Issues in Inter-Modal Transport

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Abstract:

The paper examines trends in international trade in manufactured goods and the demands these changes have placed on container transport operators. The costs to shipping operators of using round-the-world services in conjunction with a feeder service from an Asian transhipment port are compared with the costs of a direct service. The effects of micro-economic reform in Australia and the impact these reforms might have on inter-modal transport are also examined. The final part of the paper presents some preliminary results of an analysis of land-bridging possibilities in Australia.

The views expressed in this paper are those of the authors, and do not necessaryly represent those of the Bureau of Transport and Communications Economics.

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Introduction

In recent years there have been a number of proposals for particular ports to become hubs or gateway ports for Australia's international trades. These proposals are not new in concept. The then Bureau of Transport Economics (BTE) analysed an earlier proposal in 1975. At that time the BTE came to the conclusion that relative costs of land and sea transport did not favour the development of a land-bridge. Since then, major liner operators have developed a greater interest in inter-modal transport systems which have focused increasingly on door-to-door transport rather than on one link of the transport chain. A result of these trends has been the accelerated development of land-bridges in Europe and North America. This paper examines some of the issues which influenced these developments as well as domestic developments which may influence the prospect for land-bridges in Australia. The paper concludes with the results derived from a land-bridge model developed by the Bureau of Transport and Communications Economics (BTCE).

What is commonly referred to in Australia as land-bridging is regarded as mini-land-bridging in the United States. To alleviate confusion, this paper defines land-bridging as the substitution of a land transport link for a sea transport link as part of an international cargo movement. Although cargo centralisation is not usually regarded as a land-bridging option, the practice of such is clearly encompassed by this definition. The extent of land-bridging of centralised cargo is illustrated in Figure 1 which shows the origin of cargo exported and the destination of cargo imported through Sydney.

Trade developments

Growth in world trade has been mainly due to increased trade in manufactured goods. For example, in 1989 manufactured goods comprised 70 per cent of the value in world merchandise trade and 80 per cent of the growth in world trade. Trade in manufactures grew by 8 per cent in contrast to mining and farm exports which increased by 4.5 per cent and 4 per cent respectively (Far Eastern Economic Review 1991).

Much of this growth in manufactured goods has been the result of the globalisation of industry. Globalised industries are characterised by the sourcing of inputs from several countries, manufacturing or assembly of final products in another country or countries and selling globally. As a consequence much of the trade in manufactured goods has been in intra-industry trade and between countries with similar factor endowments.

Globalised industries have had to focus on the coordination of their manufacturing activities. Linkages to suppliers, distributors and buyers are important. Reductions in transport and communications costs have fostered the development of globalisation by allowing these links to be coordinated efficiently. Reductions in trade barriers have also favoured global industries. In particular it has become possible to substitute low cost external suppliers for high cost internal production of products or services.

Rapidly changing consumer demands and preferences have meant that manufacturers have not been able to rely on high inventory levels to respond to increased demands for high levels of service. In any case large inventory levels are expensive. Manufacturing techniques such as Just-In-Time (JIT) have been increasingly adopted to allow the provision of good service levels to customers while keeping inventory levels down to reasonable levels.

