

## DEMAND FOR AUSTRALIA'S INTERNATIONAL SEA FREIGHT TASK

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### ABSTRACT:

*This paper reports the development of demand models for Australia's international sea freight task, undertaken by the Bureau of Transport Economics' Forecasting Unit. The paper includes a review of sea freight task trends and gives details of the specification and estimation of aggregate demand models to analyse this task.*

*These models were developed for both exports and imports of dry bulk, bulk liquid and general cargoes to and from eight major trade areas. The models, which are estimated by ordinary least-squares regression method, use own commodity price, the price of substitutes, freight rates, national income, demographic and route/market segment specific factors as explanatory variables.*

*The modelling was undertaken as an integral part of a wider on-going BTE project to forecast the international sea freight task to the turn of this century.*

PREAMBLE

The body of this Paper is organised in four sections. Firstly, past trends of base commodity flows by type of shipping services and trade areas are reviewed. Secondly, factors affecting the derived demand for shipping services are identified. Thirdly, aggregate demand models are developed for the major export/import commodities (or commodity groups). Finally, the Paper concludes with a summary and a brief discussion of results.

The views expressed in this Paper do not necessarily reflect those of the Bureau of Transport Economics.

INTRODUCTION

Australia's international trade is dependent upon sea transport. In 1981-82 approximately 99 per cent of the Australian international freight task was carried by shipping services (ABS 1983a). The extent of this task ranked Australia as the world's fifth largest generator of shipping demand (Fearnley & Egers 1982). It also required expenditure on shipping services of over \$A5000 million (ABS 1982).

This Paper reports on part of a wider on-going project undertaken by the Bureau of Transport Economics to forecast demand for these shipping services to the year 2000 (BTE 1984) and contains the main findings and results of exploratory analyses relating to demand for major export and import commodities from which the demand for shipping services is derived.

For these analyses Australian international trade was categorised by the physical characteristics of the commodity traded. The different transport requirements of these commodity groups identify international shipping by ship types and services. Such categorisation is therefore required to allow the allocation of demands generated by Australian trade amongst the different shipping services. The categories of commodities, and associated shipping services are:

- dry bulk comprising iron ore, coal, wheat, sugar, salt and bauxite/alumina, for which bulk carriers provide the main form of transport;
- bulk liquid comprising oil and petroleum products, serviced by tankers; and
- general cargoes comprising manufactures, wool, boneless beef, transport equipment and machinery, for which container ships, reefers (refrigerated capacity), car carriers and roll-on and roll-off ships provide transport.

For each type of shipping service (dry bulk, bulk liquid and general cargo), aggregate demand models for major exports/imports were developed using time-series information commencing in the early 1970s. The ordinary least-squares regression method was used to estimate the demand models.

To allow for differences in shipping distances, local economic, social and demographic factors, technical and political considerations, the analyses were

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disaggregated to a trade area level<sup>1</sup>. For general cargo (liner shipping services) such disaggregation also overcomes, to some extent, possible biases due to organisation of the services through conferences<sup>2</sup> and the resultant geographical division of the markets for liner shipping services.

### INTERNATIONAL SEA FREIGHT TASK; AN OVERVIEW

The relative importance of the three types of shipping services for the export and import trades is shown in Table 1. Dry bulk shipping services clearly dominate the export trades, accounting for over 91 per cent of export gross weight tonnes (gwt) in 1981-82. In the import trades, bulk liquid shipments comprise the majority of seaborne movements. In 1981-82, they represented approximately 50 per cent of the import gwt, with dry bulk and general cargo services accounting for approximately 25 per cent of shipments each.

TABLE 1-AUSTRALIAN EXPORTS AND IMPORTS BY VESSEL TYPE (1981-82)  
(per cent of total gwt)

Vessel type	Exports	Imports
Bulk carrier	91.3	25.0
Tanker	2.6	49.2
General cargo	5.7	24.4
Other vessels	0.4	1.4
<b>Total</b>	<b>100.0</b>	<b>100.0</b>

Source: ABS (1983a).

This section provides an overview of the international sea freight task. For each of the shipping services the major commodities traded are identified. The commodity flows (patterns of trade) are then examined, and the developments in these flows, over the period 1971-72 to 1981-82, reviewed.

#### Dry bulk shipping services

The commodities that comprise the majority of demand for dry bulk shipping services can be categorised into two main groups:

- industrial raw materials - iron ore, coal, bauxite/alumina and salt; and
- agricultural commodities - wheat and sugar.

Although, in 1981-82, shipments of agricultural commodities comprised only 13 per cent of total dry bulk exports the commodity trades in wheat and sugar

1. Eight trade areas were defined. These trade areas (and the major countries in each) comprise Europe group 1 (EEC, Sweden and Switzerland), Europe group 2 (the centrally planned economies), North East Asia (sub-group 1 consisting of Japan and South Korea, and sub-group 2 referring to China, Hong Kong and Taiwan), North America, South East Asia (ASEAN), New Zealand, North Africa/West Asia and Pacific Islands. For a listing of countries in each of the trade areas, see BTE (1984).
2. A conference is an association of liner owners engaged in a particular trade who have agreed to limit competition among themselves.

play a significant role in dry bulk shipping markets. They determine the majority of Australia's demand for small and medium-sized bulk carriers chartered on the spot and time charter markets.

Rock phosphate is Australia's only significant dry bulk import, with Nauru and Christmas Island being the main sources.

#### Commodity flows

The pattern of shipments of industrial raw materials and agricultural commodities between 1971-72 and 1981-82 is reviewed below.

