898	0.478
Weight per shipment (kgs)	44.9	183.6	104.0
Density (kgs/cu.meter)	227.2	204.4	217.5
Pieces per shipment	2.7	7.5	4.6
Cube per piece (cu. meters)	0.073	0.120	0.104
Weight per piece (kgs)	16.5	24.6	22.6

FIGS. 2 to 11 provide an insight into the variations in density and other characteristics for the sample as a whole. Although the frequency curves of weight and cube for shipments and pieces shown in FIG. 2 and 3 cumulate uniformly over the whole density range, up to 300 kgs/m^3 the quantity of pieces cumulates more rapidly than the quantity of shipments. This means that, for example, while 35% of the number of pieces have a density less than 143 kgs/m^3 i.e. below the minimum density requirement of

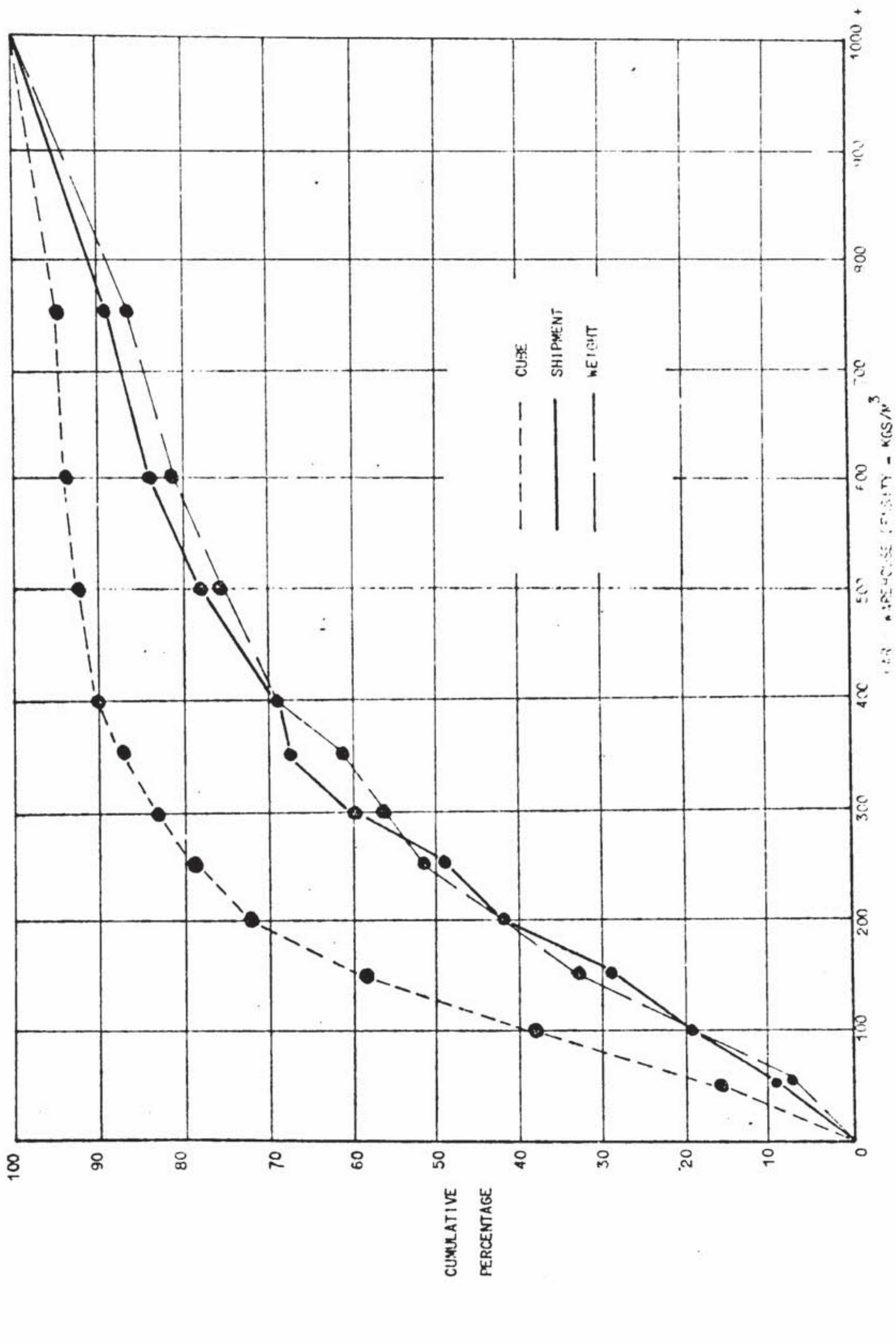


Fig 2: CUMULATIVE FREQUENCY CURVES OF SHIPMENT DENSITY

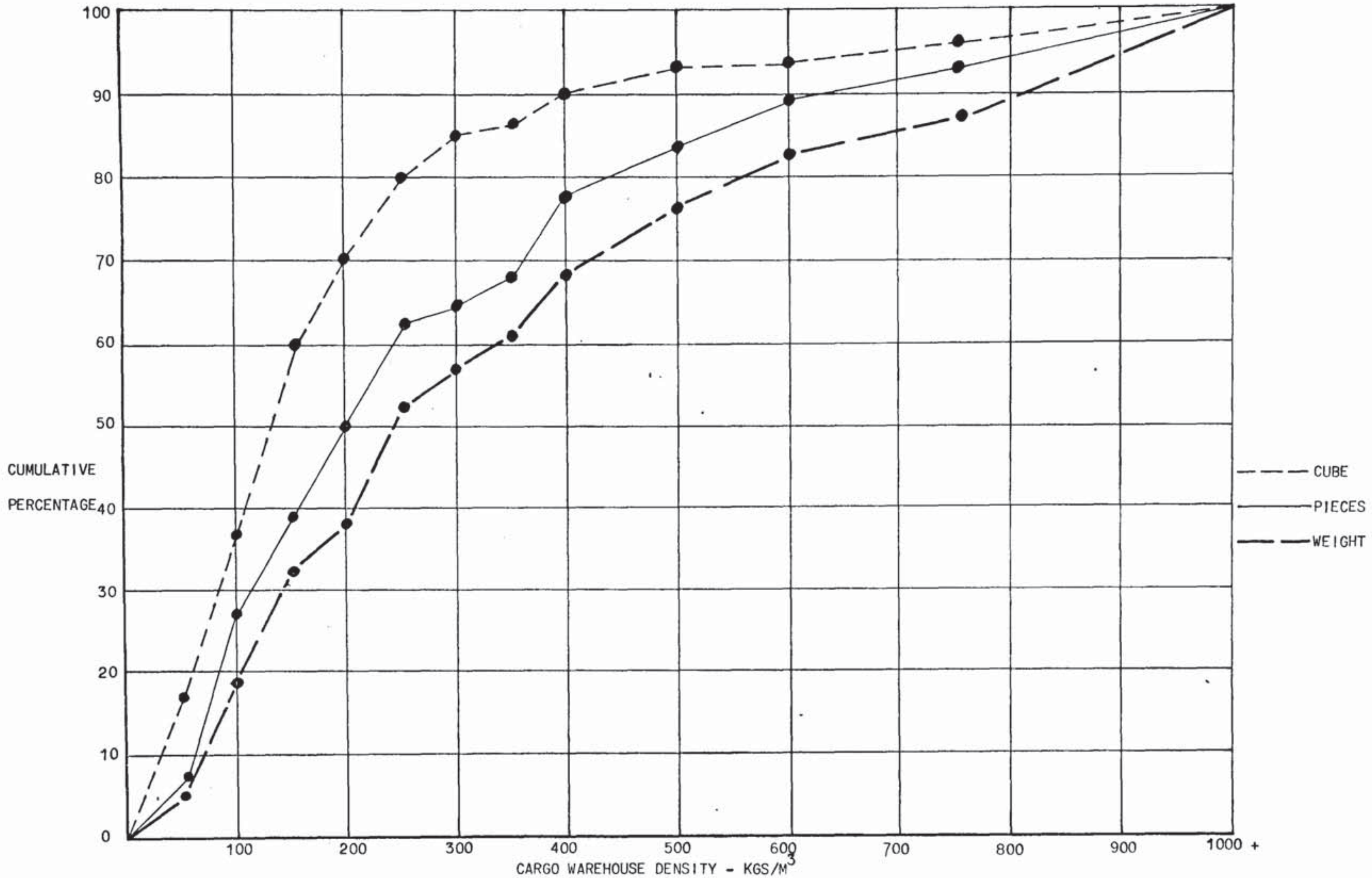


Fig 3: CUMULATIVE FREQUENCY CURVES OF PIECE DENSITY

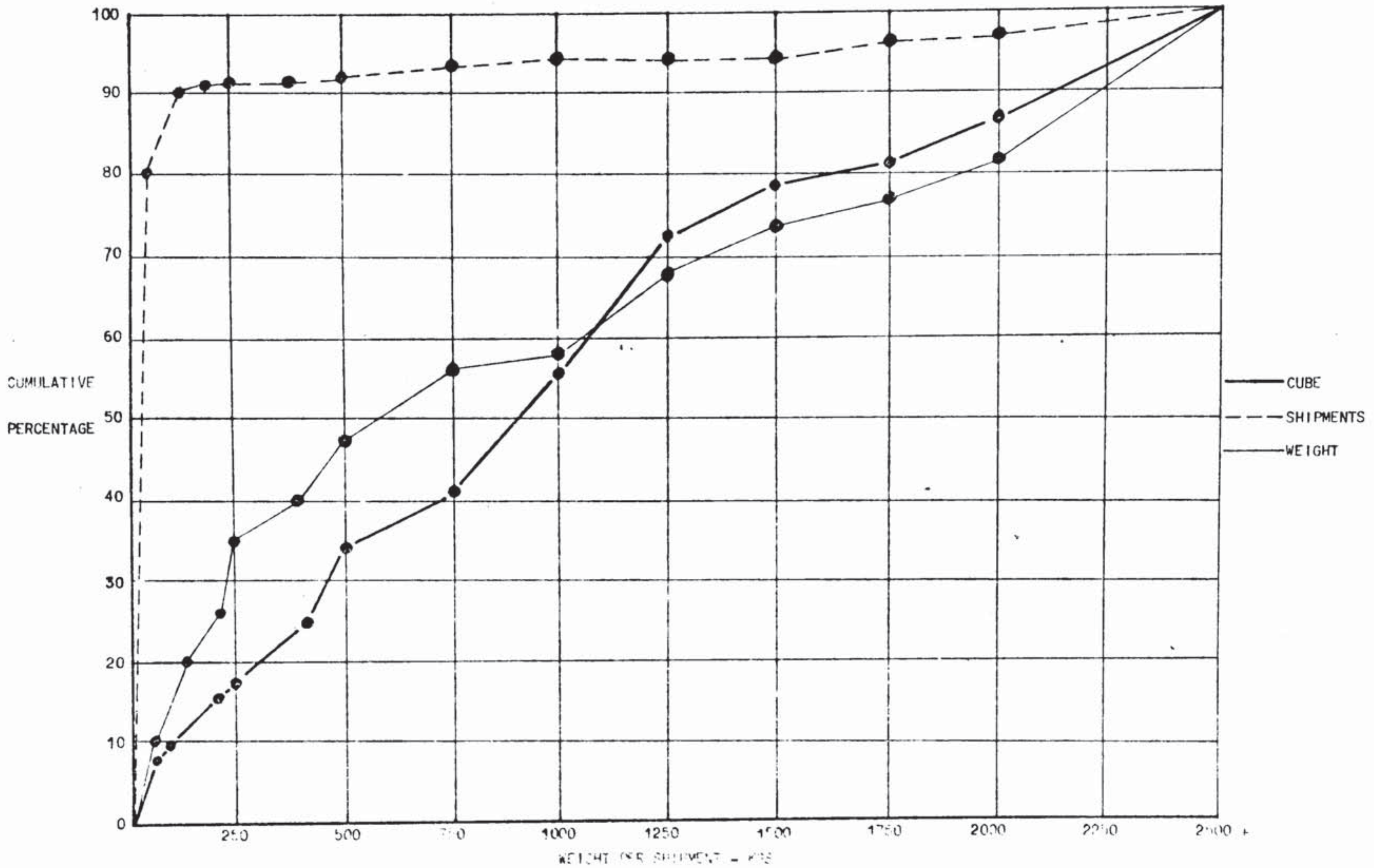


Fig 4: CUMULATIVE FREQUENCY CURVES OF WEIGHT PER SHIPMENT

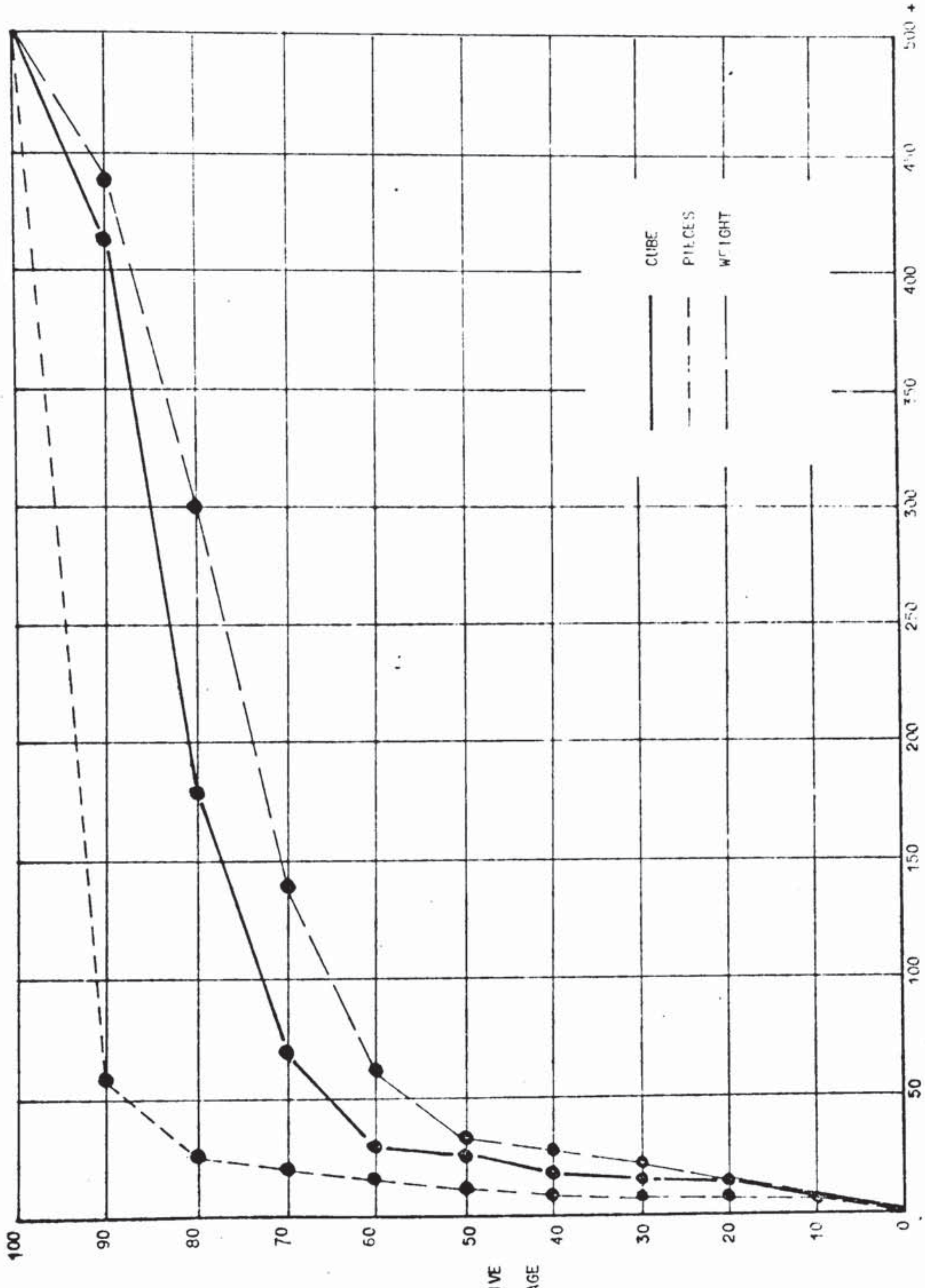


Fig 5: CUMULATIVE FREQUENCY CURVES OF WEIGHT PER PIECE

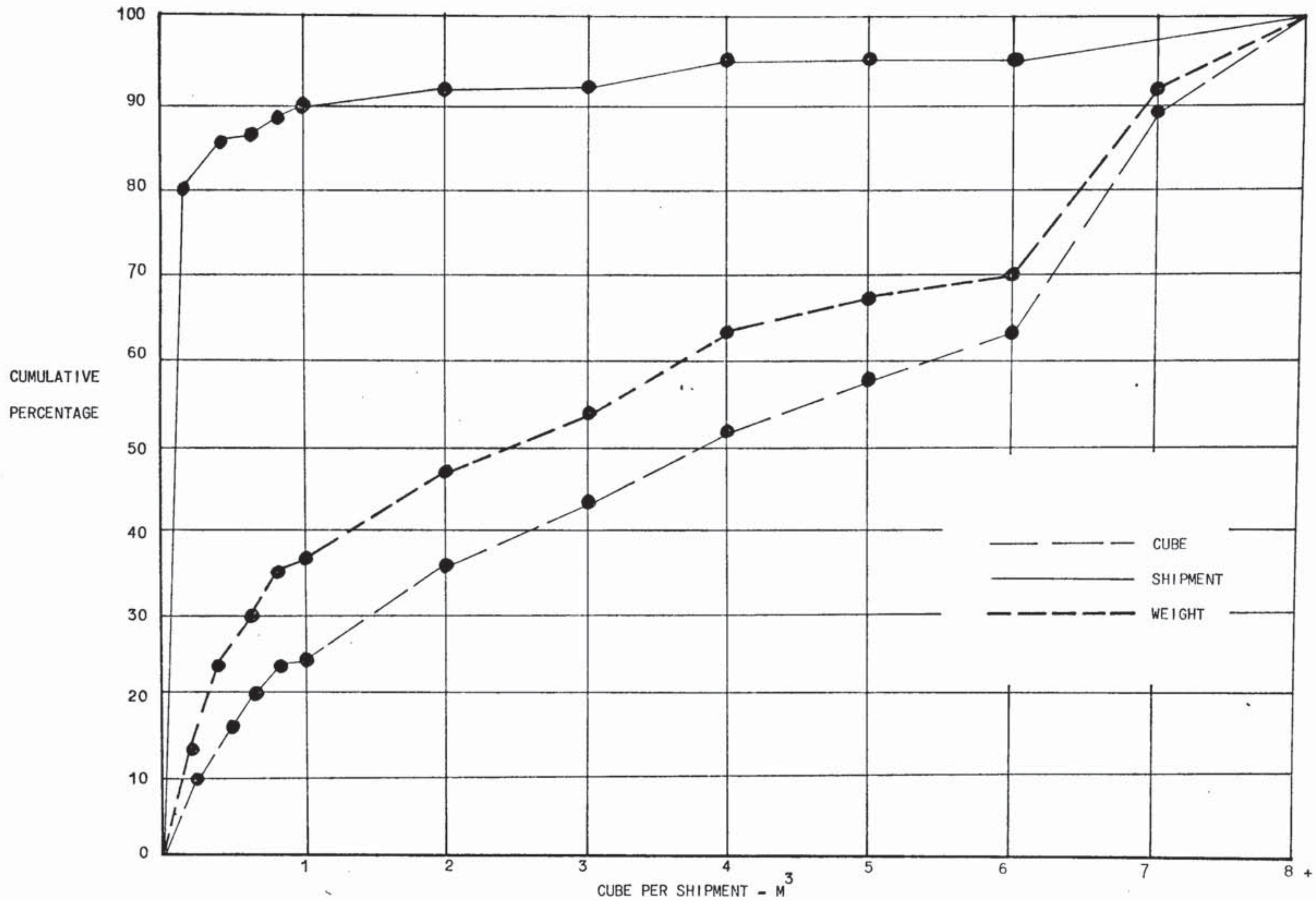


Fig 6: CUMULATIVE FREQUENCY CURVES OF CUBE PER SHIPMENT

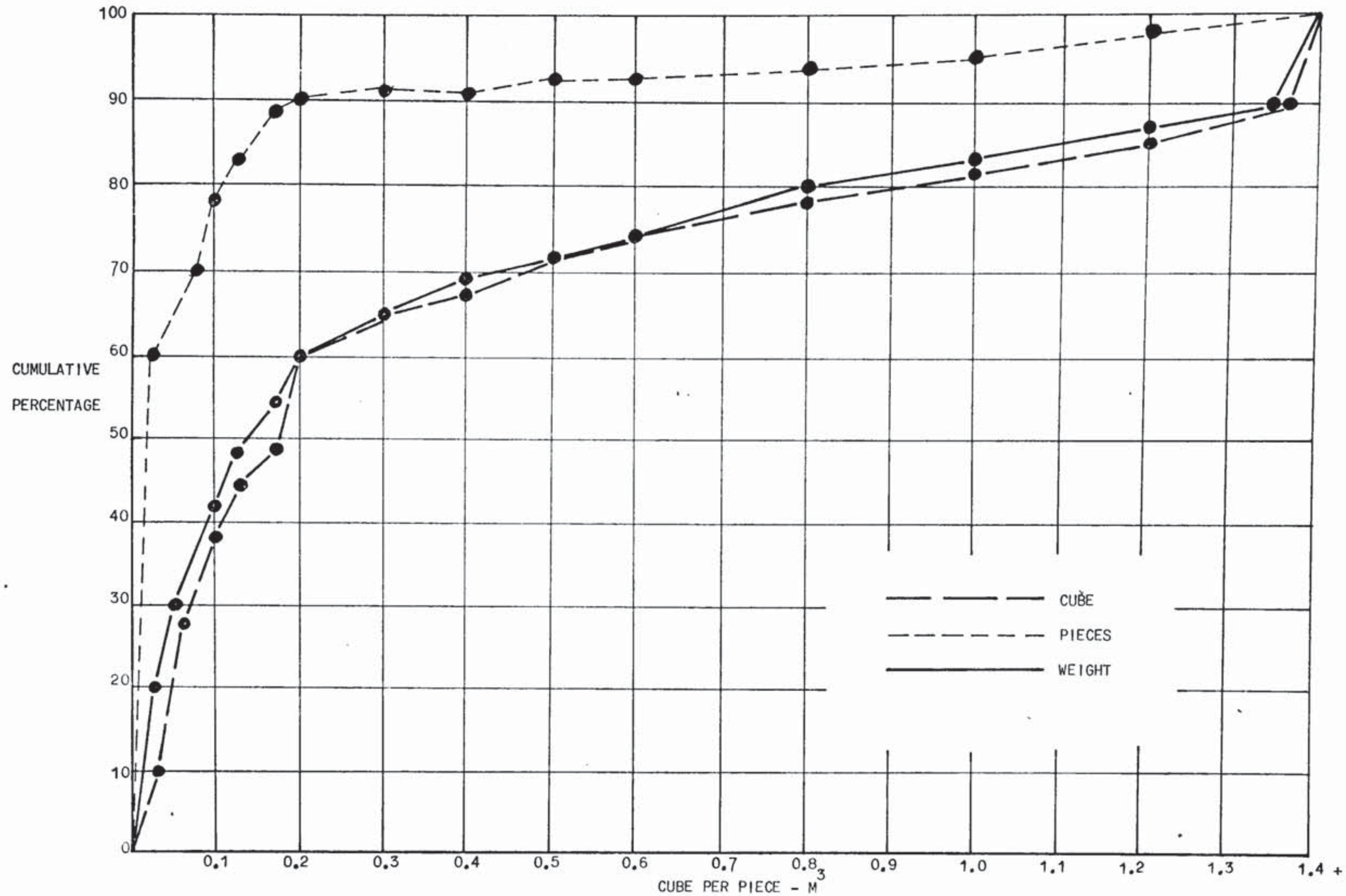


Fig 7: CUMULATIVE FREQUENCY CURVES OF CUBE PER PIECE