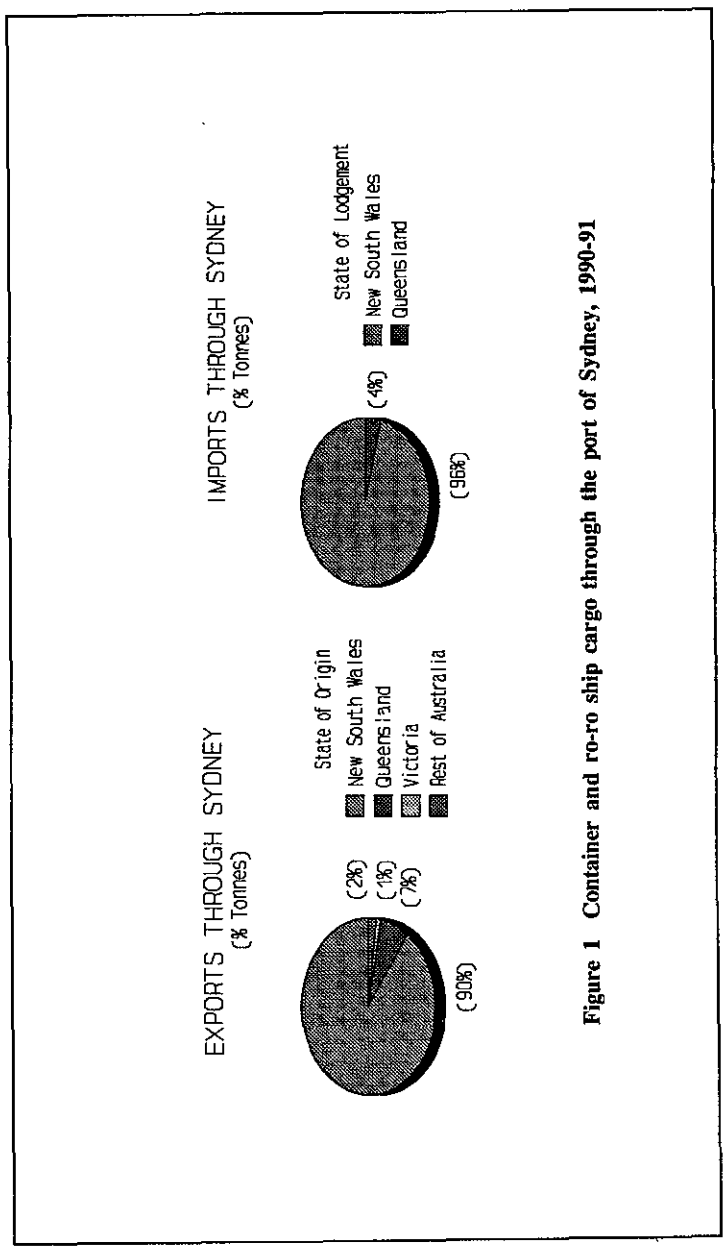
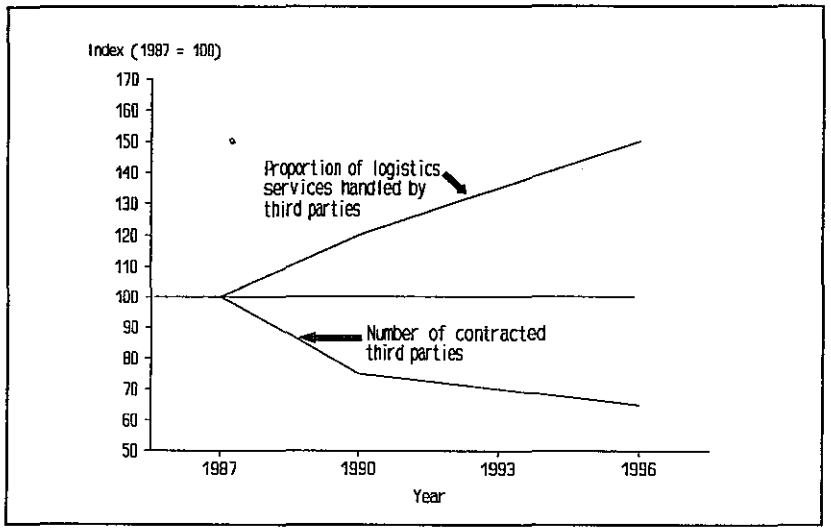


Figure 1 Container and ro-ro ship cargo through the port of Sydney, 1990-91

Source: ABS Sea and Air Cargo Statistics



Source: Peters (1991)

Figure 2 Trends in outsourcing logistics services

The trend to sourcing of inputs from outside suppliers has been accompanied by a reduction in the number of suppliers. A similar trend has also been observed in the supply of transport services. Figure 2, which is based on a World Bank survey, illustrates this trend.

Liner Shipping Trends

Liner shipping has always been global in nature, but the trends occurring in manufacturing have also influenced its organisation. A model to illustrate this has been put forward by Brooks, Blunden and Bidgood (1991) and is shown in Figure 3. In brief, the requirements of globally organised industries for reliable transport, and the preference for fewer logistics suppliers has encouraged the development of liner shipping companies to become integrated door-to-door operators. Sea-Land is a good example of this development. The company was said to have changed its emphasis from "... being a liner company - that circles the globe - to a full service transportation company offering global packages that can be competitive with firms providing contract logistics" (Middleton 1990). This was done through the forging of alliances with other major shipping companies on major trade routes and with logistics and land transport firms in Europe. In addition Sea-Land is owned by CSX, a major railway operator in the USA. Sea-Land has also been reported as having an interest in the development of Adelaide as a hub port (DCN 1992).