#### *Industrial raw materials*

The industrial raw materials commodity group represents the most significant source of shipping demand generated by Australian trade. In 1981-82, approximately 75 per cent of total export tonnage was provided by these commodities. Iron ore shipments alone accounted for over 40 per cent of exports, coal for approximately 26 per cent, bauxite/alumina for 5 per cent and salt for 2 per cent (Table 2).

TABLE 2-MAJOR DRY BULK COMMODITY EXPORTS BY TRADE AREA (1981-82)  
(million tonnes)

Trade area	Iron ore	Coal	Bauxite/ alumina <sup>a</sup>	Salt	Wheat	Cane sugar
Europe group 1	11.1	7.4	1.6	-	-	-
Europe group 2	-	0.2	1.5	-	2.4	-
North East Asia (sub-group 1)	52.4	31.1	2.3	3.3	1.0	0.7
North East Asia (sub-group 2)	3.8	1.5	-	0.4	1.4	0.4
North America	-	-	3.0	-	-	0.9
South East Asia	1.9	-	-	0.1	0.7	0.4
New Zealand	-	-	-	-	0.1	0.1
North Africa/ West Asia	-	0.3	-	-	3.5	-
Other	5.2	5.5	0.5	-	1.8	0.1
<b>Total exports</b>	<b>74.5</b>	<b>46.1</b>	<b>8.9</b>	<b>3.8</b>	<b>10.9</b>	<b>2.5</b>

a. Refers to 1982 calendar year.

- Nil or rounded to zero

Note: Figures may not add to totals due to rounding.

Sources: ABS (1983b) and Fearnley & Egers (1982).

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Since 1971-72 growth in these commodity flows despite some annual fluctuations, has provided a significant source of world demand for bulk carrier services. Over the period to 1981-82 iron ore exports increased by approximately 44 per cent, coal by 111 per cent, bauxite/alumina by 25 per cent and salt by 57 per cent (Tables 3 and 4).

North East Asia (sub-group 1) dominates the pattern of shipments of industrial raw materials from Australia. In 1981-82 this area accounted for over 86 per cent of total iron ore, 70 per cent of coal, 87 per cent of salt and 26 per cent of bauxite/alumina shipments. Europe group 1, at present, provides the only other major market for these commodities. The North East Asia (sub-group 2) and South East Asia trade areas are expected however to continue to account for an increasing share of the commodity flows. The trend towards a shift in world industrial activities to the newly industrialising Asian economies, and the competitiveness of Australian supplies in the Asia/Pacific region suggest that the trend in the pattern of shipments of industrial raw materials will continue to be away from the traditional markets.

### *Agricultural commodities*

The dry bulk agricultural commodities, wheat and sugar, accounted for 6.2 and 1.4 per cent of total Australian export tonnage respectively in 1981-82. Over the period from 1971-72 to 1981-82 demand for the shipment of both commodities continued to rise; wheat tonnages rose by 29.0 per cent and sugar by 24.4 per cent.

The Europe group 2 and North Africa/West Asia trade areas dominate the pattern of wheat shipments from Australia. For sugar, the North America and North East Asia (sub-group 1) trade areas account for the majority of shipments. Both trade patterns however are influenced greatly by world climatic variation, political relations and the presence of high levels of excess world supply. This renders the forecast of future trends in shipping demand difficult.

### Bulk liquid shipping services

Demand for bulk liquid shipping services is derived from the trades in crude oil and refinery products (such as avgas and low sulphur residues).

In the Australian import trades crude oil dominates shipments, although some quantities of avgas are also imported. The export trades comprise mainly shipments of refinery products.

### Commodity flows

Imports of petroleum products in 1981-82 totalled 13.2 million tonnes (DoT 1983), representing nearly 50 per cent of the total import freight task.

Over the period 1971-72 to 1981-82 tonnages varied with fluctuations in economic conditions and, in particular, oil price increases. Future growth in the market is anticipated due to the declining level of Australian self sufficiency in liquid fuels. The Department of Resources and Energy (1983) forecast that this self sufficiency will decline from 66 to 47 per cent between 1981-82 and 1991-92.

The traditional source of Australian supplies of crude oil is the Persian Gulf/Red Sea region. In 1981-82, 57 per cent of imported crude oil originated in this area (DoT 1983). However the development of alternative world

TABLE 3-MAJOR DRY BULK COMMODITY EXPORTS BY TRADE AREA (1971-72 AND 1981-82)  
(Per cent)

Trade area	Iron ore		Coal		Wheat		Sugar		Salt	
	1971-72	1981-82	1971-72	1981-82	1971-72	1981-82	1971-72	1981-82	1971-72	1981-82
Europe group 1	11.5	14.9	15.7	16.1	7.0	-	26.9	-	-	-
Europe group 2	-	-	-	0.5	7.9	22.1	6.0	-	-	-
North East Asia (sub-group 1)	85.8	70.4	83.4	67.5	17.7	9.1	27.6	28.2	98.8	86.8
North East Asia (sub-group 2)	-	5.0	0.1	3.3	2.3	12.5	-	14.1	-	11.1
North America	1.4	-	-	-	-	-	27.9	36.6	-	-
South East Asia	-	2.6	-	-	4.9	7.1	1.4	15.5	1.2	1.7
New Zealand	-	-	-	-	0.5	0.5	5.9	2.7	-	-
North Africa/ West Asia	-	-	-	0.7	33.3	32.5	-	-	-	-
Other	1.4	7.0	0.9	11.9	26.4	16.3	4.3	2.9	-	0.4
Total ('000 tonnes)	51 906	74 502	21 826	46 121	8 459	10 912	2 008	2 497	2 382	3 747
Percentage change	..	43.5	..	111.3	..	29.0	..	24.4	..	57.3

- Nil or rounded to zero  
.. Not applicable

Note: Percentages may not add to 100.0 due to rounding.

