

S.E. ASIA - AUSTRALIA LINER SHIPPING SERVICES:
A COST BASED SIMULATION ANALYSIS

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ABSTRACT: *The authors believe the simulation model can be, if it appropriately mirrors cargo allocation decisions, a powerful tool for analysing economic behaviour in the complex world of containerised liner shipping. In this paper, they describe the development of such a model and how it has been used to analyse technical or cost efficiency of the system of liner shipping services linking Australia to South East Asia. The paper also illustrates how a cost based simulation model can provide quantitative evidence to support analyses of the various economic characteristics of liner shipping. Those economic characteristics subjected to analysis in this paper are: the extent of excess shipping capacity in the trades (the problem of overtonnaging); the impact of costs and delays on the Australian waterfront; the way the system responds to overall increases in ships' speed; and the costs of using Australian crewed ships.*

INTRODUCTION

This paper is very much condensed version of a paper being published as part of a series of ASEAN-Australia Economic Papers. This longer, more explicit version of the paper should be published around the time the 9th ATRF is in session.

The series of papers referred to, above, is part of the output of the ASEAN-Australia Economic Relations Research Project. The Project is jointly sponsored by the Governments of Australia and the five ASEAN nations. It is funded by the Australian Government and organised through the Research School of Pacific Studies at the Australian National University. The Project is divided into seven studies, one of which is on "Shipping". One of the authors of this paper was invited to participate in the shipping study in 1981.

This paper is concerned with the development of a cost based simulation model, and the application of the model to the liner shipping services which link South East Asia and Australia.

The model is concerned with what economists call technical efficiency in liner shipping. Consequently, it is concerned with all of the costs of supplying liner shipping services rather than the prices or freight rates charged to shippers.

The paper can be regarded as being made up of two parts.

The first part of the paper deals with the development and specification of the model. It also deals with the model's basic input, the physical and cost data generated by reducing the Existing System of liner shipping services between South East Asia and Australia to a stylised form, thus making it amenable to analysis.

The second part of the paper deals with the simulation model's output. That output allows us to explore and analyse economic behaviour in the Existing System. The output also allows us to identify a range of alternatives to the Existing System and to analyse those options which seem superior to it in some way.

That part of the real world subjected to analysis per medium of the simulation model, that is the Existing System of liner services, is described briefly in the Appendix to this paper. The Appendix relates to the Existing System as it was on 1 January 1982.

PART 1
MODEL DESCRIPTION

The choice/costing model does not incorporate a formal algorithm designed to locate and define the best possible pattern or system of liner shipping services. Nor does it attempt to assess the cost of operating any given pattern of services in an ideal world. The model has been designed to mirror the limitations which a fragmented decision-making process and imperfect price signals impose on the minimisation of the total costs associated with any given shipping pattern. It also provides the researcher with the information on system performance necessary for him to adopt an intelligent heuristic approach to the exploration of alternative routes to more cost efficient ways of performing a given liner shipping task⁽¹⁾.

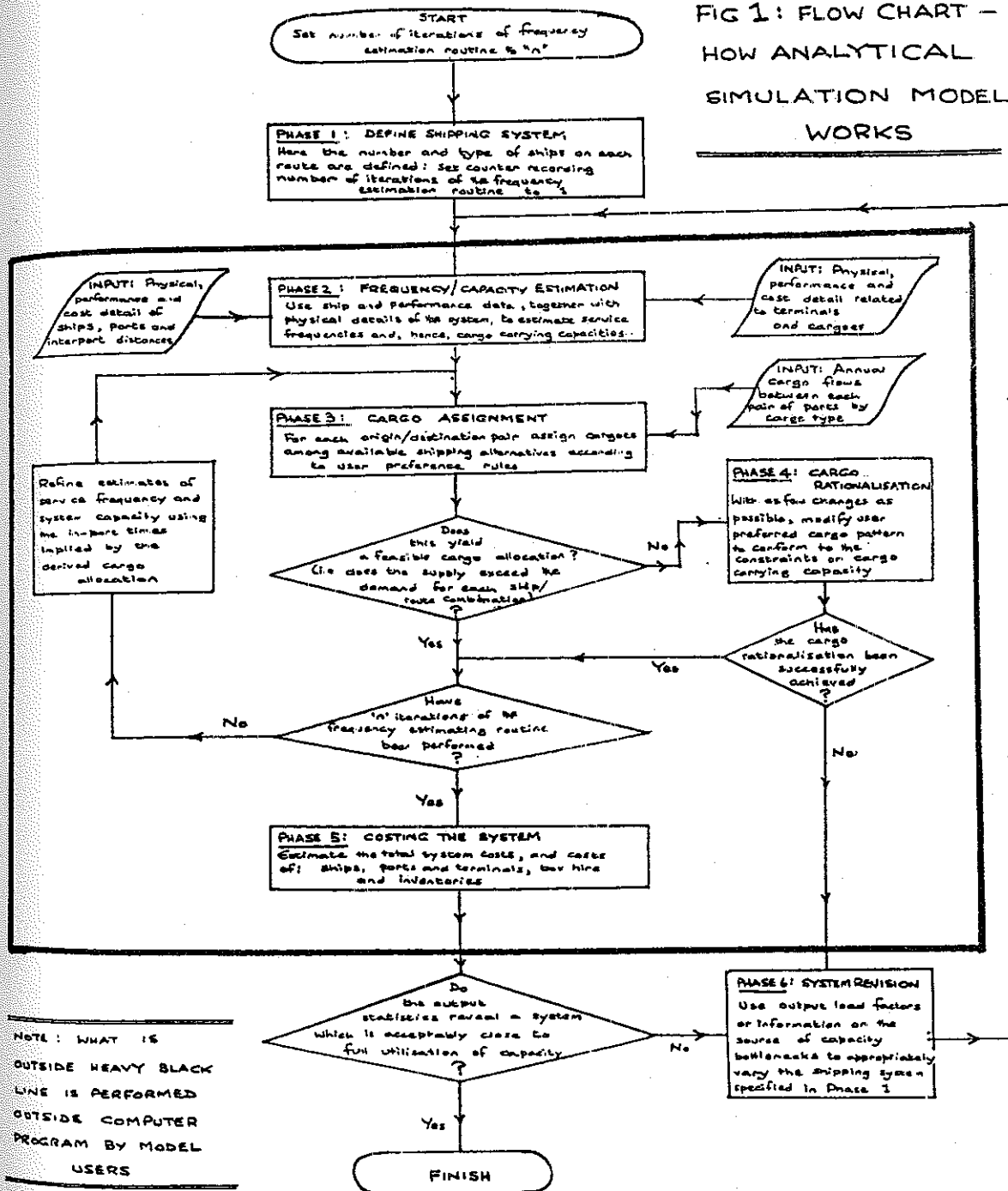
Conceptually, the operation of the model can be partitioned into six self-contained tasks:

1. Definition of a shipping system.
2. Estimation of cargo carrying capacities and service frequencies.
3. Allocation of cargo amongst shipping alternatives according to user-choice rules.
4. Comparison of the 'preferred' cargo pattern with cargo-carrying capacity, and, if necessary, modification of the cargo pattern to conform to capacity constraints.
5. Costing of the shipping system.
6. Examination of the allocation pattern to detect the existence of excess capacity in the system.

Figure 1 illustrates the way in which these modules are combined in a complete application of the model.

(1) This was made possible by the fact that, by building consistent decision rules into the model, the non-integer components of the objective function - the cargo volumes and delays - could be derived from the values of the integer variables - the number and type of ships on each route. In conceptual terms, the definition of the shipping system would, given a set of decision rules, imply a particular allocation of cargoes between competing shipping services.

