The Economics of an Australian Landbridge

Report

The study examines the economics of a landbridge based on Fremantle, and also considers Adelaide and Melbourne as terminal ports for the European trades. In addition, the benefits and costs implied by a strategy of alternate calls at Sydney and Melbourne are considered.

BUREAU OF TRANSPORT ECONOMICS

THE ECONOMICS OF AN AUSTRALIAN LANDBRIDGE

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FOREWORD

The availability of a standard guage rail link across Australia and the problems of congestion in the major east coast ports has led to a renewed interest in the 'landbridge' concept in Australia. A landbridge would involve terminating international shipping at one port and distributing and collecting cargo by rail.

The study examines the economics of a landbridge based on Fremantle, and also considers Adelaide and Melbourne as terminal ports for the European trades. In addition, the benefits and costs implied by a strategy of alternate calls at Sydney and Melbourne are considered.

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SUMMARY

The rail distance from Fremantle to the eastern states is almost equal to the sea distance. Hence, a rail link across Australia serving the UK/European liner trade from a terminal port at Fremantle would not be a landbridge in the same sense as those operating across continental U.S.A. and U.S.S.R. This, together with the small quantity of freight generated by Fremantle relative to Melbourne and Sydney, means that an Australian landbridge would have no economic advantages. This result is based on a simple analysis of the trade-off between ship savings and the costs of overland rail transport.

A similar analysis of a cargo centralising strategy based on Adelaide showed that relatively small savings could be achieved, but only by separating the Australian and New Zealand trades to UK/Europe; an unlikely development. At present, only four of the twenty or so ships in the Australia - UK/Europe Conferences call at New Zealand. A further six ships out of this twenty are expected to begin calling at New Zealand within two years. Given its commercial advantages, the trend towards increasing integration of the Australian and New Zealand trades is likely to continue. Centralising cargo through Adelaide would therefore not be commercially attractive.

Melbourne was also examined in the same way and found not to offer any cost savings, even with totally separate Australian and New Zealand trades.

Alternate calls at Melbourne and Sydney, instead of at both ports as at present, could be economically attractive. Forwarding containers to the other port by rail could partly offset the lower frequency but would involve added rail costs nearly equal to the savings in ship costs.

CHAPTER 1 INTRODUCTION

The original 'landbridge' concept evolved out of the benefits in time and cost of forwarding sea cargo across a land mass by rail, rather than around it by sea. The best known applications are those across the USA and the USSR serving principally the Europe-Japan trade. The concept has also been encouraged by containerisation,[1] which lends itself to efficient transfer between sea and land modes. In the Australian context, it has been suggested that ships sailing in the UK/Europe trade, via the Indian Ocean, need not call at east coast ports - mainly Melbourne and Sydney, but should instead discharge and load all cargo at Fremantle. The Trans-Australian railway link would then be used to distribute and collect cargoes to and from the eastern states (Fig. 1). Implied is the assumption that rail capacity would be adequate to carry this additional traffic. The economic benefit of such an operation would be determined by the trade-off between the improvement in productivity of container ships, as a result of shorter steaming and fewer port calls, and the cost of overland rail transport. Unlike the USA and USSR landbridges, the Australian version would not offer significant savings in linehaul distance.

In 1968, W.D. Scott & Co Pty Ltd prepared a "Report on the Feasibility of Fremantle as a Terminal Port for Australia" for the Director General of Transport, Western Australia. The report concluded that there was not a substantive case for the landbridge concept in Australia based on a new container berth in Fremantle. Since the report was written, a significant proportion of ships in the UK/Europe-Australia container trade have begun calling at New Zealand ports. This reduces the potential advantages of the landbridge because calls into Melbourne and Sydney are almost en-route to New Zealand.

However, recent congestion problems in the port of Sydney, and the very adequate capacities of the Fremantle container port and the Trans-Australian rail link have renewed interest in an Australian landbridge. This report presents a re-assessment of the idea.

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(1) The 'containers' referred to in this report are the standard I.S.O. units (20' x 8' x 8' or 40' x 8' x 8'. The unit of measurement used in the report is the 20' x 8' x 8' container.

Because an Australian landbridge would essentially involve a cargo centralising strategy, the report also examines the use of Adelaide or Melbourne instead of Fremantle. These two ports have the advantage of being closer to the demand/supply centres of Melbourne and Sydney. A variation on this idea would be alternate calls between two ports where at present ships call at both ports. Melbourne and Sydney are evaluated with regard to such a strategy.