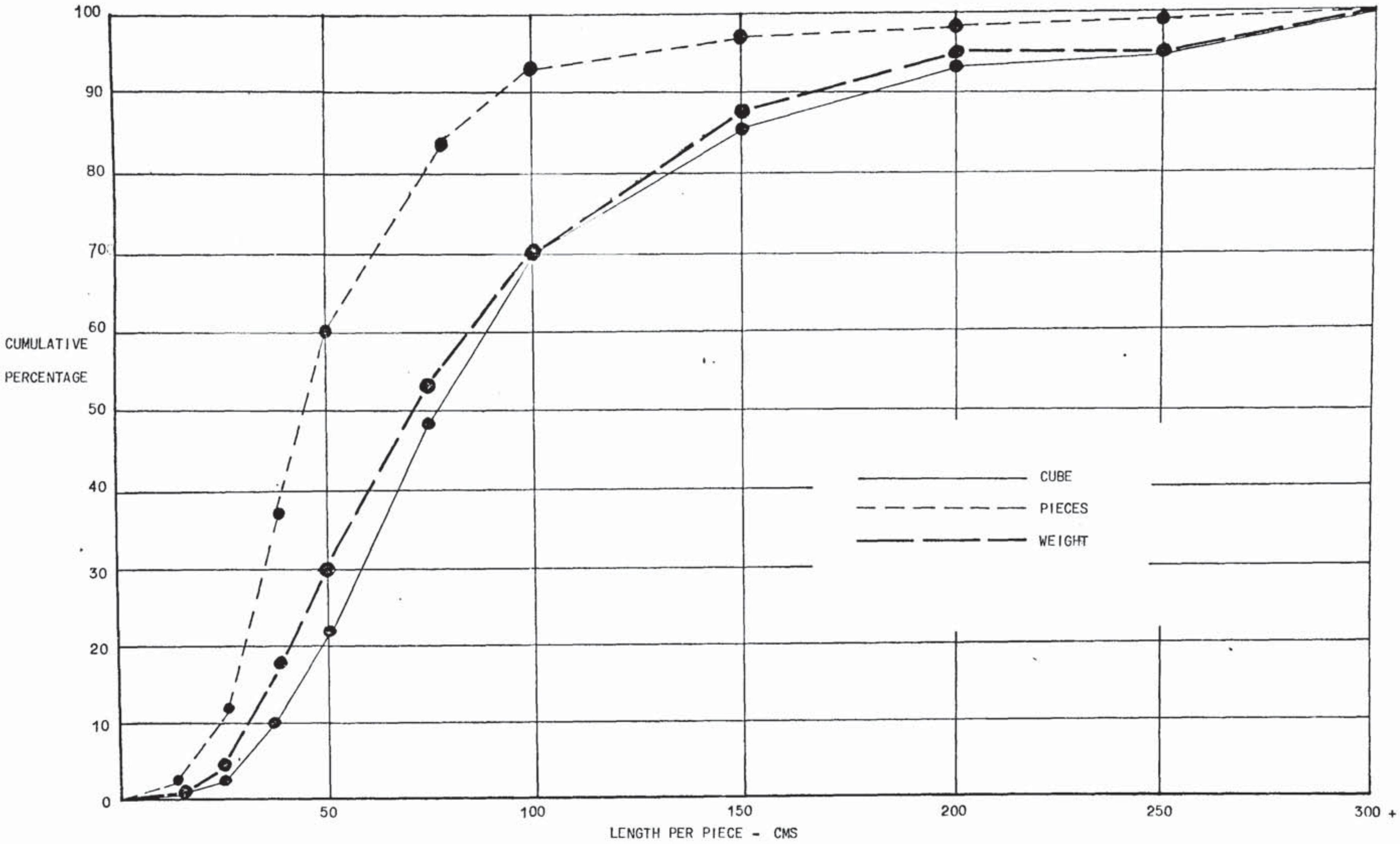


Fig.8: CUMULATIVE FREQUENCY CURVES OF LENGTH PER PIECE

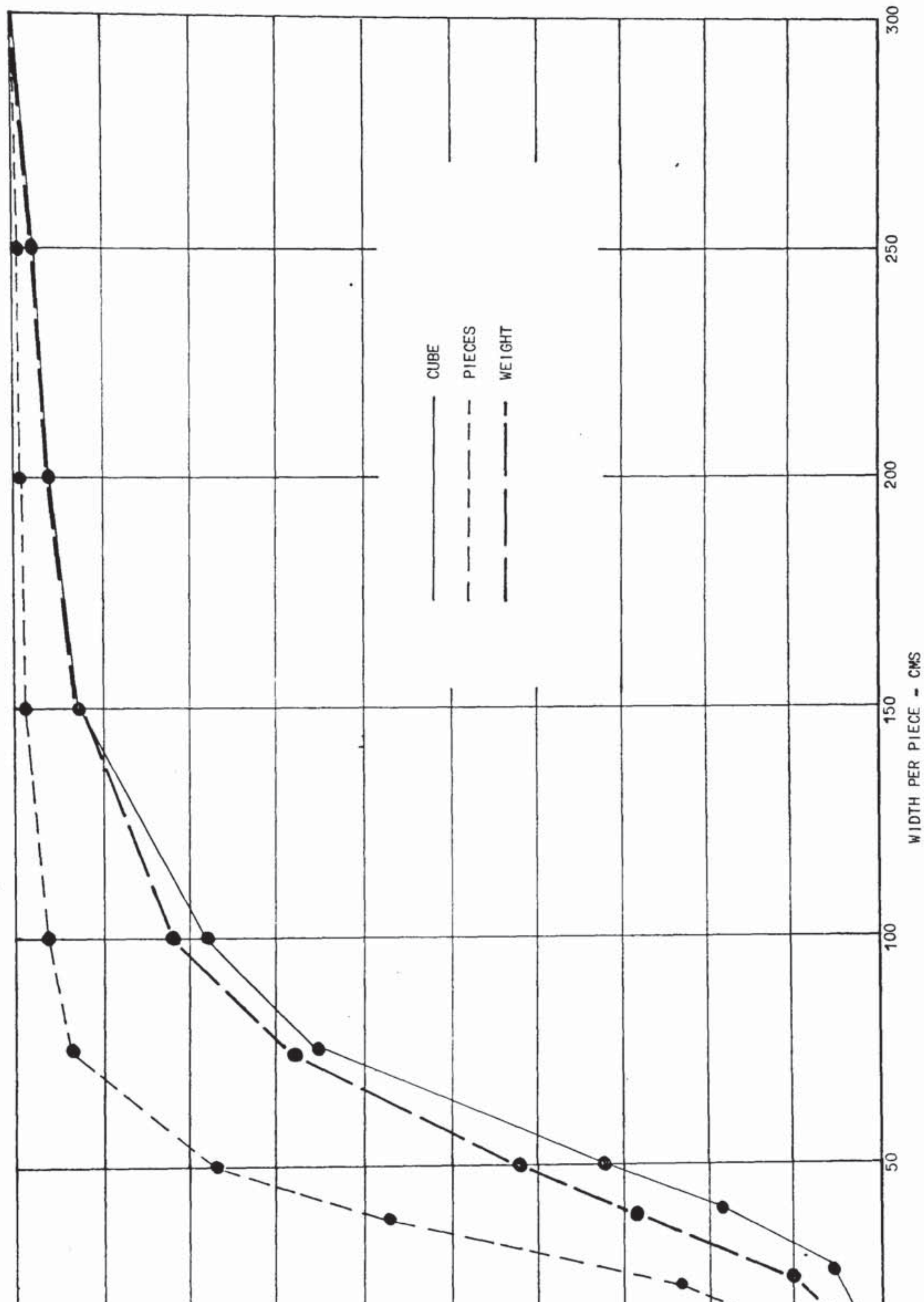


Fig 9: CUMULATIVE FREQUENCY CURVES OF WIDTH PER PIECE

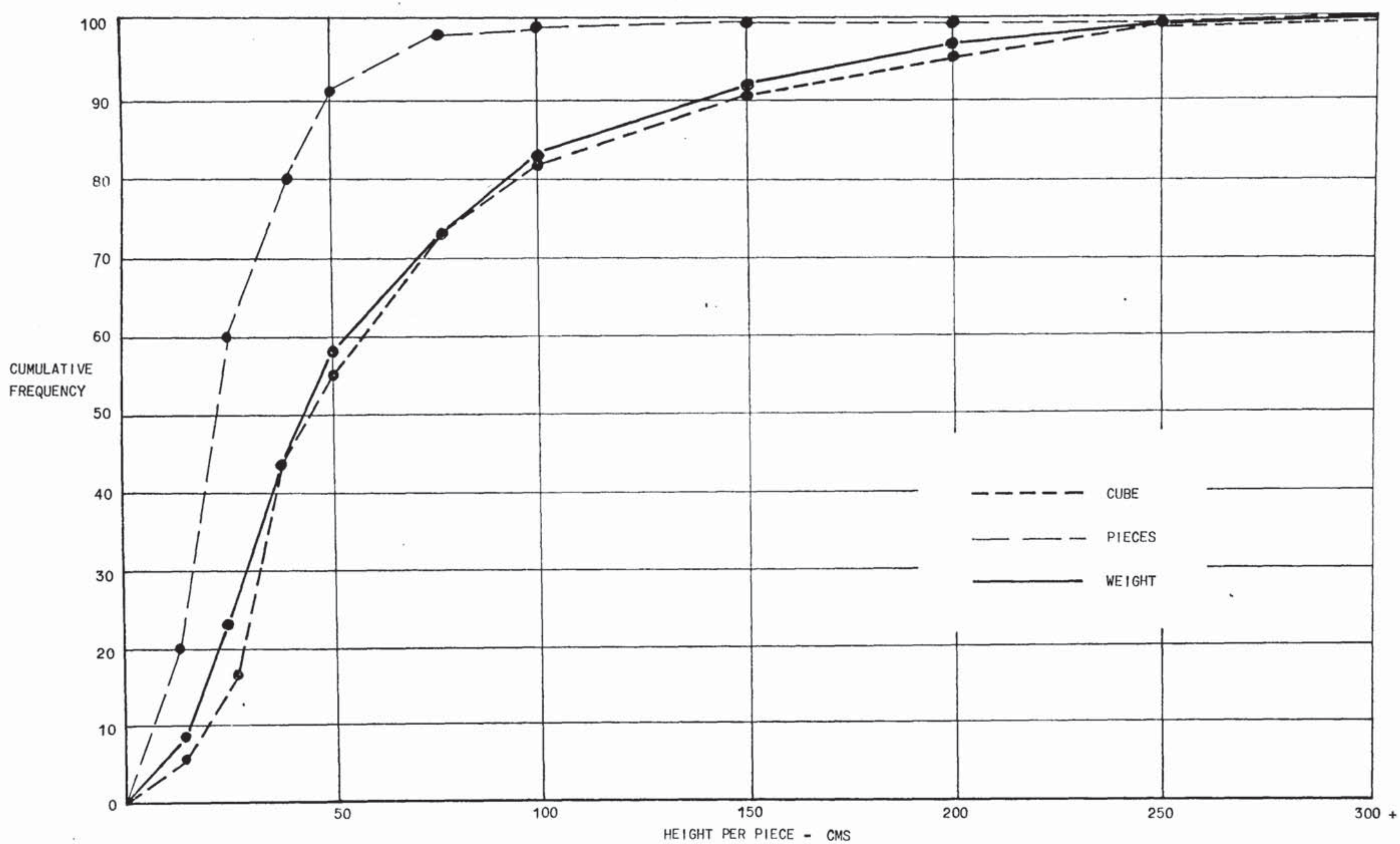


Fig 10: CUMULATIVE FREQUENCY CURVES OF HEIGHT PER PIECE

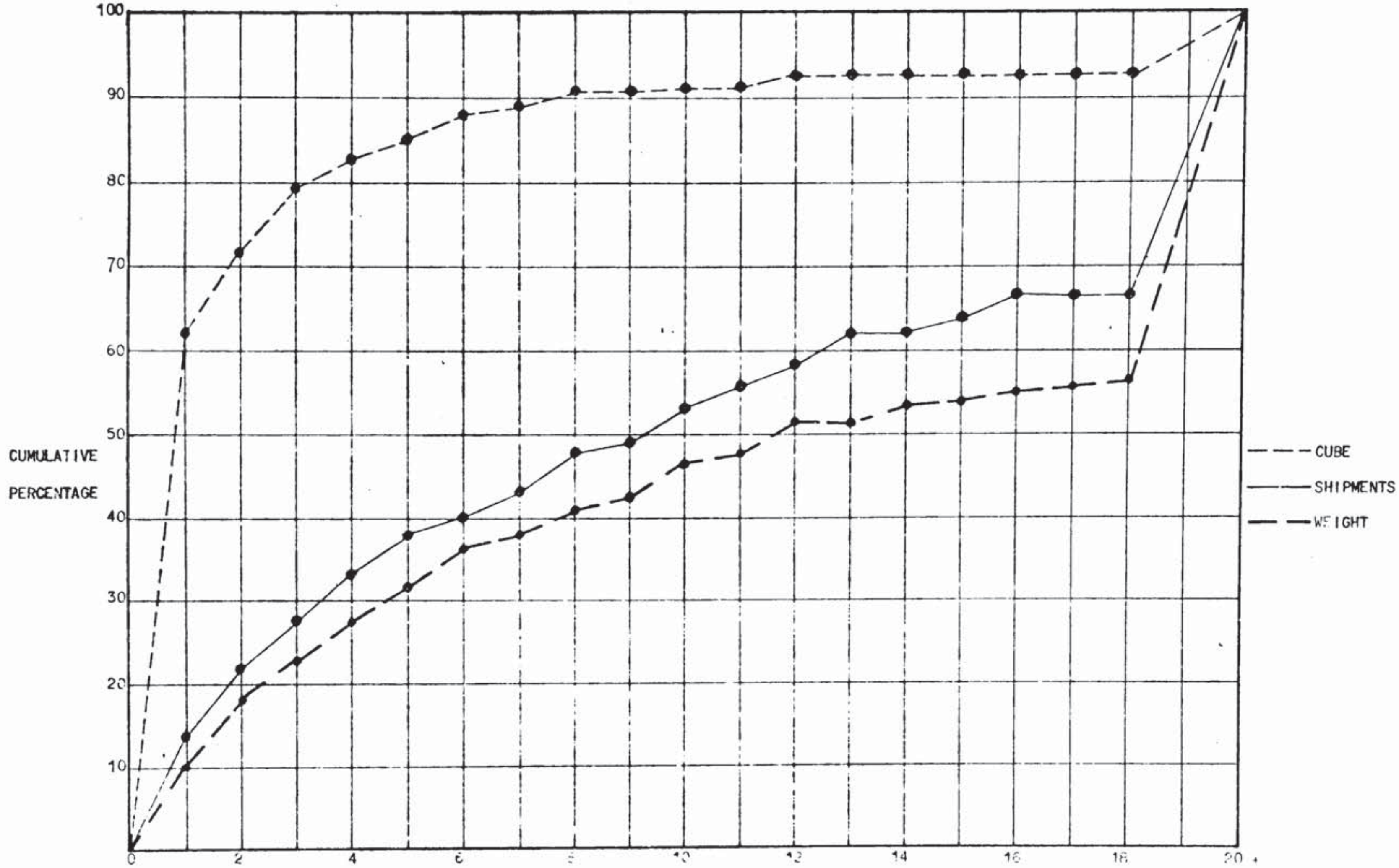


Fig 11: CUMULATIVE FREQUENCY CURVES OF NUMBER OF PIECES PER SHIPMENT

the IATA tariff, only about 25% of all shipments are below this level. FIGS. 4 and 5 show the frequency curves of weight per shipment and per piece. The shipment weight curve shows that some 80% of all shipments weigh less than 45 kgs and nearly 90% less than 100 kgs. Since shipment weight cumulates faster than cube through this range these smaller shipments tend to be of higher density than the overall average. Shipment density appears to decrease over the weight range from 300 kgs to 1,250 kgs and significantly so between 750 kgs and 1,250 kgs. The 5% of shipments above 1,250 kgs tend to be of relatively higher density, accounting for 32 and 27% respectively of the total sample weight and cube. FIG. 5 indicates that whilst almost 90% of all pieces weigh less than 50 kgs they account for only a little over a half the traffic flow by weight.

