23rd Australasian Transport Research Forum
Perth, Western Australia. 29 September – 1 October 1999

Access to Rail: Some Issues Relating to Economics of Size in Rolling Stock Operations

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Abstract

Economic issues concerning access to railway tracks are considered in this paper. The policy background to access arrangements to rail is presented. Conceptual issues concerning access provision and size economies are reviewed. This review suggests that the presence of economies of size in the rolling stock operation may differ between type of transport service offered. Models for costing rail passenger services and rail freight services are presented and applied to representative long-haul freight and short-haul passenger services in Queensland. Economies of size in the rolling stock operations are then explored for the two different services provided. The main findings are that size economies appear to be strong in rolling stock operations involving long-haul freight by unit trains. Size economies are found to be weak for short-haul passenger services, for which load factor economies are much stronger. The main policy implications from this finding are considered.

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Introduction

A major initiative under the *Competition Policy Reform Act 1995* was the provision of third-party access to essential infrastructure, to encourage more competition in those industries subject to such access provision. The main industries affected include telecommunications, energy, water and transport. Within the transport sector, railways were seen as an essential facility in which such access provision should occur. The separation of track or infrastructure provision from the above track rolling stock or transport service operations was a key part of the National Competition Policy Review (Hilmer *et al* 1993). Since this review a number of States have taken action to put in place access provision arrangements (National Competition Council 1997).

The justification for disaggregating the provision of infrastructure from the provision of transport services concerns the economic characteristics of the vertically-integrated industry structure. The provision of rail track capacity is classified as naturally monopolistic while the use of track capacity is viewed as potentially competitive (Cubukgil 1987, King and Maddock 1996). The railway economics literature devotes considerable attention to the measurement of scale economies and economies of density using a variety of cost estimation techniques (Caves *et al* 1988, Waters and Woodland 1984, Small (1992).

The natural monopoly characteristics of the track are largely due to large sunk costs. Economies of density are important and are related to scale economies in line haul operations and the fixed costs associated with the rail infrastructure. Hilmer *et al* (1993) advised that a more efficient and pro-competitive solution was to provide through legislation provision for third-party operators to the essential infrastructure, the railway line and related facilities in the case of rail.

In making this recommendation, an implicit assumption was that the provision of freight services by rail rolling stock was probably less subject to scale economies than those prevailing in the provision of the track and related facilities. A further underlying assumption in the National Competition Review was that more competition in the provision of rail transport services would improve the efficiency of its delivery. For rail operators, conscious choices can be made which by design affect the scale economies, the scope economies and the economics of capacity utilisation. We return to this later in the paper.

As noted above the literature distinguishes between economies of scale (returns to firm or plant size) and economies of traffic density. The latter refers to the relationship between inputs and outputs with the rail network held fixed. Returns to scale refer to the relationship between inputs and the overall size of operations, including both outputs and network size (Caves et al 1985). In this paper the analysis is focused on the economics of rolling stock operations and treats the railway and related infrastructure facilities as provided by a separate infrastructure entity. In the interests of brevity very little emphasis is placed on economies of scope.

Using a relatively simple costing model, the average costs per ton or per passenger are calculated for two representative routes in Queensland. The focus is on the minimum economic size of train for two types of transport service: (1) long-haul bulk freight, grain from Goondiwindi to Brisbane Port; and (2) short-haul passenger services, based on the current timetable for the Gympie-Ipswich line. Data for this analysis were obtained from a variety of sources but were not available from Queensland Rail for reasons of confidentiality.

Background to National Competition Policy in Australia

The *Competition Policy Reform Act 1995* was enacted by the Commonwealth of Australia. It is a key element of the competition policy package which involves states and the federal government taking initiatives and adopting reforms by 2000.

