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The Business of Australia's Railways: Proceedings from the Australian Railways Business and Economics Conference, Perth Australia, 20th July 2009

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Preface

The *Australian Railways Business and Economics Conference* was held in Perth, Australia, on July 20th 2009, bringing together 30 participants from industry, government and academia. The conference heard from six presenters:

- Paul Larsen – General Manager, Westnet Rail.
- Professor Tim Brennan – Professor of Public Policy, University of Maryland Baltimore County.
- Brett Hughes – Director of Policy, Australasian Railway Association.
- Jian Wang – Postdoctoral Research Fellow, Faculty of Business & Law, Southern Cross University.
- Anusha Mahendran – Research Associate, Centre for Labour Market Research, Curtin University.
- Nick Wills Johnson – Research Fellow, Centre for Research in Applied Economics, Curtin University.

The papers which underpinned these presentations are included in this volume. Paul Larsen and Brett Hughes did not produce papers, but rather gave highly informative industry overviews and, because the perspective of key industry players is crucial for understanding the industry itself, their slides have been included in this volume.

Paul Larsen focuses on the grain lines in Western Australia, a topic which has generated controversy recently because many of the lines require significant investment in order to remain viable, but generate insufficient returns to warrant such investment. The grain rail lines in WA, along with most of the rest of the network in the South West of the State (outside Perth) was privatised almost a decade ago. Westnet is the current operator of these lines, and is the only private, stand-alone below-rail operator in the world. As Paul points out, five million tonnes of grain are shipped on 2500 km of track, and 45 million tonnes are shipped on 2,600 km of track; fully half the network is unviable, earning losses of between $5 and $10 million per annum for Westnet. In such a situation, Westnet is neither willing nor obliged by the terms of its concession to fund the roughly $200 million it would cost to upgrade the grain network. The WA Government, however, has been proclaiming its desire that this occur, and this has been the basis of the controversy.

Part of the problem is that, although half of the network is not viable, its alternatives are even less so when viewed from the perspective of the community as a whole. The alternative is to use B-double trucks, which not only generate significant road-safety issues, but also, according to Paul, cost roughly $300,000 per annum each in road subsidies. In New South Wales, where the grain rail network is even more moribund than in WA, trucking rates have increased by 50 percent in response to the extra demand. A further part of the problem is that, if Westnet were to upgrade the network and charge the farmers the cost of doing so, access charges would double or triple. This would not breach regulatory revenue caps on most lines, but it is likely to render rail unviable for the growers. The solution, as Paul sees it, is for government funding for the track which is commercially unviable. This allows for the farmers to obtain the track they require without the costs exceeding their capacity to pay, and allows the government to save some $350 million on road investment costs that it would otherwise have to outlay in order to accommodate the roughly 300,000 truck movements that a cessation of grain rail services would engender.

Tim Brennan brings considerable breadth to the discussion of the regulation of railways by looking at the US context, and the lessons one can learn from telecommunications and electricity. Both are useful perspectives for the rail industry in Australia; railways in the US have been regulated private businesses for more than 100 years, providing a wealth of historical knowledge to inform the much younger Australian regulatory framework, and other sectors such as electricity and telecommunications often provide templates for regulators when they come to a new industry. The access regimes for rail in Australia are substantially based upon earlier regimes in electricity and telecommunications. Tim discusses the regulatory experiences of telecommunications and electricity, drawing lessons from them for the rail industry. In particular, each (in the US at least) offers a different kind of model, and neither is sufficiently similar to rail to warrant the duplication of their respective models for rail.

Tim also looks at the interface between antitrust, or competition law, and regulation, noting the exemption US railways have had from antitrust law since its inception in the 19th Century. The exemption means that the Surface Transportation Board, the regulator of rail in the US, sets rates and approve mergers, and that its decisions cannot be challenged under antitrust law. This exemption has been challenged recently and, although the bill was defeated, it is likely that bills to repeal rail's antitrust exemptions may be brought before Congress in the future. Tim thus looks at whether repealing rail's exemption from antitrust law would give rise to antitrust liability for rail. He suggests a number of scenarios whereby it might, but suggests that, even where the courts might find breaches of antitrust law on the part of rail, they would likely defer to the regulatory agency (the STB) because the remedies would generally require price controls of some kind that the courts are ill-equipped to impose. The recent *Trinko* case in telecommunications is cited as an example of where the courts viewed regulation as an adequate substitute for competition law. He also looks at the way in which the removal of an antitrust exemption might provoke some competition between the Department of Justice (one of the competition agencies in the US) and the STB, noting that the dual role of the ACCC as competition agency and industry regulator may mean that such competition occurs within the organisation.

Jian Wang and Michael Charles consider the impacts of the rail industry on the Australian economy by considering them through the lens of input-output analysis. This not only allows them to consider the overall impact of the industry on the national economy, but also to highlight the sectoral decomposition of that impact. In addition, they model the impacts of a modal shift from road to rail. Underpinning their analysis is the Australian Input-Output Table, put together regularly by the ABS.

Jian and Michael find that the total economic impact of the rail industry is roughly $18.5 billion in industrial outputs per annum, as well as generating more than 65,000 jobs and over $4.4 billion of household income. Sectorally, the industry has its greatest impacts in the railway equipment, the metals and metal products and the construction sectors, where direct and indirect effects are dominant. However, the industry also stimulates large public and private services responses such as finance, business and insurance services through indirect and induced spending.

By examining the impacts of a shift from road to rail, the authors look at both a technologically neutral shift of ten percent of final transport demand, and a shift which induces a ten percent productivity improvement to the rail sector. They find that the first shift would have no output effect, but that it would have net positive flow-on household income effect to the economy due to the higher wage structure of the rail sector relative to that of road. The second shift suggests the importance of creating higher-value-added services through innovation and investment, which could lead to larger economic impacts. In both cases, overall employment would fall, as rail workers are generally more efficient than the road freight industry in terms of the labour-output ratios.

Brett Hughes brings a unique, whole-of-industry perspective to the debate, through his position as the Director of Policy at the Australasian Railway Association; the peak industry body in Australia. He focuses on the transport industry in general, particularly in response to the sustainability debate, and upon the challenges faced by rail within this broader debate about transport. He is critical of the transport planning and policy framework, arguing that the best that is being done is only going to get us to multiples of existing problems such as congestion and road-freight movements. Moreover, he highlights an important disconnect between recent data and projections. In particular, historical growth in passenger car use is much steeper and in urban rail use, much shallower than it has been in recent years. Transport planning is yet to reflect these changed realities, which is important if they are not transitory phenomena.

Brett then goes on to look at issues of transport emissions, which would expand to cover two-thirds of overall targeted Australian emissions by 2050 if nothing is done to render the transport sector less carbon-intensive. Most of the problem, as he sees it, is tied to private cars, which are neither efficient nor improving their efficiency significantly. Moreover, he points out some other deleterious externalities associated with high private car use, highlighting in particular the correlation between areas of high mortgage stress and areas on the periphery of cities where residents face long car trips to commute each day. He also points out that many of the problems associated with traffic, particularly congestion, are increasing faster than traffic itself.

Rail, as Brett sees it, has considerable scope to contribute to solving many of these problems. Not only can it remove many cars from the roads in peak commuter periods, but it also much less energy intensive for both passenger and freight traffic. Not surprisingly, he sees rail as an important part of solutions to climate change, but he argues that the current policy framework is poorly constructed to deliver the kinds of policies necessary in this respect. In particular, he highlights numerous market distortions associated with policies pertaining to transport at present, but he also points towards the ingredients for a better, more long-term policy paradigm. In a more concrete sense, he advocates government playing a stronger role in facilitating modal shift from road to rail, which he suggests result in a reduction in emissions of up to one quarter. This would require the development of freight networks which more fully utilise rail as a central link, and urban forms which are more compact and suited to rail passenger transport.

Anusha Mahendran focuses on a critical issue for the rail industry in Australia at present; shortages in appropriately skilled workers. The paper is part of a broader project to develop a profile of the industry's workforce, and emerging critical needs within that workforce. In part, the skills shortage is a legacy of industry reform and rationalisation in the1990s, when the overall workforce was halved, and intakes of new workers slowed considerably. However, the industry still faces ongoing problems in terms of attracting and retaining staff (it is seen as "old economy"), as well as a steady ageing of its workforce.

Industry employment is still concentrated in blue-collar roles such as drivers, machinists and other trades-people, even though these were the groups where reductions in workers was greatest in the period from 1991 to today. The industry is also characterised by people with no formal qualifications (roughly half of total employees) or those with Certificate level qualifications (roughly a third of the total). The age profile of workers between the 1996 and 2006 Census has largely shifted upwards, indicating essentially that the same people working in the industry are still there, and roughly a decade older; there has been limited infusion of new workers. The gender profile of workers is also skewed, particularly in the blue-collar roles, but overall, women make up only 15 percent of the workforce.

The age, education and gender profile of the industry exposes it to considerable risks. Whilst workers are at work, ensuring they remain in good health is likely to be more expensive than for other firms and, as they retire from work, the industry faces the prospect of substantial losses of institutional knowledge. For a time, this could be combated by encouraging later retirement, but ultimately, there is a need to attract younger workers of both genders in order to sustain the industry into the future. This, according to some of the findings presented in Anusha's research, may require some quite fundamental paradigm shifts in the employment structure of the industry, with less hierarchy, less of a "cradle to grave" mentality and greater opportunities for women.

Nick Wills-Johnson develops a cost function for the Australian railways using data covering almost all of the 20th Century, from 1900 to 1992. He examines two functional forms, the translog and the generalised McFadden. The former has been widely used to study railways overseas and the latter has more recently found favour. Neither has been used in the context of Australian railways before. He finds that the translog provides better estimates of the cost structure of Australian railways, though neither does a perfect job. This seems most likely to be a product of the data; data on fixed capital at Australian railways has traditionally not been particularly good.

The models suggest that the separation of freight from passenger services, whilst it might have allowed governments to better target subsidies for loss-making passenger services, is likely to have slightly increased costs. They also suggest considerable economies of density (meaning track was used too lightly) as well as some evidence of economies of scale, meaning the networks could have reduced costs by expanding track and above-rail services.

Westnet's Grain Lines

Paul Larsen

General Manager - Westnet Rail

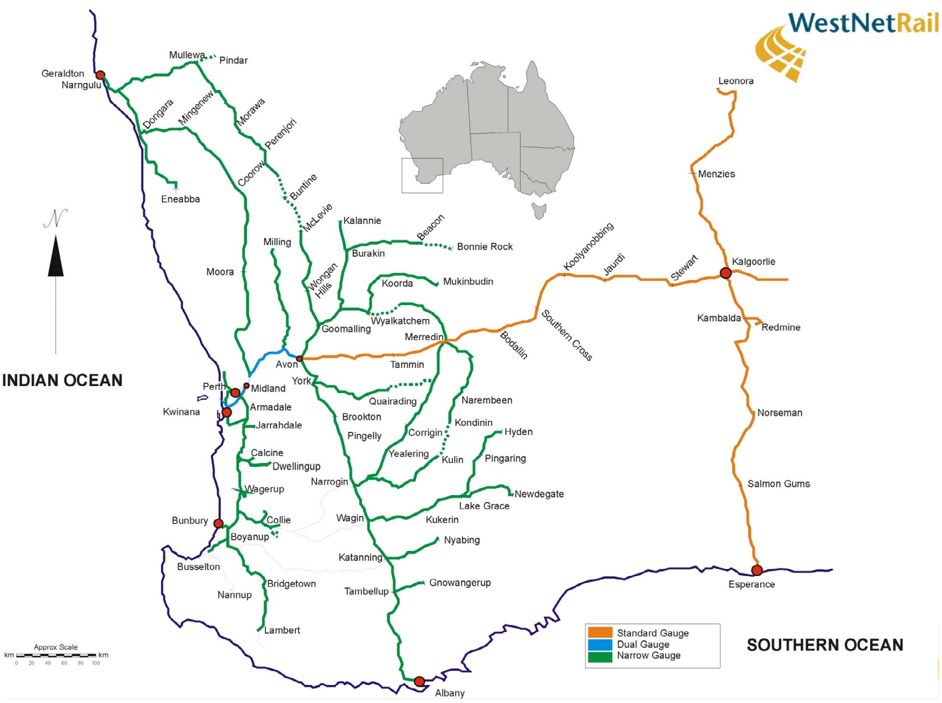
Grain Lines

ARA Forum – Perth, WA

Paul Larsen, General Manager

July 2009

WestNet InfrastructureGroup



The Business

WestNet Rail

- 5,100km network in the south-west of Western Australia
- 50 million tonnes moved per annum
- 49 year lease from the WA government
- Strong commitment to safety, efficiency and reliability
- Access charges regulated by Economic Regulation Authority
- 240 people employed directly, close to another 200 through major contractor