FIG. 6 shows that although only 10% of the number of shipments are larger than 1 m^3, they account for 64% by weight and 76% by cube of the total sample. Some 80% of all shipments are by comparison smaller than 0.2 m^3. FIG. 7 shows that approximately 90% of all pieces are less than 0.2 m^3 and account for some 60% by weight and cube of the total sample. Almost 85% of the sample by weight is in pieces of 1 m^3 or less.

FIGS. 8, 9 and 10 illustrate the sample cumulative frequency curves for piece length, width and height respectively. Approximately 90% of all pieces exhibit lengths, widths and heights less than 90, 70 and 50 cms respectively.

FIG. 11 shows that over 60% of all shipments are of a single piece, 80% of 3 pieces or less and 90% of 8 or less, these proportions accounting for 12, 37 and 48% respectively by weight. Almost 25% by weight is in shipments of 18 or more pieces.

Over 95% of the shipments surveyed had complete origin-destination information. Only 40 of the 857 city pairs identified, however, had any appreciable cargo flow and 14 of these major city pairs involved 5 or less shipments. To balance possible variations from these large shipments and to provide an overall view of the pattern of cargo movement it was decided, therefore, to show the percentage flow composition and mean characteristics by region only. This information is presented in Table 3.

European intercontinental exports account for well over a third of the total air trade flow in terms of weight, and equals the total for all intra-European traffic. Intercontinental imports are considerably less, representing a little under 25% of the total. Over two thirds of all European intercontinental trade appears to be with North America, accounting for 53% of exports and 76% of imports. North Atlantic trade flow are of approximate equal scale in the east and westbound directions.

Shipment characteristics vary greatly between regions and by direction

Table 3: Regional pattern and characteristics of cargo traffic flow

Cargo traffic flow by region	Percentage of				Mean shipment			Mean piece		Mean density (kgs/m³)
	Shipments	Pieces	Weight	Cube	Weight (kgs)	Cube (m³)	No. of pieces	Weight (kgs)	Cube (m³)	
European exports to:										
Africa and the Middle East	12.2	9.2	8.4	7.1	71.6	0.279	3.7	19.4	0.075	259
Asia and Australasia	2.6	2.0	3.4	2.5	136.0	0.462	3.5	38.9	0.132	295
North America	11.2	26.1	19.9	34.5	184.8	1.479	10.7	17.3	0.138	125
South America	5.5	4.9	6.0	4.3	113.5	0.376	4.1	27.7	0.092	301
Total intercontinental exports	31.5	42.8	37.7	48.4	124.5	0.738	6.3	19.8	0.117	169