FIG 1: FLOW CHART -
HOW ANALYTICAL
SIMULATION MODEL
WORKS



Phase 1 Definition of the Shipping System

The supply side of the shipping system is fully described by identifying each operative vessel and the route it plies. In reality, each ship may be slightly different and each route distinct. In order to reduce the problem to manageable proportions, the system must be stylised to some extent: in our case, every ship was approximated by one or other of four selected vessel types, while the number of possible routes was reduced by ignoring variations in the path taken by a ship within each 'port group'. This process of stylising the system is described in greater detail in the next section headed "Stylising a Liner Shipping System".

Phase 2 Estimation of service frequencies and cargo carrying capacity

In reality, since loading and unloading times form a significant proportion of round trip times, service frequencies are a function of the way cargo is allocated among the various vessels in the liner shipping system. At this early stage of the model flow, however, the way cargo will be allocated, within the liner shipping system option then being simulated, is not and, indeed, cannot be known. It is therefore necessary to make a number of more-or-less arbitrary assumptions in order to obtain initial estimates of round-trip times, and hence of frequencies.

The principal assumptions in obtaining initial estimates of service frequencies were:

- i) the average overall load factor on all ships was taken to be 0.80
- ii) irrespective of the number of ports of call, two complete cycles of cargo loading and unloading were performed during each round trip
- iii) the extent of loading and unloading was the same within each port group.

Under these assumptions, a ship calling at four port groups would load and unload 40 per cent of its cargo carrying capacity within each port group. A ship calling at two port groups, on the other hand, unloads 80 per cent of capacity within each group.

The calculation of the initial frequency (and hence capacity) estimates was then straightforward.

This procedure is used to estimate capacities and frequencies on all "Closed System" routes⁽¹⁾.

(1) Definitions of "Closed Systems" and "Open Systems" and the distinction between them are described later in the section headed "Stylising a Liner Shipping System".

SIMULATION ANALYSIS: LINER SHIPPING

Phase 3 Allocation of cargo using user-choice rules

The fundamental assumption underlying the estimation of preliminary cargo assignment was the usual one of economic rationality: shippers will attempt to minimise the costs they face. Their costs consist, essentially, of freight rate and inventory costs. The assumption was made that, for any given shipper, the rate charged by liner services will be governed only by the origin, destination, and type of cargo: that is, it will be independent of the ship type and route. The problem, from a shipper's perspective, then reduces to one of minimising inventory costs: put simply, the shipper will attempt to get his cargo aboard that ship which gets it to its destination at the earliest date.

Each shipper has available to him a finite set of alternatives for shipping his produce. Let there be 'm' possible ships which he could use. Then the chance that he will use any particular ship 'k' can be represented as a function of two sets of variables:

a_j , $j = 1, \dots, k, \dots, m$, the time before ship 'j' arrives in the origin port,

and T_j , $j = 1, \dots, k, \dots, m$, the transit time between the origin and destination ports for that ship.

The shipper's decision must be made on the basis of expectations of transit times, since he does not know in advance the actual time. For this reason, it is not unreasonable to treat T_j as a deterministic value, based on either published shipping schedules or past performance, rather than a random variable. We can make the further reasonable assumption that T_j is the same for all ships 'l' which are of the same type and which ply the same route. This allows us to model the choice decision as one between groups of ships, 'k', rather than between individual craft, where each group is comprised of a set of ships of a specified type on a given route. In this formulation, a_j is the time before the next ship of group 'j' arrives in the origin port. In conformity with the inventory cost minimisation hypothesis, the shipper will prefer alternative 'k' if

$$a_k + T_k < a_j + T_j \quad \text{for all } j, k \quad (4)$$

The distribution of the random variables a_j will be determined by the assumptions made about the distribution of ship arrivals, and the interrelation between the production of the commodity to be shipped and shipping schedules. For the distribution of arrival headways within each group, an independent negative exponential function was assumed.

On the basis of these assumptions, we can derive an expression for the probability that any specific alternative 'k' is chosen. If E_k is the event that alternative 'k' is chosen, then

$$\begin{aligned} \text{Prob}(E_k) &= \Pr(a_j + T_j > a_k + T_k) \text{ for all } j \neq k \\ &= \Pr(a_j > a_k + T_k - T_j) \end{aligned}$$

It can be shown that, under the assumptions given above,

$$\text{Prob } (E_k) = \sum_{j \leq k} (\exp(K_j)/D_j) \cdot (\exp(-D_j \cdot T_j) - \exp(-D_j \cdot T_{j+1})) \quad (7)$$

where alternatives 'j' are ranked so that

$$T_1 < T_2 < \dots < T_n$$

$$\text{and } D_j = \sum_{m \leq j} \lambda_m$$

$$\text{and } K_j = \sum_{m \leq j} \lambda_m T_m$$

$$T_{n+1} = \infty$$

λ_j = the arrival frequency for ships of group 'j'

- Phase 4
- Comparison of 'preferred' cargo pattern with cargo-carrying capacity
 - Modification of the cargo pattern to conform to capacity constraints.

Before the 'preferred' cargo assignment pattern can be compared with the available capacity, the pattern must be converted to ship loadings by means of an incidence matrix. This concept is probably best explained by illustration. Consider the route depicted in Figure 2 below.

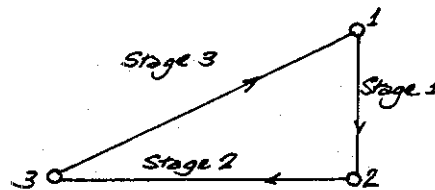


Figure 2 Diagrammatic Representation of Typical Route

Not all of the cargo carried on this route is present on any particular stage. For example, Stage 1 carries cargo movements from Port 1 to Port 2, Port 1 to Port 3, and Port 3 to Port 2, but not those from Port 2 to Port 3, Port 2 to Port 1, or Port 3 to Port 1.

Under these conditions, and given that each individual makes his own choice without considering the implications of his decision for other shippers, it is possible that bottlenecks will occur in the system although there is, under an efficient assignment system, adequate capacity. In reality, some re-allocation of cargo is likely to occur in order to make more efficient use of the capacity available. This rationalisation of cargoes is likely to be done by shipping lines or their agents. Modelling the way in which this re-allocation is done requires some assumptions to be made about the behaviour of shipping lines/agents under these circumstances. The following plausible assumptions underpin the rationalisation procedure applied by the model.

SIMULATION ANALYSIS: LINER SHIPPING

1. Shipping lines make the minimum possible number of changes to the desired cargo allocation.
2. Shipping lines are more prepared to modify shipping arrangements for low-value cargoes than high-value cargoes.
3. Shipping lines will attempt to get re-assigned cargo on-board ship at the earliest possible date. This concern is, albeit imperfectly, in the re-allocation model by re-assigning to the highest frequency service having excess capacity.

The rationalisation process can then be represented as a linear programming problem. The objective function is to minimise the quantity of cargo re-assigned, and the constraints are that capacities must not be exceeded, all cargo must be shipped, and all assigned volume non-negative. The cargo allocation pattern obtained from the "user-choice" phase is then an optimal (the volume of cargo re-assigned is zero) but infeasible (some capacity constraints are violated) solution to this problem. The dual simplex method⁽¹⁾ is employed to move from this starting solution to the best feasible solution - our 'rationalised' cargo pattern.

Phase 5 Estimation of costs

Having found the final assignment pattern, the estimation of costs is straightforward if somewhat intricate. The original estimates of pre-embarkation cargo delays during the preliminary assignment phase are updated to accommodate the revisions to the assignment pattern effected in Phase 4. Given the complete cargo assignment and revised pre-embarkation delays, it is then possible to estimate the total delay incurred by each unit of cargo, and the number of days each ship spends in port and at sea. This is the essential information required to perform a full costing of the hypothetical shipping system.

Phase 6 Revision of the shipping system specification

As has been said, this phase is performed manually. An incidental output of the costing module is a load-factor table, which indicates the extent to which available cargo capacity is utilised on each ship type on each route. This table was used in conjunction with subjective judgment to create promising revisions to the specified shipping system.