The policy has emerged from the National Competition Policy Review (Hilmer, Rayner and Taperell 1993). At the April 1995 meeting of the Council of Australian Governments (COAG) agreements were signed to adopt National Competition Policy. Further details are outlined in Industry Commission (1995), but essentially the agreements support the earlier principles developed during the Hilmer Review. The agreed principles for a national competition policy are presented in Table 1.

Table 1. Agreed Principles for a National Competition Policy

(a)	**No participant in the market should be able to engage in anti-competitive conduct against the public interest**
(b)	**As far as possible, universal and uniformly applied rules of market conduct should apply to all market participants regardless of the form of business ownership**
(c)	**Conduct with anti-competitive potential said to be in the public interest should be assessed by an appropriate transparent assessment process, with provision for review, to demonstrate the nature and incidence of the public benefits and costs claimed**
(d)	**Any changes in the coverage or nature of competition policy should be consistent with, and support, the general thrust of reforms:** **(i) to develop an open, integrated domestic market for goods and service by removing unnecessary barriers to trade and competition** **(ii) in recognition of the increasingly national operation of markets, to reduce complexity and administrative duplication.**

Source: Hilmer, Rayner and Taperell (1993), p.17

As part of the federal *Competition Policy Reform Act 1995* a number of features of the national competition policy review were legislated, including: widening the coverage of trade practices legislation to the unincorporated sector and to State Government businesses; extending the competitive conduct rules; establishing a new national regime for access to 'nationally significant' infrastructure services; extending prices surveillance to public enterprises; establishing the Australian Competition and

Consumer Commission (ACCC) and the National Competition Council (NCC). The latter sets the broad direction for competition policy while the former, which embraced the Trade Practices Commission and the Prices Surveillance Authority, is the principal arm (and watchdog) of the policy.

Main Features of National Competition Policy

The main features of the policy as recommended by the Review and enacted are:

(1) limiting anti-competitive conduct of business
(2) reforming regulation which unjustifiably restricts competition
(3) reforming the structure of public monopolies to facilitate competition
(4) providing third-party access to certain facilities essential for competition
(5) restraining monopoly pricing behaviour
(6) fostering 'competitive neutrality' between business, publicly-funded institutions and government when they are in competition.

Feature (3) is aimed at removing or reducing the monopolist elements of certain government business enterprises, notably electricity, gas, water and telecommunications. These industries are typified by large amounts of capital infrastructure and related economies of size and of scope. Consequently, natural monopolies may exist for these government enterprises for particular state markets. National competition policy seeks to encourage competition between enterprises of different states and to foster a more competitive approach within states. However, where natural monopolies are present in government business enterprises the public interest case for retaining monopolistic elements will be strong. Under these circumstances, attempts might be made to break down the large vertically-integrated monopolies, but the costs of doing so should be weighed carefully against the potential disadvantages.

Feature (4) is closely related to (3). Many industries providing 'essential facilities' have characteristics of natural monopolies. Thus to foster a competitive model as a replacement may be inefficient, involving the establishment of a two or more competing infrastructures which may be heavily under-utilised. Feature (4) recognises this and seeks ways of permitting competitors to buy access to essential facilities already in existence or planned. Some classic examples of this already exist in Australia, including:

- airlines buying access to airport facilities
- companies accessing pipelines carrying water, gas or oil and having the right to buy or sell part of the pipeline facility
- shipping or trading companies buying into particular port loading or unloading berths where ports are publicly backed.

Issues concerning access to essential facilities include when such access should be made available as a private right, what price should be paid for the right, what conditions might be needed to protect the owner of the facility and what operational guidelines, safeguards and remedies might exist in its use. Hilmer *et al.* (1993) emphasised that ownership of essential facilities, while traditionally the right of the Crown in Australia, does not have to be that way. Thus the national competition policy proposal is neutral concerning ownership of essential facilities.

Other countries, including the USA, Japan and European countries have some essential facilities that are owned privately. Australia's tradition of heavy public ownership of essential facilities is a legacy of history. Public ownership and management of essential facilities may be an inefficient way of using these facilities, especially when work incentives and performance are unrelated. National competition policy is designed to foster efficiency in the use of essential facilities whether privatised or not.