WestNet InfrastructureGroup

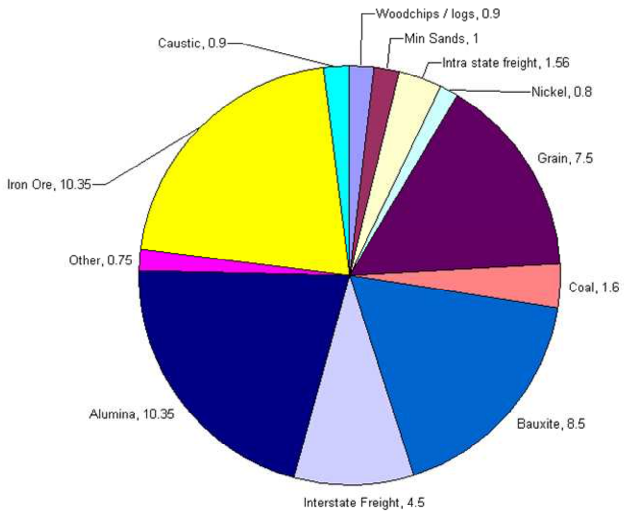
The Business

WestNet Rail

- Charge rail operators access to run trains on the tracks
- Responsible for maintenance and capital upgrades of track
- Responsible for controlling all train movements
- Responsible for safety accreditation and safe working
- Network is subject to open access to all Train Operators

WestNet InfrastructureGroup

Freight Task - 50 mtpa



Investment to date

- WNR has invested **over $1bn** to date into the rail network.
- The key achievements have been;
  - $237m on grain network
  - $120m sleeper replacement on Kwinana to Bunbury
  - $140m sleeper replacement on main line to eastern states
  - $30m optic fibre backbone, train control and signaling
  - $30m resleepering Esperance Line
  - $30m new crossing loops and extensions
  - $540m on annual maintenance

The facts

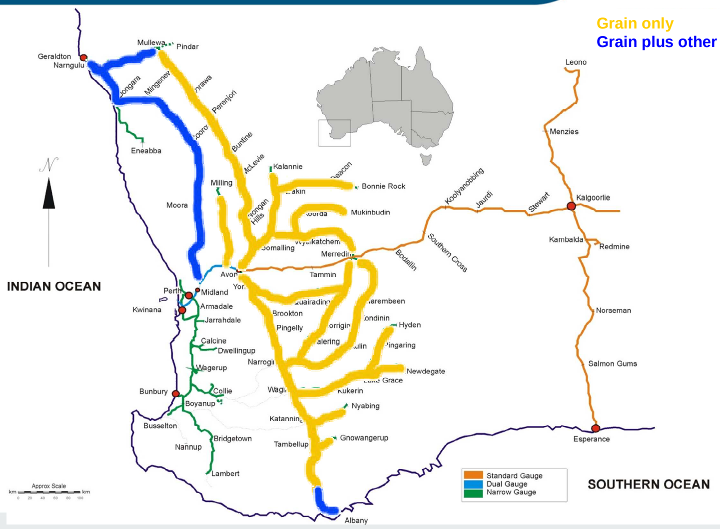
WestNetRail

- WNR loses lots of money running the grain network
  - Grain = 5 million tonnes on 2,500kms
  - Rest = 45 million tonnes on 2,600kms
- WNR is meeting its obligations in its contract with government
- Grain lines need $200m of investment to keep it going for another fifteen years and be a viable alternative to road
- WNR is entitled to seek government investment in these lines because they are uneconomic

WestNet InfrastructureGroup

Grain Network

WestNetRail



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Way forward

WestNet Rail

- WNR and Government have agreed to work co-operatively
- Industry and Farmer groups to help Government decide on rail and road network configuration
    - Deregulated market!!
- Government has acknowledged that it needs to invest, but due diligence required
- Industry / farmer group to make recommendations;
    - Near term – Northam to Albany
    - before end of 2009 – rest of network

WestNet InfrastructureGroup

Industry Group

WestNet Rail

- WAFF
- PGA

- CBH
- ARG
- WestNet Rail

- Public Transport Authority (Govt Railway)
- Department of Planning and Infrastructure
- WA Local Govt Association

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Grain Industry Benefits

WestNet Rail

- WA grain rail network is a critical link to the export ports
- Rail provides transport competition – without rail freight costs to grain industry will increase
- Ensures long term sustainable grain freight network with capacity to meet large harvests & predicted future growth
- Upgrade program achieves key logistical benefits:
  - higher reliability
  - 24hr port turnaround

WestNet InfrastructureGroup

WA Economy Benefits

WestNet Rail

- Strengthens competitiveness of $4 billion pa grain industry
- $135m investment from Federal Govt
- Secures $450m industry investment over 10 years
- Additional jobs created to undertake the upgrade program
- Grain freight network supports regional towns & businesses
- Saves the State $350m expenditure on road infrastructure to support the same freight task

WestNet InfrastructureGroup

Community Benefits

WestNet Rail

- Upgrade program provides regional employment opportunities and direct flow on effects to regional towns and businesses
- Keeps 300,000 heavy vehicle movements pa off roads
- Better safety outcome for all road users
- Avoids significant congestion issues around ports
- Better environmental outcome – rail more energy efficient
- Less road maintenance expenditure by Shires and the State

WestNet InfrastructureGroup

Summary

WestNet Rail

- WestNet has invested significantly
- Business / asset in good shape
- Clear process and timeline for grain

WestNet InfrastructureGroup

The changing antitrust/regulation interface in the US: Railways and beyond

Timothy J. Brennan

Professor, Public Policy and Economics - University of Maryland Baltimore County, USA, and Senior Fellow - Resources for the Future, Washington

Abstract

The transition from regulation to competition creates both structural and governance issues in rail, as it has in telecommunications and electricity. The latter two sectors provide both models for handling structural issues through either strict separation or fostering competition among vertically integrated firms and lessons regarding when separation may be problematic regarding operations and investment. We then turn to the antitrust/regulation interface, describing present rail immunities and using proposed legislation to identify competitive problems involving bottleneck control and conditions on sales of routes to short lines. Even if immunity were lifted, antitrust may (and perhaps should) be unable to address alleged problems. Addressing substantive harms may also be precluded by a recent radical shift in US law, making antitrust defer to regulatory authority. Recent political changes may herald a reversal, with consequences going far beyond rail.

Keywords: Rail, antitrust, regulation, single-firm conduct

Introductory Observations

As is familiar to those who work in, study, or provide public policy guidance toward the railway sector, it shares with some other sectors, notably telecommunications and electricity, two associated economic and legal properties that do not affect other industries to the same significant degree. First, the railway industry is a formerly regulated industry that is seeing competition used to an increasing degree to set prices and terms of service. Whether this competition takes place among vertically integrated railroads, among restructured above-rail carriers with access rights to monopoly rail systems, or some other variant, is one manifestation that varies around the world (Wills-Johnson, 2007).

Second, the institutional oversight of the rail sector remains in flux, as both competition law and residual regulatory institutions both retain some authority. This evolution is likely to vary widely across countries as well, not least of which because of prior historical governance systems. The flux in authority can take place in at least two dimensions. First, competition may require that one rail provider obtain access to or interconnection with facilities owned by another provider, such as use of tracks or interline services so that it can carry cargo destined for locations outside its network. If so, the rules for that access could be subject to both price regulation and access rules set under competition policy. A second issue, particularly important in the US and a major focus of this paper, is that the residual regulatory institutions may retain authority that duplicates and perhaps trumps the authority of general competition law.

A description, evolution, and assessment of the US situation are the subjects of this paper. I will begin with a very brief assessment of the vertical separation problem, illuminated in the US with the different degrees of separation, and different degrees of success, in the telecom and electricity sectors. Following will be a review of the antitrust treatment of rail in the US. Part of this will review a recently withdrawn legislative proposal to amend that authority, because the supporting documentation for that proposed statute indicates which competition-related concerns in the US are more prominent, and presumably (but not necessarily) most consequential. I will conclude with observations on whether these concerns could be addressed under US antitrust law. In particular, I have strong doubts regarding both the substantive illegality of these practices and whether, after recent rulings, US antitrust courts would have to defer when regulators have nominal authority over competitive practices.

Before getting to that, I offer a caveat. My perspective is that of an economist working on general issues of regulatory policy and competition, most recently regarding single firm conduct. My experience is largely in telecommunications and electricity; my drawing from that experience is likely to bring implicit presumptions that can and should be made explicit to make these observations less biased and more applicable. I hope nevertheless that this discussion will prompt some questions, and I look forward to learning a great deal from the comments and questions in this session and from the presentations to come.

Comparison to Other Utilities

Telecoms

In the US, the telecommunications sector is the strongest exhibit for both the changing potential for competition and the institutional complexity associated with its implementation. For most of the 20th century, telephone service from the handset to intercontinental transmission was essentially handled by a single monopoly, AT&T. AT&T was regulated at both the state and federal levels, with the former handling local service and the latter the long distance side.[1] Beginning in the 1950s, technological change—the advent of microwave communication—eliminated the scale economies associated with terrestrial long distance lines, enabling independent entry and potential competition for long distance calls. This began with firms using spectrum internally for long distance communication, followed by bulk and private line service, and eventually offering by-the-minute service to consumers.[2] While this was going on, similar efforts by entrepreneurs made it clear that AT&T's monopolies over equipment used by customers

[1] Court decisions and public policies led to regulatory price structures in which some of the costs of providing local telephone service, e.g., the lines that connect telephones on a customer's premises to the network, were allocated to the federal jurisdiction to be covered through long distance rates. This was not just a matter of regulatory confusion; the result that AT&T's long distance rates were above long distance costs because of this allocation may have fostered entry described below.

[2] Interestingly for this conference, some of the initial rights of way used for long distance microwave traffic were along railway routes. The opening two letters of one of the leading US telecom companies, Sprint, come from one of its founders and route providers, the Southern Pacific railroad.

and in the provision of the service itself were unjustified, and that rivals' equipment could be harmlessly connected and used on the network.

These developments led to over a quarter century of institutional controversy. The US's communications regulator, the Federal Communications Commission (FCC), initially resisted change, particularly when it would affect AT&T's core long distance and equipment markets. It relented on customer equipment, but let new entrants into long distance only when the US courts determined that the FCC bore the burden of showing that entry was not justified, rather than the reverse as the FCC (and AT&T) then claimed (Huber, Kellogg & Thorne, 1999). However, the Department of Justice (DOJ), through its Antitrust Division determined that the AT&T was unduly blocking entry into its markets through assorted discriminatory access services and "pricing without regard to cost.

AT&T argued, among other things, that FCC regulation pre-empted the reach of the antitrust laws, but the trial court did not buy that argument—a theme to which I return below. Seeing it was going to lose, AT&T essentially conceded the case and settled by giving DOJ what it sought—full divestiture in 1984 of its local operating monopolies, equal access for all long-distance firms to those local monopoly networks, and bans against the re-entry of those companies into competitive lines of business. Bans on the information side were short-lived, as AT&T had little interest in keeping the divested local telephone companies out of that business. With a change in antitrust administrations, DOJ was no longer inclined to support the result of the case. The court thus reluctantly allowed the divested companies into those sectors.

Full re-entry of those companies into long distance occurred only as a result of statutory change, passage of the Telecommunications Act in 1996. This transferred administration of the divesture from the judicial system to the FCC, setting up a process by which the local companies could provide long distance service if they met a checklist of conditions designed to prevent artificial impediments to local competition. That, and a succession of mergers of then geographically non-overlapping local service companies, led to the current structure of largely two fully integrated telephone companies—Verizon and a new AT&T—who overlap primarily in wireless markets.[3] Competition in local service has been facilitated by the growth of wireless—with two other significant competitors—and Internet-based voice service delivered over cable television broadband facilities.

Electricity

A less dramatic and less draconian chain of events took place in electricity. The technical change was the development of relatively small, economical natural gas-fueled power plants that held out the promise for competition in generation. The wires sides of the sector, local distribution and long distance transmission, remain regulated monopolies. Local distribution is a monopoly for the familiar and obvious scale economies precluding multiple companies running electric wires through the streets. Transmission, on the other hand, is a natural monopoly because electric energy generated at point A takes all paths in a grid before being taken off at point B. Even if separate companies own separate

[3] Tom Spavins has pointed out to me that they also compete in offering long distance service to businesses.

lines, because those lines are interconnected and that routing electricity along specific paths is prohibitively expensive, the lines operationally constitute a single region-wide grid [4]

As with telecom in the US, the impetus to opening markets to competition was a somewhat unintended consequence of other policies. In response to the energy crises of the 1970s brought on by two rounds of huge oil price shocks, the US Congress enacted a statute requiring states to open transmission grids to "qualifying facilities," primarily industrial co-generation plants, to reduce US oil imports.[5] Although that legislation led to some very costly electricity policies, it showed that non-utility generators could supply power into the grid economically and effectively.