Source: ABS (1983b).

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TABLE 4-EXPORTS OF BAUXITE AND ALUMINA BY MAIN TRADE AREA (1971 AND 1982)<sup>a</sup>

Trade area	(per cent)	
	1971	1982
Europe group 1	21.3	18.2
Europe group 2	7.4	16.6
North East Asia (Japan)	44.1	25.9
North America	21.5	33.6
Others	5.6	5.6
Total ('000 tonnes)	7 091	8 878
Percentage change	..	25.2

a. Calender years.

.. Not applicable

Note: Percentages may not add to 100.0 due to rounding.

Source: Fearnley & Egers (1982).

supplies in Indonesia, and more recently in China, has changed the pattern of crude oil shipments. The competitiveness of these alternative supplies and the continuation of political instabilities in the Middle East region suggest that this trend towards the Asia/Pacific region may continue.

Exports of refined petroleum products fell by 20.5 per cent over the period 1971-72 to 1981-82 due partly to a drop in demand from North America and North East Asia (sub-group 1) (Table 5). The South East Asia trade area recorded the only significant growth in demand.

### General cargo shipping services

The commodities which comprise the majority of demand for general cargo shipping services differ between the export and import trades. For exports the major commodity groups are manufactures, non-bulk general cargo, and agricultural products (boneless beef and wool). The major commodity groups for the import trades are manufactures and transport equipment and machinery.

### Commodity flows

The pattern of shipments of the manufactures and agricultural products (boneless beef and wool) between 1971-72 and 1981-82 is discussed below.

#### *Manufactures and transport equipment and machinery*

In 1981-82 exports of manufactured goods totalled 2.8 million tonnes or 1.6 per cent of the total export freight task (ABS 1983a and 1983d). The major markets for these commodities lie in the Europe group 1 and the South East Asia trade area. In 1977-78 these trade areas accounted for approximately 23 and 22 per cent of total exports respectively (IAC 1981). This pattern

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TABLE 5-EXPORTS OF PETROLEUM PRODUCTS BY TRADE AREA (1971-72 AND 1981-82)  
(Per cent)

Trade area	1971-72	1981-82
Europe group 1	-	1.3
Europe group 2	-	-
North East Asia (sub-group 1)	11.9	4.8
North East Asia (sub-group 2)	-	2.0
North America	19.9	8.2
South East Asia	9.3	33.1
New Zealand	20.2	26.8
North Africa/West Asia	-	-
Other	38.7	23.8
Total ('000 tonnes)	2 168	1 724
Percentage change	..	-20.5

- Nil or rounded to zero

.. Not applicable

Source: ABS (1983c).

represents major change in the distribution of Australian manufactured exports. In 1968-69 North America accounted for about 28 per cent of the total, by 1977-78 its relative importance had fallen to only 10 per cent. The South East Asia trade area and Europe group 2 provided the only major sources of market growth over this period.

The pattern of Australia's import trades has also changed since the late 1960s. The EEC and North America regions have accounted for a decreasing share of the Australian market for general cargo commodities. In particular the pattern of the transport equipment trades has changed markedly. Japan is now the major supplier of vehicles, whereas prior to 1970 it supplied only 15 per cent of the Australian trade. South East Asia has also provided a major source of market growth, particularly in the shipment of miscellaneous manufactures. Almost 20 per cent of these cargoes are currently derived from this region, as compared with only 6 per cent in 1968-69 (Table 6).

The trend towards a shift in world manufacturing activities to the ASEAN region should institute it as a major source of manufactured imports in the future. For the export trades, revival of protectionism in North American and European markets will further increase the importance of trade with South East Asia.



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TABLE 6-SOURCES OF MAJOR IMPORTS BY REGION  
(per cent)

Region	Miscellaneous manufactures		Equipment and machinery		Transport equipment	
	1968-69	1977-78	1968-69	1977-78	1968-69	1977-78
North America	23.7	19.0	35.7	33.6	46.2	22.8
Japan	16.8	17.7	8.6	24.2	15.0	42.6
EEC	42.2	30.7	48.1	30.5	36.6	25.8
South East Asia	5.9	18.6	0.3	3.3	-	3.7

- Nil or rounded to zero

Source: IAC (1981).

*Boneless beef and wool*

In 1981-82 Australian exports of wool and boneless beef<sup>1</sup> totalled 498 000 and 489 000 tonnes respectively (Table 7). Each of the commodities account for about 0.3 per cent of the total export freight task. The major markets for boneless beef are North America and North East Asia (sub-group 1); for wool, the European trade areas and North East Asia (sub-group 1) are the major markets. Since 1971-72 total shipments of boneless beef increased by approximately 31 per cent. The major sources of market growth were in the North East Asia trade area, whilst Europe group 1 and North America became less significant to the freight task.

Over the same period shipments of wool declined by some 28 per cent. The dominant markets for these commodities in 1971-72, Europe group 1 and North East Asia (sub-group 1), decreased their imports of Australian wool by 46 per cent and 57 per cent respectively, during the period to 1981-82 (ABS 1983d). East European and other Asian markets provided some compensation but insufficient to provide major market growth. Similar to other agricultural commodities, the markets for boneless beef and wool are subject to the influence of world climatic variation, political relations and competitive world supplies.