Some Conceptual Issues in Access Provision and Size Economies

Case of No Size Economies in Rolling Stock Operations

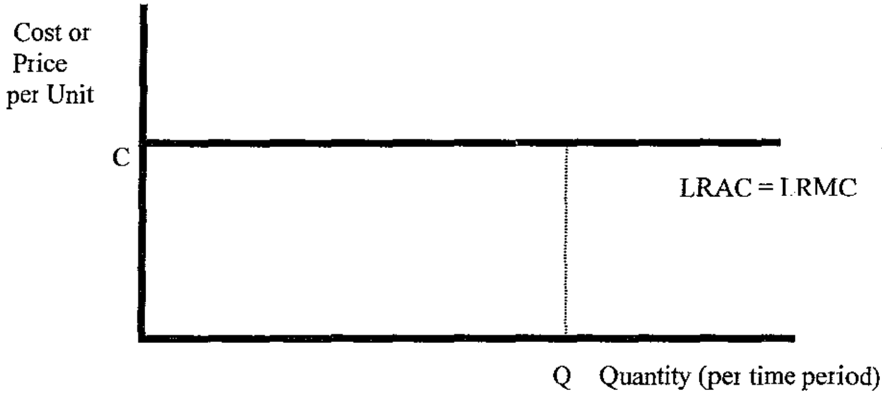
The transport economics literature distinguishes between two dimensions of size in analyses of rail and other transport cost functions - the size of the network and the volume of passengers and freight transportation services carried. This allows an important distinction to be made between returns to density (the change in unit costs caused by increasing transportation services within a network of given size) and returns to scale (the change in unit costs with respect to proportional changes in both network size and the quantity of transportation services).[1] In this paper attention is focused on the nature of economies of size of the rolling stock operation.[2] Of special interest is how long-run costs vary for different sized rolling stock. For simplification, economies of scope in rolling stock operations are ignored, the track size is taken as given and the track is presumed to be uncongested.

Consider a rail transport service in which there are no economies or diseconomies of size in the rolling stock operations. In this case the long-run average cost curve will be horizontal, and will equal the long-run marginal cost curve (Figure 1). Given that an efficient access charging regime exists, there will be a tendency for the more efficient operators to capture a higher share of the total market (Q). They may be more efficient not only because of lower costs but also because of superior quality of product or service relative to rivals (Mansfield 1996, pp.462-3). Thus where no size economies exist with the above-track operations, competitive efficiency will determine the share of the transport services provided by different operators under an efficient access charging regime. In the long run, the price of transport services will tend to reflect the long-run average cost (C). Any inefficient operator will have an incentive to sell their access (thus conceding market share) to efficient operators under an efficient access charging regime.

[1] For elaboration on the terms employed see Caves and Christensen (1988)

[2] No distinction is made between economies of size and economies of scale in this paper

Figure 1. Case of No Size Economies in Rail Rolling Stock Operations

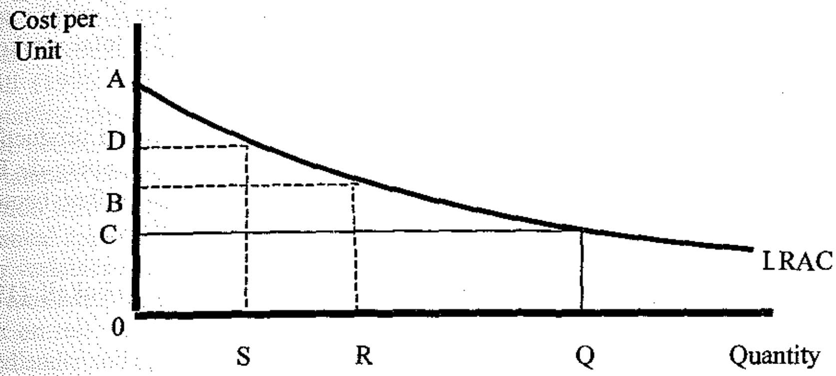


Case of Size Economies in Rolling-Stock Operations

The situation where strong size economies prevail in rolling-stock operations is depicted in Figure 2. Take it for now that the incumbent and potential entrants are of the same efficiency (i.e. they both face the same long-run average costs curve - this might not be far from reality in an industry which is fairly contestable). The usual decline in the long-run average cost curve is shown for increasing levels of output.