This realization, combined with a general movement toward deregulation, led to passage of a statute in 1992 ordering the Federal Energy Regulatory Commission (FERC), the US national energy regulator, to come up with a plan to open bulk wholesale markets under its jurisdiction. In 1996, FERC issued its Orders 888 and 889, which set the rules for opening regulated transmission grids to independent generators.[6] This was supplemented at the end of 1999 with Order 2000. At the same time, some states opened retail markets under their jurisdiction to competition, which would enable end users at the industrial, commercial, and eventually residential levels to choose their energy supplier. The national government was considering legislation to mandate retail competition as well. The retail effort came to halt following the market meltdown in California in 2000-01; since then, some states have reversed course and re-regulated retail markets.

Even at the wholesale level, FERC instituted the rules for how markets would work if states elected to participate, but not all do, so some regions of the US follow these procedures while others do not. Where wholesale markets are opened to competition, FERC has adopted separation rules, although not as draconian as a full divestiture.[7] FERC requires that transmission companies be "functionally unbundled" from generation, with their operation independent of generation companies that own some of the lines under the authority of the "regional transmission organization" (RTO). A few years ago, FERC attempted to obtain authority to establish a standard design of how wholesale electricity markets would work within RTOs, but that failed in Congress.

Rail Implications

Reviewing these other sectors is a reminder that the various standpoints and problems regarding rail structure have been confronted in other sectors. The telecom experience illustrates issues at the ends of the spectrum—full separation and equal access, followed by competition among fully integrated suppliers after technological change. These are

[4] In this regard, electricity differs from telecommunications, where the long distance end was among the first parts of the industry where competition flourished. The difference is that telephone calls are easily switched and carried on particular carriers' facilities, while electrons cannot be so routed.

[5] At the time, the US generated over 15% of its electricity from oil. That percentage is now minuscule.

[6] The number "888" came from the street address of what was then FERC's new building, just north of the US Capitol building.

[7] Some states, in adopting competition, ordered utilities to spin off generation units. This may have been motivated both to prevent abuse of access to regulated local distribution grids and to deconcentrate the generation sector itself.

akin to the two models identified by Pittman (2009) for rail. One, competition just among rail car companies with regulated access to separately-owned monopoly tracks, follows the model employed following the break-up of AT&T. The second, competition among fully integrated providers, is the model set up by the 1996 Telecommunications Act and largely in place today.[8] The electricity model sits in the middle, with functional but not corporate separation of the regulated wires sectors from competitive generation.

Differences between these models and rail are illuminating. Two factors led to a monopoly in local telephone service. One is the physical scale economies in constructing a network. The premise underlying the 1996 Telecommunications Act was that those physical impediments were disappearing as other technologies (cable television) and new technologies (wireless) were increasingly able to compete in that market. The second is the network externality of everyone being able to reach everyone else. This continues to be addressed through policies to require mutual interconnection so all entrants can reap the economies of being on the same network. In considering the relevance of the telecom experience for rail, it is important to note that this interconnection is what we might call horizontal or parallel, not vertical. It is interconnection among firms in principle equally positioned to compete to serve any customer, but where the value of the service depends on reaching all customers (Brennan, 1997). It is not interconnection akin to that in which a rail carrier that competes in the A-to-B market but not the B-to-C market might get from carriers that serve the latter so it can offer A-to-C service.

The physical aspect of telecommunications competition also illuminates likely differences with rail. In the US, the presence of two competing physical wire networks for offering telephone service is perhaps a technological accident. Telephone lines lacked the bandwidth to offer television service, so a new technology was needed to get beyond spectrum limitations on television channels and to enable viewer payment mechanisms. On the other hand, cable television networks were designed topologically to provide one-way communications from a single site that aggregated video programs, not all imaginable customer-to-customer links. Only with the advent of Internet protocols over digital broadband facilities were cable systems able to take advantage of software-based routing to offer customer-to-customer communications service. In this sense, the competition in telecom may be more akin to intermodal competition between trucks and rail, rather than competition among suppliers of an identical transportation technology. Whether telecom competition proves to be sustainable over the long run, or whether very high capacity fibre networks restore the monopoly in local communications markets, remains to be seen.

The electricity model is useful in illuminating the vertical issues highlighted in Wills-Johnson (2007), although not all of the specific aspects apply equally to rail. A first is that because the grid is interconnected and electricity generally cannot be economically stored,[9] a failure of one supplier to meet customers' demands at any time can cause the

[8] My understanding is that most states have local telephone service tariffs in place, but these are largely non-binding as telephone companies, wireless providers (some owned by the telephone company), and cable providers compete to offer voice service.

[9] As large scale batteries remain prohibitively expensive, pumped-storage hydroelectric facilities is the only significant exception at present, and is available only where hydroelectric power constitutes a significant fraction of generation capacity.

entire grid to be blacked out. This makes system reliability a public good, requiring as a practical matter some degree of *ex ante* central control.[10] The degree of central control necessary to ensure adequate grid reliability remains a matter of controversy. In particular, jurisdictions differ on the value of having separate "capacity markets" to meet reserve requirements and to produce sufficient revenues to ensure investment in future generation.[11]

Two other issues, one in the short run and one in the long run, highlight problems with separation in electricity that undoubtedly have analogues in rail (Brennan, 2006). These are best seen in contrasting electricity with telecom. The short-run problem involves pricing. In telecommunications, it was relatively easy for regulators to establish access prices, and for long distance carriers to offer service to customers at those prices. In electricity, efficient congestion management requires separate, time-varying prices at every node in the electricity grid (Hogan, 1992). Accordingly, strict separation of regulatory pricing from competitive supply and demand can become harder to manage. Arguments in rail that track and rail operations cannot be coordinated simply through price would resonate with this concern, although it may be that track access prices can work well in the rail sector.

The situation is worse in the long term. In telecommunications, expansion of both the long distance network and local access capacity could be relatively gradual and thus could be implemented consistently with separately administered and relatively stable access prices. In electricity, the investments on both the competitive side—new generation units—and the regulated side—new transmission lines—both take place at significant scales. Neither can happen without the other, moreover, coordination may require disclosure of plans among generation competitors who would be using added transmission capacity. As Adam Smith's famous line about coordinated planning says:

> *"People of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public, or in some contrivance to raise prices…. But though the law cannot hinder people of the same trade from sometimes assembling together, it ought to do nothing to facilitate such assemblies, much less to render them necessary." (The Wealth of Nations,* Book IV Chapter VIII*)*

Whether in rail, electricity, or any other sector such meetings run counter to the entrepreneurial independence required for competition to thrive.

Before leaving structural issues and moving to the antitrust analysis of competition in the US, one geographic difference between the US and Australia may speak to the relevance of different competitive models. In the US, the ability to have competition at the track level, and not just railcar operators, is because there are typically multiple paths freight

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[10] *Ex post* liability for blackouts has not been adopted. Likely reasons include difficulties in assigning responsibility in a horizontally and vertically interconnected system, calculating damages, and preventing the use of bankruptcy to escape obligations to compensate.

[11] Although the blackout externality is specific to electricity, rail systems do require traffic control to prevent collisions.

can take between two points in the U.S. This is because the topography of the US, particularly the location of major navigable rivers, has led to population in the US being distributed across two dimensions. Shipments can follow rail paths along routes going north, south, and through the middle of the country. Australia, on the other hand, is a country where the population is distributed almost entirely on a single line running almost entirely along the east and southeast coasts, with Perth on the west side of the Great Australian Bight. If rail routes match this population distribution, competition at the track end would require multiple tracks along the same route. Unless rail traffic is sufficiently great that a single track would be routinely congested, competition among tracks would not be feasible, making the case for divested tracks with access stronger for Australia than in the US.[12]

Antitrust or Regulation? Immunities and Concerns

Present Rail Status: Regulatory agency, not antitrust court

At present, railroads share with a number of industries special treatment in the US under its general antitrust laws. To understand this special status, a brief review of the US antitrust laws is in order. Compared to other competition laws around the world, including the Trade Practices Act of 1974, the US antitrust statutes are minuscule. The substantive content only renders illegal a "contract, combination … in restraint of trade," "monopolize, or attempt to monopolize," or mergers or acquisitions when "the effect of such acquisition may be substantially to lessen competition, or to tend to create a monopoly" (15 U.S.C. §§1, 2, 18). In effect, antitrust in the US is a common law regime in which courts and enforcement agencies (until reversed by courts) determine what practices these phrases cover. The vast list of practices covered, and the evolution of attitudes toward those practices, has since passage of these statutes in 1890 and 1914 been in the hands of the courts, largely though private lawsuits, stimulated by the prospect of treble damages.[13]

The flexibility accorded by the common law nature of US antitrust means that it should be generally applicable throughout the economy, including for rail. However, numerous sectors have obtained specific statutory exemptions from this framework. Railways are among a list of over thirty statutory exemptions or immunities accumulated over the years (Bush, Leonard & Ross, 2005). Among the sectors covered are labour organizations (15 U.S.C. §17), state-regulated insurers (15 U.S.C. §1012), and professional sports leagues (15 U.S.C. §1291-93).[14] In addition to antitrust immunity, some sectors are subject to review by multiple agencies including the antitrust authorities, where mergers in particular have to pass muster with all of them. These include

[12] Intermodal competition between trucks and trains would, where significant, mitigate some of these concerns about the absence of rail competition through alternate pathways.

[13] Two government agencies in the US have the authority to bring antitrust cases, the U.S. Department of Justice (an executive branch department) and the Federal Trade Commission (a so-called "independent" agency headed by appointed commissioners). Only the former can bring criminal cases, generally restricted to cartel conspiracies.

[14] Among my favourites is that the exemption for the professional (American) football league's collective marketing of television broadcast rights is a restriction that the league not broadcast games on Friday nights and Saturdays during the high school and college football seasons—a market allocation agreement that would generally be criminal conduct in the U.S. were it not protected by law.

telecommunications (FCC) and electricity (FERC) as noted above, as well as banking, in which the Department of the Treasury, Comptroller of the Currency, and Federal Reserve all can intervene (Shull & Hanweck, 2001).

The specific exemptions for rail resemble those in other transportation sectors, notably airlines and trucking.[15] Rail remains regulated by the Surface Transportation Board (STB), the institutional successor to the Interstate Commerce Commission, the first federal regulatory agency in the US.[16] The STB's authority essentially pre-empts antitrust enforcement. Rate agreements and mergers approved by the STB cannot be contested on antitrust grounds (49 U.S.C. §§10706, 11321). The Antitrust Division can, and has, raised objections to mergers to the STB, but the STB is under no obligation to defer. Once the STB rules, it may be subject to general law regarding the propriety of administrative procedures, but there is no recourse for those believing that competition might be adversely affected by an agreement or merger. In particular, rail is immunized from antitrust suits by private plaintiffs. If cases do make it to courts, current law orders judges to defer to STB rulings.

Consequent Concerns

Although delegation of authority to a sector-specific regulator rather than a general interest competition authority increases the risk of exploitative capture by the regulated sector (Stigler, 1975), it is not necessarily the case that the current immunity leads to anticompetitive outcomes. Nevertheless, the US Congress has considered and may reconsider proposed legislation (S. 146) that would largely eliminate this special treatment of rail and bring it under the purview of the antitrust laws. The proposed bill is worth a look not because it is necessarily likely to pass—in fact, it was recently withdrawn, but may be reintroduced at a later time. However, the Senate report accompanying the bill is useful in indicating the kinds of problems that at least some observers as sufficiently important to undertake efforts to correct for perceived weaknesses in antitrust enforcement in this area.[17]

A first concern is consolidation. In 1976, there were thirty Class I (large) railroads; at present there are only seven.[18] According to a US Government Accountability Office (GAO) study, the market share of the top 4 Class I (large) freight railroads rose from around 40-45% to about 89% of revenues between 1985 and 2004 (GAO, 2006). National figures in and of themselves may not be competitively relevant, as competition in rail is likely to be along routes rather than nationwide. Nevertheless, the DOJ has

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[15] Airline exemptions are similar to those described in rail, where the executive branch Department of Transportation (DOT) has authority to that described below of the STB (which sits within DOT) (49 U.S.C. §41308. The STB's authority to immunize rate agreements in trucking is describe at 49 U.S.C. §13703.