European imports from:										
Africa and the Middle East	2.0	2.1	1.4	1.3	72.7	0.311	4.8	15.1	0.065	232
Asia and Australasia	6.8	7.4	4.4	4.4	67.3	0.296	5.0	13.5	0.059	229
North America	13.8	16.5	18.8	15.9	141.7	0.553	5.5	25.8	0.101	225
South America	0.6	0.2	0.1	0.1	17.4	0.080	1.5	11.6	0.053	219
Total intercontinental imports	23.2	26.2	24.7	21.5	110.7	0.445	5.2	21.2	0.086	247
Intra-European traffic	45.3	31.0	37.6	30.1	86.3	0.319	3.1	27.8	0.103	270
TOTAL	100.0	100.0	100.0	100.0	104.0	0.478	4.6	22.6	0.103	217

of trade, the average shipment size in intercontinental air trade, for example, being some 37% greater than for intra-European traffic. There is, however, a wide range of average shipment weights within the intercontinental traffic, especially between North Atlantic traffic and the rest. In the east and westbound directions average shipment weights in North Atlantic air trade are approximately 28 and 48% greater respectively than the average for European exports as a whole. In terms of the average number of pieces per shipment North Atlantic traffic is again outstanding. The overall sample average is 4.6 pieces per shipment, but this would fall to around 3.5 if the 5.5 and 10.7 averages for North Atlantic traffic east and westbound were excluded.