The trend towards a revival of protectionism in North American and European markets and the Japanese negotiation of bilateral trade agreements for an expanded beef trade with the United States suggest that these traditional markets will provide only limited opportunities for increased tonnages. Other Asian markets, however, should again provide for market growth as the development of textile industries and the trend towards increased meat consumption continues.

1. Export of live sheep to the Middle East region was not analysed in this Paper as this trade is not yet classified as a major export commodity. However, there was a marked increase in this trade over the last decade (from \$4.4 million in 1971-72 to \$169.6 million in 1981-82 (ABS 1983c)).

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 TABLE 7-EXPORTS OF BONELESS BEEF AND WOOL BY TRADE AREA (1971-72 AND 1981-82)  
 (Per cent)

Trade area	Boneless beef		Wool	
	1971-72	1981-82	1971-72	1981-82
Europe group 1	10.7	1.6	40.2	29.7
Europe group 2	-	-	8.4	22.1
North East Asia (sub-group 1)	13.4	20.0	42.2	25.3
North East Asia (sub-group 2)	-	4.3	3.2	10.6
North America	72.2	60.7	2.3	2.2
South East Asia	0.5	1.4	-	1.4
New Zealand	-	-	0.1	-
North Africa/West Asia	-	2.5	0.7	0.6
Other	3.2	9.4	2.8	8.0
Total ('000) tonnes	374	489	689	498
Percentage change	..	30.7	..	-27.7

- Nil or rounded to zero

.. Not applicable

Note: Percentages may not add to 100.0 due to rounding.

Source: ABS (1983b).

#### DEMAND FACTORS

The volume of international trade and the shipping distances implied by the pattern of this trade provide the main determinants of shipping demand. Subsequently, the various socio-economic, demographic, technical and political factors which influence the level of international commodity flows are also fundamental to the demand for shipping services. This section reviews the main factors identified as influencing the level of shipments of each of the major commodity groups which comprise Australian international trade.

#### Dry bulk industrial raw materials

The demand for industrial raw materials is primarily derived from the levels of industrial activity/production in major world industrial zones. Relevant industrial activities for the individual commodities comprise steel production for iron ore and coking coal; electricity generation for steaming coal; transportation, packaging, construction and electricity generation industries for bauxite/alumina; and the chemical, food-processing, paper and plastics industries for salt.

Australia faces intense competition in the export of industrial raw materials. Hence, price competitiveness of Australian supply plays a major role. Factors

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contributing to this competitiveness comprise production costs (both in Australia and overseas), relative exchange rates and shipping costs where proximity to the trade area becomes important. Whilst proximity to trade areas places Australian exports at a disadvantage in the more distant European and North American markets, it favours exports to the nearby expanding Asian markets. For example, the percentage of freight rate to fob price for steaming coal to Japan was nearly half the equivalent percentage for steaming coal exported to Western Europe (Table 8).

TABLE 8-STEAMING COAL PRICES AND SHIPPING FREIGHT RATES 1981

Route	Price fob US\$	Freight rate US\$	Price cif US\$
US (East Coast) - N. Europe	50	7-12	57-62
Poland - W. Europe	58	6	64
S. Africa - W. Europe	43	8-13	51-56
Australia - W. Europe	53-57	15-20	68-77
US (East Coast) - Japan	50	18-20	68-70
S. Africa - Japan	43	15	58
Australia - Japan	53-57	7-9	60-66

Note: cif cost of insurance and freight included  
fob free on board

Source: Lloyd's (1981).

Availability and the price of substitute commodities (including their environmental costs) also affect demand for industrial raw materials. Examples include adaptability and price of scrap metals in the steel-making process for iron ore, and alternative energy sources (oil, nuclear, hydro and solar) for steaming coal.

The importance of these economic and technical factors in determining the demand for exports of industrial raw materials is tempered however, by the influence of government policies and production strategies of major industry buyer groups. Bilateral trade agreements often encompass political and/or non-economic considerations. The US-Japan steaming coal trade agreement is an illustration (refer to Table 8 for a comparison of cif prices of American and Australian steaming coal). Strategies adopted by major industry buyer groups aim, among other things, to foster the development of diverse world supplies. These strategies usually involve the imposition of market shares on different suppliers, thus further reducing the role of the economic rationale of comparative advantage in determining trade flows.

### Dry bulk agricultural commodities

Demand for Australian agricultural commodities in the different trade areas is basically determined by the competitiveness of their prices, disposable income and population. Overseas markets for both wheat and sugar are characterised, at present, by intense competition. BAE (1983) and Drewry (1984) estimate

world stocks at the end of the 1983 season to be about 25 per cent and 40 per cent of wheat and sugar world trades respectively. Consequently, international agreements on allocation of trade quotas would be expected to be a major influence on shipment levels.

Market specific factors of particular relevance to these commodity trades are threefold. First is the availability of foreign reserves in centrally planned and developing countries. Hence, also of importance to demand are developments in oil and other commodity prices, interest rates and so on. Second are national governments' policies concerning the promotion of domestic productions through tariffs, quotas and bilateral trade agreements. Of particular significance to Australian trade are the stances on protectionism adopted by the governments in Europe and North America. And third is climatic variation; this will continue to be the major source of short-term fluctuation in Australian and overseas supply.