[16] Among industry observers, this organization is also known as the SurfBoard.

[17] The list of concerns and facts cited here are drawn from U.S. Senate, 111th Congress, The Railroad Antitrust Enforcement Act of 2009, Report 111-9 (Mar. 18, 2009), hereafter "Senate Report," available at http://frwebgate.access.gpo.gov/cgi-bin/getdoc.cgi?dbname=111_cong_reports&docid=f:sr009.111.pdf.

[18] The definition of a Class I railroad, a standard in the US, is provided by the Association of American Railroads. See its site, "Class I Railroad Statistics," available at http://www.aar.org/PubCommon/Documents/AboutTheIndustry/Statistics.pdf.

opposed mergers of Class I railroads on competitive grounds, or suggested conditions to protect competition; the STB nevertheless rejected those recommendations.[19]

Beyond consolidation, two specific practices have come under question. A first involves captive shippers who would like to use an alternative carrier for part of the route they wish to use. This is the "vertical interconnection" issue outlined above. A captive shipper is one at location A that has no choice but to use the only carrier, call it X, that serves A. Suppose X is the only carrier to B—a "bottleneck"—but then competes with other carriers Y and Z on the route from B to C. The captive shipper may want to use carriers Y or Z to get its freight to C, but to do that, X has to offer it a rate just to B that will allow it to switch its freight to Y or Z. According to the Senate Report, the STB does not require X to quote a rate to reach a competitor.

The second practice identified in the Senate Report is similar in character. As US Class I railroads consolidated their operations since rail was substantially deregulated in the US in 1980, many of them spun off operations on relatively underused track to short lines. In some cases, these short lines could deliver traffic to a number of Class I railroads. These transfers, however, were often conditioned on a requirement that the short line deal only with the Class I railroad from which it obtained these operating rights. Such transfers, with these conditions, were typically approved by the STB or its predecessor, the ICC. The Senate Report quotes a 2004 DOJ report as stating that because of this approval, these agreements "may be exempted from the reach of the antitrust laws."

Would Changing the Law Create Antitrust Liability? Substance

Bottleneck Carriers and Refusals to Deal

According to the Senate Report, a DOJ official, in response to a Congressional inquiry, stated that but for the railroad immunity, the practice "could be evaluated as a refusal to deal … or as a tying arrangement." However, even if the antitrust laws were permitted to review bottleneck refusals to deal, finding the practice illegal in the US would be far from a sure thing. Regarding the first, firms in the US, even with market power, are given wide latitude regarding the ability to refuse to deal, particularly with competitors. In 2004, the U.S. Supreme Court stated that a refusal to deal would be anticompetitive only if the firm was stopping a practice it had formerly been undertaking, and would lose profits by stopping the practice but for the anticompetitive benefits.[20] In doing so, it said that the case setting these standards was "at or near the outer boundary of §2 liability."

An approach that might have more traction could be to call this not a refusal to deal with a B-to-C competitor, but a tying arrangement, in which the A-to-B carrier that has captive customers—and thus presumably has market power—ties A-to-B service to using its B-to-C service. Current US antitrust jurisprudence nominally regards tying by a firm with

[19] One possible reason for a difference in viewpoint is that the efficiency benefits of consolidation may be opposed by rail interests, e.g., labour unions.

[20] *Verizon v. Trinko*, 540 U.S. 398 (2004), citing *Aspen Skiing Co.* v. *Aspen Highlands Skiing Corp.*, 472 U.S. 585 (1985). We return below to an assessment of *Trinko*, and the Supreme Court's decision in *Credit Suisse v. Glen Billing*, 551 U. S. 264 (2007), with regard to changes in the degree to which antitrust should, in the Court's view, defer to regulatory authority even without specific immunity.

market power as illegal.[21] Since the current DOJ has rejected what it perceives as the standpoint regarding single-firm conduct taken by the DOJ during the administration of Pres. George W. Bush, the present administration under Pres. Barack Obama may attempt to increase the potential liability for this type of conduct (Varney, 2009).[22] However, ultimately it is up to the Supreme Court to interpret the antitrust statutes, and it may take some turnover of the judges—who have lifetime appointments—to see a change.

Even if the antitrust authorities were to pursue cases along these lines, and less likely, the courts were to find liability, the question remains whether there is an effective remedy under the antitrust laws. Simply ordering the A-to-B monopoly carrier to offer an interline rate would accomplish little. In principle, it can simply set a price that extracts the full monopoly margin associated with demand from A for the B-to-C route, fully exercising its market power while still offering a rate that allows carrier switching.[23] An effective remedy entails not just an order to deal, but regulation of the price at which the dealing takes place. Under US antitrust laws, price regulation is generally not a feasible remedy because it would place the court administering the case in the role of a price regulator.

A structural remedy might be more appropriate if the refusal to deal was undertaken for strategic reasons, e.g., to somehow prevent a B-to-C carrier from entering the A-to-B route and reducing the present monopolist's market power. A story of this sort lay behind the theory of the US antitrust case against Microsoft, where restricting access to competing browsers was posited not as a means of exercising current market power but as a way to impede future entry into markets for application platforms (Brennan, 2001).[24] But to my knowledge, no strategic entry deterrence argument is being made here. The only issue is whether a railroad that already has market power is exploiting it, not whether the practice is creating new market power were it formerly existed.[25] Absent price regulation of the monopoly link, either from a pre-existing regulatory structure or imposed as a remedy, there is no new monopoly created and, thus, no reason to presume that the tying or refusal to deal reduces net economic welfare for either consumers or the economy as a whole.

Transfers Conditioned by Exclusive Dealing

The second concern was that divesting a route to a short line, on the condition that freight from that line would go only on to the divesting Class I railroad, would constitute an unreasonable restraint of trade under the antitrust laws. The obvious concern created by

[21] In *Illinois Tool Works Inc. v. Independent Ink, Inc.*, 547 U.S. 28 (2006), the Supreme Court restated the market power requirement for illegal tying that it established in *Jefferson Parish Hospital Dist. No. 2* v. *Hyde*, 466 U.S. 2 (1984), finding that having a patent does not in and of itself convey market power.

[22] For a critical commentary, see Priest (2009).

[23] Such prices, in the form of an "efficient component pricing rule," have been advocated as necessary to restrict entry to firms in the B-C route that have lower cost than the incumbent. Such a rule neglects the economic benefits arising from competition over monopoly, even if some of the rivals' costs are not as low as the monopolist.

[24] This article also notes mutual inconsistencies among the theory of the case, the evidence brought forward, and the remedy proposed.

[25] For a useful discussion of the contrasting relevance of extension and exploitation in interpreting single-firm conduct under US antitrust laws, see Carlton & Heyer (2008).

the so-called "paper barriers" to entry brought about by conditioning sale of a route to a short line on exclusive dealing with the selling Class I railroad is that it would reduce the profitability of competitors to the Class I railroad who would also be able to take shipments from that short line. In and of itself, this does not appear to create any harm to competition beyond those that would have existed and presumably been legal prior to the sale of that line.[26] If the Class I lined retained that railroad, it would generally be free to refuse to deal with competitors, absent the strong conditions described above. The threat of liability and an imposed remedy could be evaded simply by refusing to sell the route under any condition. That outcome would presumably reduce the overall economic efficiency of that portion of the railroad sector, as the choice to sell with that condition presumably produces gains that would not be available otherwise.

We might also note that such conditions are common in markets where dominance is not an issue. Selling the route on the condition that traffic to go beyond that route not use another rail carrier is akin to a non-compete clause in a labour contract, where the employee agrees not to work for a competitor if it leaves the firm.[27] The route in this case is akin to the employee, and similar incentive effects may apply. Absent a non-compete clause, a firm may not have as strong an incentive to develop the employee's productivity in this sector. Perhaps with the luxury of not knowing a great deal about the rail sector, I can imagine as well that if the Class I railroad had exerted effort in developing that route, it may not want those efforts used to benefit its competitors through delivery of traffic to them.

The situation could be interesting, however, if the route sale to the short line included other conditions, notably a restriction on entry by that short line into other routes served by the Class I operator. If the route is sold to the short line at a price below its market value, the money left on the table could be a side payment to the short line not to compete in other markets. This, in effect, would be implementing an agreement between the short line and the Class I railroad not to compete in these other markets. Such an agreement would likely be viewed as an unreasonable restraint of trade.[28] The Senate Report (2009) does not express concern over these kinds of agreements, however, so this may be a prospect more hypothetical than real.

Would Antitrust Work? The regulation/antitrust relationship

Even if substantive competition problems were identified that warranted antitrust concern in rail, US courts may continue to defer to the STB even if explicit antitrust immunities are withdrawn.[29] Because antitrust law is made by the courts, the issue turns on the balance courts take between antitrust and regulation when both may cover the same

[26] An exception might be if the Class I railroad had acquired the line it is divesting through some anticompetitive means.

[27] Such clauses may require consideration and harm to the employer from breach in order to be enforceable (Bergeron, 2007).

[28] This is the theory behind accusations that companies holding patents on drugs "settle" patent infringement suits brought by competitors, where in exchange for the settlement payment, the generic drug entrant agrees to stay out of the market for some period of time. Such cases have not fared well in the courts, because competition concerns are trumped by a presumption that settlements are preferable to litigation.

[29] The following discussion draws on arguments in Brennan (2004, 2005 & 2006).

conduct. In the 1980s, the prevailing standard was that the antitrust laws should apply absent a clear indication to the contrary. As one of the US's Courts of Appeal (just below the Supreme Court) said in a private antitrust case against the then-monopoly AT&T:

> *It is well established, however, that regulated industries "are not per se exempt from the Sherman Act." Georgia v. Pennsylvania R.R., 324 U.S. 439, 456 (1945). "Repeal of the antitrust laws by implication is not favored and not casually to be allowed. Only where there is a '<u>plain repugnancy</u> between the antitrust and regulatory provisions' will repeal be implied." Gordon v. New York Stock Exchange, 422 U.S. 659, 682 (1975), (quoting United States v. Philadelphia National Bank, 374 U.S. 321, 350-51 (1963). As a further limitation, repeal is to be regarded as implied only where necessary to make the regulatory scheme work, and even then, only to the minimum extent necessary. Silver v. New York Stock Exchange, 373 U.S. 341, 357 (1963). [Emphasis added, citations abbreviated.]*[30]

Regulation was not just an obstacle but a crucial reason to prosecute cases against AT&T, and not a defence. The incentive to discriminate against rivals in access to monopoly services is that the artificial competitive advantage it creates allows that monopolist to capture profits regulation otherwise limits. Absent regulation, the firm could capture those profits directly, and if anything would prefer competition in its vertically related markets. Similarly, the ability to cross-subsidize, i.e., to take costs of providing unregulated services and shift those the accounts to a cost-based regulated service, allows the regulated monopolist to increase the regulated price closer to the monopoly level, thwarting regulation. Moreover, the ability to shift costs may enable the regulated firm to cover losses from predatory pricing against entrants that dare to enter its unregulated markets. Absent cost-of-service regulation, that ties regulated prices to nominal costs, the ability to increase profits by misallocating expenses or to make predatory threats credible is somewhere between minimal and nonexistent. The purpose of separating ownership of competitive firms from control of the regulated monopoly is to take away the incentive to carry out these anticompetitive tactics (Brennan, 1987).[31]

In the last five years, the US legal stance toward the antitrust-regulation balance has changed radically. The major statement was the aforementioned *Trinko* decision in 2004. In that case, Verizon was accused of conduct virtually identical to that of AT&T in the 1970s—discriminating in making available monopoly telecommunications services, here local loops and network elements that entrants into local telecommunications would need to provide service.[32] While in the earlier cases the presence of FCC regulation was the cause of the problem and neither a substantive defence nor a justification for immunity, the *Trinko* court viewed regulation as a substitute for antitrust. Because the FCC was nominally in place to oversee competition, the benefits of additional antitrust

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[30] *MCI v. AT&T*, 708 F.2d 1081, 1102 (7th Circ., 1983).

[31] Russell Pittman has observed to me that vertical separation may accomplish little if the unregulated side of the business fails to be competitive.