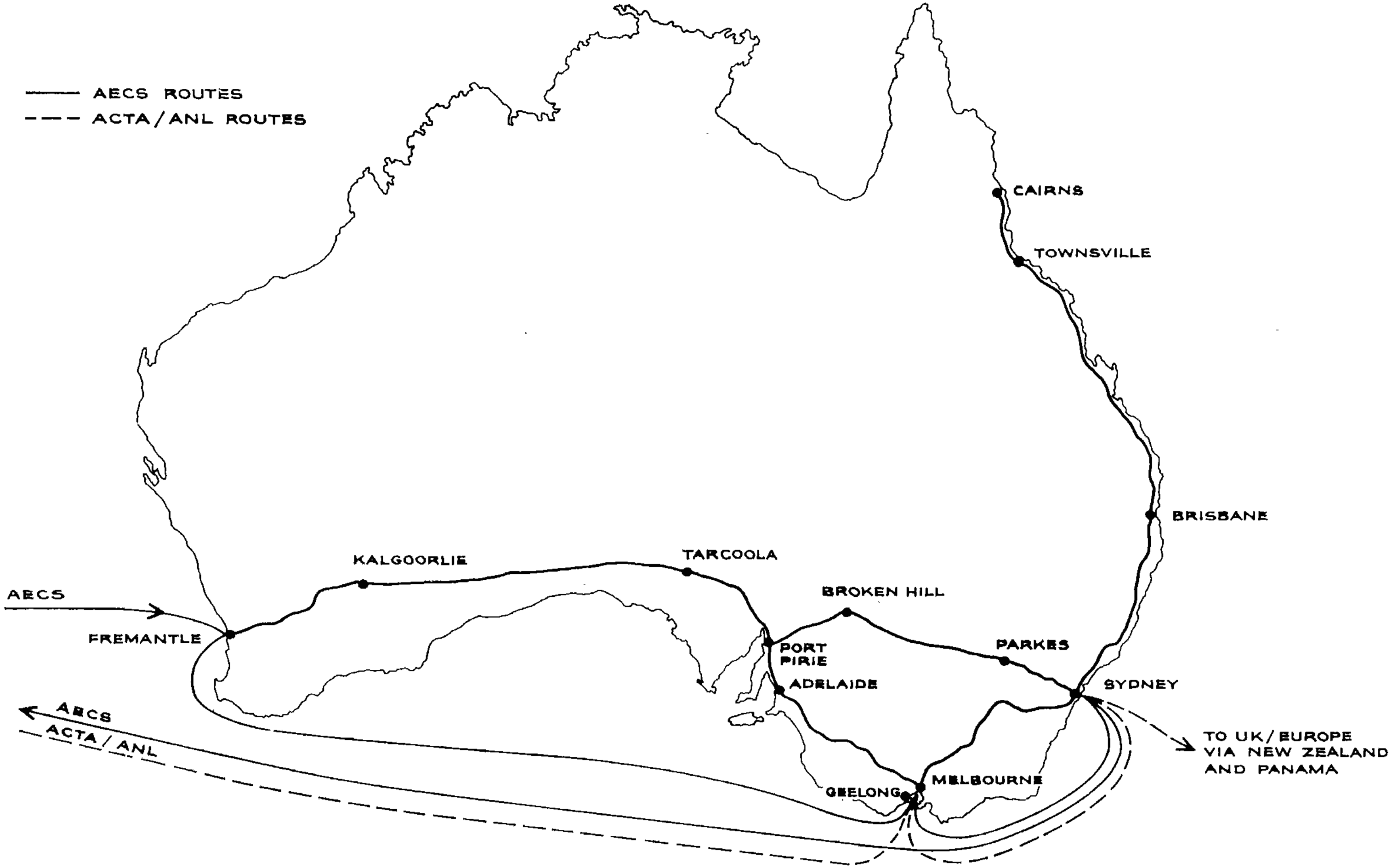

FIG. 1 LANDBRIDGE IN AUSTRALIA

EXISTING MAIN LINE RAIL LINKS AND EXISTING CONTAINER SHIPPING ROUTES FOR THE AUSTRALIA TO UK / EUROPE TRADES

CHAPTER 2 APPROACH

GENERAL ISSUES

Measures which reduce the transport costs of exports and imports can lead to a variety of outcomes for the transport operator, the exporter and the importer.

Shipping between Australia and UK/Europe is provided by closed liner Conferences. Essentially, these are groups of shipping lines, self regulating as to each member's trade share, which negotiate agreed rates with exporters. The negotiations are based on the need of many shippers for regular and reliable services to several ports on the one hand, and on the shipowners' desire for a predictable market, free of rate competition, on the other. The arrangement is not completely closed; lines outside the Conference are able to negotiate contracts with exporters for specific commodities, and this possibility, in fact, generates some competitive pressure on the Conference to keep its services adequate and efficient.

BENEFITS TO IMPORTERS AND EXPORTERS

Freight rate negotiations between a Conference and shippers involve some adjudication in that an independent auditor examines the shipowners' accounts to verify that the returns from the trade conform to some generally accepted rate of return on the capital invested in ships and equipment. If an innovation, such as landbridge, does lead to lower transport costs then some reduction in freight rates in the long term would be likely; at best, the reduction would absorb all of the cost saving. In assessing the incentives for landbridge, we have assumed this limit.[1]

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(1) This would be less of an issue from the Australian point of view if all shipping were Australian owned; the transport cost savings could be counted as an increase in total Australian welfare independently of the ultimate recipient. In fact, however, the Australian share of UK/Europe trade is only about eight percent.

It is shown in Annex A that the upper bound of an increase in economic welfare to an exporting/importing country from a reduction in transport costs is simply the full transport saving. This value is an upper bound because:

- transport savings, in this favourable case, would be fully passed on as reduced freight rates;
- the elasticity of supply of both exports and imports would be infinite; i.e., an increase in demand would not increase the supply cost. The annex also shows that the increase in welfare due to increased consumption flowing from lower transport costs may be neglected for this particular problem.

SHIP SAVINGS

In trading off the land transport costs of a landbridge against the savings in ship costs, account is taken of ship operating cost savings arising from shorter steaming distances and fewer port calls. In addition, there would be an increase in ship productivity which, at best, would be reflected in a reduction of fleet size. At worst, because, say, of the specialised nature of the ships, there would not be any productivity savings in the short term. In a trade growth situation, productivity savings would be reflected in a postponement of procurement of additional tonnage. Even in a zero growth situation, replacement of life-expired tonnage could be postponed and full productivity savings would be achieved after a lapse of time. In the practical short term, productivity savings would be somewhere between zero and the long term upper bound. The analysis examines both these limiting values.

The Australia-UK/Europe liner trade has three participants providing container services: the Australia-Europe Container Service (AECS) with eleven ships; the ACTA/ANL Independent Service with four container ships; and SCAN AUSTRAL with five RoRo ships. Although ACTA/ANL is the only group currently serving both New Zealand and Australia, AECS has announced its intention to integrate its New Zealand and Australian trade within about two years. This will substantially reduce the potential ship economies of a landbridge, as the steaming savings of calling at one Australian port and then returning to UK/Europe are not realised by a ship serving New Zealand ports.

It is expected that the present trend towards combining the Australian and New Zealand trades will continue; even if ANL and the Shipping Corporation of New Zealand (SCONZ) withdrew from cross trading, there would still remain substantial European and British participation in the Conferences. Given the present commercial advantages in combining the trades, they are not likely to separate their Australian and New Zealand services. However, to obtain a measure of how important New Zealand port calls are in relation to an Australian landbridge, three possibilities are examined:

- New Zealand port calls by ACTA/ANL only as at present;
- New Zealand port calls by ACTA/ANL and AECS, as is expected shortly;
- no New Zealand port calls by Conference ships.

The last possibility would be expected to be the most favourable to landbridge.

Annex B summarises the relationships used to estimate savings arising from shorter ship voyages following a reduction in the number of port calls. The following important assumptions should be noted:

- Terminal port facilities are assumed adequate to handle the forecast traffic level. No allowance has been made for investment in port facilities beyond current plans;
- Container handling times are assumed the same at all ports considered. Savings in ship port time would thus be only composed of berthing and casting-off time. The total load-unload time would be unaffected by port schedule changes.

Annex B distinguishes between the two categories of savings that would accrue from landbridge, namely operating cost savings from shorter steaming distances and fewer port calls, and productivity gains due to a reduction of voyage time for ships on the trade.