#### Crude oil and petroleum products

Generally, there is a positive relationship between demand for petroleum products and population and the level of income or economic activity in the consuming countries (Australia for imports and New Zealand, Asian, Pacific Island and North American countries for exports). Other factors which determine the volume of this trade and (hence its impact on the demand for tankers) are briefly commented upon below.

The first factor is the share of petroleum fuels in total primary energy consumption. This share reflects the combined effects of the price of petroleum fuels relative to the prices of alternative fuels, the adaptability of these fuels, and the degree of energy efficiency in the major fuel consuming industries. In Australia, the share of petroleum fuels in the total primary energy consumption is forecast to decline from 40.5 per cent in 1981-82 to just over 33 per cent in 1991-92 (Department of Resources and Energy 1983). Competition from alternative fuels is likely to be similar in export markets. Further, the size of these markets will be also limited by the development of refinery capacity and availability of alternative petroleum supplies, notably from Indonesia and China. Secondly, Commonwealth Government actions and policies may also affect the level of tanker shipments to and from Australia. These include import parity pricing to restrict, among other things, depletion of domestic reserves and taxation allowances for resource development to encourage development of Australian deposits. Finally, shifts in the world distribution of oil production will also have an impact on demand for tankers. As Indonesian and/or Chinese sources of supply become more important to the Australian market, the tonne-kilometre requirement of the import task will fall.

#### General cargo

Although demand for general cargo carriers is derived primarily from the volume of commodity trades (in the same way as demand for dry bulk and bulk liquid carriers), it differs in one major respect. That is, competition from air transport is available. Inter-modal competition can be attributed to certain special features of the general cargo trade. Firstly, the high unit value of commodities reduces the relative significance of transport costs (Walker and Schneider 1980). This allows air services to provide competitive freight services as consignors are more able to trade off increased transport costs for improved service, speed, frequency, and so on. Secondly, the trade's widespread pattern of origins and destinations, and the progressive unitisation of cargoes, increases the viability of transshipment and/or

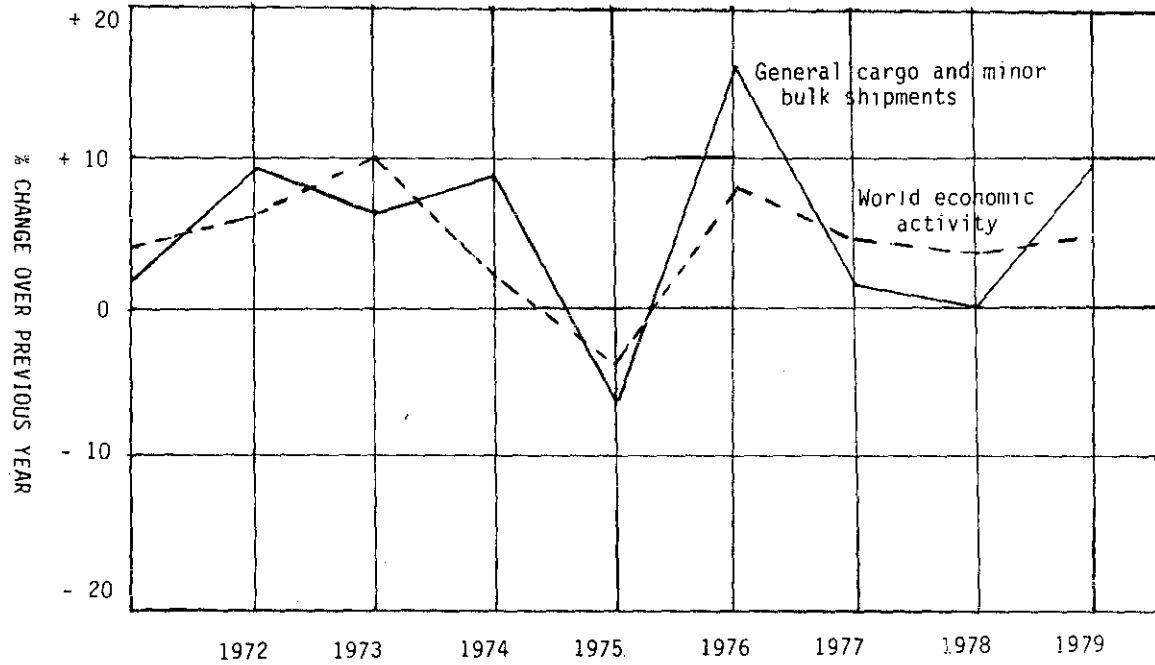


FIGURE 1: WORLD INDUSTRIAL ACTIVITY AND GENERAL CARGO TRADE (1972-1979)

Source: Lloyd's(1982)

'landbridging' options. Thirdly, productivity gains resulting from centralisation of cargoes to a single port for transhipment to continental markets promotes the competitiveness of alternative modes. Finally, the diverse transport requirements of a large number of consignors involved in the trade in turn requires a flexible transport system unable to be served by a single mode.

Hence, factors influencing choice between alternative transport modes such as relative freight rates and quality of service are important. Quality of service is a multi-dimensional concept comprising service speed, frequency, reliability, 'port' servicing, and so on. It should be noted however that the quality of service is, at least in part, a relative concept depending on available transport alternatives. It seems reasonable to assume that reductions in the cost and improvements in the quality of alternative modes will adversely affect demand for liner shipping services.