[32] The plaintiff, Curtis Trinko, was a New York attorney who was a customer of one of those entrants, ironically, the post-divestiture AT&T, prior to its purchase by Southwestern Bell, creating the present AT&T.

enforcement were stated to be less than the cost of chilling effects associated with forcing firms such as Verizon to deal with competitors. The Supreme Court reached this conclusion despite the inclusion of a specific "savings clause" in the 1996 Telecommunications Act that explicitly preserved antitrust jurisdiction. The Court instead expressed the view that the regulation created by the 1996 Act would constitute a "good candidate for antitrust immunity," and then went on to decide the case as if the savings clause essentially was not there.[33]

Prognosis for Antitrust in US Rail (and beyond)

Had *Trinko* been the law in 1980, my view is that DOJ would not have been able to prosecute successfully its antitrust cast against AT&T and not secure the divestiture. If so, even if antitrust immunities in rail are nominally repealed, the courts will defer to the STB following the principles expressed in this decision and its successors. The courts, following this ruling, would likely conclude that the STB has already done the cost benefit test, and competition law can only muddy those waters.

Evaluating whether this is a sound legal prediction for the US requires a look at how we got to this juncture and where we may be going. The *Trinko* ruling did not take place in a vacuum; it was strongly supported in a joint *amicus* brief filed before the Supreme Court by the two federal antitrust agencies, the DOJ and FTC. That brief, and the *Trinko* decision, were largely premised on a very skeptical stance toward monopolization cases generally. The regulatory aspect of the *Trinko* may have been an afterthought, perhaps because the earlier AT&T divestiture was the result of a settlement, not a legal decision that would have given more authority to the view that regulation creates the circumstances for anticompetitive conduct, not alleviates them. Hence, that baby may have gone out with the bathwater.

It is hard to envision that the Supreme Court's views on this balance will change anytime soon. *Trinko* and *Credit Suisse*, the leading case on the matter since, both had six of the nine judges adopting the majority view.[34] However, as observed above, the new administration of DOJ has promised a more aggressive approach to single-firm conduct. This opens up a possibility that DOJ could advocate a greater role for antitrust in regulated industries, rail in particular. This new attitude is not without its risks, however. Outside the regulatory arena, a greater aggression toward single-firm conduct is appropriate primarily when practices pre-empt competition in a complement market (e.g., retailing or distribution), that denies access to rivals (Brennan, 2007). So far, the statements by the new administration do not indicate a discrete approach that would focus on complement market monopolization or regulatory evasion.

The way this new perspective plays out over the next few years has consequences for antitrust enforcement far beyond rail, and beyond US borders to the extent US policy

[33] In *Credit Suisse v. Glen Billing*, 551 U. S. 264 (2007), the Court restated this view in deciding that alleged collusion in among investment bankers be left to the US securities regulator than subjected to antitrust review.

[34] In *Trinko*, the three agreed with the outcome, but would have ruled on the basis that Mr. Trinko's law firm lacked standing to sue. In *Credit Suisse*, one of the three other justices recused himself, and a second concurred in the result, with only one dissent.

influences competition policy around the globe. As one only barely familiar with the regulatory structure in Australia, I am not qualified to predict how this will play out here. One factor affecting the development is the unitary role of the ACCC as both a regulator and a competition agency, so perhaps these battles are waged within the bureaucracy than in the courtroom. A second aspect is the extent to which US antitrust policies, whatever they are, carry weight because of the size of the US economy and the length of the US antitrust history. I do hope that awareness of the US reversal of position on the relative standing of competition law in regulated sectors would inform whatever processes bear on how that issue is addressed in Australia.

Bibliography

Bergeron, D. (2007), 'Employment Law: Non-compete clause', *AllExperts*: *Dec. 11 2007*, available from http://en.allexperts.com/q/Employment-Law-924/non-compete-clause.htm.

Brennan, T.J. (1987), 'Why Regulated Firms Should be Kept Out of Unregulated Markets: Understanding the divestiture in *U.S. v. AT&T*', *Antitrust Bulletin* **32**, 741-93.

Brennan, T.J. (1997), 'Industry Parallel Interconnection Agreements', *Information Economics and Policy*, **9**, 133–49.

Brennan, T.J. (2001), 'Do Easy Cases Make Bad Law? Antitrust innovation or missed opportunities in *U.S. v. Microsoft*', *George Washington Law Review* **69**, 1042-102.

Brennan, T.J. (2004), 'Regulation and Competition as Complements', in Crew, M. & Spiegel, M. (eds.), *Obtaining the Best from Regulation and Competition*, Norwell, MA: Kluwer Academic Press.

Brennan, T.J. (2005), '*Trinko* v. Baxter: The demise of U.S. v. AT&T', *Antitrust Bulletin* **50**, 635-64.

Brennan, T.J. (2006), 'Alleged Transmission Inadequacy: Is restructuring the cure or the cause?', *Electricity Journal* **19(4)**, 42-51.

Brennan, T.J. (2007), 'Saving Section 2: Reframing U.S. monopolization law', in Ghosal, V. & Stennek, J. (eds.), *The Political Economy of Antitrust*, Amsterdam: North-Holland.

Brennan, T.J. (2008), 'Essential Facilities and *Trinko*: Should antitrust and regulation be combined?', *Federal Communications Law Journal* **61**, 133-47.

Bush, D. Leonard, G.K. & Ross, S.F. (2005), *A Framework for Policymakers to Analyze Proposed and Existing Antitrust Immunities and Exemptions*, SSRN Working Paper, available from: http://ssrn.com/abstract=956597.

Carlton , D.W. & Heyer, K. (2008), *Appropriate Antitrust Policy Towards Single-Firm Conduct*, Economic Analysis Group Discussion Paper No. EAG 08-2, available from: http://ssrn.com/abstract=111166.

General Accountability Office (GAO) (2006), *Freight Railroads: Industry Health Has Improved, but Concerns about Competition and Capacity Should Be Addressed*, GAO-07-94, available from http://www.gao.gov/new.items/d0794.pdf.

Hogan, W.W. (1992), 'Contract Networks for Electric Power Transmission', *Journal of Regulatory Economics*, **4**, 211-42.

Huber, P., Kellogg, M. & Thorne, J. (1999), *Federal Telecommunications Law*, New York: Aspen Law and Business.

Pittman, R.W. (2009), 'Railway Mergers and Railway Alliances: Competition issues and lessons for other network industries', Economic Analysis Group Discussion Paper No. EAG 08-2.EAG 09-2, available from: http://ssrn.com/abstract=1410132

Priest G. (2009), 'The Justice Department's Antitrust Bomb**',** *The Wall Street Journal***,** June 2nd 2009.

Shull, B. & Hanweck, G.A. (2001), *Bank Mergers in a Deregulated Environment: Promise and peril*, Santa Barbara, CA: Greenwood Publishing Group.

Stigler, G. (1975), *The Citizen and the State: Essays on Regulation*, Chicago: University of Chicago Press.

Varney, C. (Assistant Attorney General for Antitrust), (2009), *Vigorous Antitrust Enforcement in this Challenging Era*, speech before the Center for American Progress, Washington, DC (May 11, 2009), available from http://www.usdoj.gov/atr/public/speeches/245711.pdf.

Wills-Johnson, N. (2007), *Competition Policy and Railway Investment in Australia*, Planning and Transport Research Centre Working Paper No. 12, available from: http://ssrn.com/abstract=965608.

Applying Input-Output Analysis to the Australian Rail Industry: A Value Chain Modelling Approach

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Abstract

It has long been recognized that there are wider economic benefits through rail's inter-industry and intra-industry linkages, in addition to the direct impacts in time and costs savings that are assessed in conventional cost benefit appraisal. The impacts of rail are felt in other sectors of the economy through the effects of industry purchases and subsequent rounds of indirect and induced spending. This paper employs an input-output analysis to estimate the contribution of the industry on national economic output, income and employment. Empirical results show that input-output modelling provides policy makers with a powerful tool to quantify these linkages and assess the direct and indirect economic implications of a potential policy or regulation.

Keywords: Supply Chain Analysis, Input-Output Modelling, Rail Industry.

Introduction

Rail industry in Australia is a national and diverse industry and a key element in the nation's increasingly integrated logistics supply chain. In broad terms, the industry comprises freight and passenger train operators, infrastructure providers and maintainers, rolling stock manufacturers and maintainers, and other supply chain and logistics operators. The industry has strong linkages with other industries such as manufacturing and construction sectors in Australia that add value to these industries throughout the value chain. These industries make purchases from and sell to the rail industry, which, in turn, purchases from other industries in a cascading series of transactions that creates a stimulating effect on industries across the broader economic spectrum. In addition, rail-related employment supports the expenditure of households that circulate throughout the economy, thereby creating additional earnings and employment. In many regional centres of Australia, employment in the rail industry, or indeed rail-related sectors, comprises a major source of employment, which suggests that the rail industry has an important societal value in these areas of the nation (ARA, 2007).

Conventional rail cost benefit analysis largely concentrates on counting the direct impacts of a rail project on those immediately affected by it; that is, those who will use the project, those who will supply it, and those who will be subjected to various external effects, which are principally time and cost savings (ATC, 2006). It has long been recognized that there are wider economic benefits through rail's inter-industry and intra-industry linkages, in addition to the direct impacts in time and costs savings that are assessed in the conventional appraisal, as signalled above (Banister 2007).

Despite this, it is argued here that the inclusion of wider economic benefits via appropriate economic data, such as output and employment, will help to produce estimates of the direct and indirect economic implications of a potential action, such as the undertaking of a large infrastructure-type investment, or the implementation of a policy or regulation that will have an impact on the rail and allied industries. Input-output analysis is generally not well known outside the discipline of economics, and it has never, as far as can be ascertained, been applied to the Australian rail industry.

In view of these considerations, the purposes of this study are as follows:

- Estimate the economic values of the rail value chain (i.e., railway equipment manufacturing, and freight and passenger operation) through the input-output multiplier analysis;
- Provide insights into integrated supply chain linkages between the rail sectors and other industry sectors in the Australian economy; and
- Produce estimates of the direct and indirect economic implications of a potential modal shift from road to rail in response to increased focus on sustainability issues.

This study is divided into five sections. The first section provided an introduction to this research. The second section reviews recent economic input-output studies in Australia, while the third describes methodological features of the input-output analysis, the industry definitions, and input data used in this study. The fourth section presents the results, with impact estimates provided in aggregate, while the study concludes with a summary and conclusion.

Input-Output Analysis

Input-Output Analysis in Australia

The first Input-Output tables for Australia were developed by Burgess Cameron in 1946-47. Since then the Australian Input-Output tables have been utilized by a large number of applied economists and policy researchers. Dixon & Rimmer (2002) note that a flagship use of the Australian Input-Output tables is the production of the MONASH model, which is a dynamic Computable General Equilibrium (CGE) model of the Australian economy. The MONASH framework has also been disaggregated into eight sub-national state and territory regions (Naqvi & Peter 1996).

The Australian Input-Output tables were also used by the Australian Productivity Commission for analysing industry assistance policies, as well as for measuring assistance afforded by tariff concessions in Australia (Gretton, 2005). In addition, these Input-Output tables have been used in various regional economic studies[1], which have resulted in the development of several stand-alone regional input-output models. Powell & Snape (1992) point out that the rise of economic literacy has been an important component in the evolution of policy development in Australia. By engaging Australian policy makers in an analytical process that looks at their proposal within an economy-

[1] See Centre for Agricultural and Regional Economics (2003) for New South Wales, Queensland Treasury (2004), Clements and Qiang (1998) for Western Australia, and South Australian Department of Trade and Economic Development (2005).

wide perspective, the quality of the debate on matters pertaining to the economy has been improved substantially. Indeed, the Australian Input-Output tables and the economic models developed from these tables have played a key role in the evolution of policy in this country (Powell & Snape, 1992).

Input-Output Analysis and Australian Transport Sector

Given the above, it is somewhat surprising that there has not been much work done on the application of input-output analysis to the Australian transport sector. Most of the economic analysis in the transport sector has been undertaken by CGE modelling for the evaluation of a proposed project or policy. However, significant variation in estimates can be produced using the same CGE model. This is because the flexibility of these models allows the analyst to incorporate professional judgement in determining the appropriate economic environment and initial project or policy specification.

We chose an input-output model because it is the simplest model and allows an analysis of economic activity in a production life-cycle context. Moreover, input-output analysis is politically and ideologically neutral; it does not incorporate any specific behavioural conditions for the individual, companies, or indeed the state. Finally, an input-output approach to the rail industry can be reproduced in every country, for almost any base year, and by any institution, since input-output tables are generated and published in regular intervals by statistical bureaux around the world (Foran, Lenzan & Dey, 2005).