(1) See Taha, H.A., pp. 97 - 99.

STYLISING A LINER SHIPPING SYSTEM

The sort of simulation analysis being described in this paper required, as well as a realistic behavioural model of a liner shipping system, the creation of a stylised version of an existing liner service (or set of liner services). This would allow sensible input to be generated for the model and would provide an appropriate context for comprehensible interpretation of model output. The method of stylisation described in this section closely reflects reality but generalises the workings of, in this case, the Existing System of liner shipping services linking a selection of South East Asian countries to Australia. This generalisation serves to eliminate a mass of irrelevant detail and those marginal variations in input parameters which are not relevant to analysis of the key economic variables in the system.

Closed or Open Systems?

The ability of simulation analysis to usefully reflect economic reality could be seriously weakened by assumptions on the allocation of costs which are likely to appear arbitrary. If the model was to be a tool which permitted rigorous economic analysis or allowed us to gain useful economic insights into the workings of the South East Asia-Australia liner shipping system, these sorts of assumptions had to be kept to a minimum in the stylisation of the system. This requirement influenced the stylisation in relation to whether or not to regard the system as an "Open System" or a "Closed System".

It would be possible to avoid subjective and apparently arbitrary assignments of costs to cargoes or routes, provided the stylised liner shipping services could be regarded as a "Closed System". In this "Closed System", liner service vessels could call at ports in Australia, in the ASEAN Region⁽¹⁾ and in Hong Kong or Taiwan, BUT nowhere else. In other words, within a "Closed System" approach to stylising the Existing System, no ship would operate on a route which did not connect ports in Australia to ports in South East Asia: that is to ports in either or both of the following two groups of countries:

- (1) Singapore, Malaysia
Indonesia, Thailand (SMIT); or
- (2) Hong Kong, Taiwan,
the Philippines (HKTP).

While this sort of "Closed System" approach to stylising the Existing System might satisfy the need to avoid subjective and/or apparently arbitrary cost assignments in a simulation analysis, it might not adequately reflect what is happening in the real world of South East Asia-Australia liner shipping. There are a number of shipping lines which not only link South East Asia to Australia, but also link Australia to ports in other parts of the world, such as the Indian

(1) The ASEAN Region is comprised of Singapore, Malaysia, Indonesia, Thailand and the Philippines.

SIMULATION ANALYSIS: LINER SHIPPING

Subcontinent, the Arabian Gulf, Japan and North America. Perhaps less than 30 per cent of South East Asia-Australia cargoes are on ships which serve ports outside the "Closed System" defined above. However, the proportion is high enough to convince us that they could not be ignored in the simulation analyses. In other words, the stylisation should reflect the realities of a partially "Open System" and, at least for cargoes travelling on ships which served outside ports, some subjective and apparently arbitrary allocation of costs would have to be made.

In summary, there are problems with using a simulation model to analyse economic characteristics of a liner shipping system, regardless of whether a "Closed System" or a partially "Open System" approach is used. The "Closed System" avoids the need for weakening objective analyses by subjective and/or arbitrary cost allocations, but it does not adequately reflect reality. The partially "Open System" can adequately reflect reality, but it does introduce the necessity to introduce subjective and perhaps arbitrary cost allocations in relation to some, albeit a relatively small proportion of cargoes.

In the end, it was decided that both a "Closed System" and an "Open System" would be stylised. The model would be applied to both and the two different types of system analysed side by side.

Cargo Task

Stylisation of the cargo task with which the simulation analysis is essentially concerned has been based on actual cargo movements in 1980/81. The annual cargo task appropriate to the stylisation is set out in Table 1.

TABLE 1
S.E. ASIA-AUSTRALIA LINER SHIPPING SIMULATION:
ANNUAL CARGO TASK

Asian Ports	Australian Exports		Australian Imports	
	East Coast Ports	West Coast Ports	East Coast Ports	West Coast Ports
CARGO TYPE 1: LADEN REEFER CONTAINERS ('000s TEU)				
..Singapore, Malaysia				
..Indonesia, Thailand	4.5	2.0	1.4	0.2
..Hong Kong, Taiwan, ..Philippines	9.0	1.3	0.2	0.0
CARGO TYPE 2: LADEN DRY CONTAINERS ('000s TEU)				
..Singapore, Malaysia,				
..Indonesia, Thailand	19.0	6.0	14.7	6.3
..Hong Kong, Taiwan, ..Philippines	36.9	3.1	53.6	5.6
CARGO TYPE 3: TIMBER PACKS/STEEL PACKS ⁽¹⁾ ('000s tonnes)				
..Singapore, Malaysia,				
..Indonesia, Thailand	60	15	100	10
..Hong Kong, Taiwan, ..Philippines	186	10	15	2
CARGO TYPE 4: BREAK BULK ('000s tonnes)				
..Singapore, Malaysia,				
..Indonesia, Thailand	127	15	64	10
..Hong Kong, Taiwan, ..Philippines	115	10	29	1

Note: The figures in this table are based on Australian Bureau of Statistics and Australian Department of Transport statistics on trade and cargo movements for 1980/81.

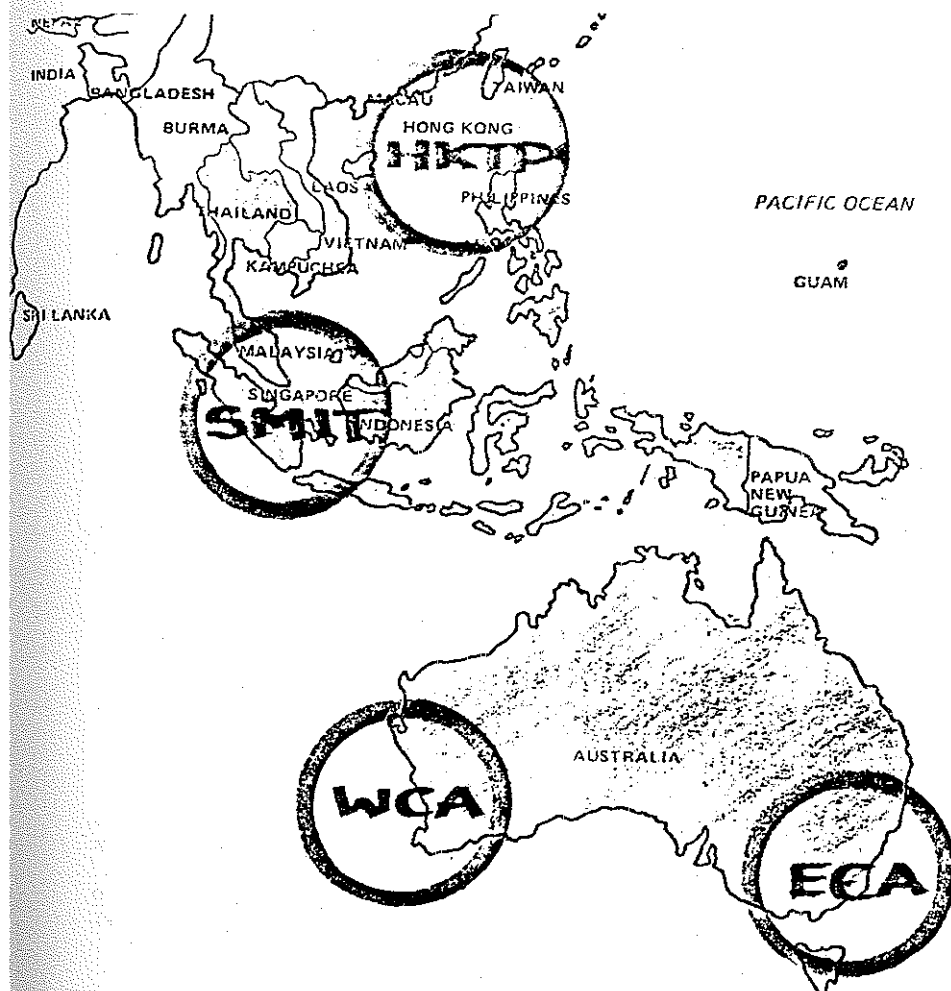
(1) And other cargoes sent in similarly "unitised" form.