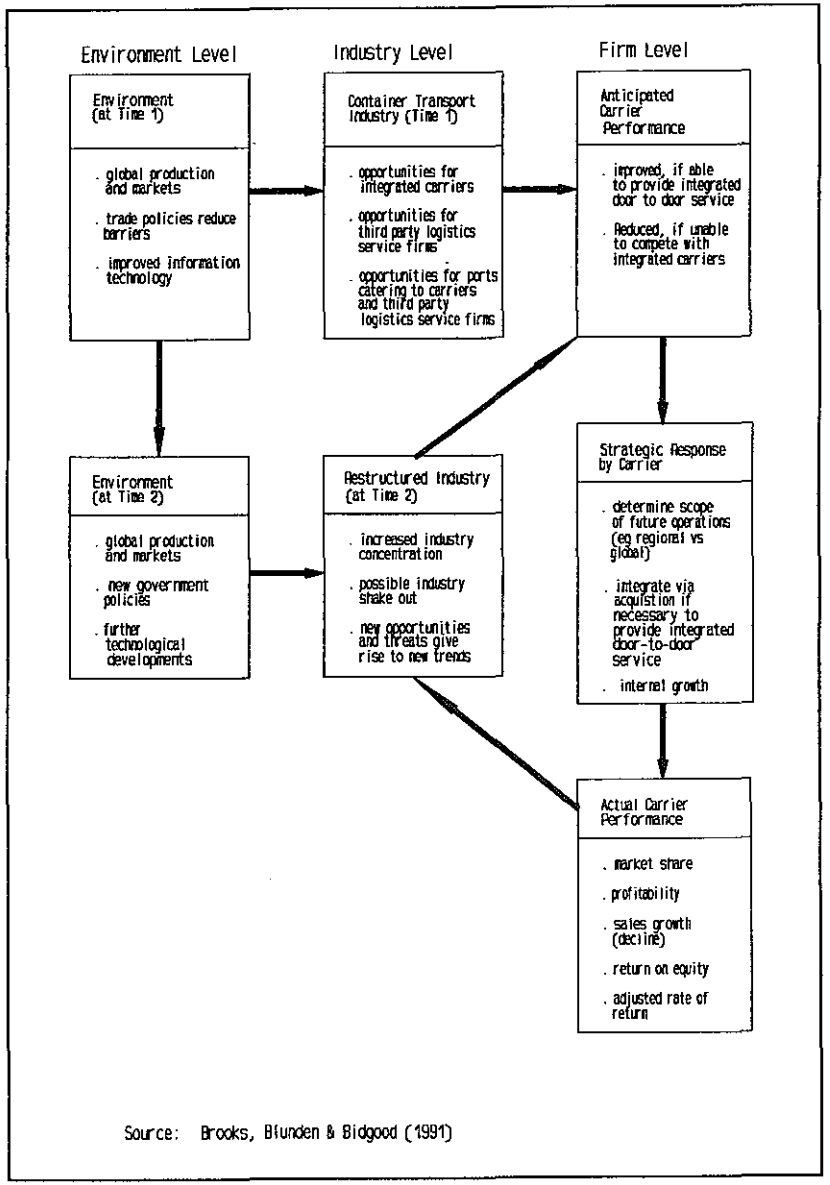


Figure 3 A model of strategic behaviour in the container transport industry

Land-bridging in North America has thus become a natural development of these trends as liner shipping companies have extended their control over container movements from purely wharf-to-wharf to door-to-door.

Another important development in liner shipping has been the development of round the world services. These services are operated by very large container ships, typically of around 4000 TEU capacity with even larger ships likely before the turn of the century. These ships call at a few large transhipment ports with other ports served by feeder services employing smaller vessels. Direct services are typically provided by ships intermediate in size between round the world ships and feeder ships.

Intra-Asia trade is well developed, with South East Asia being serviced by feeders through Singapore. Because of its strategic position, Singapore is becoming increasingly more important to Australian and global liner shipping. In April this year, Lloyd's Shipping Economist expressed the Singapore connection this way:

> "Two years ago end-to-end operations terminated at Hong Kong or Taiwan, with only round-the-world or pendulum operations reaching as far as Singapore. Now a direct call at Singapore is highly desirable, if not essential, as a means to make in roads into the growing SE Asian market. Its scope as a transhipment hub has also grown, and includes connecting services to the Bay of Bengal, the West coast of India, Pakistan and the Middle East Gulf."

> "Many lines have set up their own intra-Asian services (or vastly upgraded existing ones), largely to take advantage of the boom in cargo between Asian countries, but also to act as feeders for the mainhaul transpacific routes. Those carriers without such services are increasingly using connecting carrier arrangements or commercial feeders to extend their market range."

The continued importance of Singapore to liner shipping may provide significant benefits for Australia. The opportunity is there for Australia to be linked to world trade through global and pendulum services via a feeder service from one or more Australian ports to Singapore. This option may provide a lower cost transport option than the present direct service operations, although participants at a land-bridging workshop conducted by the Bureau expressed the view that this was unlikely to happen.