RAIL COSTS

Applying arguments developed by Jones and Walker[1], the cost of carrying an increment of traffic on rail is directly expressed as a long run marginal cost. In addition to the short run costs of crew, fuel and loading-unloading, the long run costs of motive power and rolling stock investment may be estimated simply by expressing the capital as an annuity per unit distance travelled. Currently, achieved annual mileages of motive power and rolling stock are known. The implicit assumption is that trains would be made up from a continuously replenished fleet of locomotives and rolling stock. If the track is considered to be maintained indefinitely, and maintenance cost is a function of

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(1) "Scheduling Investment in Main Railway Lines", 1st Australian Transport Research Forum, Sydney, April 1975.

traffic expressed as gross tonne-km, then this cost may also be expressed as an incremental cost per train.

Ultimately, additional rail traffic from a landbridge would cause excessive congestion on some links and so advance the time at which they would need upgrading. An estimate of the cost arising from an earlier commitment to upgrading would require a detailed assessment of the characteristics of the line and its traffic, and evaluation of a range of upgrading options(1). This aspect has been ignored for the present study. To this extent, the assumed rail costs would be understated.

The assumptions used in rail cost estimates and the relevant relationships are summarised in Annex C. Annex D summarises the method of estimating the rail terminal costs that would be incurred by landbridge traffic which, it is assumed, would require additional gantry crane facilities at all the ports concerned.

CARGO FLOWS

Container flows are taken to be uniform during the year. This implies perfectly regular ship calls without seasonal variations in load and allows a uniform schedule of train departures for landbridge, thus minimising the size of wagon fleet that would be required. This ideal would not be achieved in practice and the rail costs would therefore tend to be understated. Container flows arising from imports and exports have been assumed balanced for each port. In fact, each port would have its own imbalance, corrected as necessary by internal movement of containers. Fewer ports of call, as implied by landbridge, would tend to reduce internal balancing movements.

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(1) Unpublished BTE research.

The current level of trade between Australia and UK/Europe is equivalent to about 100,000 containers per year in each direction with the following approximate distribution between ports:

Sydney	Melbourne and Tasmania	Adelaide	Perth
36%	44%	10%	10%

The results of the present study would not be sensitive to the level of container flow because almost all of the costs and savings would be directly proportional to the number of containers.

INVENTORY IN TRANSIT

Changes in freight transit time would give rise to changes in inventory cost. If a landbridge were to reduce the overall transit time then there would be inventory cost savings; the converse would be true if transit time were increased. Annex E indicates that a terminal port at Fremantle would have a small unfavourable effect on inventory costs, a terminal port at Adelaide a small favourable effect and alternate port calls between Melbourne and Sydney a neutral effect. Because these effects are shown to be small and it is difficult to estimate inventory value, no further calculation of this cost (or benefit) was made.

CHAPTER 3 RESULTS

LANDBRIDGE

Annex F shows the derivation of rail cost and ship saving relationships which are the main determinants of the feasibility of landbridge. For the simple case of two ports connected by rail, one of which is no longer to be served by sea, the formulation is shown to be the following:

- landbridge is justified in the long term if

$$(N_B.D_R.C_1+N_B.C_2+C_3) \text{ is less than } (N_S.D_S.C_4+N_S.C_5)$$

where N_B = the number of containers forwarded to and from the landbridge port

D_R = the rail distance between the two ports

N_S = the number of ships engaged on the trade prior to landbridge

D_S = the steaming distance between the ports

C_1, C_2, C_3, C_4, C_5 are constant cost and operating parameters.

The general formulation is the same whether ship productivity gains are included or not.

The above formulation suggests in particular that:

- Fremantle would offer the greatest ship savings but would also have high rail costs. The latter arising from its distance from south eastern ports (high D_R), together with the high proportion of containers that would need to be moved by rail (high N_B) because of the relatively minor amount of cargo generated by Fremantle;

- Adelaide as a terminal port would lead to lower ship savings than Fremantle (lower D_S), but also lower rail costs (lower D_R, the same as N_B);
- Melbourne would offer lower ship savings (low D_S) than Adelaide's, but its rail cost would be expected to be lower (lower D_R and N_B)[1];
- participation in the New Zealand trade would be unfavourable to any terminal port (reduced D_S).

Calculated results for a landbridge operated by all container carrying ships to any one of the three ports are shown in Table 1. Because the results are sensitive to whether ships are turned around at the Australian landbridge terminal or whether they also proceed on to New Zealand, the calculations are repeated for three possible levels of participation (or non-participation) in the New Zealand trade.

The main features of the results are:

- Fremantle terminal port - in all cases studied there would be no net benefit from using Fremantle as a terminal port. Even if all 15 ships in the combined ACTA/ANL and AECS fleets did not serve New Zealand, but turned around at Fremantle, the maximum ship savings would be only a little over 70% of the additional land transport costs;
- Melbourne terminal port - in no case examined would the ship savings exceed the rail costs. Melbourne would be an economically inferior option to Adelaide:

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(1) In fact, Melbourne's rail distance advantage over Adelaide would be partly negated by the former's higher requirements for motive power for the NSW section of the Melbourne-Sydney link.

Adelaide terminal port - only if there were no participation in New Zealand trade would the long term ship saving exceed the rail costs ($7.6m compared with $6.9m). As discussed elsewhere, this would not be likely in view of the trend towards combining the Australian and New Zealand trades.

ALTERNATE PORT CALLS BETWEEN MELBOURNE AND SYDNEY

One of the arguments against reducing the number of port calls by liner shipping is that shippers prefer to move their cargo through the port of production or consumption. This could be important in Australia where the largest centres of population are located at major ports. This argument may have been valid in the past due to intermodal transfer costs, and fear of pilferage, loss or damage in the additional overland movement. However, the use of containers tends to make these disadvantages negligible.

There is also some reluctance on the part of the shipping lines to commit their operations to one port only, where they would be too vulnerable to industrial stoppages and unforeseen operational difficulties. For these reasons we have examined a compromise cargo centralising option, based on alternate calls between Melbourne and Sydney.

Even if shippers were to go to the trouble of forwarding consignments between Melbourne and Sydney, the frequency of service would not match that of a schedule which included calls at both ports. The present frequency of call of the combined UK and European Conferences(1) is about one call every 4½ days. It is shown in Annex G that if shippers were to forward consignments between ports whenever it offered a time

(1) Although these are separate Conferences, some combined marketing of an integrated service is offered; e.g., AECS.

advantage under an alternate port call schedule, then the effective frequency would be approximately one call every six days; for shippers not forwarding cargo to the other port, the frequency would be nine days. Annex G also demonstrates that full use of rail forwarding with these frequency parameters would lead to a rail movement of 33,000 containers per year for each of the export and import trades of 100,000 containers.