Methodological Application

Structure of the Input-Output Table

Input-output tables, which were first published by Leontief (1936), are regarded as one of the Twentieth Century's major advances in economics. They allow an economic system to be analysed using real data. Furthermore, they represent numerical models of the relationships between the production sectors of an economic system. By showing details of the flow of goods and services between industries, input-output tables provide an analysis of the process of production, the use of goods and services, and the income generated as a result of production.

The format shown in Table One below is essentially the same as that used by the Australian Bureau of Statistics (ABS). Quadrant II shows the various components of final demand, these include:

- Consumption expenditure by government and household.
- Gross domestic fixed capital formation.
- Change to inventories.
- Exports.

The rows in quadrant II show the distribution of intermediate outputs to these final demand sectors, while the columns show the value consumed by each final demand sector. Value added to the output from the various industrial sectors, and value added in the consumption of intermediate output by the various final demand sectors, is shown in sectors III and IV respectively.

Table 1: Structure of an Input-Output Table.

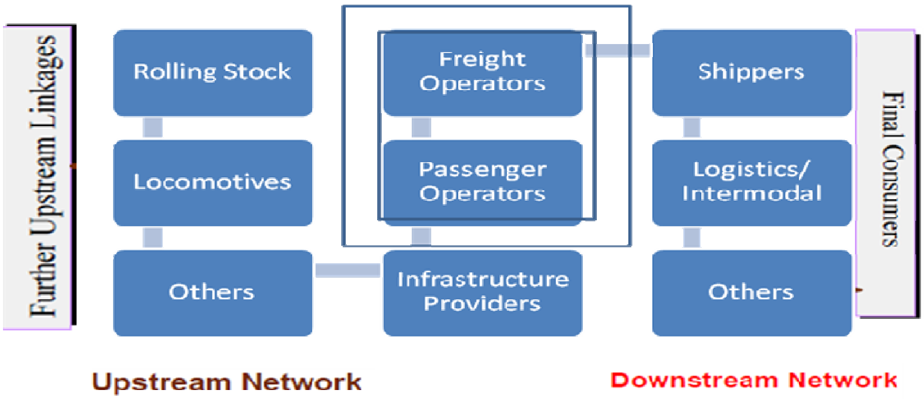
	Industry 1	Industry 2	Industry 3	Household Consumption	Government Consumption	Capital Formation	Change in Stocks	**Total Outputs**
Industry 1	**Quadrant Ⅰ Intermediate. Flows from industries (row) to industries (column).**			**Quadrant Ⅱ Final Demand. Flows from industries (row) to final consumers (column).**				**Total Outputs from industries**
Industry 2								
Industry 3								
Wages etc	**Quadrant Ⅲ Primary Inputs. Inputs (row) to industries (column).**			**Quadrant Ⅳ Direct flows between primary inputs and final demand.**				
Taxes								
Surplus								
Imports								
Total Inputs	**Total inputs to industries**							

Source: Adapted from ABS (2000).

Application of Input-Output Analysis to Rail Industry

This research focuses on an investigation of the magnitude and distribution of the social-economic values generated by the Australian rail industry. It will use input-output techniques as shown in Figure One.

Figure 1: The Australian Rail Value Chain.



Estimates of rail's contributions vary significantly, depending on what is defined as 'rail' (see Figure One) and on the methodology used to develop those estimates. As stated previously, we chose an input-output model because it is the simplest model and, what is more, allows us to gain an overview of economic activity in the production life-cycle context that concerns us here. The input-output analysis is a very useful tool for analysing the complex linkages within the economy, making it an ideal tool for transport policy analysis. In this research, we include the railway equipment manufacturers sector, in addition to the rail transport sector, so as to analyse the rail industry's contribution to the national economy, all of which with the caveat of adequate data availability. [2]

[2]The most recent ABS input-output table does not provide a satisfactory representation of the rail value chain in its original form because of lack of information on sectors such as rail infrastructure providers and maintainer, and rail supply chain and logistics operators. Therefore, these sectors are excluded from this analysis due to the data availability.

Data Sources

The base table used for this analysis was the Australian Input-Output Table (indirect allocation of imports, basic prices, 109 industries), constructed for the 2004-2005 financial year. The table was updated for 2008-2009 using the Consumer Price Index (CPI) and the growth of employment for the scenario analysis.[3] With the modified rail input-output table, it is possible to capture the economic values of the rail value chain.

Impact Analysis

If there is an increase in final demand for a particular product, it can be assumed that there will be an increase in the output of that product, as producers react to meet the increased demand. This, of course, is the direct effect. As these produces increase their output, there will also be an increase in demand on their suppliers and so on down the supply chain. These represent the indirect effect (production-induced effect). As a result of the direct and indirect effects, the level of household income throughout the economy will increase as a result of increased overall employment. A proportion of this increased income will be re-spent on final goods and services. This is the induced effect (consumption-induced effect). In view of these considerations, Type I and Type II multiplier analysis will be used to estimate the economic significance of the Australian rail industry. In summary, Type I multipliers aggregate direct and indirect effects, while Type II multipliers also include the induced effects.

Output Multipliers

The output multiplier for an industry, in this case rail, is defined as the total value of production by all industries of the economy required to satisfy one extra dollar's worth of final demand for that industry's output.

Output = $X = (I - A)^{-1} F$ (1)

Where X = n×1 vector of sector outputs

$(I - A)^{-1}$ = n×n input-output total requirements matrix

F = n×1vector of final demand for rail

Type I output multiplier for rail is defined to be the column sums from the Type I Leontief inverse matrix $(I - A)^{-1}$).Similarly, the Type II output multipliers are given from the column sums of industry rows (i.e., they exclude compensation of employees) from the Type II Leontief.

Income Multipliers

The Type I and Type II income multiplier for an industry, in this case rail, is defined as the total value of income from wages, salaries and supplements required to satisfy a dollar's worth of final demand for the output of that industry.

Income = $Y = vX = v(I - A)^{-1} F$ (2)

[3]The CPI for the 2009 Mach quarter was 166.2, a rise of 12.7% from 2005 March quarter (ABS, 6401.0). In 2009 March full-time employment across the industry was 7623,600, a rise of 7.7% from 2005(ABS, 6202.0). These ratios have been applied as inflators to update the table.

where Y = n×1 vector of income originating in each sector of the economy owing to rail
v = an n×n diagonal matrix of value added per dollar of sector output coefficients.

Employment Multipliers
The Type I and Type II employment multipliers can be obtained by using the row vector of employment coefficients. The employment coefficients are calculated by dividing the number of FTE (full-time equivalent) employed persons in a given industry, in this case say rail, by the level of production generated by that industry. [4]

$$E = L((I - A)^{-1}F \qquad (3)$$

Where L = n×n diagonal matrix of FTE coefficients per dollar of sector output
E = n×1 vector of sector employment needs related to the level of rail defined in vector F.

Empirical Analysis

Once a modified rail economic model is in place, it is possible to model the economic values generated by the rail industry. This section will assess the contribution of the rail industry to the Australian economy, and community by extension, by summarizing and comparing the following economic significances:

- Economic values of the rail value chain (i.e., railway equipment manufacturing, and freight and passenger operation) through the multiplier analysis;
- Integrated supply chain linkages between the railway equipment sector, rail transport sector and other industry sectors in the Australian economy; and
- Estimates of the direct and indirect economic implications of a potential modal shift from road to rail based on two hypothetical scenarios.

In this section, economic impacts are evaluated using three different measures, these being total industrial output, household income, and employment.

Economic Value of the Rail Industry

Direct Effects
The direct effect of the rail sector in 2005 is reported in Table Two. The rail sector accounted for $7.5 billion in total output, directly employed approximately 23,661 workers, and generated over $2 billion in household income.

Table 2: Australian Rail Industry Direct Output, Employment & Income, 2005.

Sector	Output ($m)	Income ($m)	Employment (FTE)
Railway Equipment	510	122.2	784
Rail Transport	7,009	1,937	22,877
Total	7,518	2,059	23,661

Source: Calculation based on 2004-05 Input-Output Table.

[4] ABS's input-output tables are measured on a full-time equivalent basis (FTE), i.e., the full-time equivalent of part-time employment is added to full-time employment. For these estimates the full-time equivalent of part-time employment is assumed to be 50 per cent of the part-time employment.

Backward Supply Chain Linkages: Indirect Effects

Producers increase their output as a result of direct effects, so that there will also be an increase in demand on their suppliers, and so on down the supply chain; this, as stated previously, is the indirect effect (production-induced effect). The indirect effect of the rail sector in 2005 is reported in Table Three. Here, the rail sector accounted for $7.4 billion in total output, employed approximately 24,982 workers, and generated over $1.5 billion in household income.

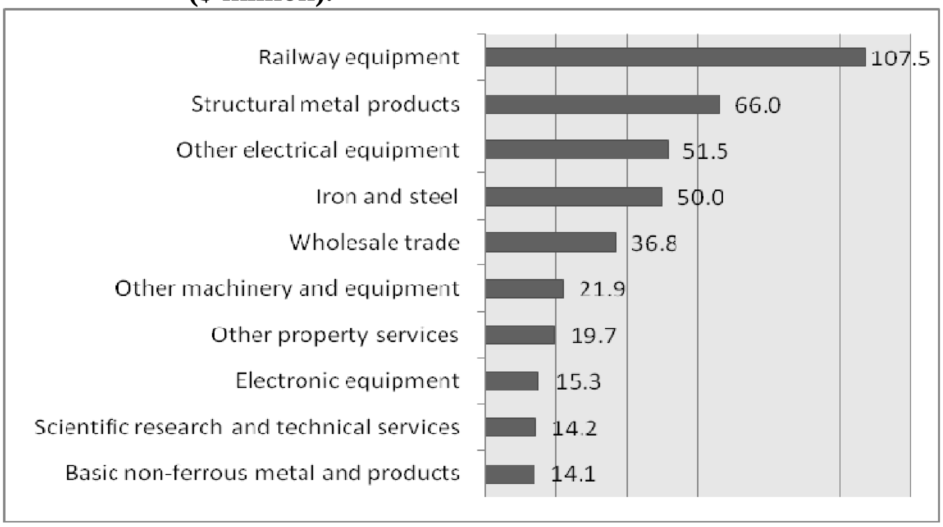
Table 3: Australian Rail Industry Indirect Output, Employment & Income, 2005.

Sector	Output ($m)	Income ($m)	Employment (FTE)
Rail Equipment	581	114	1,584
Rail Transport	6,816	1,391	23,399
Total	7,398	1,505	24,982

Source: Calculation based on 2004-05 Input-Output Table.

The degree to which an industry sector maintains backward supply chain linkages provides an understanding of the capacity of the sector to stimulate economic activity across the economy. This is clearly important with regard to valuing properly the overall benefits of any planned investment in rail infrastructure or other rail-centric activity. For each dollar of output generated by the railway equipment sector in Australia, it is estimated that $0.58 is spent on intermediate goods and services produced in Australia. This represents a substantial figure. These purchases represent supply chain linkages that provide economic benefits across a number of industry sectors valued at $0.6 billion in total industrial output. It is even possible to identify the industry sectors that benefit most from the rail industry. The ten industry sectors in Australia that benefit the most from the expenditure by the railway equipment sector are detailed below in Figure Two.

Figure 2: Railway Equipment Indirect Backward Supply Chain Linkages, 2005 ($ million).

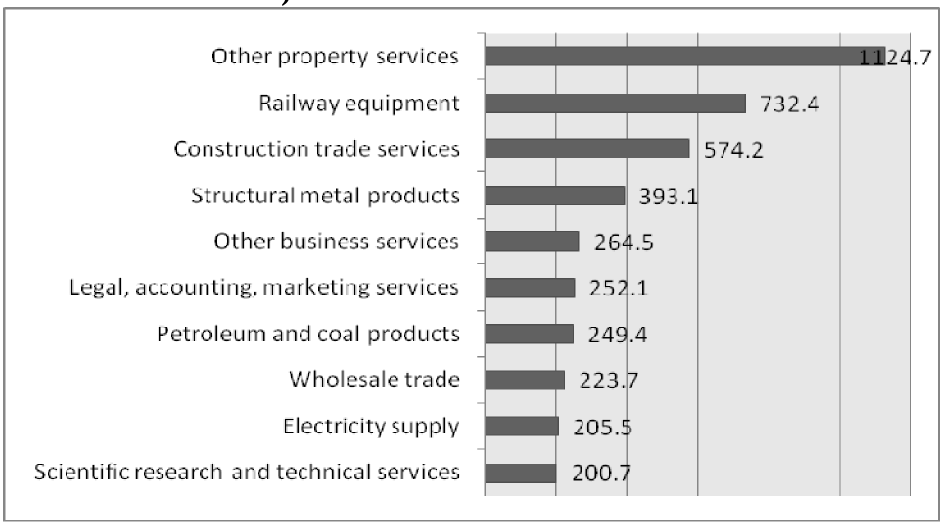


Source: Authors' calculations based on 2004-05 Input-Output Table.