Ignore for now what determines the total size of the rail transport market (i.e. demand factors, price of the service and its quality, competition from road and other transport options and so on). The nature of the size economies suggests that a natural monopoly will prevail in this part of the rail transport market. Given the demand curve, total output of rail transport will be at the level Q and average costs at this level will be C. Note that for a competing rail transport service operator to enter the market in a small way it will face an average cost of A (providing it has the same efficiency as the incumbent.) The difference between C and A may be sufficiently high to deter entry. Only when the competing entrant is given sufficient access to the track to capture half the market share for transport services does it move to an equal cost footing with the incumbent (depicted by average cost B and an output R for both the entrant and incumbent, where OR = 0.5 OQ.)

Figure 2. Case of Size Economies in Rail Rolling Stock Operations.



What happens in the situation where say three entrants and one incumbent share equally the original market? In this case provision of the service on average is more costly (at D) at the level of output S where OS = 0.25 OQ.

The simple model above illustrates that in a situation where size economies of rolling stock operation are strong, average cost per unit for the new entrant will tend to be much higher than that of the incumbent because the entrant is operating well below the minimum efficient scale of plant. Furthermore, by breaking up the rolling stock operations into more separate companies (horizontal disintegration) industry costs will tend to rise on average, the greater the degree of disintegration. An efficient access charging regime would lead to the incumbent retaining its natural monopoly except in the situation where new entrants are much more efficient than the incumbent.

Introducing Different Efficiencies by Firm

The analysis of Figure 2 changes very dramatically where the incumbent is less efficient than potential entrants - one of the main reasons for third-party access provision to essential facilities. The matter then becomes one of considering the extent of the economies of size in the rail transport industry relative to the differences in efficiency between the incumbent and the potential entrants. Differences in efficiency may arise because the potential entrants use current technology more effectively or have new technologies not used by the incumbent. If the efficiency advantage of the potential entrant exceeds the difference in costs attributable to size economies (AC in Figure 2) then the entrant will have a cost advantage and will be able to enter profitably. The greater the share of the total market realised by the entrant the greater will be the entrant's capacity to grow and to capture market share, because they are realising economies of size.

Under this model the incumbent can readily be replaced by a new entrant natural monopolist providing the latter is more efficient by at least the extent of the economies of size. Where economies of size are small, more efficient firms will readily enter and compete without the industry tending to become concentrated. Where economies of size are large, much greater efficiency of the potential entrant is needed before the incumbent firm is under threat. However, if the incumbent firm does sacrifice some share of the market, the efficiency advantage of the entrant suggests it could readily become the new leader in the industry (i.e hold a high share of the total market or industry value added).

Various studies of differences in firm efficiencies suggest that inter-firm productivity can vary considerably within a particular industry (Turvey and Lowenberg-de Boer 1988, Prior 1996, Miller and Noulas 1996, Marin 1998). The question then becomes whether the size economies are greater, near or well less than this variation.