The ship savings and rail costs that would result from an alternate port call policy are shown in Table 2 and are based on the arguments and parameters developed in Annex G. The rail costs are a lower bound to the extent it is assumed that the additional rolling stock required for forwarding between Sydney and Melbourne would be fully utilised (Annex G). Thus, the case for alternate port calls depends on how quickly and completely long term ship savings could be attained and on the proportion of shippers to whom frequency of service would be important enough to induce them to accept a combined sea/rail movement. The shipping lines would be expected to exploit the advantages of alternate port calls if the operational advantages were to outweigh the marketing disadvantages; our results show that under some circumstances there might be such an incentive.

TABLE 3.1 - LANDBRIDGE RAIL COSTS AND SHIP SAVINGS

($m)

Landbridge Terminal Port	Rail Costs	Ship Savings	
		Short Term(a)	Long Term(b)
ONLY ACTA/ANL SERVING NEW ZEALAND(c)			
Fremantle	16.5	2.7	9.9
Adelaide	6.9	2.0	6.6
Melbourne	5.6	1.6	4.9
ACTA/ANL AND AECS SERVING NEW ZEALAND(d)			
Fremantle	16.5	1.4	3.9
Adelaide	6.9	1.4	3.9
Melbourne	5.6	1.4	3.9
NO ACTA/ANL OR AECS SERVICES TO NEW ZEALAND			
Fremantle	16.5	3.2	12.1
Adelaide	6.9	2.3	7.7
Melbourne	5.6	1.7	5.2

(a) Includes only direct operating savings from shorter steaming distances and fewer port calls.

(b) Includes short term savings plus savings from a reduced total fleet requirement arising out of the productivity improvement (see Chapter 2).

(c) The current situation.

(d) The currently proposed future situation.

TABLE 3.2 - ANNUAL RAIL COSTS AND SHIP SAVINGS FROM CALLING ALTERNATELY AT MELBOURNE AND SYDNEY

$m

Ship savings:	
Short term	0.66[(a)]
Long term	2.40[(b)]
Rail forwarding cost	1.46

(a) Includes only savings from fewer port calls and shorter steaming.

(b) Includes productivity gains from fewer port calls and shorter steaming.

CHAPTER 4 CONCLUSIONS

An Australian landbridge serving the European trade from a Fremantle port would incur considerable losses. The cost of using the land route would be greater than the shipping costs available because:

- the rail distance between Fremantle and the south eastern ports is not much shorter than the sea distance.
- Fremantle generates only a small proportion of Australia's trade and hence most of the containers woul have to be carried over the landbridge.

A cargo centralising policy based on Adelaide or Melbourne would not be economically attractive, even if Conference ships did not make more than the present number of calls at New Zealand. Only in the unlikely event of a total separation of Australian and New Zealand trades would the use of Adelaide as the single Australian terminal port lead to net savings in transport cost in the long term.

Alternate port calls to Sydney and Melbourne as compared to calls at both ports could be economically attractive in the long term. Shipping lines would be expected to reduce the number of port calls as and when commercially advantageous and subject to their judgment of the acceptability of lower ship frequency, possibly combined with rail forwarding.

ECONOMIC BENEFITS OF REDUCED TRANSPORT COSTS FOR IMPORTS AND EXPORTS

Consider the simple case of a single import commodity and a single export commodity with demand and price expressed as:

	D	-	demand
	P	-	price
suffix	x	-	exports
suffix	m	-	imports

Let a reduction in unit transport cost dC_t lead to a reduction in price dP and an increase in demand dD. Following Ray(1) we express the increase in welfare as:

$$dW = D_m dP_m + \tfrac{1}{2} dD_m dP_m + D_x dP_x + \tfrac{1}{2} dD_x dP_x$$

The new equilibrium will be a function of the supply functions of exporters and demand functions of importers, at both ends of the sea transport link. The increase in welfare will be a maximum when the supply function is infinitely elastic, so that the reduction in transport cost is passed on entirely as a drop in price. The maximum increase in welfare then becomes:

$$dW_{max} = D_m dC_t - \tfrac{1}{2}\frac{D_m}{P_m} \cdot e_m (dC_t)^2 + D_x dC_t - \tfrac{1}{2}\frac{D_x}{P_x} \cdot e_x (dC_t)^2$$

where e_m and e_x are the demand elasticities for imports and exports respectively. This simplifies to:

$$dW_{max} = dC_t \left(D_m - \tfrac{1}{2}\frac{D_m}{P_m} e_m dC_t + D_x - \tfrac{1}{2}\frac{D_x}{P_x} \cdot e_x dC_t\right)$$

For multiple commodities, the result is basically the same, expressed as a sum.

If this formulation is applied to the trade between Australia and UK/Europe, by assuming the following average values for the variables:

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(1) Ray, A. <u>The optimum depth of water in a port</u>, Economics Department Working Paper 67, International Bank for Reconstruction and Development, February, 1970.

dC_t = \$20 per container at most[1]

$D_m = D_x$ = 100,000 containers

$P_m = P_x$ = \$20,000 per container at least [2]

we get:

$$dW_{max} = 20\left\{200{,}000 - 50\ (e_m + e_x)\right\}$$

This implies that the absolute value of the sum of the import and export demand elasticities would have to exceed 40 for the welfare to be affected by more than one percent. This is highly unlikely. The terms involving elasticities may therefore be neglected and the maximum increase in welfare simplified to:

$dW_{max} \doteq dC_t\ (D_m + D_x)$, that is, the upper bound of the increase in welfare from a reduction in sea transport cost is approximately that saving in full.

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(1) It turns out that the maximum achievable transport cost saving is about \$10 per container.

(2) This is based on a low value for general goods of \$1,000 per ton.

SHIP SAVINGS

Ship savings accrue from fewer port calls, shorter steaming time, and higher fleet productivity required as a result of the shorter steaming time.