The possibility of some Australian liner shipping services being provided by feeder services via an Asian transhipment port has implications for the potential for land-bridging. Since the analysis of land-bridging requires comparing the costs of carrying cargo by land with the costs of sea transport between two ports, the size of ship used for sea transport is of obvious importance. As part of the investigation into land-bridging, the Bureau analysed some of the possible feeder/global service options and compared their costs with those of direct services.

The analysis focused on three major trade routes; Europe, North Asia and West coast North America. The analysis examined the costs of the options using ship costs derived from a model developed by the UN Economic and Social Commission for Asia and the Pacific (ESCAP). This model is based on a World Bank model and gives the daily operating costs of new ships in US dollars. Results for an analysis of the route to Europe are shown in Table 1.

Table 1 A comparison between Rotterdam/Fremantle direct service and Rotterdam/Singapore/Fremantle hubbing.

Data	Rotterdam/ Fremantle	Rotterdam/ Singapore	Singapore/ Fremantle
Vessel Size (teu)	1500	4000	800
Speed (Kn)	19	17	21
Distance (Nm)	9585	8350	2239
Travel Time (days)	21	20	4
Cost at Sea/Day ($)	31 483	49 352	22 430
Total at Sea Cost ($)	661 143	987 040	89 720
Days in Port	1	1	1
Cost in Port/Day ($)	28 381	45 743	19 706
Total in Port Cost ($)	28 381	45 743	19 706
Total Voyage Cost ($)	689 524	1 032 783	109 426
Cost per teu at;			
100% capacity ($)	460	258	146
80% capacity ($)	575	323	182

Source BTCE estimates based on ESCAP Ship Cost Model, Lloyd's Shipping Economist, Reed's Distance Tables.

These results suggest that the feeder service option has lower costs than the direct service. However, the analysis does not take account of transhipment costs in Singapore nor does it take account of inventory costs of cargo in transit. Many shippers prefer to use direct services to transhipment services and are willing to pay a premium to avoid transhipment of their cargo. Nevertheless there is a relatively small difference between the costs of the two options, suggesting that a feeder service option through Singapore might be feasible.

The factors excluded in the costs analysis tend to add to the costs of the feeder service option. However, a significant proportion of Australian exports face pan-Australian freight rates. Exports from Western Australia to Europe would face higher freight rates under a pan-Australian freight system than if freight rates more closely reflected sea transport costs. If the feeder service was not subject to pan-Australian freight rates and the direct service was, the difference in freight rates between the two types of service form Fremantle and possibly other ports may be more in favour of the feeder service than the costs differences in Table 1 suggest.

Australian Factors

There have been a number of changes within Australia which have an influence on the potential for land-bridging. Some of these are:

- technical/structural change in Australian industry;
- rail freight reforms;
- port pricing; and
- waterfront reform.

Technical/structural change in Australian industry

The penetration of JIT into manufacturing and retailing has probably been a factor in the development of land bridges in North America. The geography of North America has also assisted in the development of land bridges. The sea voyage via the Panama Canal is much longer than the alternative rail journey between the Eastern and Western coasts of North America. Furthermore, much of North America's industry is located inland from the ports so that land transport over considerable distances has been a characteristic of North American international trade for a considerable time. However, these geographic factors are largely absent in Australia. Consequently it is not clear that land-bridging would have much effect on transit times in Australia. Land-bridging in Australia must rely on quality of service factors or low land transport costs for it to succeed.

Perhaps a more important issue is the bipartisan support for eliminating import tariffs by the end of the century. One may conjecture that this might lead some Victorian manufacturers to abandon peripheral markets in Western Australia and Queensland to imports. Many Australian manufacturers tend to price their products relatively uniformly throughout Australia so that they may compete with importers in all States. The transport costs involved in selling products in the more distant States are absorbed in the higher margins achieved in the local markets. In an environment of lower tariffs, imports can be priced competitively in the more distant States making it more difficult for Victorian manufacturers to retain those markets. This could lead to greater volumes of finished consumer products being landed directly into the final consumer markets (ie the capital cities). This would tend to reduce domestic freight movements and possible backhaul opportunities.

Rail freight reforms

Intermodal transport, in the context of modern manufacturing techniques, requires what is frequently referred to as a "seamless" transport system. By this it is meant that, as far as the shipper is concerned, change of modes occur with minimum delay and minimum trouble. If a door-to-door operator is used, the shipper may not even care what mode is used so long as he can find out where his consignment is and knows it will arrive when he wants it. The existing rail system is not particularly good at meeting these requirements and the poor reputation of rail must have a negative influence on the development of integrated container transport operators. The degree of intermodal transport for international containers Australia presently experiences (commonly referred to as centralisation rather than land-bridging) has more to do with ship economics than with the provision of a reliable door-to-door service.