With respect to physical density intra-European traffic appears to have the highest being some 60% above European intercontinental exports, almost 25% above the overall sample average and 9% above European intercontinental imports. North Atlantic air trade totally is some 24% lower than the sample average density, 42% below westbound but 18% above eastbound.

2.2. Packaging and handling characteristics of the cargo flow

Classified by the packaging and handling categories shown in Table 1 the most common type of cargo is non-unitized and packed in stackable cartons requiring only general handling consideration. This class accounts for some 70% of all pieces and 44% by weight. Considering packaging only, cartons account for more than 80% of the pieces, 60% of cube and 50% by weight and have physical characteristics (167 kgs/m^3, 0.081 m^3, 13.5 kgs and 53 x 39 x 39 cms) lower than the arerage for all surveyed pieces (217 kgs/m^3, 0.104 m^3, 22.6 kgs 63 x 45 x 36). Pallets or boxes are the next most common packaging with 13% and 31% respectively of the traffic by weight. The nature of cargo shipped on pallets or in boxes is reflected by their higher than average package charateristics: 285 kgs/m^3, 0.248 m^3, 70.8 kgs 110 x 55 x 41 cms.

Cargo requiring only general handling accounts for 85% of all pieces and 80% by weight. All other forms of handling requirments are negligible, with the exception of fragile cargo which represents approximately 10% of the pieces and 16% by weight. Less than 1% of all pieces appear to be liable to damage from stacking but, by virtue of above average characteristics (321 kgs/m^3, 0.562 m^3, 180 kgs and 110 x 58 x 88) this traffic represents some 6% of the total traffic by weight. Most of the unstackable cargo is shipped on pallets and lacks any protective packaging.

2.3. Commodity characteristics of the cargo flow

General cargo (SITC 9319) accounts for 13% of the pieces and 14% of cube and weight. The characteristics per shipment of this kind of traffic are lower than the overall sample average in respect of number of pieces 2.7, weight 66.5 kgs and cube 0.283 m^3 but slightly higher in density 235 kgs/m^3. Characteristics per piece are, however, slightly above the average at 25.0 kgs and 0.105 m^3. Because of its composite nature this category has been excluded from the commodity rankings shown in Table 4.

The top twenty commodities by weight account for 39, 48 and 47% of the total sample by number of shipments, pieces and weight respectively. Taken together the mean shipment characteristics of this traffic flow (202 kgs/m^3, 133 kgs, 0.662 m^3 and 5.6 pieces) are slightly below the overall sample average in terms of density but above in all other respects.

A mean warehouse density of approximately 250 kgs/m^3 is generally required to obtain full utilization of the payload capability of present all-cargo aircraft given an optimum stacking efficiency of 70-75%. As density increases the required level of stacking efficiency decreases. Table 4 shows that Beverages, Chemicals, Machinery and Machinery Parts, and Printed Materials all provide excellent air cargo from the density standpoint. Other factors such as the fragility of bottled beverages or the flammability potential of some chemicals may, however, seriously downgrade the attractiveness of such commodities. Statistical Machines and Automobile Parts exhibit marginally high densities but are limited as to stackability when heavy packaging is omitted as it usually is. Travel goods, clothing, footwear and plastic articles are all of low density and generally offer little possibility from a stacking point of view.

The variations in density shown in Table 3 are caused by differences in the commodity composition of traffic between regions. European exports to North America, for example, have a density mean some 42% below the sample mean due to the predominance of low density commodities e.g. clothing, footwear, travel goods, manufactures of leather and textile fabrics. Exports to the less developed regions exhibit by contrast a higher than average density due to the greater flow of capital goods such as machinery and machinery parts.

Table 4: Physical characteristics of the cargo traffic flow in the top twenty commodities

SITC Code	Commodity description	Percentage of sample				Mean shipment			Mean piece		Mean density (kgs/m^3)
		Shipments	Pieces	Weight	Cube	Weight (kgs)	Cube (m^3)	Pieces	Weight (kgs)	Cube (m^3)	
1124	Distilled alcoholicbeverages	0.75	1.66	1.21	0.53	176.5	0.339	10.2	17.3	0.033	524
5100	Chemical elements and compounds	1.15	1.35	1.15	0.50	108.9	0.207	5.4	20.2	0.038	532
6412	Other printing and writing paper	0.29	3.09	0.87	1.40	328.4	2.329	49.5	6.6	0.047	140
6530	Woven textile fabrics	1.47	1.06	1.14	1.14	83.9	0.371	3.3	25.4	0.112	227
7143	Statistical machines	0.44	0.42	4.52	4.25	1118.1	4.613	4.4	254.1	1.048	242
7183	Other food processing machines	0.15	0.06	1.92	1.13	1367.6	3.538	1.9	719.8	1.862	387
7199	Machinery and parts	3.52	1.48	7.54	4.60	398.3	0.934	3.1	128.5	0.301	427
7290	Other electrical machinery	0.94	0.49	1.07	1.29	124.3	0.657	2.4	51.8	0.274	189
7328	Automobile parts	4.04	1.95	3.65	3.47	98.4	0.410	2.2	44.7	0.186	240
7349	Aircraft parts	2.78	1.08	1.27	1.75	49.7	0.303	1.8	27.6	0.168	164
8310	Travel goods, handbags, etc.	0.52	0.91	1.05	2.48	221.1	2.298	8.1	27.3	0.284	96
8410	Clothing	1.53	1.69	0.84	1.97	59.6	0.614	5.1	26.3	0.120	219
8510	Footwear	1.68	8.33	2.53	9.49	422.3	3.421	22.7	18.6	0.151	123
8911	Gramophones, tape-recorders, etc.	0.32	1.95	1.42	1.81	476.7	2.663	27.6	17.3	0.096	180
8912	Recorded tapes & gramophone records	1.21	4.37	2.21	2.59	199.6	1.027	16.7	12.0	0.061	197
8920	Printed matter n.e.s.	8.59	6.61	3.19	1.92	43.9	0.085	6.4	6.9	0.013	531
8921	Printed books, pamphlets, etc.	1.07	1.30	0.83	0.32	84.6	0.144	5.6	15.1	0.026	581
8922	Newspapers and periodicals	1.30	2.01	3.04	0.72	254.9	0.263	7.1	35.9	0.037	994
8930	Plastic articles	0.59	4.12	1.69	4.00	309.9	3.221	32.0	9.7	0.101	96
9310	Personal effects	6.44	3.54	6.30	8.30	106.6	0.617	2.5	42.6	0.247	172
	TOTAL	38.78	47.47	47.44	53.66	133.4	0.662	5.6	23.6	0.117	202

Appendix III

Data appendix

YEAR	TKM	TKHR	ASTK	RTKM	DRTKM	RTKM/NA	TON/NA	DCI
1949	539	1104	40	25.0	29.94	41.91	4.9	275
1950	735	1200	46	23.2	26.73	39.68	6.2	291
1951	870	1205	55	23.4	24.20	40.64	7.5	613
1952	940	1320	64	23.9	25.43	42.83	8.2	376
1953	990	1412	75	24.6	26.54	43.07	8.9	298
1954	1040	1541	86	25.1	27.02	40-94	9.9	316
1955	1240	1653	99	25.6	27.47	37.58	13.0	466
1956	1400	1729	114	24.9	25.88	36.92	18.5	537
1957	1530	1840	133	24.4	24-65	39.13	20.3	417
1958	1570	1945	146	24.4	24.30	40.66	23.9	247
1959	1830	2154	162	24.0	23.86	37.94	32.8	243
1960	2040	2597	184	22.[illegible]	22.74	31.63	46.1	249
1961	2360	3270	212	21.8	21.73	29.73	62.9	261
1962	2770	3841	233	20.3	20.18	26.37	79.7	224
1963	3110	4264	274	20.6	20.54	27.80	90.2	261
1964	3760	4691	306	19.7	19.60	25.22	110-0	258
1965	4800	5190	354	18.2	17.76	22.47	161.4	290
1966	5700	5608	397	16.2	17.00	21.19	200.2	261
1967	6530	6298	497	17.4	16.40	20.[illegible]6	229.8	252
1968	7950	7020	580	16.8	15.46	19.69	301.0	258
1969	9750	7706	673	16.7	14.78	18.33	364.0	265
1970	10460	8315	735	16.2	14.11	18.10	402.8	271
1971	11490	8710	800	15.9	13.78	17.65	489.7	275

FTKM = Million cargo tonne-kilometers
ASTK = Available seat-kilometers billions
RTKM= Cargo yield per tonne-kilometers in US cents
RTKM= Cargo yield North Atlantic
DCI = Dry cargo price index

TKHR = Tonne-kilometers available per flown hour
DRTKM=RTKM deflated by US Wholesale price index
TON = Cargo tonnage North Atlantic

Sources: TKM, TKHR, ASTK ICAO Digest of Statistics "Traffic - 1960 to date- Annual
RTKM RTKM/NA ICAO -"- -"- "Finance" - 1960 to date Annual
For other references see text.