From the calculations presented in this study, the rail equipment sector is estimated to stimulate activity across a number of industry sectors via its expenditure on intermediate goods and services in Australia. Approximately $107.5 million of this activity, moreover, is estimated to occur between the sub-sectors of the railway equipment sector. As expected, strong linkages are also evident with the structural metal products and the other electrical equipment sectors.

For each dollar of output generated by the rail transport sector in Australia, it is estimated that $0.48 is spent on intermediate goods and services produced in Australia. Again, this represents a substantial, if not quite as high as the $0.58 calculated in the context of the railway equipment sector. These purchases represent supply chain linkages that provide economic benefits across a number of industry sectors and are valued at $6.8 billion in industrial output. The ten industry sectors in Australia which benefit the most from the expenditure by the rail transport sector are described in Figure Three below.

Figure 3: Rail Transport Indirect Backward Supply Chain Linkages, 2005 ($ million).



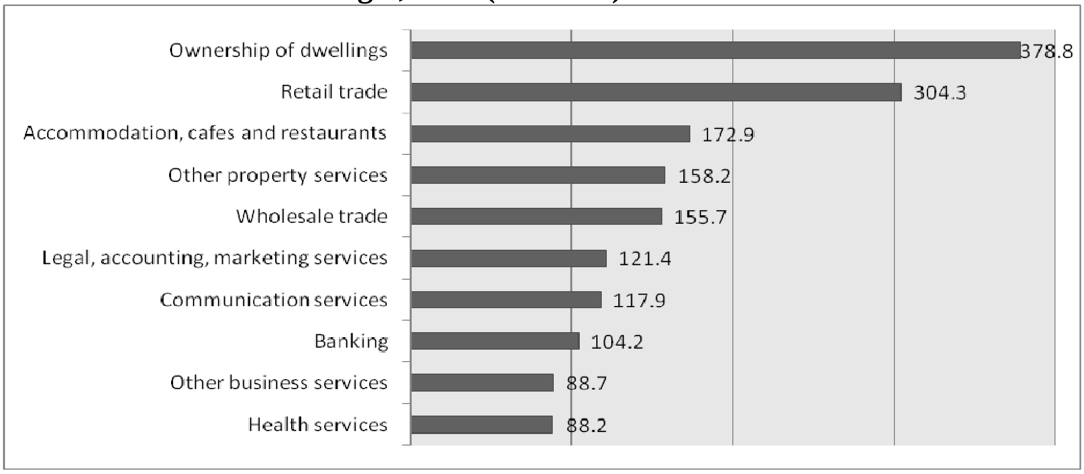
Source: Authors' calculation based on 2004-05 Input-Output Table.

From Figure Three, it is estimated that the other property services, the railway equipment and the construction trade services sectors in Australia service demand from the rail transport sector to the value of $1127.4 million, $732.4 million and $574.2 million per annum respectively.

Backward Supply Chain Linkage: Induced Effects

As a result of the direct and indirect effects, the level of household income throughout the economy will increase as a result of increased employment, all of which stems from investment in the Australian rail industry. It is reasonable to assume, in this context, that part of the increased wages will result in additional consumer spending in the economy; that is, the induced effect (consumption-induced effect). As we would expect, for some sectors, such as retail trade, banking, health and social services, the impacts are chiefly induced (see Figure Four).

Figure 4: Railway Equipment and Rail Transport Induced Backward Supply Chain Linkages, 2005 ($ million).



Source: Authors' calculation based on 2004-05 Input-Output Table.

Total impacts in terms of output, household income and employment for the respective sectors of the railway equipment, in addition to the rail transport sector, are detailed below in Table Four below. This table indicates that the total industry output or sales impact of the rail sectors in Australia was $18.5 billion in 2005, while employment was 65,361, and household income nearly $4.4 billion. This impact includes indirect impacts and induced impacts. The corresponding multipliers are 2.46 for output, 2.11 for household income, and 2.76 for employment.

Table 4: Australian Rail Industry Total Output, Employment & Income, 2005.

	Output ($m)	Income ($m)	Employment
Rail Transport and Equipment			
Direct	7,518	2,059	23,661
Indirect	7,398	1,505	24,982
Induced	3,606	791	16,717
Total	18,522	4,355	65,361
Multiplier	2.46	2.11	2.76
Rail Transport			
Direct	7,009	1,937	22,877
Indirect	6,816	1,391	23,399
Induced	3,332	731	15,450
Total	17,158	4,059	61,725
Multiplier	2.45	2.10	2.70
Rail Equipment			
Direct	510	122	784
Indirect	581	114	1,584
Induced	273	60	1,268
Total	855	174	2,851
Multiplier	1.68	1.42	3.64

Source: Authors' calculation based on 2004-05 Input-Output Table.

Table Four also breaks down the direct, indirect, induced, and total impacts separately for the rail sectors. The railway equipment sector accounted for $0.86 billion in total industry output, approximately 2,851 jobs, and nearly $0.2 billion in household income. The rail transport sector had a total impact of approximately $ 17.1 billion in total industry output, approximately 61,725 jobs, and slightly over $4 billion in household income. The multipliers associated with the rail transport sector are larger than those for the railway equipment sector.

The impact of the rail industry was felt in other sectors of the economy, detailed in Table Five.

Table 5: Total Impact of Australian Rail Industry by Major Sector, 2005.

	Output ($m)	Income ($m)	Employment
Animals	50.6	4.6	350
Crops	60.8	9.4	432
Forestry and fishing	30.8	7.8	163
Coal, oil and gas	229.8	10.9	81
Mining NEC	92.4	11.8	172
Food, drinks and tobacco	270.5	37.9	774
Textiles, clothing and footwear	94.5	10.1	287
Wood products	54.6	10.7	291
Paper and publishing	207.0	47.2	797
Petrochemicals	313.2	8.1	132
Other chemical products	284.2	29.7	430
Non-metallic mineral products	74.8	14.9	202
Metals and metal products	878.9	167.7	2162
Railway equipment	1351.5	324.2	2080
Other machinery and equipment	646.3	64.0	1143
Manufacturing NEC	67.6	8.7	239
Electricity	271.6	35.0	445
Gas and water	65.5	11.0	142
Construction	629.6	126.2	4422
Trade services	1053.1	325.0	8384
Accommodation, cafes and restaurants	241.0	56.7	1743
Road transport	195.1	44.5	1134
Rail transport	7053.9	1949.6	23024
Water transport	12.8	2.0	43
Air transport	32.5	4.4	64
Transport NEC	146.7	26.6	452
Communication services	256.1	41.5	886
Finance, insurance and business services	3325.4	719.9	9964
Government services	280.0	175.7	2891
Services NEC	250.9	69.2	2032
Total	18522	4355	65361

Source: Authors' calculation based on 2004-05 Input-Output Table (30 sectors).

The largest effects were experienced in the rail transport, the construction, and the metals and metal products sectors, especially in terms of employment, where direct and indirect effects were dominant. However, railway equipment and transport stimulated large public and private services responses through the effects of industry purchases, household, and other institutional purchases and subsequent rounds of spending. The effects trickled down throughout the Australian economy and affected every sector to some extent. For some industries, such as the finance, insurance and business services, the trade service, and the government services sectors, the impacts were chiefly induced.

Modelling Modal Shift

Undertaking modelling of the benefits of different policies is a standard practice in the discipline of economics, especially with respect to policy evaluation. This section of the study applies input-output modelling techniques so as to provide an appropriate framework for such analysis. In its most simple form, the model can be explained as replacing the final demand of the required transport sectors by monetary values. The following example uses two hypothetical scenarios to demonstrate the economic implications of a ten per cent transport final demand shift from road to rail, together with an increase of ten per cent productivity in rail through technological improvements.

Scenarios and Results

The first scenario, viz., Scenario One, moves ten per cent of final transport demand from road transport to rail transport in monetary terms. The second scenario, viz., Scenario Two, builds on the previous scenario by assuming that technological improvements occur in the rail sector, such as introduction of new rolling stock and control technologies that have the potential to increase overall system efficiency and reduce negative social and environmental externalities. The technological improvements are assumed to result in a ten per cent increase in the industry's productivity (in terms of changes in coefficient matrix of the rail transport sector).

Table 6: Scenario Summary.

Scenario One: Increased Rail Freight and Passenger Traffic	
Output ($m)	-27
Income ($m)	58
Employment (FTE)	-5381
Scenario Two: Increased Rail Freight and Passenger Traffic and Technological	
Output ($m)	307
Income ($m)	129
Employment (FTE)	-4018

Source: Authors' calculation based on 2004-05 Input-Output Table.

Table Six provides details about the changes of activities in the different scenarios once the direct, indirect and induced effects have been taken into account. The results from Scenario One show that, even though the net initial output impact is zero, there is a net positive flow-on household income effect to the economy. This is a result of the higher wage structure of the rail sector relative to road, which can be seen by comparing the wage-output ratios. In brief, every million dollars' worth of output produced by the rail transport sector results in average 0.28 million Compensation of Employees (COE), whereas only 0.22 equivalent COE are required, on average, by the road transport sector. Despite this, there has been a net decrease in output and employment impacts. This has occurred because the road transport sector is more labour intensive than the rail transport sector in general, which can be seen by comparing the labour-output ratios. In short, every million dollars' worth of output produced by the road transport sector requires, on average, 5.8 full-time equivalent (FTE) persons, whereas only 3.3 FTE are required on average to produce $1 million of rail transport output. From this, it might be inferred that any cutback in the road transport sector would, on average, have a greater impact on employment and output levels than a corresponding change in the rail transport sector. From the results of Scenario Two, it is reasonable to assume that the introduction of new rail technologies would reduce cost and contribute to operational improvements, all of which would help to offset the negative impacts of flow-on industrial output and employment effects. The results suggest that not only increasing the volume of rail's final demand is important, but creating higher-value-added services through innovation and investment is also important, which can lead to larger economic impacts.

These two examples highlight the importance of taking into account the relatives and sectoral interrelationships in an impact situation. A net positive change in output levels does not necessarily flow through to positive change in income and employment. It is very difficult to analyse these effects outside of an input-output or other general equilibrium type framework. Indeed, these two hypothetical scenarios also demonstrate how input-output modelling has the ability to carry out desktop impact analysis of proposed changes, thereby allowing parties seeking funds for transport infrastructure improvement to provide more robust and meaningful support for their applications for government infrastructure funding. The use of the tools signalled in this study would allow such parties to provide data relating to increased output, income and jobs resulting from the successful funding of the proposed transport infrastructure project.

Limitations of the Model

Although the above analysis is fairly straightforward, it is important to bear in mind the limitations of an input-output approach. First, the increase in the value of output should not simply be due to an increase in product price levels that are not reflected in an increased usage of physical inputs. Second, the increased production should not simply be an aberration incurred as a result of climatic or other conditions that affect physical output without affecting the purchases of inputs. Only if the change is a genuine expansion of the industry in terms of inputs and outputs should this approach be used for impact assessment. Third, the input-output equations are assumed to apply equally to increases and decreases in output. In practice, the process of contraction is not usually a mirror image of the process of expansion, so some caution is required before generalizing from expansion to contraction situations. Finally, the sectors in the table subjected to the initial impact must be an accurate representation of the industries under study. If the impacted firms or industries are sufficiently different in coefficient structure that they cannot be uniquely identified in the table, the transactions or direct coefficients table must be modified in some way.

Summary and Concluding Remarks

In 2005, the direct effect of the Australian rail sectors accounted for $ 7.5 billion in total output, approximately 23,661 employees, and over $2 billion in household income. Yet the economic effects of these activities are felt far beyond the rail sectors. The rail sectors purchase inputs from other industries, generate wages and income for workers and owners who spend the income in the economy, and contribute to the viability of rail-related industries. When these effects are aggregated, the total economic impact of railway equipment and rail-transport-related industries is $18.5 billion in total industrial output or sales, $4.4 billion of household income, and 65,361 jobs.

Both the railway equipment sector and the rail transport sector maintain important supply chain linkages within the Australian economy. The largest effects are in the railway equipment, the metals and metal products and the construction sectors, where direct and indirect effects are dominant. However, the railway equipment and the rail transport sectors stimulate large public and private services responses through indirect and induced spending. The flow-on economic stimulus delivered via these supply chain linkages is referred to as indirect and induced effects.