Nomenclature

Let P_T	=	total port time saved per voyage
D_S	=	reduction in the return sea voyage length
P_C	=	reduction in port charges/voyage
S_S	=	ship steaming speed in km/year
C_S	=	total ship capital cost in \$ per ship
FC_S	=	ship capital equivalent annual charge
C_C	=	ship crew costs in \$/year
C_{BS}	=	ship bunker costs/year steaming at present utilisation
N_V	=	present number of voyages per year per ship
V	=	voyage cycle time, without landbridge
N_S	=	number of ships in fleet

Operating Cost Savings

It is assumed that the time taken to load and unload containers will be the same in any port. Thus port time savings are berthing and casting off times only.

$$\text{Steaming time saving} = \frac{D_S}{S_S} / \text{ voyage}$$

$$\text{Therefore crew savings} = C_C \left(P_T + \frac{D_S}{S_S}\right) / \text{voyage/ship}$$

$$= N_V C_C \left(P_T + \frac{D_S}{S_S}\right) / \text{year/ship}$$

Annual fuel savings $= N_V \frac{D_S}{S_S} C_{BS/ship}$

Annual port charge saving $= N_V P_{C/ship}$

Total annual operating cost saving for N_S ships

$$= (C_C \ (P_T + \frac{D_S}{S_S}) + \frac{D_S}{S_S} C_{BS} + P_C) N_V . N_S$$

Ship Productivity Savings

Time saved per voyage $= \frac{D_S}{S_S} + P_T$

Equivalent annual ship capacity $= \frac{(\frac{D_S}{S_S} + P_T) N_S}{V}$ ships

Equivalent annual ship capital saving =

$$\frac{(\frac{D_S}{S_S} + PT)}{V} N_S . FC_S, \text{ if realizable}$$

Assumed Values of Cost and Operating Parameters

N_V = 83

T_P = 0.0082 years

C_S = $22m

FC_S = $1,735,800/year

C_C = $ 321,200/year

C_P = $ 5,860/voyage

S_S = 296,054 km/year

C_{BS} = $ 668,315/year/ship

P_T = 1.5 days/port call

D_S (AECS) = 7276 km for Fremantle, 3948km for Adelaide and 1864 km for Melbourne.

D_S (ACTA/ANL) = 933 km

P_C = 5000/voyage

V = 71 days

N_S = 4 for ACTA/ANL

= 11 for AECS

The derived ship savings corresponding to these single terminal ports, Fremantle, Adelaide, Melbourne are summarised for the case in which ACTA/ANL serve New Zealand in Table B1.

TABLE B.2 - ANNUAL SHIP TIME AND DISTANCE SAVINGS
(per ship)

	Only ACTA/ANL Serving New Zealand			Both ACTA/ANL and AECS serving New Zealand
	Fremantle	Adelaide	Melbourne	Fremantle
Sea Distance:				
AECS	7,276 km	3,948 km	1,864 km	933 km
ACTA/ANL	933 km	933 km	933 km	933 km
Sea Time:				
AECS	9 days	4.9 days	2.3 days	1.2 days
ACTA/ANL	1.2 days	1.2 days	1.2 days	1.2 days
Part Time:				
AECS and ACTA/ANL	3 days	3 days	3 days	3 days

TABLE B.1 - ANNUAL SHIP COST SAVINGS
($m)

	Only ACTA/ANL serving New Zealand						Both ACTA/ANL and AECS serving New Zealand
	Fremantle		Adelaide		Melbourne		Fremantle
Port Charges		0.913		0.913		0.913	0.913
Bunker Savings:		1.080		0.607		0.108	0.175
AECS	1.038		0.565		0.266		
ACTA/ANL	0.042		0.042		0.042		
Crew Savings:		0.737		0.510		0.367	0.303
AECS	0.664		0.437		0.294		
ACTA/ANL	0.073		0.073		0.073		
Capacity Savings							
AECS	19% or 2.06 ships		14% or 1.36 ships		8% or 0.90 ship		
ACTA/ANL	6% or 0.23 ships		6% or 0.23 ships		6% or 0.23 ship		
Equivalent Annual Charge to:	2.29 ships	7.204	1.59	4.600 ships	1.13	3.269	6% or 0.9 ship 2.604
MAXIMUM SAVINGS		9.934		6.630		4.857	3.995

NOTE: Figures have been compiled for an AECS fleet of 11 ships and an ACTA/ANL fleet of 4 ships.

ANNEX C

DETERMINATION OF RAIL CONTAINER MOVEMENT COSTS, EXCLUDING TRAIN LOADING AND UNLOADING

This analysis assumes that all rail rolling stock will be purchased for the project, and that rolling stock maintenance and operating costs, plus increased track maintenance costs should be attributed to the project.

Nomenclature

Let N_B = number of boxes moved in each direction per annum

N_T = number of trains to move N_B boxes/year

N_L = number of loccmotives/train

N_W = number of wagcns/train

N_{BT} = number of boxes/train

N_{BW} = number of boxes/wagon

D_R = return trip distance by rail

S_T = train average speed, miles per year

T_L = locomotive a return journey time

T_W = wagon return journey time
= $T_L + T_{WT}$ where T_{WT} is the terminal turnaround time for wagons

MC_L = locomotive maintenance costs per km

MC_W = wagon maintenance ccsts per km

C_L = locomotive capital cost of a (including 20% down time allowance)

C_W = wagon capital cost of a (including 5% dcwn time allowance)

$F\ C_L$ = annual capital charge per locomotive

$F\ C_W$ = annual capital charge per wagon

W_T = gross weight of train in '000 tonnes

C_F = locomotive fuel cost per gross 1,000 tonne

C_{CR} = annual train crew cost per train

M_{CT} = average increase in track maintenance cost per gross tonne kilometre arising from the proposed increase in annual gross train tonnage

Basic Relationships

For each route connecting the major demand/supply centre with the port:

- number of train trips/year $= \frac{N_B}{N_{BT}}$
- number of trains required $= \frac{N_B}{N_{BT}} \cdot \frac{D_R}{S_T}$
- number of locomotives required $= \frac{N_B}{N_{BT}} \cdot N_L \frac{D_R}{S_T}$
- number of wagons required $= \frac{N_B}{N_{BW}} \left(\frac{D_R}{S_T} + T_{WT}\right)$
- annual train mileage $= \frac{N_B}{N_{BT}} \cdot D_R$

Hence:

(1) . Annual capital cost of locomotives $= FC_L \cdot \frac{N_B}{N_{BT}} \cdot \frac{D_R}{S_T} \cdot N_L$

(2) . Annual capital cost of wagons $= FC_W \cdot \frac{N_B}{N_{BW}} \left(\frac{D_R}{S_T} + T_{WT}\right)$

(3) . Annual maintenance charges for locomotives $= MC_L \cdot \frac{N_B}{N_{BT}} \cdot D_R \cdot N_L$

(4) . Annual maintenance charges for wagons $= MC_W \cdot \frac{N_B}{N_{BT}} \cdot D_R \cdot N_W$

(5) . Annual locomotive fuel costs $= \frac{N_B}{N_{BT}} \cdot D_R \cdot W_T \cdot C_F$

(6) . Annual train crew costs $= C_{CR} \cdot \frac{N_B}{N_{BT}} \cdot \frac{D_R}{S_T}$

(7) . Increase annual in track maintenance cost $= MC_T \cdot \frac{N_B}{N_{BT}} \cdot D_R \cdot W_T$

NOTES: (a) The total rail transport cost (excluding loading and unloading) is the sum of items (1) to (7) over all routes.