Port Groupings

From the outset, it was realised that two factors would be important to developing a simulation which provided analytical insights into a liner shipping system and output which was meaningful and readily understood.

The first is that, in aggregate terms, the trade or traffic patterns being analysed should be compact. In other words, the system being analysed should be simple and easily identified as such. Selection of the South East Asia-Australia liner trades for simulation analysis fulfils this requirement. Selection of, say, all liner shipping serving Australia would not.

Fig 3 : S.E. ASIA-AUSTRALIA LINER SHIPPING SIMULATION
RELATIVE LOCATIONS OF FOUR PORT GROUPS



The other important factor is keeping the number of origin and/or destination points in the simulation as small as possible. A large number of origin/destination points would lead to a very much larger number of conceivable routes to which traffic or trade could be assigned. A small increase in the number of origin/destination points can lead to a very large increase in the number of routes linking them.

Thus, in the stylised version of the Existing System, there are only four origins and destinations (see the map. Figure 3). They are code named SMIT, HKTP, ECA and WCA.

A set of characteristics of shipping line behaviour has been defined for each of these four port groups. In the simulation analysis, these stylised characteristics are assumed to be constant regardless of whether the Existing System or any alternative to it is being subjected to simulation analysis. The characteristics are described in Table 2, below.

TABLE 2
S.E. ASIA-AUSTRALIA LINER SHIPPING SIMULATION
CHARACTERISTICS OF PORT GROUPS

No.	Code name	Area description	Number of ports in Group no.	Sailing distance within Group nautical miles	Entry/exit ports
1	SMIT	Singapore, Malaysia, Indonesia, Thailand	4	1290	Jakarta and Singapore
2	HKTM	Hong Kong, Taiwan, the Philippines	3	885	Hong Kong and Manila
3	ECA	East coast of Australia	3	1100	Brisbane and Melbourne
4	WCA	West coast of Australia	1	nil	Fremantle

Ports and Terminals

For the purposes of the simulation analysis, voyage by voyage variations in cargo throughput at each port within a port group are irrelevant. On the spot research showed that it was realistic to assume that each port within a group will behave similarly in relation to the service given to liner ships. Consequently, the information contained in Table 3, below, provides the basis for calculations of the time liner service vessels spend in port during their round trip voyages.

SIMULATION ANALYSIS: LINER SHIPPING

TABLE 3
S.E. ASIA-AUSTRALIA LINER SHIPPING SIMULATION
ANALYSIS OF IN-PORT TIME

Type of port	Idle time (1) in each port	Time spent moving in and out of port	Containers: loading or unloading rate	Break bulk cargo: loading or unloading rate
	hours	hours	TEU/per working hr.	tonnes per working hr.
Australian ports	18	6	10	50
South East Asian ports	6	6	20	80

(1) The idle time estimate for Australian ports contains an allowance for waterfront strikes and stoppages.

Routes and Cargo Flows

The realities of the trade and transport systems being analysed demanded some basic rules for the definition of the route patterns which are basic to the very large number of alternative operating strategy options which can be catered for within the simulation model. Thus, the stylisation demands that:

- a route must link at least one South East Asian port group with at least one Australian port group;
- while a route may link the two Australian port groups, no cargo which relates to trade between the port groups code named ECA and WCA⁽¹⁾ can flow on the route; and
- if the route which directly links the two South East Asian port groups, code named SMIT and HKTP, priority must be given to cargoes flowing between South East Asia and Australia - nevertheless, any amount⁽²⁾ of top-up cargo not related to those trades can flow between these two South East Asian port groups.

(1) Cabotage of Australian coastal cargoes demands adherence to this rule.

(2) In effect, for simulation purposes, this means that an infinite quantity of top-up cargo can flow, in either direction, between the port groups SMIT and HKTP.

Applying this set of rules left us with fourteen possible "Closed System" shipping routes linking the four defined port groups: four which link two of the port groups in shuttle like routes; eight which link three port groups with triangular route structures; and two which link all four port groups.

It was necessary to devise some additional rules constraining shipping on "Open System" routes. These are:

- .. ships plying them can only enter and/or leave the South East Asia-Australia trades via an Asian port: that is via a port in groups SMIT or HKTP; and
- .. the link between the Australian and South East Asian port groups must be direct, and not via some port outside the stylised system.

Ships: Selection and Capacity Constraints

An essential feature of the stylisation of the Existing System was the selection of four ship types to undertake the identified cargo task.

The four simulated ships were selected so as to cover the wide spectrum of ship types likely to be seen in a "Mid Sea" trade such as that between South East Asia and Australia.

The stylised ships were as follows:

- .. a "Strider", which is a small, flexible, and, to some extent, self-sustaining container ship with a ro-ro-ramp. Its essential capacity ratings are:
320 IEU; and
6,600 dwt.
- .. a fully cellular conventional container ship, referred to as "FC700". It has cell guides but is not self-sustaining and has no ro-ro ramp. It cannot take break-bulk cargoes. Its essential capacity ratings are:
700 TEU; and
14,300 dwt.

SIMULATION ANALYSIS: LINER SHIPPING

an "Anro" type medium sized container vessel. It is not self-sustaining, but it is a ro-ro vessel with a stern ramp. It can take break-bulk cargoes. Its essential capacity ratings are:

1,225 TEU; and
23,000 dwt.

a conventional "Break-Bulk" liner ship, like those normally in service before the containerisation era. It has a capacity of around 10,000 dwt.

In the simulation analysis it has been necessary to limit capacity utilisation for any one of the four selected vessel types on any single leg of a round trip voyage, so that:

- no more than 95 per cent of reefer capacity is occupied by fully laden reefer containers;
- no more than 90 per cent of container carrying capacity is occupied by a combination of fully laden reefer and fully laden dry containers;
- no more than 90 per cent of unitised cargo capacity is occupied by timber packs and steel packs;
- no more than 90 per cent of break bulk cargo capacity is occupied by break bulk cargo; and
- overall, no more than 85 per cent (by weight) of cargo carrying capacity is used up.

In its cargo assignment mode, the model took these constraints into account in precisely the order they are listed above.

COSTS: CONSIDERATIONS AND CALCULATIONS

Essentially, the simulation analysis is concerned with two sets of costs and their interaction with one another. The two sets of costs are:

- the costs of supplying liner shipping services; and
- the costs to shippers of holding inventories of goods in transit.

Where liner services are technically efficient, shipping companies will be seeking to minimise the cost of carrying out a given cargo task and the shippers of that cargo will be seeking to minimise inventory costs.

Cost Conventions

The shipping industry convention of assessing costs on a daily basis has been adhered to in calculating shipping costs, container costs and inventory costs.

Shipping costs vary according to whether a ship is operating at sea or is in port. The trade-off between days at sea and days in port is most important in the pursuit of cost efficiency in shipping. Minimising the number of days cargo is in transit is most important to shippers. Thus, calculating costs on a daily basis is a convention which is appropriate to the simulation analysis.

All costs are, as near as possible, relevant to the first half of 1982. All are expressed in Australian dollars using, where necessary, the exchange rates applicable at or near 1 January 1982. Where necessary, unit cost parameters were adjusted by an appropriate index to account for the effects of inflation.

Costs Input

The basic cost input used in the simulation analysis has been set out below.

Ship Costs:

Ship costs, set out in Table 4, relate only to the vessel itself. They do not relate to the cargo. They include the costs of acquiring ships, paying and feeding crews, repairs and maintenance, insurance, administration and overheads (mostly related to shore based management of ship operation) and fuel. The costs are worked out on a daily basis, but are based on a 350 day year. Thus, an allowance of 15 days a year is made for a vessel to be laid up.