The establishment of the National Rail Corporation (NRC) should improve the reliability and cost of the rail system for interstate freight transport. For example, the Bureau of Industry Economics (BIE 1992) estimated that Australian railways should be able to reduce operating costs by 25 per cent to match world best practices after adjustment for terrain, input prices and traffic levels. Presuming that some of these savings are passed on, lower freight rates and improved levels of service should favour land-bridging. But it does not necessarily follow that the smaller ports will benefit. Improved land transport links can also improve the prospects for increased centralisation of cargo on the major ports.

An important issue is the existence of back loading opportunities on interstate rail links. Land-bridging proposals put forward by Western Australia and Queensland assume that lower freight rates on the back haul from Fremantle and Brisbane can be exploited to allow these ports to become gateway ports. The problem is that if low back haul rates are required to justify the development of a land bridge, then this puts an upper limit on the extent that land-bridging can be employed. Once the imbalance in freight flows has been taken up, the low freight rates available in the back haul direction are likely to disappear.

Port pricing

In the last few years most of the capital city ports have restructured or have considered restructuring their pricing structures. Port Authorities in Sydney and Melbourne have changed their structures to place greater emphasis on charges on rentals and ship calls, and a lesser emphasis on cargo charges.

Port authority pricing has been examined in a previous BTCE publication (BTCE 1989). Essentially the major issue is how to charge for the fixed costs of a port's infrastructure. While economic theory is clear that welfare is maximised if the prices of a service are set equal to their marginal costs, for most port authority services this would result in an under recovery in costs. If port authorities are expected to achieve full cost recovery, including a rate of return on their assets, then some prices in excess of marginal costs must be set. For berths and cargo handling equipment leased by port authorities to stevedores the method suggested by the Bureau and others is to recover the costs in excess of marginal costs by means of rentals. For the remaining costs, the theory of Ramsay pricing can provide a guide but is unable to give a firm prescription. The principle behind Ramsay pricing is that the prices in excess of marginal cost should be set so as to minimise the loss of welfare, or, in the context of port authority pricing, this means to minimise the reduction in demand for port services.

A reduction in cargo charges and a greater emphasis on ship based charges in the larger ports could be expected to make it attractive to ship operators to exchange as many containers as possible at these ports. This could be done by increasing the extent of centralisation of containers from the smaller ports. The BTCE (1989) investigated this possibility by considering the likely effect the restructured charges in Melbourne might have on the relative attractiveness of Adelaide and Melbourne as ports of call for liner shipping. The result of the analysis was that under the prevailing average number of containers exchanged per ship call there was unlikely to be any significant effect.

For the ports of Sydney and Melbourne, port authority charges per TEU have declined in real terms between 1985 and 1991 (BTCE 1992). The changes in price structure and the level of prices may have an effect, most probably small, on the potential for competition between some ports, especially between Sydney and Brisbane and between Adelaide and Melbourne.

Waterfront reform

Reforms to the stevedoring industry have produced some positive results on waterfront performance. The effect of waterfront reform and possibly port pricing reform has been to improve ship turnaround times and correspondingly reduce berth occupancies. Port capacity has been increased, delays to shipping reduced and truck queues are reported as minimal. Although improved turnaround times have been consistently achieved at some terminals, shipping companies are reacting cautiously. These improved container exchange rates will need to be sustained before shipping schedules are changed to reflect the shorter times required in port.

These improvements have improved the reliability of the waterfront and will have taken some of the driving force out of the push for land-bridging based on the smaller capital city ports. A good deal of the original argument for land-bridging asserted that the unreliability of Sydney and Melbourne could be avoided by using the smaller, less congested and more reliable ports. Some of the gains in Sydney and Melbourne may be the result of the recession, but it is likely that when Australia emerges from the recession much of these gains will remain. There is some anecdotal evidence for this. One terminal operator experiencing impressive performance gains told the Bureau that in 1991, despite the recession, he was handling a record throughput with reduced berth occupancy and virtually no truck queues.