To add perspective to the simple discussion of concepts above, Cubukgil (1987) reported:

"Even in the absence of economies of firm size, increasing returns on traffic density could give rise to a natural monopoly situation. Along a specific route it may be more efficient for a single firm to handle all the existing traffic than for two or more firms. In the absence of economies of firm size, the natural monopoly will, of course, only be a local one. With increasing returns to density, competition will drive all but the most efficient of the competing railways on the same route out of business. Once the most efficient firm is left alone on that route, however, it does not follow that the firm will be able to extract full monopoly rents. Increasing returns to density is not a sufficient condition for the single firm to behave as a monopolist. As long as there are no barriers to entry and exit and free access to the same technology, the single firm will operate under the threat of 'hit-and-run' entry. This will make the firm a 'contestable natural monopoly' ... " (pp8-9)

" Density economies in railway operations can be attributed to two factors. First there are scale economies involved in line haul operation. This issue has not received much attention in the econometric literature, and empirical evidence is scarce. However, operational considerations clearly suggest that crew, fuel and even switching costs decline with train size. The railway's ability to assemble large trains is determined by the volume of traffic. As traffic volume increases, the railways can utilise their equipment more effectively, reducing both the capital and maintenance costs of rolling stock. At higher densities therefore, the railway can perform line-haul operations more efficiently. However, even if such density economies from line haul operations were significant enough to lead to an natural monopoly situation on a given route, they should no raise serious concern (pp9-10)

We now turn to the issue of measuring economies of size in rolling-stock operations in Australia

A Costing Model for Capital Equipment

There is an extensive literature on estimation of rail cost functions A review of this literature reveals a variety of approaches (Waters and Woodland 1984, Small (1996, p.52). The approaches may be classified broadly as follows: (i) accounting approaches which utilise the accounts of rail enterprises and adjusting data where necessary to provide estimates of opportunity costs and attribution of costs to the provision of various outputs;(ii) the engineering approach which constructs a production function from technical data and uses input price data to generate costs; and (iii) the statistical approach which infers the relationship between costs and output levels and other variables based on observations of costs for a single firm over a large time period or a cross-section of firms over a single time period Much of the recent econometric work on rail costs employ more flexible translog cost functions than earlier studies (Friedlander and Spady 1981, Caves, Christensen and Swanson 1981)

The general costing model employed in this paper is illustrated below and is analytically simple. It is akin to the engineering approach in that it accounts for full cost for the length of life of the plant depending upon a reasonable set of operational parameters depicting the rolling-stock operation

A method of calculating the average annual cost of operating capital equipment drawn from Witney (1988) and Ahmad, Hussain and Longmire (1993) is now considered. The main cost items included are: (a) cost of financing the equipment termed the capital cost, (b) depreciation, (c) fuel and energy, (d) repairs and maintenance, (5) labour and (6) miscellaneous fixed costs. Where other cost items are relevant they can be added. The general formulae for the individual cost items are as follows. The capital cost is calculated as the average cost of financing capital equipment over the costing period. Depreciation is calculated on a straight-line basis.

a) Capital (Finance) Cost

$$C = i[(1+v)P_a/2]/h$$

where C = capital cost of machine per hour
i = real cost of capital
v = salvage value of the machine as a proportion of acquisition value
P_a = current acquisition value of the machine
h = number of hours worked per year.

b) Depreciation

$$D = [(1-v)P_a]/nh$$

where D = depreciation cost per hour
n = number of years of operation
and other variables as defined above.

Note that this is the cost associated with the capital equipment losing value as it is used simply because it is suffering wear and tear and it is ageing and being superseded by more modern equipment.

c) Fuel and Energy

$$F = \gamma p(1 + o)$$

where F = fuel cost per hour
γ = fuel consumption per hour
p = fuel price per litre
o = constant percentage to add on to fuel cost for lubricants

d) Repairs and Maintenance

$$M = mP_a/nh$$

where M = repairs and maintenance cost per hour
m = ratio of repairs and maintenance cost to current acquisition value

e) Labour Cost

$$L = bw/8$$

where L = labour cost of operation per hour
b = average wage paid to operator(s), as a percentage of the minimum wage
w = daily wage rate

f) Miscellaneous Fixed Costs

$$A = \delta/h$$

where A = hourly cost of management and administration of the machine
δ = annual management and administration cost for the machine.