TABLE 4
S.E. ASIA-AUSTRALIA LINER SHIPPING SIMULATION:
COSTS PER DAY FOR SELECTED VESSEL TYPES

Costs per Day	Vessel Types			
	Strider	FC700	Anro	Break Bulk
At sea	\$A 13,840	\$A 19,300	\$A 34,240	\$A 10,530
In port	10,660	14,210	26,550	7,080

Port Costs:

Port costs include charges for the following: tug hire, pilotage, mooring, wharfage, berthing and unberthing, navigational aids and lights. They also include minor, almost incidental charges for things like water, electricity and garbage disposal services for ships in port. The port costs used in the simulation analysis are set out in Table 5 below.

SIMULATION ANALYSIS: LINER SHIPPING

TABLE 5
PORT CHARGES PER PORT CALL FOR
SELECTED VESSEL TYPES

Port Location	Vessel Types			
	Strider	FC700	Anro	Break Bulk
	\$A	\$A	\$A	\$A
" South East Asia	3,000	6,000	9,000	5,000
" Australia	6,500	11,000	15,000	9,000

Terminal Costs:

Port charges are a charge on the ship using a port, whereas stevedoring and terminal charges are a charge on the cargo. Because of this essential difference, it was necessary to separate port charges and terminal and stevedoring charges in the simulation analysis.

The unit costs of loading and unloading cargo in the stylised system are set out in Table 6 below.

TABLE 6
TERMINAL AND STEVEDORING COSTS
USED IN SIMULATION ANALYSIS

Type of cargo	Loading or unloading costs	
	at Australian ports	at South East Asian ports
" Laden reefer containers	\$A290 per TEU	\$A120 per TEU
" Laden dry containers	\$A290 per TEU	\$A 85 per TEU
" Empty containers	\$A120 per TEU	\$A 60 per TEU
" Break bulk cargo	\$A 17 per tonne	\$A 7 per tonne

Container Costs:

Like terminal costs, container costs relate essentially to the cargo rather than the vessel which carries that cargo. Terminal costs, in aggregate terms, remain constant for a given transport task. However, container costs will vary from option to option simply because, for a given containerised freight task, the length of time during which individual cargoes remain loaded in containers will vary from option to option. In addition, some allowance has to be made in the cost calculation for the long periods of time containers are empty and/or idle.

For the stylised liner shipping system, daily hire costs of \$A16 for an ISO standard reefer container and \$A2 for an ISO standard dry container have been used. Daily container costs appropriate to the stylised system are:

Reefer containers	\$A43.95 per TEU per day in transit
Dry containers	\$A 6.38 per TEU per day in transit.

Inventory Costs:

The following representative values have been derived for commodities in each of the four categories relevant to this paper.

Reefer containers	- \$A25 per FCL ⁽¹⁾ per day
Dry containers	- \$A12 per FCL per day
Timber packs/steel packs	- \$A0-20 per tonne per day
Break bulk cargoes	- \$A0-20 per tonne per day

(2) FCI means Full Container Load - typically, around 15 tonnes of cargo.

SIMULATION ANALYSIS: LINER SHIPPING

PART 2

OUTPUT: THE EXISTING SYSTEM AND AN EFFICIENT ALTERNATIVE

The Existing System

The first objective of the simulation analysis was to analyse how the stylised version of the Existing System of South East Asia-Australia liner services copes with the cargo task identified in Table 1, when it is performing according to the behavioural rules set out in Part 1. The most essential output from applying this system of liner services to that cargo task, per medium of the simulation model, was that related to systemwide costs. Using 1981/82 cost data, the costs of performing the cargo task were estimated, by the simulation model, to be as follows:

• Ship costs	\$A216.3 million	55.4%
• Loading and unloading costs	\$A 80.5 million	20.6%
• Port charges	\$A 14.7 million	3.8%
• Container hire costs	\$A 17.7 million	4.5%
• Inventory costs	\$A 60.8 million	15.6%
<hr/>		
Total costs attributable to stylised 1981/82 cargo task	\$A390.1 million	100.0%

Thus, the first and most basic output of the simulation model was an estimate of the total resource cost of moving liner cargoes between South East Asia and Australia during 1981/82. The estimate of \$A390 million which yields an average of \$A121 per tonne of liner cargo shipped.

For each of the four cargo types used in system stylisation, the cost estimates most pertinent to the consolidated freight bills which shipping lines present to shippers in the South East Asia-Australia liner trades are as follows:

- Reefer containers	\$A163 per tonne
- Dry containers	\$A103 per tonne
- Timber/Steel packs	\$A 95 per tonne
- Break bulk cargoes	\$A 80 per tonne

These unit cost estimates do not include inventory costs as that cost is borne by the shippers themselves.

Flexibility and User Choice

As explained in the discussion of the workings of the simulation model in Part 1, the closer one gets to the mix of ships and route patterns, which is optimal in terms of technical efficiency, the more user choice is constrained. Eventually, the point is reached where available cargo capacity is stretched so tightly that all cargo assignment is effectively in the hands of the shipping lines. This kind of strained situation is so lacking in flexibility that it does not credibly reflect reality. There are many near optimal alternative systems which retain

enough flexibility to leave most cargo assignment decisions in the hands of shippers. In other words, there is little point in totally reversing our user choice maxim in the hope of cost gains of less than, say, 50 cents per tonne of cargo.

In the heuristic application of our simulation analysis approach to finding more cost efficient solutions, many combinations of ships and routes which offered much lower cost shipping than the Existing System were identified. While none of these were identified as optimal for the stylised version of the liner services, many of them were obviously reasonably close to optimal.

Option A

The simulation model output for one of these more technically efficient alternatives has been selected for analysis and comparison with the output for the Existing System.

Option A, as it is referred to in this paper, is really a tightened up version of the stylised Existing System. The heuristic approach to simulation allowed the stylised Existing System to be gradually trimmed until all or most of the ships on both the "Closed System" and the "Open System" were operating at or near their defined cargo capacities on most route segments.

The most essential output from applying Option A to the stylised cargo task for 1981/82, per medium of the simulation model, was the following set of systemwide costs:

.. Ship costs	\$A182.2 million
.. Loading and unloading costs	\$A 80.5 million
.. Port charges	\$A 11.8 million
.. Container hire costs	\$A 19.8 million
.. Inventory costs	\$A 71.1 million
Total costs attributable to stylised 1981/82 cargo task	<u>\$A365.6 million</u>

Comparing the Options

Stylised versions of both the Existing System and Option A are compared, in summary form, in Table 7.

SIMULATION ANALYSIS: LINER SHIPPING

TABLE 7
S.E. ASIA-AUSTRALIA LINER SHIPPING SIMULATION
STYLISTED DESCRIPTIONS OF EXISTING SYSTEM AND OPTION A

No.	Scheduled Route Description by direction of service	No. of vessels on route		
		Vessel type	Existing System	Option
				A
		No.	No.	No.
"Closed System" Routes				
1	SMIT...ECA...SMIT...	FC700	2	2
1	SMIT...ECA...SMIT...	Breakbulk	2	1
3	HKIP...ECA...HKTP...	FC700	4	3
3	HKIP...ECA...HKTP...	Anro	9	7
9	SMIT...ECA...WCA...SMIT...	Strider	-	1
9	SMIT...ECA...WCA...SMIT...	Anro	3	1
10	SMIT...WCA...ECA...SMIT...	Anro	2	1
13	SMIT...HKTP...ECA...WCA...SMIT...	Anro	-	3
"Open System" Routes				
15)	ECA...WCA...HKTP...	Anro	3	3
16)	...OUTSIDE...ECA...			
17)	ECA...HKTP...SMIT...OUTSIDE...	Strider	6	6
18)	SMIT...HKTP...ECA...			
19)	WCA...SMIT...HKTP...OUTSIDE...	FC700	8	8
20)	...HKTP...SMIT...WCA...			