Levels of economic activity in the major developed economies are of particular significance to world general cargo trade (Figure 1). Available information suggests that demand for general cargo shipping services is very responsive (elastic) to the level of economic activity (Lloyd's 1982). For Australian exports of manufactures, economic growth in oil producing countries and other developing nations is of particular importance in view of these countries increased significance in the trade mentioned earlier.

Finally, revival of protectionism would be expected to adversely affect demand for shipping services. Recent Australian studies indicate that protectionism in Australia will continue to fall (Study Group on Structural Adjustment 1979 and Committee on Australia's Relations with the Third World 1979). However, the observed revival of protectionism overseas and the use of bilateral trade agreements especially by the US Government continues to threaten the course of the general cargo export trades.

#### EMPIRICAL ANALYSIS

This section starts by reviewing the assumptions made relating to the structure of the market for shipping services. These assumptions form the basis of the model specifications reported below. The time-series data used and the estimation procedure followed are indicated. Finally, the results obtained are commented upon.

##### Underlying assumptions

The five basic assumptions believed to reflect the structure of the market for shipping services are:

- supply of shipping services for a given commodity (or commodity group) by trade area is completely elastic in the short run;
- any fluctuations in the demand for shipping services from its expected level would be met through the use of laid-up tonnage or by diversion of supply of shipping services to or from other uses;
- quantities demanded of export/import commodities are in one-to-one relationship to demand for shipping services (no stock buildup or rundown);
- freight rates are established by some authority (for example, conferences for liner shipping services); and

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the demand for shipping services is reconciled with supply during a given time period.

Hence, the market for shipping services can be (in a sense) described as a 'buyers market'. Further, the system of the market structural functions representing the demand and supply relationships and the market clearing identity can be reduced to a single equation. Such a single market function would approximate the Cournot-Marshall demand curve and its specification (following the standard approach, Eriksen 1983) is discussed below.

### Model specification

To allow for differences in shipping distance and market characteristics, both exports and imports were divided into eight trade areas. For each trade area, aggregate demand models were specified for the main export and import commodities by type of shipping service: that is, dry bulk, bulk liquid and general cargo.

Such specification is justifiable since demand for shipping services for a given commodity is derived from the demand for that commodity. In general, the different demand models for exports by trade area and type of shipping service can be expressed in functional form as follows:

$$\text{demand} = f(\text{own price and prices of substitutes, freight rate, income, level of domestic production, population}). \quad \text{Model 1}$$

Imports were considered to be affected by their own price, Australia's socio-economic environment, freight rate, population, production, tariffs and so on. Demand models for imports by trade area and type of shipping service were specified in similar functional forms to Model 1.

The above specification of export/import demand models, yield direct estimates of shipping services responsiveness to changes in freight rates. Bennathan and Walters (1969) proposed an indirect procedure to assess such responsiveness (elasticity of demand of shipping services with respect to freight rates<sup>1</sup>). The Bennathan and Walters alternative procedure was not used in this Paper due to the lack of information on the elasticity of supply of the commodities (or commodity groups) by trade area and shipping service and because of the wider objectives of the BTE study.

### Data and estimation procedure

Annual time-series data covering the period between 1971 and 1982 were used in estimating the parameters of the different demand models for the major export and import commodities by trade area and type of shipping service. Where time-series data were available, North East Asia trade area comprised Japan, South Korea, Hong Kong, Taiwan and China. Otherwise, this trade area consisted only of Japan and South Korea (sub-group 1).

1. Briefly, the alternative procedure utilises both demand and supply price elasticities and the ratio of the commodity transport cost to its price. In the special cases where demand or supply is completely elastic, the procedure reduces to the ratio of transport cost to price being multiplied by either the elasticity of supply or that of demand respectively. A limitation of this approach is, however, that it does not allow for substitution between shipping services.

Sources of information on quantities, prices, freight rates, income (GDP), population, production levels, and so on included the Australian Bureau of Statistics (ABS), Department of Transport (DoT), Department of Trade, Department of Resources and Energy, Australian Shippers' Council (ASC), International Monetary Fund (IMF), Lloyd's Shipping Economist and Drewry's Shipping Statistics and Economics.

The ordinary least-squares regression method was used to estimate the co-efficients of the export/import commodities demand models. In the majority of cases these models were in 'double-log' specification. In such cases, the estimated co-efficients represent average 'constant' elasticities.

### Results and discussion

The results of the statistical analyses for exports of dry bulk, bulk liquid (tanker) and general cargo commodities are reported in Tables 9, 10 and 11 respectively and in Table 12 for imports.

On the whole, the estimated regression models provided very satisfactory explanations of annual variations in export and import commodities (as indicated by the  $R^2$  values). Almost all the estimated co-efficients were of the expected sign on *a priori* grounds and were statistically significant. Finally, Durbin-Watson statistics indicated the absence of any serious serial/auto correlation problems. The main conclusions to be drawn from the analyses are discussed below.

#### Dry bulk export commodities

- Demand was responsive to income and population (estimated demand elasticities were greater than unity) for all trade areas. The exception being wheat exports to Japan where wheat is subject to an import substitution program.
- The own price elasticity of demand for coal, and iron ore and concentrates was about unity possibly reflecting (to some extent) availability of substitutes and subsequent competition.
- For industrial raw materials (particularly coal and iron ore) the greater than unity income and industrial production elasticities suggest responsiveness of demand to the levels of economic activity.
- The estimated freight rate elasticities were generally less than unity indicating limited responsiveness of demand for dry bulk commodities (and hence bulk carriers) with respect to freight rate. The exception was North Africa/West Asia where Australia's wheat exports face competition from North American and EEC countries (demand elasticities with respect to own price and freight rate were about -1.6 and -1.4 respectively).