In addition to maintenance and administration, this might include insurance, vehicle registration (if applicable), taxation or rates.

Thus

$$T_t = C_t + D_t + F_t + M_t + L_t + A_t$$

where T = Total hourly cost of operating a machine in period t.

This method of costing is simple and has wide applicability. Variations of the formula can readily be employed to calculate the costs of different forms of transport, when allowance must be made for differences in vehicle (or vessel) speed, load size, distance load is carried and downtime.

Applying the Costing Model: Long-Haul Freight Service and Short-Haul Rail Passenger Transport Service

The above costing model was adapted to cost two particular rolling stock operations:

(i) long-haul freight of grain from Goondiwindi, Queensland to Brisbane Port, using unit trains
(ii) short-haul passenger services from Caboolture, Queensland to Roma Street Station to Ipswich, return.

Data were not available for this costing exercise from Queensland Rail, the current provider of the above transport services because the information was commercial-in-confidence. Nevertheless, considerable information could be obtained from various sources and this permitted the costing exercises to reasonably approximate reality. For example, the details of loading, unloading, time taken for the journey and typical load were obtained from the people who load trains at Goondiwindi and from knowledgeable railroad engineers. The approximate new prices of a freight locomotive and of a bulk grain wagon was obtained from a manufacturer of such locomotives in Newcastle, New South Wales.

Similarly, details of the timing and average speed for a typical passenger round trip were inferred from the timetable for the trip currently available from Queensland Rail and from knowing distances between the relevant stations. Details of energy consumption, passenger capacity and size of a 3-unit suburban electric train were obtained from the company manufacturing such trains. Since the electric multiple unit costed is not yet in operation and the selling price of such units is commercial-in-confidence, a "guesstimate' of new price was employed.

All assumptions employed in costing the freight and passenger operations are presented in Appendix A. Some faith can be taken from the average costs calculated because:

(i) average cost of the rolling stock component of the long-haul freight was $14.80 per ton when the actual freight rate prevailing is just over $22 per ton.
(ii) average cost of the rolling stock component of the round trip per passenger from Caboolture to Ipswich was $14.50 at a load factor of 1 when the peak-hour round trip fare was actually $12.40.

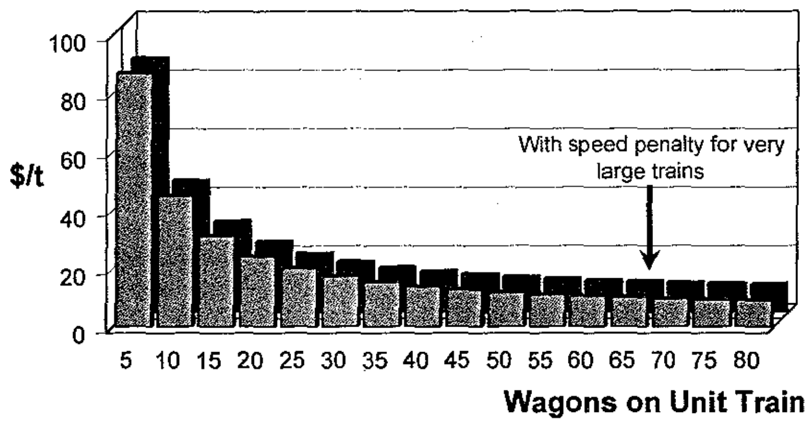
While not precisely mimicking the fares, the magnitudes are deemed reasonably close to assess size economies with the costing model.

Assessed Size Economies of Rolling-Stock Operations

The long-run average cost curve of the long-haul freight operations was calculated by varying the number of wagons per size of unit train, holding other variables constant. Since "B" type wagons number 36 on the typical unit train, the number of wagons was varied from 5 to 80. The number of locomotives in the standard train was kept constant (at 2) and a penalty for reduced speed was added for unit trains greater than 40 wagons (the penalty was a 1% reduction in the average speed for each additional wagon beyond 40 on the unit train).