As Table 7 shows, in both the stylised Existing System and Option A, "Open System" services would remain unchanged. The most significant difference between the stylised route patterns for the Existing System and Option A is that, in the latter, three Anro type vessels operate on a continuous circuit which embraces all four port groups: that is Scheduled Route No. 13⁽¹⁾. Within the stylised Existing System, all vessels link the port groups in either shuttle or triangular route patterns.

In Table 8, the capacities and costs of the shipping fleets, which are required for the same cargo task in the simulations of the operation of the stylised Existing System or Option A, are compared.

(1) In fact, after the end of 1981/82, this circuitous route pattern was introduced to the South East Asia-Australia liner trades.

TABLE 8
S.E. ASIA-AUSTRALIA LINER SHIPPING SIMULATION
COMPARISON OF SHIPPING FLEETS IN EXISTING
SYSTEM AND OPTION A

Item	Liner Service Strategy	
	Existing System	Option A
- Vessels in "Closed System"		
Number	22	19
Rated capacity TEUs	21,350	18,520
'000s dwt.	429	364
- Vessels in "Open System" (1)		
Number	17	17
Rated capacity TEUs	11,195	11,195
'000s dwt.	223	223
Fleet Operating Costs (2)		
- Attributable to defined cargo task		
\$A millions	216.3	182.2
- Attributable to SMIT/HKTP		
top up cargo \$A million	0.1	4.8
- Total \$A Million	216.4	187.0

(1) Note: Vessels in "Open Systems" not strictly comparable with vessels in "Closed System", as the former spend a large proportion of the year outside the South East Asia-Australia liner trades.

(2) As they relate to the defined 1981/82 South East Asia-Australia liner cargo task.

Table 8 presents evidence of considerable excess capacity in the South East Asia-Australia liner trades. The output for Option A suggests that the system could have been operated with three less vessels. From the evidence presented in Table 8, we would estimate that there was around 3,000 TEU of excess capacity in the trades during 1981/82. In tonnage terms, this excess amounted to the equivalent of around 35,000 dwt. across the liner service fleet.

Table 8 also provides a measure of the extent of technical inefficiency in the South East Asia-Australia liner shipping system. In cost terms, the excess capacity in the shipping system is, on the basis of the Option A/Existing System comparison, estimated to be \$A35 million per annum at early 1982 prices. Averaged across the total cargo task, this represented an unnecessary resource cost burden on shippers of around \$A12 for each tonne of liner shipping cargo.

SIMULATION ANALYSIS: LINER SHIPPING

For each of the four cargo types used in system stylisation, the cost estimates pertinent to the consolidated freight bills which shipping lines present to shippers in the South East Asia-Australia liner trades, are compared, for both the stylised Existing System and Option A, below.

	<u>Existing System</u> per tonne	<u>Option A</u> per tonne	<u>Difference</u> per tonne
- Reefer containers	\$A163	\$A150	\$A13
- Dry containers	\$A103	\$A 89	\$A13
- Timber/Steel packs	\$A 95	\$A 83	\$A11
- Break bulk cargo	\$A 80	\$A 71	\$A 9

OUTPUT AND ANALYSIS:
ECONOMIC CHARACTERISTICS

Exploration and Analysis

The model was used extensively to explore the feasibility and efficiency of alternative shipping patterns and to investigate the responsiveness of total system costs to changes in key economic and physical parameters.

The simulation model explorations described in this paper relate to:

- .. increases in ships' speed;
- .. the costs of Australian crews;
- .. the costs of port and terminal services; and
- .. time lost at Australian ports.

Increases in Ships' Speed:

An increase in a ship's speed brings about an increase in the rate of fuel consumption and, therefore, an increase in fuel costs. These cost increases would be offset by reductions in sailing time and, therefore, reductions in inventory costs and container hire charges.

The essential questions asked in applying the simulation model to this particular analysis were: would an overall increase in ships' speed replace Option A with a technically efficient option in which less vessels were required and, what would be the systemwide cost breakdown for this new option?

It was calculated that increasing vessels' service speed by 2 knots over the whole fleet would increase ship operating costs, per day at sea, as follows:

<u>Vessel type</u>	<u>Cost increase</u>
.. Strider	+\$A2,020
.. FC700	+\$A2,690
.. Anro	+\$A3,790
.. Break/Bulk	+\$A2,290

However, the simulation model showed that the 2 knot overall increase in service speed would increase service frequency to the extent that the designated cargo task could be completed with two less vessels than in Option A. The net results of these increases in fuel costs and decreases in required capacity are shown in Table 9.

SIMULATION ANALYSIS: LINER SHIPPING

TABLE 9
S.E. ASIA-AUSTRALIA LINER SHIPPING SIMULATION
SYSTEMWIDE CONSEQUENCES OF 2 KNOT INCREASE
IN SHIPS' SPEED

Item	Liner Service Strategy	
	Original Option A	Option A modified for 2 knot increase in ships' speed
<u>Vessels</u>		
- Vessels in "Closed System"		
Rated Capacity	Number TEUs	
	19 18,520	17 17,500
<u>Costs</u>		
	\$A millions	\$A millions
- Ship costs	182.2	180.5
- Loading/unloading costs	80.5	80.5
- Port charges	11.8	11.6
- Container hire charges	19.8	18.7
- Inventory costs	71.1	65.1
Total costs attributable to stylised 1981/82 cargo task	365.6	356.4

Source: Simulation model output.

What the figures in Table 9 indicate is that, while the nett effect on shipping costs from an increase in ships' speed would be minimal, there would be significant gains from savings in container hire charges (from quicker turnaround of containers) and shippers' inventory costs.

Australian Crews:

In Table 10, the daily costs pertinent to Asian and Australian crews are compared for the vessel types selected for the simulation analysis.

TABLE 10
S.E. ASIA-AUSTRALIA LINER SHIPPING SIMULATION
ESTIMATES OF COSTS PER DAY FOR ASIAN OR AUSTRALIAN CREWS
(as at 1.1.1982)

Cost Item	Vessel Types			
	Strider	FC700	Anro	Break Bulk
	\$A	\$A	\$A	\$A
Asian Crew				
Wages, salaries and allowances	1,490	1,720	2,070	1,650
Providoring	550	700	880	650
Australian Crew				
Wages, salaries and allowances	3,710	4,310	4,890	4,000
Providoring	750	950	1,200	870

In addition to the costs of paying and feeding the crew, there is another extraordinary cost item associated with manning vessels with Australian crews. Most vessels must be modified to meet the crew accommodation requirements laid down by Australia's maritime unions. These costs would amount to around \$0.3 million per annum per vessel.

One way of providing an insight into the impact of Australian manning requirements on the competitive ability of ship owners and operators who sail under the Australian flag is to use the simulation model to estimate the relative shipping costs for two liner fleets, one crewed entirely by Asians and the other crewed entirely by Australians.

This comparison was made using both the stylised Existing System and Option A used as test cases. Output for the four model runs is compared in Table 11.

TABLE 11
S.E. ASIA-AUSTRALIA LINER SHIPPING SIMULATION
SYSTEMWIDE ANNUAL COST COMPARISON FOR
ASIAN/AUSTRALIAN CREW OPTIONS

Option	Ship operating costs	Total costs attributable to 1981/82 cargo task
	\$A million	\$A million
Existing System		
Asian Crew	216.3	390.1
Australian Crew	248.0	421.8
Option A		
Asian Crew	182.2	365.6
Australian Crew	209.9	392.9

Source: Simulation model output

From Table 11 it is apparent that operating the entire fleet of vessels with Australian rather than Asian crews would add between \$A27 million and \$A32 million to the cost of the resource inputs needed to carry out the defined cargo task. Expressed in these aggregative terms, these figures reveal very little about the trade. However, reduced to a unit cost basis, the figures give a fairly realistic indication of the cost penalty incurred when an Australian rather than an Asian crew is used: that is \$A9 per tonne of liner cargo carried between South East Asia and Australia. On the basis of the simulation analysis, meeting all of the requirements of an Australian crew would add about 15 per cent to the costs of operating a liner ship in the South East Asia-Australia trades.