Analysis of the potential for land-bridging

The Bureau developed a model to examine the costs of a land-bridge relative to sea transport. The model is based on the following assumptions:

- Ship costs are based on the ESCAP ship cost model.
- Rail freight rates are those published by the National Freight Group of Railways of Australia (1992). These are shown in Table 2.
- Port charges are estimated from price schedules by port authorities and tug operators. Stevedoring charges are those previously estimated by the BTCE for its' submission to the House of Representatives Standing Committee on Transport Communications and Infrastructure inquiry into the efficiency of the interface between sea ports and land transport (BTCE 1992).
- Container transfer rates are those published in reports by the Waterfront Industry Reform Authority. Berthing delays are derived from the same source.
- Port throughputs of international containers were derived from the Containerisation International Yearbook with corrections to allow for coastal cargo. These throughputs on their own do not reflect the ultimate destination of imports or the origin of export containers. Australian Bureau of Statistics (ABS) Sea and Air Cargo Commodity Statistics of state of origin for exports carried by liner container and Ro-Ro ships, and state of lodgement for imports, were used to adjust the throughput data to reflect origins and destinations for exports and imports respectively.

Table 2 Rail freight rates used in the analysis ($/teu)

				To	
From	*Fremantle*	*Adelaide*	*Melbourne*	*Sydney*	*Brisbane*
Fremantle	-	331	432	521	848
Adelaide	1593	-	311	611	936
Melbourne	1801	372	-	496	1205
Sydney	1885	623	379	-	616
Brisbane	1913	605	533	338	-

Source: Railways of Australia (1992)

- Import containers on each ship can be allocated to destinations in any proportions and, similarly, export containers can be allocated to origins in any proportion. Obviously the proportions for imports and exports should each sum to one.
- The model allows ship routes to be specified which include any number of the major ports and in any order. Cargo for or from ports not called at can be specified to be discharged or loaded at any of the ports at which the ship calls. A port at which the ship does not call can have its imports discharged at a port different from that at which its exports are loaded. This facility can be useful in analysing options such as those considered by the Queensland Department of Transport in its evaluation of the standard gauge link between Acacia Ridge and Fisherman Islands. One of these options was to consider a routing pattern where a ship would call at both Brisbane and Sydney. At Brisbane imports for Brisbane and Melbourne would be discharged and exports from Brisbane loaded. At Sydney, Sydney imports would be discharged and Melbourne and Sydney exports loaded.
- The model also calculates the inventory costs of containers in transit. For this purpose, import containers for the port of discharge have inventory costs calculated up until the time the ship leaves the berth and exports have inventory costs calculated from the time the ship arrives in port. Containers moving by rail include the time at the berth for both imports and exports. Transit times for rail are those specified by the National Freight Group in its pricing schedule. Sea transit times are calculated from the inter-port distances and ship speeds typical for the size of vessel.
- Only one value can be assumed for the value of containerised cargo. In practice there will be considerable variation in the value per TEU of containerised cargo. Some land-bridging options which do not show up as being favoured using an average value per TEU may be more promising for more highly valued or time sensitive cargo. Conversely the potential for some options will be overstated for low valued cargo.

The particular example of the service to Europe using either the direct or feeder service is used to illustrate the type of analysis that can be undertaken. At the time of writing the model needed to have the data verified so not too much should be made of the following results.

The analysis examines 14 port call combinations for a typical ship used for direct calls. The ship analysed has a capacity of 1500 TEUs and operates at 75 per cent load factor. The results for this ship are compared with a typical feeder ship with a capacity of 800 TEUs. This ship also operates at 75 per cent load factor. Both ships are assumed to have an operating speed of 19 knots. The value of containerised cargo was set at $50 000 per TEU. This is the average value used by the BTCE in an analysis of shore-based shipping costs (BTCE 1992). The interest rate for estimation of inventory costs of containerised cargo in transit was set at 15 per cent. This was considered to be a reasonable estimate of the cost of capital being approximately the long term bond rate plus 6 per cent. Six per cent is a common estimate of the risk premium for the market portfolio. Shippers can incur time costs other than inventory costs. These other costs can be high and are usually associated with issues of reliability. Perishable or seasonal goods which arrive later than expected can result in high costs for shippers. JIT manufacturing techniques can also place an important requirement on reliability as discussed earlier in the paper.

The cargo on each ship was assumed to service the average pattern of container trade. This assumption is restrictive, as it is always open to a liner shipping operator to plan his voyages so that cargo on a particular ship carries cargo for a limited set of destinations and to load cargo in Australia from a limited set of origins. The remaining origins and destinations could be served by other voyages. The ship operator could in this way trade off voyage costs against frequency of service.

The port calls analysed were combinations of the five mainland capital city ports. The combinations anaysed are shown in Table 3.