The relationship between average cost and total size of the unit train is presented in Figure 3 Size economies are strong up to a unit train of about 60 wagons in size. Beyond this size, little further decline in average costs occurs. This is not unexpected because large unit trains are employed in long-haul freight in countries like the USA as well as on private mineral hauling operation in the North West of Western Australia.

Figure 3. Average Freight Cost by Size of Unit Train: Long-Haul Grain from Goondiwindi-Brisbane Port, Empty Back-Haul



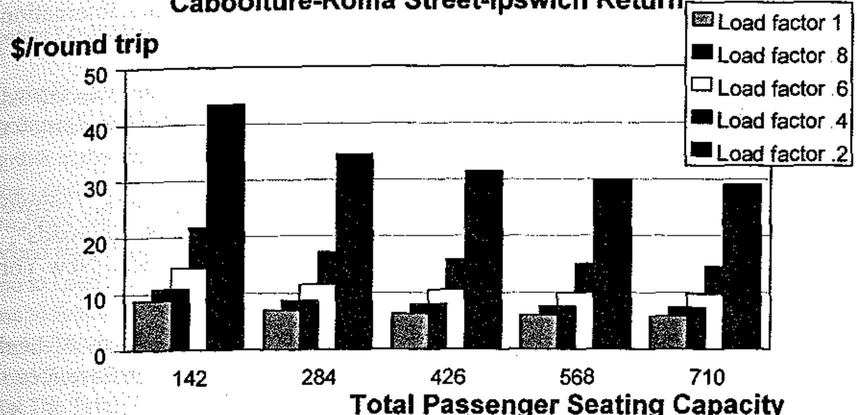
Note: Average load per wagon is 42t one-way distance for trip is 445k, normal number of 42t wagons per unit train is 36, actual freight rate is just over $22/t. Freight cost is for rolling stock and related labour and time in loading and unloading Costs of the track and other non-rolling stock activities are excluded

The size economies relationship for the passenger service contrasts quite markedly with that of long-haul freight (Figure 4). Note the tendency for average cost to decline very slowly with increased size of a unit passenger train Note how in this case load factor is a much more important factor determining average costs of passenger service. This emphasises a very important point, that capacity utilisation is probably the most important determinant of costs of short-haul passenger operations Size of a unit train is much less important as a determinant of costs. Thus modular type operations on suburban rail systems are more likely to prevail because of the different underlying cost characteristics to those of long-haul operations.

Access Provision Implications

In the above analysis the long-run average cost characteristics of different rolling-stock operations have been found to differ considerably. In particular, economies of size probably prevail in long-haul freight and, by inference, long-haul passenger operations For short-haul operations, more frequent services with smaller modular rolling stock are likely to be more economical, especially given the nature of demand for short-haul services.

Figure 4. Average Cost per Passenger Round Trip by Size of Passenger Train: Short-Haul Passenger Service, Caboolture-Roma Street-Ipswich Return



Note: The seating capacity of the standard three-car electric multiple unit costed is 142 Thus the far right hand side columns imply that 5 x 3-car units are operating as a single unit. This would require much longer station platforms than exists and is reported in this chart to illustrate size economy effects with the rolling stock operation only

What are the implications for access provision? Firstly, no blanket provision should be considered applicable to all types of rail access. The findings suggest that access provision should be provided on a case-by-case basis. For example, access to long-haul freight and passenger services might encourage greater efficiency by sale of wagon slots on the large unit trains operated by the incumbent than by sale of complete unit train slots. In contrast, access to short-haul might encourage greater efficiency by sale of time slots to potential competitors to run modular unit trains. No blanket approach to access provision should be attempted.