Because of these influences, analyses related to the time ships spend in port is illustrated, below, only in relation to Option A.

SIMULATION ANALYSIS: LINER SHIPPING

Costs of Port and Terminal Services:

The simulation analyses of these costs was carried out by measuring the costs of Australian ports against the costs of using South East Asian ports. In other words, we used the simple device of substituting South East Asian costs for Australian costs. This was done in relation to the costs to ship operators of using Australian ports, mainly port authority costs, and the costs of supplying stevedoring services at wharves and container terminals.

The relevant cost inputs for the four vessel types and the four cargo types in the stylised system are set out in Tables 3 and 5 in Part 1.

The consequences of substituting South East Asian costs for Australian costs for ports and terminals are shown, for the stylised Existing System and for Option A, in Table 12, below.

TABLE 12
S.E. ASIA-AUSTRALIA LINER SHIPPING SIMULATION
EXPLORING EFFECTS OF VARIATIONS IN PORT AND TERMINAL
COSTS ON SYSTEMWIDE ANNUAL COSTS
(for 1981/82 cargo task)

Option and Test	Port charges	Terminal and Handling Costs	All Other Costs	Total Costs attributable to Cargo Task
	\$Amillions	\$Amillions	\$Amillions	\$Amillions
Existing System	14.7	80.5	295.0	390.1
Existing System modified by setting costs at S.E. Asian levels				
-for port charges	11.0	80.5	295.0	386.5
-for terminals	14.7	39.9	295.0	349.6
-for both ports and terminals	11.0	39.9	295.0	345.8
Option A	11.8	80.5	273.3	365.6
Option A modified by setting costs at S.E. Asian levels				
-for port charges	8.9	80.5	273.3	362.7
-for terminals (stevedoring)	11.8	39.9	273.3	325.0
-for both ports and terminals	8.9	39.9	273.3	322.0

Source: Simulation model output.

The most striking consequences of the substitutions illustrated in Table 12 are those related to terminal and/or stevedoring costs. For the stylised Existing System, setting all terminal/stevedoring costs at South East Asian levels would have the effect of reducing total system costs by 10.4 per cent. For Option A, the effect is an 11.1 per cent decrease in total system costs.

Setting all port charges at South East Asian levels would have the effect of reducing systemwide annual costs attributable to the total task by 1.0 per cent for the stylised Existing System and by 0.8 per cent for Option A. Thus, variations in terminal and stevedoring costs have more than ten times the impact of variations in port charges.

Time Lost at Australian Ports:

Simulation analyses of time spent in port and at terminals were carried out in a similar fashion to those related to the costs of using these facilities. In other words, South East Asian cargo handling rates and port delay estimates were substituted for Australian cargo handling rates and delay estimates. The substitution only related, of course, to Australian ports and terminals.

The relevant handling rates or loading and unloading rates, in TEUs or tonnes per hour, are set out for the stylisation in Table 6. So are the estimates of idle time spent in each port. For Australian ports, idle time estimates used in the stylisation differ from those relevant to South East Asian ports only in relation to an allowance made for the industrial disruptions which have been endemic on the Australian waterfront, but are virtually unknown in South East Asian ports. The allowance for industrial delays at Australian ports is 12 hours per port call per vessel⁽¹⁾.

The consequences of substituting South East Asian cargo handling rates and delay estimates for their Australian counterparts are shown for Option A, only, in Table 13.

(1) This is perhaps a little more than was needed to reflect the waterfront industrial scene in Australia in 1981/82 and 1982/83. However, the figure is based on experience over a longer run of years. In relative terms, the industrial scene on the Australian waterfront has been quiet in recent years.

SIMULATION ANALYSIS: LINER SHIPPING

TABLE 13

S.E. ASIA-AUSTRALIA LINER SHIPPING SIMULATION
EFFECTS OF VARIATIONS IN CARGO HANDLING RATES AND IN
PORT DELAYS ON SYSTEMWIDE ANNUAL COSTS
(for 1981/82 cargo task)

Option and Test	Systemwide Annual Costs					Total Attrib- utable to Cargo Task
	Ship Operating	Cargo Inventories	Container Hire	Port Charges	Terminal and Steve- doring	
	\$Amill.	\$Amill.	\$Amill.	\$Amill.	\$Amill.	\$Amill.
Option A	182.2	71.1	19.8	11.8	80.5	365.6
Option A modified by setting at S.E. Asian levels:						
-all cargo handling rates ¹	168.9	64.6	18.5	11.5	80.5	344.1
-delays at all ports ²	176.0	67.3	19.1	12.0	80.5	355.1
-both cargo handling rates and delays ³ at ports	162.7	60.8	17.8	11.3	80.5	333.1

1. "Closed System" ships reduced by 2, from 19 to 17 - take out 1 x Strider type and 1 x FC700 type.
2. "Closed System" ships reduced by 1 from 19 to 17 - take out 1 x Anro type.
3. "Closed System" ships reduced by 3, from 19 to 16 - take out 1 x Strider type, 1 x FC700 type, and 1 x Anro type.

Source: Simulation model output.

The figures in Table 13 are significant. Firstly, if shipping capacity is being fully utilised, then system resource costs would be \$A21 million lower if stevedores and terminals in Australia worked both container and break bulk cargoes the same hourly rate of throughput as their South East Asian counterparts. Secondly, if shipping capacity is being fully utilised, then system resource costs would be around \$A10 million lower if hours lost through industrial disruption were the same

at Australian and South East Asian ports. Resource costs would be \$A31 million lower if cargo handling rates and delays through industrial disruption were the same at Australian and South East Asian ports, but only if shipping capacity is being fully utilised.

The importance of this capacity qualification cannot be over-emphasised. When, as is the case with the Existing System, there is considerable excess shipping capacity in the liner trades, there are no economies to be gained from improving cargo handling rates and the extent of industrial disruption on the waterfront.

The exception is those economies which relate to shippers' inventory costs. In a buyers' market, shippers are likely to seek out shipping lines which offer the fastest door to door transit times. This does put some competitive pressure on shipping lines to ensure that time spent in port is minimised.

Another way of looking at the slower handling rates and delays at Australian ports is that they are also manifestations of excess capacity in the system. Comparing the stylised Existing System with Option A led us to conclude that excess capacity in the system amounted to the equivalent of 3 liner service vessels or around \$A30 million per annum.

CONCLUSIONS

The essential objectives of this paper were to briefly describe a cost based simulation model and demonstrate how it can be applied in the complex world of containerised liner shipping. We think that both of these objectives have been realised in this paper.

In addition, we think that our findings related to that small part of the model's output exposed in this paper illustrate another one of the advantages of simulation approach to economic analysis. The simulation model takes into account the workings of the whole transport system. Therefore, the analyst can view his findings on individual characteristics of the system in an appropriate perspective. Thus, for example, the economic impact of using Australian crews on ships is not judged in isolation from knowledge about other critical economic influences in the system.

In summary, the model output discussed in this paper revealed the following:

During 1981/82, the South East Asia-Australia liner trades were overtonnaged. It is estimated that the system could have been efficiently operated with three less vessels, without imposing serious constraints on shippers' choices of vessel. Averaged across the total cargo task, this over tonnaging represented an unnecessary resource cost burden on shippers of around \$A12 per tonne.

SIMULATION ANALYSIS: LINER SHIPPING

While the nett effect of an increase in ships' speed on the resource costs of undertaking a fixed liner cargo task would be minimal, there may be significant gains to shippers from savings in container hire charges and inventory costs.