Table 3 Combinations of ports of call and land-bridging analysed

No. of ports visited	*Ports of call*	*Land-bridging*
1	One mainland capital city port (five combinations)	Between port of call and other capital cities
2	Fremantle in combination with one other mainland capital city port (four combinations)	Between the non-Fremantle port of call and the remaining capital city ports
3	Fremantle, Adelaide, Brisbane; and Fremantle, Melbourne, Sydney	Between Adelaide and Melbourne and between Brisbane and Sydney
4	Fremantle, Adelaide, Melbourne, Sydney	Between Sydney and Brisbane
4	Fremantle, Melbourne, Sydney, Brisbane	Between Melbourne and Adelaide
5	Fremantle, Adelaide, Melbourne, Sydney, Brisbane	No land-bridging

These routes omit New Zealand which is included in many of the Australian/Europe services. Further research is required to analyse the effect of including New Zealand in the model.

Table 4 shows the cost components for the four lowest cost options for a feeder service. Table 5 shows the same information for the direct service.

The four lowest cost options are the same for both the direct and the feeder service, although the ranking of the four is different. The difference in costs between the lowest cost option and the fourth lowest cost option is not large (6 percent for the feeder service and 3 per cent for the direct service). The single port options generally do not offer any cost advantage. The best of the single port options was that based on Melbourne. It was ranked seventh in the feeder service analysis and sixth in the direct service analysis. This option was 27 per cent more costly than the lowest cost option for the feeder service and 13 per cent more costly in the direct service analysis. The single port options generally had high rail costs which more than offset the lower inventory costs that the faster transit times of rail were able to offer.

The feeder service had lower costs than the direct service. This is analysed further in Table 6 which shows the cost per TEU for the cost components of the lowest cost option for the direct service compared with the costs of a feeder service calling at the same ports. The table also shows the cost components per TEU for the lowest cost option for the feeder service.

Table 4 Cost components of lowest cost options for a feeder service[a]

	Ports of call[b]			
Cost component	F,M,S,B	F,A,M,S,B	F,M,S	F,A,M,S
Ship costs:				
at-sea[c] ($,000)	206	216	201	212
in-port ($,000)	103	106	98	101
Port charges ($,000)	411	432	393	415
Rail charges ($,000)	26	0	94	68
Inventory costs[d] ($,000)	146	151	140	145
Total costs ($,000)	892	906	927	941
Costs per TEU ($)[e]	1486	1510	1545	1569

a. 800 Teu ship operating at 75 per cent load factor.
b. F = Fremantle, A = Adelaide, M = Melbourne, S = Sydney, B = Brisbane.
c. At-sea costs in excess of those incurred for a single call at Fremantle.
d. Inventory costs are based on time in port plus rail transit time plus at-sea time corresponding to at-sea costs.
e. Averaged over the occupied slots on the ship (i.e. 600)

Table 5 Cost components of lowest cost options for a direct service[a]

	Ports of call[b]			
Cost component	F,M,S	F,A,M,S	F,M,S,B	F,A,M,S,B
Ship costs:				
at-sea[c] ($,000)	371	386	460	475
in-port ($,000)	243	244	244	249
Port charges ($,000)	710	740	733	763
Rail charges ($,000)	177	128	49	0
Inventory costs[d] ($,000)	382	383	444	451
Total costs ($,000)	1880	1888	1930	1938
Costs per TEU ($)[e]	1671	1678	1715	1722

a. 1500 Teu ship operating at 75 per cent load factor.
b. F = Fremantle, A = Adelaide, M = Melbourne, S = Sydney, B = Brisbane.
c. At-sea costs in excess of those incurred for a single call at Fremantle.
d. Inventory costs are based on time in port plus rail transit time plus at-sea time corresponding to at-sea costs.
e. Averaged over the occupied slots on the ship (i.e. 1125).

Table 6 Comparison of costs per TEU between feeder and direct services ($/TEU)[a]

Cost component	Direct F,M,S[b]	Feeder F,M,S[b]	Feeder F,M,S,B[b]
Ship costs:			
at-sea[c]	330	335	343
in-port	213	163	171
Port charges	631	656	685
Rail charges	157	157	43
Inventory costs[d]	340	234	244
Total costs	1671	1545	1486

e. Averaged over the occupied slots of the ship (i.e. 600 for the feeder and 1125 for the direct service).
b. F = Fremantle, A = Adelaide, M = Melbourne, S = Sydney, B = Brisbane.
c. At-sea costs in excess of those incurred for a single call at Fremantle.
d. Inventory costs are based on time in port plus rail transit time plus at-sea time corresponding to at-sea costs.