Secondly, the results imply that the contestability of different rail transport services will vary. For example, the cost of entering the long-haul freight market appears to be higher than that of entering the short-haul passenger market, relatively, because of the greater size economies in the former. With passenger services, the overall network and hub-type operations may deliver greater economies of scope than for the long-haul ones. That remains a question for further study, but a reasonable hypothesis would be that such economies are greater in the suburban short-haul market.
Thirdly, this study suggests that much more analysis needs to be undertaken to appreciate the true cost and demand relationships underlying the market for rail transport services. Only by better understanding these relationships will future policy concerning rail and access to rail infrastructure be placed on a sound footing.

Finally, the impact of competition from road transport is important. If economies of size are significant in rail freight transport there may be no need to vertically separate the rail track from the rolling stock operations since competition from road transport is highly effective. Improvements in rail productivity and cost reductions could be achieved by corporatisation or privatisation of the rail freight operation. Third party access arrangements may not even be necessary.

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Appendix A Assumptions and Costs in the Models for Deriving Average Costs of Transport Service

Costing Long-Haul Freight Goondiwindi-Brisbane Grain | Wagons | Load | Cost/t

Assumptions		Locomotive	Wagons	
Net Tons per Wagon			42	
Number in the Unit		2	36	
Total Load			1512 t	
New Price 1994		3750000	100000 $	
Second Hand Price		0.2	0.2 Ratio of new price	
Time to Load		8.3 mins/wagon		
Time to Empty		5 mins/wagon		
Average Speed kph	Laden	35 Empty	50 kph	
Speed Penalty for Large Loads		1 % Speed Loss per Extra Wagon above 36 wagons		
Total Trip Time		29.6 hrs		
Distance One Way		445 k		
Wages + On-Costs	Drivers	40 Loaders	20 $/hr	
Total Labour	Drivers	2 Loaders	3.2	
Repairs & Maintenance		5	2 % of new price	
Fuel Price		55 c/l		
Fuel Consump. l/km	laden	10 empty	7	
Lubricants		10 % of fuel cost		
Overheads & Admin		20 % of value added		
Interest Rate		5 % real		
Downtime Percentage		30 %		
Total Trips Per Year		207		
Total Working Life		20 Years		
Total Tons Carried per Year		313,290 t		

Costing Unit Train ($/t)

Overall Cost/ton	Capital Cost	Dep'n Cost	Repairs & Maint	Fuel & Lubes	Labour Costs	Overheads & Admin
14.83	1.06	1.42	1.43	6.05	1.90	2.97

Note: Unit train only, excludes costs of track and loading and unloading facilities

Costing Short-Haul Passenger Services Caboolture-Roma Street-Ipswich Return

Last Update: 31 May 1999	Number of 3-car units	Load Factor	Cost per Round Trip $
Using the Electric Multiple Unit (SMU Series 220)	1	1	14.48

Assumptions		Seated	Standing
Passenger Capacity per Unit		236	266
Number of 3 Car Units		1	
Load Factor		0.6	0
Total Passengers		142	0 t
New Price 1994		2500000	$
Second Hand Price		0.2	0.2 Ratio of new price
Average Speed kph		62.5 kph	
Total Trip Time		4.00 hrs	
Round Trip Distance		150 k	
Total Labour	Drivers	2 Crew	3 Crew includes service at stations
Wages + On-Costs	Drivers	40 Crew	30 $/hr
Repairs & Maintenance		7 % new price	
Electricity Consumption		1440 kwh per 3 car unit	
Electricity Price		10.3 c/kwh	
Lubricants		10 % of electricity cost	
Overheads & Admin		20 % of other costs	
Interest Rate		5 % real	
Downtime Percentage		50 %	
Total Round Trips Per Year		1095	
Total Working Life		20 Years	
Total Passenger km Per Year		23 Million passenger km	

Costing Unit Train ($/t)

Overall Cost/Passenger Round Trip	Capital Cost	Dep'n Cost	Repairs & Maint.	Energy & Lubes	Labour Costs	Overheads & Admin
14.48	0.40	0.64	1.13	4.61	4.80	2.90

Note: Costs are for the 3-car unit, or multiples of it, and for passenger service but not for track.