It is estimated that the cost penalty incurred when an Australian rather than an Asian crew is used is \$A9 per tonne of liner cargo carried on a vessel operating between South East Asia and Australia. Meeting all of the requirements of an Australian crew would add about 15 per cent to the costs of operating the ship. As there are only three vessels in the South East Asia-Australia liner trades which have Australian crews, the impact across the whole cargo task is not very great. Use of Australian crews on these vessels adds less than \$A1 per tonne to the resource cost of carrying out that task.

In relation to terminal and port charges, the simulation analysis revealed that setting all terminal/stevedoring costs at South East Asian, rather than Australian, levels would reduce total system costs by more than 10 per cent. Setting all port charges at South East Asian, rather than Australian, levels would reduce systemwide annual costs by 1 per cent or less.

The resource costs of carrying on the South East Asia-Australia liner shipping task would be \$A31 million lower if cargo handling rates and delays through industrial disruption were the same at Australian and South East Asian ports, but only if shipping capacity is being fully utilised.

The analyses do suggest that, regardless of the extent of excess shipping capacity in the system, there are great gains to be made from reducing the costs of handling cargo at Australian ports. However, costs imposed by slow hourly throughput and industrial disruptions at Australian ports can only show up when shipping capacity is tightly stretched. That is unlikely to happen over the next two or three years.

If we assume that underutilized capacity can be put to work outside the system of liner services linking South East Asia to Australia, it is possible to estimate of resource cost losses from this source simply by adding the costs of these inefficiencies identified when the simulation analysis was applied to the 1981/82 cargo task. In the present economic climate, the validity of that assumption is questionable. Nevertheless, we did identify, in the simulation analysis, two areas where the way in which available capacity was utilized seemed technically inefficient. These related to, the way ships and cargoes were deployed in the system (that is, the extent of overtonnaging), and delays and rates of cargo handling at Australian ports. If the simulation model outputs on these two influences are aggregated, we have an estimate of technical inefficiency in the system of \$A60 million per annum. Put in another way, South East Asia-Australia liner services in 1981/82 could have been supplied with 5 or 6 less vessels had these inefficiencies not existed.

In view of the shakiness of the assumption on alternative uses of available capacity, perhaps the important question to be asked is who pays for these economic inefficiencies, shippers or the suppliers of shipping and cargo handling services?

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SIMULATION ANALYSIS: LINER SHIPPING

APPENDIX

A BRIEF DESCRIPTION OF THE EXISTING
(AS AT 1/1/82) SYSTEM OF
S.E. ASIA-AUSTRALIA LINER SERVICES

Route Patterns

Three groups or categories are an almost natural consequence of looking at the geographical distribution of liner shipping routes for South East Asia-Australian trade from the Australian end. As at 1 January 1982, the lines and vessels could be grouped as follows:

1. East and West Coast Australia Services (10 vessels):

Anro Line	(3 vessels)
Jumbo Line	(2 vessels)
NYK Line	(2 vessels)
AES/BBS Lines	(3 vessels)
2. East Coast Australia Services (17 vessels):

Karlander Line	(2 vessels)
Antoll Line	(3 vessels)
Anline	(6 vessels)
Jumbo Line	(2 vessels)
Fesco Line	(4 vessels)
3. West Coast Australia Services (8 vessels):

EAC/Knutsen	(8 vessels)
-------------	-------------

The services fall quite neatly into three categories. Dividing them up in this way provides a useful insight into the way they operate.

An equally revealing insight into the nature of the South East Asia-Australia liner services can be obtained from looking at their route patterns from a South East Asian point of view. Singapore, Malaysia, Thailand and Indonesia seem to be regarded as a single trading area by liner service operators. Liner service operators seem to group Manila with Hong Kong and Taiwan as a single trading area. Under these two headings, the liner services fall out as follows:

1. Singapore, Malaysia, Indonesia, Thailand Services (22 vessels):

Anro	(3)
Jumbo	(4)
NYK	(2)
Karlander	(2)
Antoll	(3)
EAC/Knutsen	(8)
2. Manila with Hong Kong and Taiwan (13 vessels):

Anline	(6)
AES/BBS	(3)
Fesco	(4)

The shipping routes plied by each of the liner services referred to above are shown in the twelve maps which make up Figure A1.

SIMULATION ANALYSIS: LINER SHIPPING

Service Frequencies

The frequency of calls received at ports serviced directly in the South East Asia-Australia liner trades is shown in Table A1, below.

TABLE A1

S.E. ASIA-AUSTRALIA LINER SERVICES

FREQUENCIES OF DIRECT CONNECTIONS BETWEEN PORTS

(Estimated average period
between sailing as at
1.1.82)

<div> <div>Australian ports</div> <div>South East Asian ports</div> </div>	Brisbane	Sydney	Melbourne	Tasmanian ports	Port Adelaide	Fremantle
	days	days	days	days	days	days
Semarang ⁽¹⁾	-	37	37	-	-	-
Surabaya ⁽¹⁾	-	37	37	-	-	-
Jakarta	20	5½	9½	28	20	15
Singapore	5	2½	3½	7½	5	3½
Port Kelang	6½	3½	5	7½	6½	3½
Penang	8½	6½	6½	10	8½	4½
Belawan ⁽¹⁾	-	37	37	-	-	-
Manila	7½	6	6	-	-	28
Hong Kong	4½	3	3	15	15	6
Taiwanese ports	5	4	4	15	15	6

(1) Break-bulk vessels only - no direct containerised service.

Source: Study estimates from published schedules.

Shipping Capacity and Trade

The general cargo trade between the relevant countries in South East Asia and Australia for 1981/82 is very briefly summarised in Table A2.

TABLE A2
S.E. ASIA-AUSTRALIA TRADE:
CARGOES CARRIED ON LINER SERVICE
VESSELS IN 1981/82

Type of cargo	Australian Exports	Australian Imports
<u>Containerised Cargoes (1) - in '000s TEU</u>		
- Ports in Singapore, Malaysia, Indonesia and Thailand	31.5	22.6
- Ports in Hong Kong, Taiwan and the Philippines	50.3	59.4
<u>Break-bulk Cargoes (2) - in '000s tonnes</u>		
- Ports in Singapore, Malaysia, Indonesia and Thailand	217	184
- Ports in Hong Kong, Taiwan and the Philippines	321	47

- (1) Includes both refrigerated containers (reefers) and dry containers.
(2) Includes unitised cargo such as timber packs and steel packs.

Source: ABS and Commonwealth Department of Transport (Australia) statistics.

From the figures in Table A2, it is possible to deduce that something like 3.2 million tonnes of liner cargoes moved between the relevant South East Asian countries and Australia during 1981/82. A ball park estimate of liner shipping capacity provided for these cargoes is 5.8 million tonnes of cargo carrying capacity⁽¹⁾. On the basis of these figures, it could be inferred that only 55 per cent of available liner shipping capacity was utilised in these trades during 1981/82. This seems to imply that shippers have been paying for considerable excess capacity on the liner shipping routes linking South East Asia and Australia.

However, such a ball park estimate of shipping capacity is crude and simplistic. It is unfair to shipping lines, because it does not take into account the following factors: imbalances in cargo flows; priorities of one cargo type over another; cargoes with high volume to weight ratios; LCL cargoes; correct stowage and trimming of cargoes; empty container movements; seasonal variations; and the ability of shipping lines to act together to rationalise cargo flows. The ball park estimate may also be unfair to shippers as there is no guarantee that shipping lines have scheduled their vessels in a way which maximises available shipping capacity and/or minimises costs.

- (1) Based on rated cargo carrying capacities of vessels in the trade and the number of round trips performed in a year.

Fig 1A: SOUTH EAST ASIA - AUSTRALIA LINER TRADES AS SHIPPING ROUTES BY LINE