#### Bulk liquid export commodities

- The own price elasticity of demand for refinery products was less than unity for all trade areas.
- Demand response with respect to freight rate was found to be statistically non-significant.



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TABLE 9-ELASTICITIES OF DEMAND FOR DRY BULK CARGO EXPORTS BY TRADE AREA

Trade area and commodity	Own price	Price of substitute	Relative price <sup>a</sup>	Freight rate	Income (GDP)	Population	Production	Dummy variable	R <sup>2</sup>	Durbin-Watson
<b>North East Asia (sub-group 1)</b>										
Coal			-0.41 (-2.50)	-0.08 (-2.47)	2.49 (9.13)				0.94	1.50
Iron ore and concentrates	-0.81 (-4.69)	0.74 (4.10)			0.94 (2.27)				0.69	1.73
Wheat	-0.25 (-5.94)			-0.06 (-1.95)	-0.87 (-7.80)		-0.14 (-4.34)		0.92	2.58
Cane sugar	-0.16 <sup>b</sup> (-1.49)					4.35 (2.21)			0.71	1.31
Salt	-0.21 (-1.04)					2.80 (3.90)			0.71	1.65
<b>Europe group 1</b>										
Coal	-0.96 (-3.22)	0.33 (1.59)		-0.24 (-5.66)	1.27 (6.07)				0.98	2.49
Iron ore	-1.16 (-7.50)	1.70 (9.13)		-0.11 (-1.70)			2.39 <sup>d</sup> (6.86)	0.08 (7.73)	0.96	2.15
<b>Europe group 2</b>										
Wheat	-0.22 (-0.31)			-0.27 (-0.51)		4.89 (0.62)	-0.33 (-0.28)	-1.33 (-2.83)	0.65	1.86
<b>North America</b>										
Cane sugar	-0.07 (-0.24)	-0.13 (-0.43)		-0.02 (-0.20)		3.84 (2.05)	-1.26 (-2.32)	-0.49 (-5.08)	0.86	2.86
<b>South East Asia</b>										
Wheat	-0.01 (-0.67)					3.12 (1.62)			0.75	1.07
Cane sugar			-0.45 (-1.59)			3.97 (4.18)			0.78	1.42
<b>North Africa/West Asia</b>										
Wheat	-1.54 (-1.29)	3.26 (2.52)		-1.44 (-5.35)	1.55 (10.73)				0.811	2.61

a. Ratio of own price to price of substitute

b. Price plus freight rate.

c. Price of petroleum.

d. Industrial production in preceding year.

e. Stocks from preceding year.

.. not applicable

Note: t values indicating the statistical significance of the estimates are given in brackets.

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TABLE 10-ELASTICITIES OF DEMAND FOR BULK LIQUID EXPORTS (PETROLEUM PRODUCTS CARGO) BY TRADE AREA

Trade area	Own price	Freight rate	Income (GDP)	Production	Dummy variable	R <sup>2</sup>	Durbin-Watson
North East Asia (sub-group 1)	-0.59 (-1.84)	...	0.99 (1.63)	...	...	0.65	1.76
North America	-0.34 (-1.07)	...	3.92 (1.11)	...	-3.92 (-6.34)	0.80	2.13
South East Asia	-0.51 (-3.60)	-0.21 (-1.00)	4.36 (13.40)	...	...	0.99	3.01
New Zealand	-0.68 (-1.76)	0.21 (0.31)	1.31 (0.29)	8.67 <sup>a</sup> (2.43)	...	0.93	2.36

a. Manufacturing activity.

... not applicable

Note: t values indicating the statistical significance of the estimates are given in brackets.

TABLE 11-ELASTICITIES OF GENERAL CARGO EXPORTS BY TRADE AREA

Trade area and commodity	Own price	Price of substitute	Relative <sup>a</sup> price	Freight rate	Income (GDP)	Population	Time variant	Production	Dummy variable	R <sup>2</sup>	Durbin-Watson
North East Asia (sub-group 1)											
Boneless beef	-0.14 (-0.40)	0.85 (2.21)	...	-1.10 (-2.19)	3.83 (3.75)	...	...	-1.10 (-3.12)	...	0.89	2.08
Manufactured goods	-0.95 (-14.05)	...	...	...	1.86 (3.28)	...	...	...	...	0.98	2.23
Wool	...	...	-0.11 (-0.33)	-0.50 (-0.96)	0.14 (0.10)	...	-0.11 (-2.20)	...	...	0.78	2.03
Europe group 1											
Boneless beef	...	...	-0.33 (-0.88)	...	2.49 (0.66)	...	...	-4.80 (-1.72)	...	0.78	0.96
Manufactured goods	-1.44 (-13.76)	...	...	...	...	...	...	2.97 <sup>b</sup> (3.47)	...	0.93	1.04
Wool	-0.26 (-3.45)	...	...	...	0.26 (0.89)	...	...	-5.63 (-9.29)	...	0.90	1.87
Europe group 2											
Wool	...	...	-0.54 (-1.21)	...	2.48 (2.68)	0.10 (0.27)	...	...	...	0.74	1.48
North America											
Boneless beef	-0.03 (-0.18)	...	...	...	0.62 (0.84)	2.66 (1.50)	...	-1.19 (-1.34)	0.03 (2.88)	0.73	1.59

a. The ratio of own price to price of substitute.

b. Industrial production.