The table shows that when the same port combinations are compared the feeder service gains its advantage through reduced in-port time which leads to lower port costs and in-port ship costs. The lower in-port time leads to lower inventory costs. The lowest cost feeder service is able to exploit this advantage by calling at more ports (four compared to three for the lowest cost direct service). The higher port charges and ship costs of the additional port call are more than offset by reduced rail charges. This result derives from an assumption that berth time is directly proportional to the number of containers to be exchanged. In practice, the smaller ships generally experience slower container exchange rates per berth time. The effect of this is that the results understate the in-port costs (ship costs, port charges and inventory costs) of the feeder service.

Both Fremantle and Adelaide have beeen promoted as possible major gateway ports for imports and exports on the European and South East Asian trades. The results of this analysis placed both of these ports well down in the rankings when considered as the only port of call. Although either port used as a single port of call for a feeder service resulted in lower inventory costs ($120/TEU for Fremantle and $170/TEU for Adelaide) and lower at sea costs, they both incurred much higher rail costs. Rail costs for a single call at Fremantle averaged $2091/TEU and $1030 for a single call at Adelaide. These are much higher than the costs for rail shown in Table 6.

The analysis was extended in two ways. The first was to examine the effect of lower rail charges and the second was to double inventory costs.

Rail charges were reduced by 25 per cent to be consistent with the BIE's (1992) estimate of the reduction in costs required to equal world best practice. This made no difference to the port call options included in the four lowest cost feeder service options but it did alter their ranking. The all ports option and the Fremantle, Melbourne Sydney option exchanged places in the ranking. Because all of these four options had relatively low rail costs to start with, the reduction in rail costs made little difference to their total costs.

The effect of a reduction in rail charges was much more significant for the direct service. The lower rail charges were able to offset the higher inventory costs of the direct service. The new four lowest cost options and their ranking is as follows:

1. Fremantle, Adelaide, Melbourne, Sydney
2. Fremantle, Melbourne, Sydney
3. Fremantle, Melbourne
4. Melbourne

The two lowest cost options were included in the four listed in Table 5, but the third and fourth were not. The results illustrate that rail costs can be important in the development of a land-bridging policy. The results also illustrate that lower rail costs may not favour the smaller ports as, in this analysis, it was the port of Melbourne that gained. The analysis assumes that the rail system is able to deliver containers within the time stated in its schedules. The difference between the cost of option one and option four is only 3 per cent. Perceived unreliability of the rail system would mean that a shipper would not lose much by choosing an option which called at more ports but relied less on rail.

The importance of inventory costs to the ranking of the options suggests that, for high value cargo, a land-bridging may be more attractive. To investigate this, container values were doubled to $100 000 per TEU while retaining the reduction in rail charges. This made no effect to the ranking of the four favoured options of the feeder service. However, it changed the ranking of the four lowest cost direct service options, although the options included in the four lowest cost options did not change. The ranking was reversed from that shown above.

The analysis, so far has focused on total costs, that is it includes shipper costs. If rail charges are assumed to reduce by 25 per cent but inventory costs are ignored, the ranking are still those shown in Tables 4 and 5. If inventory costs of goods in transit are important than shippers may have to pay a premium to encourage a ship operator to adopt a land-bridging option.

The analysis has assumed that import containers on each ship can be allocated to destinations according to the distribution of imports recorded by the ABS. Similarly, exports containers on each ship have origins consistent with the ABS recorded distribution of export origins. In practice, it is unlikely that this will hold. Liner services will concentrate on particular trades and will have different origins and destinations for their cargo. The analysis discussed here may have different results if a different distribution of cargo were assumed.

Conclusion

The paper has discussed some of the issues influencing inter-modal transport. The current trends in trade and manufacturing have highlighted the demands for reliable and flexible transport systems. The model presented allows a rapid analysis of possible sea and land transport options for Australian international container transport. The results indicate that inventory costs can play a large role in the transport choices shippers may make. They also indicate that rail transport can play an increased role in these choices as long as it can be perceived as providing a reliable transport service and if the lower costs anticipated by the BIE (1992) are translated into lower charges.

The value of containerised cargo used in the analysis is a reasonable estimate of the average value of Australian containerised cargo. Within the limited assumptions of the analysis, the results suggest that for average container values land-bridging does not offer any significant advantages but higher valued cargo may gain some advantage. Niche markets, such as those offered by time sensitive cargo (high valued cargo, perishable or JIT dependent cargo) may form the basis of a land-bridging service. The existence of low backhaul freight rates on some rail routes may also facilitate niche market strategies.

The results presented in this paper are based on a restrictive set of assumptions and have focused on only one of Australia's major trade routes. Further work is required to test the effect of relaxing the more restrictive of the assumptions and to examine the possible options in more detail.

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