YEAR	DRTKM/NA	DDCI	TKM/LA	RTKM/LA	DRTKM/LA	TON/P	RTKM/P	DRTKM/P
1949		329.34	18.89	37.37	44.76	9.98	36.07	43.20
1950	45.71	335.25	21.67	34.88	40.18	9.99	33.03	38.06
1951	42.03	633.92	24.16	32.67	33.78	12.94	34.23	35.40
1952	45.57	400.00	24.37	32.33	34.40	12.69	35.30	37.56
1953	46.47	321.47	24.98	31.87	34.37	12.43	37.33	40.27
1954	44.07	339.47	28.89	31.78	34.20	14.25	38.11	41.02
1955	40.32	500.00	31.02	30.37	32.58	16.15	38.14	40.93
1956	38.38	558.21	39.08	27.45	28.53	18.32	38.97	40.51
1957	39.56	421.21	50.00	27.12	27.39	19.70	40.10	40.51
1958	40.50	246.07	49.86	26.57	30.07	21.77	39.64	39.48
1960	37.72	241.55	53.57	25.62	25.47	26.56	3859	38.36
1961	31.41	247.57	49.93	26.74	26.55	34.77	34.48	34.24
1962	29.64	260.33	51.49	26.12	26.04	41.03	32.15	32.05
1963	26.21	222.66	54.91	25.66	25.51	51.40	29.53	29.36
1964	27.71	260.22	55.81	26.46	26.39	55.07	28.65	28.57
1965	25.1	256.72	61.74	27.13	26.99	90.23	25.75	25.62
1966	21.93	282.93	92.69	23.04	22.48	147.52	20.85	20.34
1967	20.01	246.46	102.62	23.49	22.19	205.38	18.69	17.65
1968	19.56	237-31	107.37	22.99	21.66	213.99	19.12	18.02
1969	18.11	237.35	129.24	21.82	20.07	209.65	19.77	18.19
1970	17.34	233.18	138.66	20.19	20.02	201.45	19.66	17.67
1971	16.87	229.67	154.87	18.98	18.91	198.56	18.34	17.98

NA = North Atlantic LA = Latin America P = Pacific

DDCI = Deflated dry cargo price index

For sources and other definitions see preceeding page.

YEAR	CTM/US	EXTM/US	RTM/US	EXRTM/US	DRTM/US	EXDRTM/US	RAIL	TRUCK	DRAIL
1949	106	28	19.67	33.70	23.56	40.36	1.34	5.24	1.60
1950	173	38	18.10	35.19	20.85	40.54	1.33	5.01	1.53
1951	176	42	19.01	37.04	19.66	38.30	1.34	5.17	1.39
1952	202	41	19.78	39.68	21.04	42.21	1.43	5.62	1.52
1953	210	44	20.66	39.94	22.29	43.09	1.48	5.73	1.60
1954	207	41	21.85	38.31	23.52	41.13	1.42	5.83	1.53
1955	268	51	21.15	39.64	22.69	42.53	1.37	5.80	1.47
1956	298	53	20.66	36.92	21.48	38.38	1.38	5.97	1.43
1957	350	46	21.39	34.81	21.61	35.16	1.45	6.14	1.46
1958	338	49	22.62	35.54	22.53	35.40	1.46	6.19	1.45
1959	394	57	22.76	36.51	22.62	36.29	1.45	6.28	1.44
1960	418	59	22.80	40.18	22.64	39.90	1.40	6.31	1.39
1961	473	61	22.08	38.91	22.01	38.79	1.37	6.30	1.37
1962	568	69	21.31	38.67	21.18	38.44	1.35	6.41	1.34
1963	645	70	21.72	40.29	21.66	40.17	1.31	6.38	1.30
1964	816	77	20.97	39.78	20.87	39.56	1.28	6.66	1.27
1965	1023	89	20.46	38.00	19.96	37.07	1.27	6.46	1.24
1966	1204	97	20.21	37.47	19.08	35.38	1.26	6.34	1.19
1967	1400	98	19.90	35.93	18.76	33.86	1.27	6.65	1.20
1968	1670	104	19.97	36.33	18.37	33.42	1.31	6.93	1.21
1969	1810	109	19.65	36.19	17.98	33.17	1.34	6.78	1.24
1970	2008	116	18.97	35.88	17.46	32.76	1.29	6.63	1.19
1971	2314	117	18.69	35.67	17.65	32.86	1.19	6.45	1.17

CTM/US = Cargo ton-miles United States Domestic - millions
EXTM/US= Express air cargo United States Domestic - millions
RTM/US = Cargo yield per ton-mile United States Domestic - Us. Cents
EXRTM/US=Express air cargo yield United States Domestic - U.S. Cents
DRTM/US= RTM deflated by U.S. Wholesale Price Index.
EXDRTM/US=Express air cargo yield deflated by U.S. Wholesale Price Index
RAIL = Yield per rail cargo ton-mile U.S. Cents
TRUCK = Yield per truck cargo ton-mile U.S. Cents
DRAIL = RAIL deflated by U.S. Wholesale Price Index

Source: RAIL, TRUCK and DRAIL: Transportation Association of America "Transportation - Facts and Trends" all other CAB "Handbook of Airline Statistics"

YEAR	DTRUCK	ALLDRTM	DRTM+DTR	R	TR	R/TR	POP	WP	IN
1949	6.28	2.50	6.29	535	127	99.92	150	83.5	64
1950	5.77	2.49	5.79	597	173	99.90	152	86.8	75
1951	5.35	2.27	5.36	655	188	99.91	155	96.7	81
1952	5.98	2.59	5.99	623	195	99.90	158	94.0	84
1953	6.18	2.80	6.20	614	217	99.90	160	92.7	91
1954	6.28	2.85	6.24	557	213	99.90	163	92.9	85
1955	6.22	2.72	6.22	631	223	99.88	166	93.2	95
1956	6.21	2.75	6.22	656	249	99.88	169	96.2	99
1957	6.20	2.84	6.19	636	254	99.86	172	99.0	100
1958	6.17	2.94	6.27	559	256	99.87	175	100.4	94
1959	6.24	3.01	6.29	582	279	99.86	178	100.6	106
1960	6.27	3.01	6.31	579	285	99.85	181	100.7	109
1961	6.28	3.06	6.40	570	296	99.84	184	100.3	110
1962	6.37	3.06	6.39	600	309	99.83	187	100.6	118
1963	6.36	3.08	6.66	629	336	99.81	189	100.3	124
1964	6.63	3.15	6.34	666	356	99.77	192	100.5	132
1965	6.30	2.96	6.03	709	359	99.72	195	102.5	143
1966	5.99	2.82	6.31	751	381	99.69	197	105.9	156
1967	6.27	2.98	6.43	731	389	99.64	199	106.1	158
1968	6.38	3.00	6.55	757	396	99.58	201	108.7	165
1969	6.43	2.92	6.67	784	379	99.46	218	109.7	171
1970	6.21	2.94	6.69	765	401	99.41	222	110.4	175
1971	6.18	2.87	6.73	789	395	99.36	234	110.9	178

DTRUCK = Truck cargo yield deflated by U.S. Wholesale Price Index - U.S. Cents
ALDRTM= Average yield for rail, truck and air cargo per ton-mile deflated by U.S Wholesale Price Index - U.S. Cents
DRTM+DTR = Average yield for truck and air cargo deflated by U.S. Wholesale Price Index U.S Cents
R = Rail cargo ton-miles billions US Domestic
TR = Truck cargo ton-miles billions US Domestic
R/TR = Trucking as percentage of total air and truck cargo
POP = United States population - millions
WP = United Stes Wholesale Price Index
IN = United States Index of Industrial Production
›ages except POP, WP and IN ex U.S. Dept. of Commerce, Bureau of
:t of the United States.