... not applicable

Note: t values indicating the statistical significance of the estimates are given in brackets

TABLE 12-ELASTICITIES OF IMPORTS BY TRADE AREA; DIFFERENT CARGOES<sup>a</sup>

Trade area	Own price	Tariff index	Freight rate	Income (GDP)	Population	Production	R <sup>2</sup>	Durbin-Watson
All trade areas (Petroleum products)	-0.13 (-3.48)	..	0.06 (0.92)	..	..	0.34 <sup>b</sup> (3.51)	0.89	1.94
North East Asia	-2.29 (-4.17)	-2.04 (-5.13)	..	0.08 (0.16)	..	..	0.99	2.34
Europe (groups 1 and 2)	-0.51 (-0.76)	-2.19 (-1.60)	-1.45 (-1.66)	..	-4.77 (-1.24)	..	0.95	1.47
North America	-0.79 (-0.72)	..	-1.93 (-1.15)	-0.12 (-0.10)	..	..	0.81	1.85
South East Asia	-1.97 (-2.10)	-0.77 (-0.92)	..	-	..	..	0.49	1.87
North Africa/West Asia	-1.13 (-1.08)	..	..	3.47 (2.01)	..	..	0.64	1.55
New Zealand	..	..	-	..	-1.58 (-1.07)	0.93 <sup>c</sup> (0.92)	0.97	2.07
Pacific Islands	-0.49 (-0.63)	-1.15 (-1.83)	..	0.69 <sup>d</sup> (2.59)	..	..	0.89	1.31

a. These equations were estimated for manufactures, non-bulk foodstuffs, machinery, equipment and vehicles, but not all containerised goods.

b. Index of Australia's refinery output.

c. Index of Australia's factory output.

d. Farm GDP.

- Nil or rounded to zero

.. not applicable

Note: t values indicating the statistical significance of the estimates are given in brackets.

- .. Demand was responsive to changes in income and production (such as manufacturing activity level) with elasticity estimates in excess of unity).

#### General cargo export commodities

- .. North East Asia (sub-group 1) demand for boneless beef seemed to be more influenced by prices of beef from other supply sources than by its own price.
- .. The own price elasticity of demand for manufactured goods was about unity in North East Asia (sub-group 1) and over unity in Europe group 1.
- .. The own price elasticity of demand for wool in Europe group 1 was less than unity.
- .. Demand for general cargo commodities was responsive to at least one of the following variables; income, population and/or production/industrial activity levels in overseas countries.

#### Imports

- .. Demand for petroleum products imports (from all sources) was inelastic with respect to its own price and Australia's refinery output.
- .. The own price elasticity of demand in the trade areas of South East Asia (miscellaneous manufactures) and North East Asia (mainly vehicles) was highly elastic.
- .. Imports of rock phosphate from Pacific Islands was strongly affect by farm GDP.
- .. Tariffs play an important role in determining the level of imports; that is, the lower the tariff level, the higher imports will be, and vice versa.

#### Freight rates

It is usually assumed on *a priori* grounds that demand for shipping services is less responsive to changes in freight rate than to those in the commodity own price. One or more of the following propositions are often cited as a justification for this assumption. Firstly, for most exports/imports (particularly bulk commodities) there is no substitute for shipping services. Secondly, freight rates usually represent a small proportion of the value of the cargo. Finally, alternative sources of supply for internationally traded commodities not requiring shipping services are often very limited.

Generally, the freight rate elasticities reported in this Paper were less than unity. Further they were less in magnitude than the corresponding own price elasticities (as implied by Bennathan and Walters 1969). Nonetheless, where Australian exports face competition, demand for shipping services is responsive to freight rates (wheat to North Africa/West Asia and boneless beef to Japan). For imports from North America and Europe (groups 1 and 2), demand is elastic with respect to freight rates. A plausible interpretation is that for general cargo (particularly for high unit value products and to nearby markets) air transport might be an alternative transport mode.

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### SUMMARY AND CONCLUSIONS

This Paper reports some of the results of an on-going investigation undertaken by the Bureau of Transport Economics to forecast demand for international sea freight services (dry bulk, bulk liquid and general cargo) to the year 2000. This necessitated that the analysis be conducted on the base commodity flows (for both exports and imports) comprising the freight task. To allow for differences in shipping distances and market characteristics, eight trade areas were identified.

For each trade area, aggregate demand models were specified for the major export and import commodities by type of shipping services. These models aimed at identifying the factors affecting the base commodity flows (and hence shipping services) and quantifying their effects. The ordinary least-squares regression method was employed to estimate these models using time-series data between 1971 and 1982. In general, the estimated regression equations gave reasonable approximations to annual demand for shipping services and the estimated co-efficients were of the expected sign on *a priori* grounds.

The broad observations to be made were:

- . There has been a decline in the relative importance of exports to North America and Europe group 1 (particularly to the United Kingdom).
- . This decline was compensated for by continued growth in Europe group 2 and North Africa/West Asia.
- . A shift in imports has occurred from North America towards North East Asia (sub-group 1), New Zealand, and to a lesser extent, Europe groups 1 and 2.
- . Recent economic conditions and the drought have had a marked influence on imports of crude oil and petroleum products (in gross weight tonnes) and rock phosphate respectively.
- . Freight rate elasticities, estimated directly for the major export/import commodities in this Paper, were less in magnitude than the corresponding own price elasticities. This generally depended upon the extent of competition in the commodity market, the unit value of the commodity and the availability of alternative transport.

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