(b) Trains are assumed to be scheduled uniformly throughout the year; in fact, seasonal peaks occur in both exports and imports.

Assumed Modes of Train Operation

It is assumed that no capacity constraints exist on the rail links, that 3000 gross tonne trains could run with a single 3000 hp locomotive on the Perth-Port Pirie-Parks section, and that trains will split into two 1500 gross tonne trains for the Port Pirie-Melbourne and Parks-Sydney sections, each hauled by a single 3000 hp locomotive. Current practise is to run 1,000 tonne trains between Melbourne and Adelaide although 1400 tonne trains are a possibility; while on the Sydney-Melbourne route trains are currently of the order of 1000 tonnes or less. In the long term, train weight is expected to increase. Limiting factors such as length of crossing loops and ruling grades have been ignored in the present assessment.

Assumed Values of Cost and Operating Parameters

The main sources of this data were the State Railways, and BTE research.

I Route independent parameters

- N_B = 100,000 containers
- N_B = 3
- S_T = 370,792 km per year
- C_L = \$480,000
- FC_L = \$ 56,400

- C_W = \$ 20,000
- F_{CW} = \$ 2,350
- MC_L = 12.423¢/km
- MC_W = 1.2423¢/km
- T_{WT} = 3 days or .0082 years
- C_C = \$15 hour = \$115,200/year
- C_F = \$0.35/km

II Route dependent parameters

	Fremantle Port Pirie	Port Pirie Parkes	Parkes Sydney	Port Pirie Adelaide	Adelaide Melbourne
N_L	1	1	1	1	1
N_W	40	40	20	20	20
N_{BT}	120	120	60	60	60
D_R (km)	2440	1078	444	183	845
W_T (tonnes)	3000	3000	1500	1500	1500

MC_T varied from a value of \$150/km to \$500/km depending on the increase in traffic due to landbridge and the existing traffic level on the route.

The derived rail costs corresponding to three single terminal ports, Fremantle, Adelaide and Melbourne are summarised in Tables C1, C2 and C3.

TABLE C1 - FREMANTLE TERMINAL PORT : ANNUAL RAIL COSTS

Route Section	Rail Distance (km)	Containers Carried Each Way ('000)	Train Trips Required	Locos Per Train	Locos Required	Wagons Required	Loco Mtce Costs ($'000)	Wagon Mtce Costs ($'000)	Fuel Costs ($'000)	Track Mtce Costs ($ million)
Fremantle-Port Pirie	2,440	90	750	1	10	582	454.7	1,818.7	1,281.0	3.170
Port Pirie-Parkes	1,078	36	300	1	1.644	174	80.4	321.4	326.4	
Parkes-Sydney	444	36	300	2	1.436		66.2	132.4	93.2	1.066
Port Pirie-Adelaide	183	54	450	2	0.888	130	40.9	81.8	57.6	
Adelaide-Melbourne	845	44	367	2	3.34	158	154.1	308.2	217.1	0.720
					17.308	1,044	796.3	2,662.5	1,875.3	4.956
				Add 20% for downtime allowance						
					20.78	1,097				

Crew Costs: Assumes two locomotives would be split, requiring two crews. Crew costs for 17.3 locos operating 24 hours/day are $2.07m/year.

Capital Costs: At $480,000/loco and $20,000/wagon the total capital requirements for rolling stock is $31.9m. Over a 20 year life cycle, 10% interest rate the equivalent annual capital charge is $3.7m.

Rail Cost Summary		($ million)
Capital Charge		3.7
Operating Costs -	Loco Mtce	0.796
	Wagon Mtce	2.662
	Crew Cost	2.070
	Fuel Cost	1.875
	Track Mtce	4.956
Terminal Costs		0.500
	TOTAL	16.5

TABLE C2 - MELBOURNE TERMINAL PORT: ANNUAL RAIL COSTS

Route Section	Rail Distance (km)	Containers Carried Each Way ('000)	Train Trips Required	Locos Per Train	Locos Required	Wagons Required	Loco Mtce Costs ($'000)	Wagon Mtce Costs ($'000)	Fuel Costs ($'000)	Track Mtce Costs ($ million)
Fremantle-Port Pirie	2,440	10	83	1	1.1	59	50.2	201.3	141.8	0.366
Port Pirie-Parkes	1,078			1						
Parkes-Sydney	444			2						
Port Pirie-Adelaide	183	10	83	2	0.2	3.2	7.6	15.2	21.3	0.055
Adelaide-Melbourne	845	20	167	2	1.5	93	70.2	140.2	197.6	0.254
Melbourne-Sydney	954	36	300	2	3.1	174	142.3	284.4	400.7	0.459
					5.9	455	270.3	641.0	761.4	1.134
				Add 20%	downtime	allowance				
					7.08	478				

Crew Costs: For 5.9 locos operating 24 hours/day @ $15/hour the annual cost is $775,260.

Capital Costs: At $480,000/loco and $20,000/wagon the total capital requirement for rolling stock is $12,956. At 20 year life cycle, 10% interest, the equivalent annual charge is $1.522m.

<u>Rail Cost Summary</u>

		($ million)
Capital Charge		1.522
Operating Costs -	Loco Mtce	0.270
	Wagon Mtce	0.641
	Crew Costs	0.775
	Fuel Costs	0.761
	Track Mtce	1.134
Terminal Costs		0.500
	TOTAL	5.603

TABLE C3 - ADELAIDE TERMINAL PORT: ANNUAL RAIL COSTS

Route Section	Rail Distance (km)	Containers Carried Each Way ('000)	Train Trips Required	Locos Per Train	Locos Required	Wagons Required	Loco Mtce Costs ($'000)	Wagon Mtce Costs ($'000)	Fuel Costs ($'000)	Track Mtce Costs ($ million)
Fremantle-Port Pirie	2,440	10	83	1	1.09	59	50.3	201.3	141.8	0.366
Port Pirie-Parkes	1,078	36	300	1	1.74	154	80.4	453.8	226.4	0.404
Parkes-Sydney	444	36	300	2	1.44		66.2		186.5	
Port Pirie-Adelaide	183	46	383	2	0.76	87	34.8	69.7	98.1	0.091
Adelaide-Melbourne	845	41	342	2	3.12	191	143.6	287.2	403.1	0.307
					8.15	491	375.3	1,011.0	1,055.9	1.168
Add 20% downtime allowance					9.78	515				

Crew Costs: 8.15 locos operating 24 hours/day, 365 days/year with a crew of 3 @ $15/ hour gives crew costs of $1.071m.