Bibliography

1. United Nations "Statistical Yearbook" New York. Various editions.

2. ICAO "Air Freight Europe-Mediterranean Region" Circular 97 - AT/18, Montreal, 1970.

3. IATA "World Air Transport Statistics 1972" Geneva 1973. p.14

4. TAPNER, H. "Air Cargo" London, Cassell. 1969.

5. McDonnel-Douglas Aircraft Company "DISCOM - Distribution Cost Model." Los Angeles, 1967.

6. Transportation Association of America "Transportation - Facts and Trends" Washington D.C. Annual.

7. LEWIS, H.T. , CULLITON, J.W. and STEELE, J.D. "The Role of Air Freight in Physical Distribution" Harvard University Press, 1956. p.171

8. GRAHAM, H. "The Coming Changes in Air Cargo Thinking" Aero Club of Washington D.C. 1970.

9. ALLEN, W.B. and MOSES, L.M. "Choice of Mode in U.S. Overseas Trade: A Study of Air Cargo Demand" Transportation Research Forum, 1968 pp235-248

10. WHEATCROFT, S. "Air Transport Policy" Michael Joseph Ltd., London, 1964. p.23

11. SELZNIK, P "Leadership in Administration" Row Peterson, New York, 1957.

12. LISSITZYN, O.J. "International Air Transport and National Policy" Council of Foreign Relations, New York, 1942.

13. STRASZHEIM, M.R. "The International Airline Industry" The Brookings Institution, Washington D.C. 1969. ch.2

14. THORNTON, R.L."International Airlines and Politics" The University of Michigan, 1970.

15. "Statement of United States International Air Transport Policy" Journal of Air Law and Commerce, Vol.29, 1963 pp.76-81

16. "Statement of United States International Air Transport Policy" Journal of Air Law and Commerce, Vol. 36, 1970. pp.651-660

17. "BEA Financial Targets" Ministry of Aviation, London, 1963.

18. MERCIER, J. "Financial and non-Financial Objectives of Air Transport" Institut Transport Aerien, Paris 1966. pp.20

19. WHEATCROFT, S. "The Economics of European Air Transport" Michael Joseph Ltd., London 1956. p.1

20. CHENG, B. "The Law of International Air Transport" Stevens and Sons Ltd., London 1962. pp.415-446.

21. STURMEY, S.G. "National Shipping Policies" Journal of Industrial Economics, 1965/66 p.14

22. ALEXANDERSSON, G. and NORSTRÖM, G. "World Shipping" Stockholm, 1964. p.119

23. Institut Transport Aerien "Traffic Rights and Freight Growth" Paris, 1967. pp.9-12

24. Civil Aeronautics Board "Economic Regulations Docket 24322" CAB Washington D.C. 1972.

25. European Civil Aviation Conference Document 7575-CATE1, Strasbourg 1954/ Document 7977 ECAC 31, 1959/ Document 8445, ECAC 5-1, 1964.

26. WHEATCROFT, S. "Traffic Conference Organisation and Procedure" IATA, Montreal, 1967. p.102

27. FRIEDLAENDER, A.F. "The Dilemma of Freight Transportation" Washington D.C.: The Brookings Institution, 1969. pp.50-51

28. SCHRIEVER, B.A. and SEIFERT, W.W. (co-chairmen) "Report of the Transportation Workshop, 1967. Air Transportation 1975 and Beyond. A Systems Approach" Cambridge M.I.T. 1968 p.45

29. ICAO "Manual of Air Traffic Forecasting" Doc. -AT/722, Montreal, 1972.

30. SAGINOR, I. and RICHARDS, D.B. "Forecast of scheduled domestic air cargo for fifty states, 1971-1975" CAB, Washington D.C., 1971.

31. KOOPMANS, T.C. "Measurement Without Theory" The Review of Economics and Statistics, XXIX, No.3 June, 1947. pp.161-1

32. QUANDT,R.E. and BAUMOL,W.J. "The Theory of Demand for Abstract Transport Modes: Theory and Measurement" Journal of Regional Science, 6 No.2 (Winter 1966). pp.13-26

33. MARSHALL, Alfred, "Principles of Economics" Eigth edition New York, Macmillan Company. 1920.

34. BENNATHAN, E. and WALTERS, A.A. "The Economics of Ocean Freight Rates" New York: Federick A. Praeger. 1969.

35. Civil Aeronautics Board "U.S. International Air Cargo Markets" CAB,Washington D.C. 1970. p.37

36. KINDLEBERGER, C.P. "Foreign Trade and the National Economy" Yale University Press, 1962. p.12

37. ORCUTT, G.H. "Measurement of Price Elasticities in International Trade" The Review of Economics and Statistics XXXII, No.2, 1950. pp.117-131

38. BALL, R.J. and MARWAH, K. "The U.S. Demand for Imports, 1948 - 1958" The Review of Economics and Statistics XLIV, No.4, 1962. p.397.

39. DEVRIES, B.A. "Price Elasticities of Demand for Individual Commodities Imported into the United States" I.M.F. Staff Paper, Washington,1951. pp.397-419

40. SHINKAI, Y. "Price Elasticities of the Japanese Exports: A Cross-Section Study" The Review of Economics and Statist L, No,2. 1968. p.269

41. ICAO "Air Freight, Trends and Developments in the World Air Freight Industry" Document 8235-C/937, Montreal, 1962. pp.105-108

42. The Boeing Airplane Company, "Forecasts of Free World Passenger and Cargo Air Traffic (1965-70-75)" Renton, 1969.

43. ECKHARD, E.W. "Air Cargo Growth Study 1968-1985" (CMRS 99) Lockheed Georgia Company, Mariette, Georgia, 1970. p.14

44. SEALY, K.R. and HERDSON, P.C.L. "Air Freight and Anglo-European Trade", London School of Economics and Political Science, London, 1961.

45. BENISHAY, H. and WHITAKER,G.R. "Demand and Supply in Freight Transportation" Journal of Industrial Economics XIV, No.3 1966 pp.243-262

46. SMITHIES, A. "Optimum Location in Spatial Competition" The Journal of Political Economy XLIX (1941) pp423-439. Reprinted in American Economic Association "Readings in Price Theory" Homewood, Illinois, 1952. p.491

47. GREENHUT, M.L. "Effects of Excise Tax and Freight Costs: A Geometric Clarification" Southern Economic Journal XXI 1955. pp.330-335.

48. BALASSA, B. and KREININ, M.E. "Trade Liberalisation under the Kennedy Round: The Static Effects" The Review of Economi and Statistics XLIX, No.2 1967, p.130-131

49. HAAVELMO, T. "The Statistical Implications of a System of Simultaneous Equations" Econometrica 11, No.1 1943. pp1-12

50. HOUTHAKKER,H.S. and TAYLOR, L.D. "Consumer Demand in the United States 1929-1970" Cambridge: Harvard University Press 1966. p.7

51. DAWSON M.D. "The Outlook for Air Cargo" Arthur D. Little,In Cambridge, Mass. 1968. p.13

52. CHRIST, C.F. "Econometric Models and Methods" New York, John Wiley and Sons, Inc. 1966 pp525-531.

53. FISHER, F.H. and KAYSEN, A. "A Study in Econometrics : The Demand for Electricity in the United States" Amsterdam: The North Holland Publishing Co., 1962. p.29

54. SOLOW, R.M. "Technical Change and the Aggregate Production Function" The Review of Economics and Statistics, XXXIX, No.3, 1957. pp.312-320

55. EZEKIEL, M. and FOX, K.A., "Methods of Correlation and Regression Analysis, Linear and Curvilinear" New York: John Wiley and Sons, Inc.m 1959.

56. FARRAR, D.E. and GLAUBER, R.R. "Multicollinearity in Regression Analysis: The Problem Revisited" The Review of Economics and Statistics, XLIX, No.1 1967. pp.92-107

57. BALESTRA, P. "The Demand for Natural Gas in the United States" Amsterdam: The North Holland Publishing Co., 1967.

58. DRUCKER, P.F. "The Economy's Dark Continent" Fortune, April 1962, pp103, 265-270.

Data Sources

Civil Aeronautics Board. "Handbook of Airline Statistics" Washington, D.C. Biennial.

International Air Transport Association "World Air Transport Statistics" Geneva, Annual.

International Civil Aviation Organisation "Traffic 1960 -" Digest of Statistics, Series T, Montreal, Annual

International Civil Aviation Organisation "Financial Data" Series F, Montreal, Annual.

Transportation Association of America "Transportation - Facts and Trends" Washington D.C. Annual.

Organisation for Economic Cooperation and Development "Maritime Transport" Paris Annual

U.S. Department of Commerce, Bureau of the Census, "Statistical Abstract of the United States" Washington D.C. Annual.

U.S. Department of Commerce "U.S. General Imports" Report FT 155, 1967 Washington D.C. 1968, Annual.