Capital Charges: 9.78 locos @ 480,000 and 589 wagons @ $20,000 gives capital investment of $15.0m. At 20 year life 10% interest equivalent annual charge is $1.762m.

Rail Cost Summary

		($ million)
Capital Charge		1.762
Operating Costs -	Loco Mtce	0.375
	Wagon Mtce	1.012
	Crew Costs	1.071
	Fuel Costs	1.056
	Track Mtce	1.168
Terminal Costs		0.500
	TOTAL	6.944

ANNEX D

RAIL TERMINAL COSTS

The current cycle involved in unloading a ship and delivering a container consists of:

- off ship on to terminal, hard-standing;
- from terminal to depot or consignee either by road or rail:
- if applicable, local delivery from depot or rail siding.

For a landbridge type of operation, this cycle will have an additional stage, as follows:

- off ship on to terminal, hard standing;
- on train, line haul, off train at either a rail terminal facility or at the rail siding to the depot;
- from rail terminal to depot, if applicable;
- local delivery from depot.

Full Container Load consignments do not have to stage through a depot so even if all depots were on rail sidings, there could be a requirement for direct delivery from rail to consignee. So landbridge could require additional gantry facilities at rail terminals. At the sea terminal, the train could be loaded or unloaded directly from or to the ship but this is unlikely to be feasible without special facilities. In any case, it would lead to serious bunching of trains and increases in rolling stock requirements. For the sea terminals, it is assumed storage is available for containers during the time between ships, and trains can be loaded or unloaded using existing equipment.

Handling Rates at Rail Terminals

At a rate of 3 minutes/container lift, a train of 120 containers can be unloaded in six hours. Allowing one hour for positioning of train, etc., one gantry can handle three trains per day in a 24 hour working day.

It is assumed that new container facilities will be provided for the container traffic.

For Sydney and Melbourne 100,000 lifts per year would be needed for options other than alternative port calls or Melbourne as a terminal port.

One gantry facility can handle up to three trains or 360 containers/day or, for a 320 day year, 115,200 containers/year.

Thus, the facility would need to operate three shifts/day to cope with 100,000 lifts/year. Assuming a gantry crew of two plus a yard supervisor, and a three shifts operation, we get:

Labour costs	\$55,000
Operating costs	10,000
	\$65,000

The capital cost of a gantry facility is assumed to be \$0.75m, equivalent to an annual charge of \$122,000 (this equals a capital annuity at 10% with a life of 10 years).

Therefore, the annual cost of a gantry facility equals \$187,000.

It is assumed that additional gantries would be required at the terminal port (Fremantle or Adelaide), and Sydney and Melbourne. The Melbourne and Sydney gantries would not be fully utilised. A total annual gantry charge of \$0.5m has been used in the analysis.

ANNEX E

THE EFFECT OF LANDBRIDGE ON INVENTORY COSTS

The most likely rail movement schedule would be a progressive lifting of containers from the terminal over the interval between ship calls.

Let T_R = rail transit time,

T_P = time between port calls,

T_S = sea transit time from the terminal port to the destination port

Then the first containers from a ship will leave immediately after it is unloaded, and the last containers just before the next ship calls, that is, at T_P. This would tend to be unfavourable to rail because there would be no opportunity for cargo to be distributed immediately.

The rail transit time would be T_R and the average delivery time $T_R + \frac{Tp}{2}$. Using the direct sea link the transit time would be T_S with all containers arriving at time T_S.

For the terminal port at Fremantle and a ship call frequency of 4.4 days, the average rail delivery times are calculated to be:

Sydney	-	7.6 days
Melbourne	-	7.2 days
Adelaide	-	4.3 days

The ship delivery time from Fremantle would be:

Sydney	-	9.0 days
Melbourne	-	4.8 days
Adelaide	-	7.0 days (Including rail delivery time from Melbourne)

There would thus be:

- for Sydney a saving of 1.4 days
- for Melbourne a penalty of 2.4 days
- for Adelaide a saving of 2.7 days

Similarly, for the Adelaide terminal port, the results are:

- for Fremantle a saving of 0.73 days (assuming current delivery in rail from Melbourne)
- for Melbourne a penalty of 1.66 days
- for Sydney a saving of 1.74 days

An indication of additional inventory charges can be gained for a Fremantle terminal port, assuming:

- inventory holding costs = 20% p.a.
- average value of container contents = $3000
- 36,000 containers go to Sydney, 44,000 to Melbourne, and 10,000 to Adelaide.

The delays and savings would be incurred on both imports and exports.

$$\text{Container day savings} = 1.4 \times 36{,}000 \times 2 + 2.71 \times 10{,}000 \times 2 - 2.4 \times 2 \times 44{,}000$$

$= 56{,}200$ i.e. a nett penalty of 56,200 days

$$\text{Inventory charge} = \frac{0.2}{365} \times 3{,}000 \times 56{,}200$$

$= \underline{\$92{,}000}$

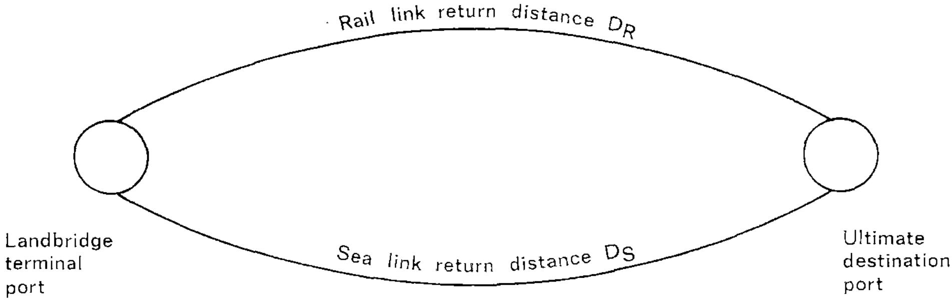
This would be an additional charge to rail. The cost element is not accurate. If it were included in the evaluations it would make the rail position worse; for Fremantle by less than 1% of rail costs and for Adelaide by less than .01% of rail costs.

In the case of alternate port calls, the inventory costs associated with the strategy would be somewhat different. If it is assumed that shippers would generally accept a lower frequency service, then the increase in inventory costs is estimated as follows:

- if cargo is assumed to build up linearly between port calls then, for a 4 day frequency 63 day voyage, the average container transit time would be <u>65 days</u>.
- for a 61 day voyage 8 day frequency, the average container transit time would be 65 days.

Thus on average, there would be no significant inventory charge associated with alternate port call strategy.

COSTS AND SAVINGS FROM A LANDBRIDGE



Consider the simple case of two ports, one being the proposed landbridge terminal port. The return land and sea distances between the ports are D_R and D_S respectively. Following from Annex C, and using the same nomenclature:

The cost of moving N_B boxes per year in each direction by rail would be:

$$N_B \cdot D_R \left\{ \frac{FC_L \cdot N_L}{N_{BT} \cdot S_T} + \frac{FC_W}{N_{BW} \cdot S_T} + \frac{MC_L \cdot N_L}{N_{BT}} + \frac{MC_W \cdot N_W}{N_{BT}} + \frac{W_T \cdot C_F}{N_{BT}} + \frac{C_{CR}}{N_{BT} \cdot S_T} \right.$$

$$\left. + \frac{M_{CT} \cdot W_T}{N_{BT}} \right\} + \frac{N_B}{B_{BW}} \cdot FC_W \quad . \quad T_{WT} + C_T$$

Where C_T is the annual cost of operating the gantry cranes at the rail terminals, assumed independent of throughput (see Annex D). Simplifying, we can say:

$$\text{Annual rail cost} = N_B \cdot D_R \cdot C_1 + N_B \cdot C_2 + C_3$$

where C_1, C_2 and C_3 are constants.

Following from Annex B, and using the same nomenclature:
Long term ship savings from landbridge:

$$N_S \cdot D_S \left\{ N_V \cdot \left(\frac{C_C}{S_S} + \frac{C_{BS}}{S_S} \right) + \frac{F_{CS}}{V \cdot S_S} \right\} + N_S \left\{ N_V (C_C \cdot P_T + P_C) + \frac{P_T \cdot F_{CS}}{V.} \right\} .$$

Simplifying again:

Annual ship savings = $N_S.D_S.C_4 + N_S.C_5$, where C_4 and C_5 are constants.

Combining these simple equations, landbridge is justified if:

$$(N_B.D_R.C_1 + N_B.C_2 + C_3) \text{ is less than } (N_S.D_S.C_4 + N_S.C_5)$$

This inequality highlights the factors which favour landbridge;

- short rail distance compared to sea distance - D_R versus D_S
- small number of land container movements in relation to the trade as a whole - N_B versus N_S

ANNEX G

ALTERNATE PORT CALLS AT MELBOURNE AND SYDNEY

This analysis assumes a situation in which ship owners offer shippers the option of forwarding their containers to either Melbourne or Sydney in order to catch an earlier ship or, in the case of imports, to achieve an earlier delivery. The rail cost would be carried by the shipowners, who would trade it off against savings in ship costs. For the purposes of this analysis, it is assumed that all shippers would use the rail service although in practice this would probably not be the case, in view of the findings on inventory costs (Annex E).

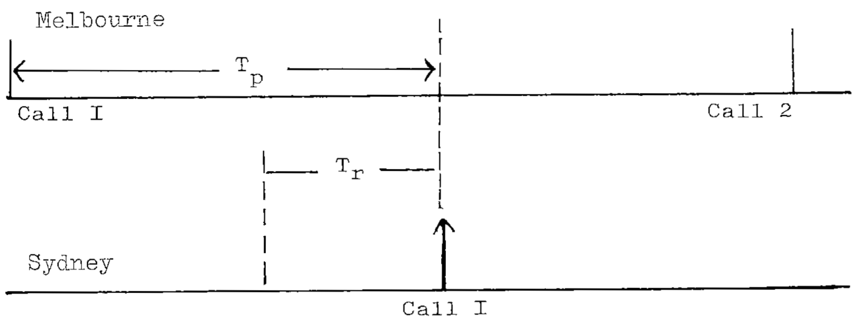
Consider first Melbourne and Sydney shippers.

Let C_M and C_S = the daily rate of export build up in Melbourne and Sydney (assumed uniform during the year),

T_R = Sydney-Melbourne rail transit time

T_P = time between port calls on the existing system.

If we assume voyages would be centred as below;



then, for each pair of calls, $C_M\ (T_P - T_R)$ containers would move to Sydney and $C_S(T_P - T_R)$ would move to Melbourne to catch an earlier ship.

The rail movement as a proportion of the total movement would therefore be;

$$\frac{(C_M + C_S)(T_P - T_R)}{2T_P\ (C_M + C_S)} = \frac{T_P - T_R}{2T_P}$$

A similar argument could be applied to imports, the proportion being the same.

In general, the flow of containers between Melbourne and Sydney would be unbalanced to the extent of the difference between the cargo flows originating and terminating in these ports. If it is assumed that Perth cargo could move through either Sydney or Melbourne, and that Adelaide cargo would prefer Melbourne, then the ratio of Sydney and Melbourne throughputs would be about 41:59 respectively. For the purposes of this analysis, the imbalance will be ignored and the total rail movement task assumed to be:

(Total container movement).$(T_P - T_R)$ in both directions.

For typical values of $T_P = 4.4$ days
and $T_R = 1.5$ days,
and a movement in and out of Australia of 100,000 containers per year in each direction, the rail movement would be approximately 66 per cent or 33,000 containers per year for each of imports and exports(1).

This rail movement would tend to be unidirectional at any particular time: when the next ship was due to arrive in Melbourne, import and export movements would be from Sydney to Melbourne, and vice versa. The worst possible situation would be for empty trains to be running in the reverse direction to the container flow. In practice, the railways would obviously make use of this capacity to earn additional revenue.

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(1) Our calculations also imply that the effective frequency of ship call, given the use of rail calculated here, would be about one ship call every 6 days. Without rail, the interval between ship calls would be the full 9 days.

A lower bound for rail costs attributable to alternate port calls has been determined by allocating half the capital and operating costs of the rail movements to this movement, thus implying that railways would make good use of the capacity made available.

Using the parameter values and formulations of Appendix A the total rail costs are:

		$M
Capital costs		0.414
Crew costs		0.526
Equipment maintenance		0.519
Track maintenance		0.417
Fuel		0.487
Terminal		0.500
	TOTAL	2.922

The rail costs attributable to alternate port calls are then $1.461m.

Assuming each ship saves the equivalent of half the Sydney/Melbourne distance per trip the ship savings are:

Operating savings	$	0.660
Capacity saving		1.736
MAXIMUM SAVING		2.396