The input-output model used in the hypothetical scenarios suggests that not only increasing the volume of rail's final demand is important, but creating higher-value-added services through innovation and investment is also important. Creating higher-value-added services through innovation and investment can also lead to larger beneficial economic (and thus social by extension) impacts. The rail equipment and rail transport sectors also impact the economy in ways that are not measured here. For instance, this study did not compute estimates of the environmental impacts of the rail sectors. However, these are important societal and ecological issues for future research.

Finally, input-output modelling, as has been demonstrated in this study, provides policy makers with a much clearer understanding of the rail economy and thus a reliable tool for more effective strategic planning. With provided data such as sectoral outputs, household income and employment, policy makers are better able to understand the interdependent nature of the rail industry and the linkages that bind rail and the rest of the economy together. The ability to quantify these relationships and assess the economic impact of changes thereby provides further insight and a powerful tool with respect to the selection of appropriate transport strategies and allocating funding for the required infrastructure to support these strategies.

Bibliography

Armstrong, H. & Taylor, J. (1985), *Regional Economics and Policy*, London: Philip Allan.

Australasian Railway Association (ARA) (2007), *Australian Rail Industry Report,* Canberra: Australasian Railway Association.

Australian Bureau of Statistics (ABS) (1993), *Australian and New Zealand Standard Industrial Classification*, 1993 Edition, ABS Cat. no. 1292.0, Canberra.

Australian Bureau of Statistics (2000), *Australian National Accounts: Concepts, Source and Methods,* ABS Cat. No. 5216, Canberra: ABS.

Australian Bureau of Statistics (2008), *Australian National Accounts: Input-Output Tables, Australia, 2004-05*, ABS Cat. no. 5209.0, Canberra: ABS.

Australian Transport Council (ATC) (2006), *National Guidelines for Transport System Management in Australia*, Canberra: Australian Transport Council.

Banister, D. (2007), *Quantification of the Non-transport Benefits Resulting from Rail Investment*, Oxford University Centre for the Environment, Working Paper, no. 1029.

Bulmer-Thomas, V. (1982), *Input-Output Analysis in Developing Countries: Sources, Methods and Applications*, London: John Wiley & Sons.

Centre for Agricultural and Regional Economics (2003), *Input-Output Tables for New South Wales and New South Wales Statistical Divisions, 2000–01,* Armadale NSW: Centre for Agricultural and Regional Economics.

Christian, D. & Esben, S.A. 1996. *Economic Interdependence and Innovative Activity : An Input-Output Analysis*. Edward Elgar, Cheltenham, UK/Brookfield, US,.

Clements, K.W. & Qiang, Y. (1998), *A New Input-Output Table for Western Australia, 1996–97*, Economic Research Centre, Department of Economics, University of Western Australia, Perth.

Dixon, P.B. & Rimmer, M.T. (2002), *Dynamic General Equilibrium Modelling for Forecasting and Policy: A Practical Guide and Documentation of MONASH*, Amsterdam: Elsevier.

Foran, B., Lenzen, M. & Dey, C. (2005), *Balancing Act: A Triple Bottom Line Analysis of the Australian Econom*y, *vol. 1,* Canberra: Department of Environment and Heritage.

Gretton P. (2005), 'Australian Input-Output Tables', *Australian Economic Review*, **38(3)** 319–32.

Leontief, W, 'Quantitative Input-Output Relations in the Economic System of the United States.' *Review of Economics and Statistics*. **18(3)**, 105-25.

Leontief, W. (1986), *Input-Output Economics*, 2nd ed, New York: Oxford University Press.Miller, R.E. & Balair, P.D. (1985), *Input-Output Analysis: Foundations and Extensions*, Englewood Cliffs, NJ: Prentice-Hall.

Naqvi, F. & Peter, M.W. (1996), 'A Multiregional, Multi-Sectoral Model of the Australian Economy with An Illustrative Application', *Australian Economic Papers*, **35,** 271–92.

Powell, A. & Snape, R.H. (1992), 'The Contribution of Applied General Equilibrium Analysis to Policy Reform in Australia', *Journal of Policy Modelling*, **15**, 393–414.

Queensland Treasury (2004), *Queensland Input-Output Tables 1996–97,* Office of Statistics and Economic Research, Brisbane: Queensland Government Treasury.

Rose, A. (1995), 'Input-Output Economics and Computable General Equilibrium Models', *Structural Change and Economic Dynamics*, **6**, 295-304.

South Australian Department of Trade and Economic Development (2005), *Input-output table for South Australia, 1999–00*, Adelaide.

Appendix: Technical Details of an Input-Output Model

The sales of *i* in the input-output table can be represented as $\sum_{ij} X_{ij} + F_i = X_i$, where X_{ij} are the transactions on intermediate input from *i* to *j*, F_i the final demand for *i* and X_i the total supply of *i*. The ratio of intermediate input *i* in *j* to total input is given by $a_{ij} = X_{ij} / X_j$, so that $a_{ij} X_j = X_{ij}$. This gives the equation $\sum_{ij} a_{ij} X_j + F_i = X_i$ which, in matrix notation, is equal to:

$$AX + F = X \qquad (1)$$

where: ***A*** = matrix of coefficients showing the shares of input X_{ij} to the total output X_j

X = the vector of sector gross output

F = the column vector of total final demands

Rearranging (1), yields

$$X = (I - A)^{-1} F \qquad (2)$$

where ***I*** = an identity matrix

Total differentiation of (2), gives

$$dX = v(I - A)^{-1} dF \qquad (3)$$

The matrix $(I - A)^{-1}$ is the table of multipliers, or total requirements matrix. It is also known as the Leontief inverse matrix. Each element in this matrix reveals the linkage between industries in the economy.

Equation (3) provides a framework to measure the effect on ***X*** given exogenous changes in ***F*** and on calculating the total impact of the change in final demand on the economy. By summing the elements of a column in the $(I - A)^{-1}$ matrix, the total multiplier can be estimated for the column that represents a sector. The total multiplier indicates the magnitude of the increase in aggregate output that is necessary to meet the increase in demand for output initiated by the increase in final demand. The increase in aggregate output represents the increase in total outputs of all sectors initiated by the initial increase in final demand.

An element of $(I - A)^{-1}$ shows by how much a sector would increase its purchases of products from the sectors supplying the inputs it needs in order to increase an output that will satisfy the increase in demand.

Railway Challenges, Realities and Business Opportunities

Brett Hughes

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Overview

This paper describes key aspects of Australia's transport system, the challenges which face it in future and its performance. It proposes why and how rail must play a more significant role in Australian transport in order to achieve business, community and environmental outcomes. The paper follow the following elements[2]:

1. Transport Challenges, summarising the issues which Australian transport systems face against objectives and external pressures.
2. Transport Future, which illustrates aspects of the performance of Australia's transport system, both at the present time and into the future.
3. Transport and Climate Change, discussing the interaction between climate change and the transport system.
4. Rail in Transport, describing the advantages of railways in contributing to a more efficient and effective transport system.
5. Rail Opportunities, by which railways can be promoted and encouraged to take a greater role in improving the transport system.

Transport is a derived demand. It must respond to external demands in recognition of the wider business, social and environmental context.

Transport Challenges

Discussion amongst governments, industry and commentators suggest there are four key challenges facing transport, which are large in scale and not limited by time:

1. Congestion
2. Fuel price
3. Emissions (predominantly greenhouse gases, NO_x & SO_x and particulates)
4. Increasing transport demand

Transport demand is primarily driven by population for passenger transport use and by both population and the economy for freight transport.

Other challenges also need to be managed, but appear to be a lower order due to smaller scale or limited timeframe.

- the current Global Financial Crisis
- Climate change (infrastructure impacts and demand changes)
- accessibility (equity of personal transport services for access)

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[1] At the time of presentation. At completion of the paper, Brett Hughes was Director Curtin-Monash Accident Research Centre at Curtin University of Technology.

[2] Diagrams relevant to in this discussion are included in the presentation slides attached and are not duplicated here.

- workforce attraction & retention
- community and business expectations (which particularly generate political pressure)

Some are sure to argue that climate change should be included amongst the key challenges. However, while climate change certainly exhibits the right scale and temporal features, the effects on transport appear to be likely to be both smaller in scale and manageable through design, maintenance and operational changes.

The question which arises is defining the role of governments and industry in response to these challenges.

Land Transport Performance

The Bureau of Transport and Regional Economics (BTRE) has recorded key transport indicators for Australian capital cities and forecast future values for these indicators, covering the 30 year period from 1990 to 2020 (BTRE, 2007). These estimates show the following increases over the period, aggregated over all Australian Capital cities:

- City Population – 40 percent
- Network Delay – 90 percent (measure of time wasted due to traffic)
- Total Vehicle Travel – 90 percent
- Road Freight – 190 percent
- Total Delay – 260 percent (a measure of all time wasted in transport)
- Congestion – 290 percent (costs due to delay and other transport effects)

There are two important points which must be recognised here, regarding the occurrence of these substantial increases:

- provided that policies which have occurred in the past to improve transport, can be continued by new policies to achieve further improvements; and
- the benefits of transport investment can continue to be achieved.

Both of these propositions appear unlikely, primarily due to diminishing returns. Polices are becoming both harder to devise and implement, and lower in effect than previous policies. Transport investments (such as road construction) are both constantly more costly to build and also less beneficial in terms of results.

Passenger Transport Forecasts

Based on Australian and OECD information, the year 2004 would appear to be a watershed year for urban passenger transport. Up to this time, public transport travel continued to decline, or remain at a base level, often low. However, public transport dramatically increased over the following four year period and passenger road transport growth collapsed, as shown in the Table One.

Table 1: Road and Rail Passenger Travel – 2000 to 2008

Period		Rail Passenger Travel Increase	Road Passenger (private vehicle) Travel Increase
2000 - 2004	per annum	1.6%	2.3%
	4 year total	6.7%	21.9%
2004 - 2008	per annum	5.1%	0.3%
	4 year total	9.4%	1.0%

The reasons for this substantial shift in user behaviour are not clear. Anecdotal evidence suggests that fuel price, traffic congestion, population increase, more inner city living and more environmentally sensitive transport choices all made some contribution. All of these factors appear likely to continue into the future. However it is not clear what the future public transport and private passenger car growth rates will be.

If the pre-2004 rates of increase occurred over the following 20 years it would result in a rail passenger travel increase of 37 percent and a road passenger travel increase of 57 percent. However if the post 2004 rates of increase occurred over the following 20 years it would result in a rail passenger travel increase of 170 percent and a road passenger travel increase of six percent!

Now the crucial point is that transport policy and planning for Australian cities is based on historical growth rates similar to those experienced up to 2004. If the post 2004 growth rates continue, Australian cities are completely unprepared for the consequences. The transport system will not be able to cope with the increasing demand and mode change, and cannot provide adequate capacity. This is evidenced by the recent experiences with urban rail passenger transport failing to meet peak demands resulting in passengers being stranded and considerable customer dissatisfaction. The clear policy implication is that the current road dominated transport investment and policy would need to be dramatically rebalanced and additional funding, incentives and complementary initiatives be provided in favour of public transport based policy and investment.

For rail transport, it is extremely difficult to meet substantially increased transport demand, especially in short time frames. In practice it takes a minimum of about five years to purchase new rail rolling stock once a decision is made by a government operator in order to progress through approvals, tendering, design, procurement and delivery phases. It also takes a minimum of about ten years to build a new passenger railway line. So at these growth rates railways should be making decisions now to purchase rolling stock and increase railway lines and capacity by 64 percent.

Greenhouse Gas Emissions from Transport

Greenhouse gas emissions (predominantly carbon dioxide) remain a critical environmental, community issue, and are therefore foremost politically. This is not the place to argue the science of climate change, so while it is an issue, government and private transport interests will respond to it.

The BTRE has estimated Australian transport CO_{2-e} emissions (BTRE, 2005). Land transport CO_{2-e} emissions comprise 14 percent of national CO_{2-e} emissions. To meet greenhouse gas emissions targets, all sectors will need to reduce emissions, but most are increasing, and transport is reported as the second fastest growth sector.

This BTRE work reports transport emissions and future estimates which reveal that transport emissions are forecast to increase by 78 percent over the period 1990 to 2020. At the same time the national emission target is a 60 percent reduction in the period 2000 to 2050. Increases in greenhouse gas emission for transport sectors are summarised in the following table.

The major component of the increase in emissions is due to increases in transport demand. However, the point remains that transport emissions are increasing over a period when the national agenda requires national emissions to decrease. At the same time there is more freight carried by rail for the 2,523 million tonnes of emissions than carried by road freight for the 39,298 million tonnes of emissions. Plus the rail emission includes considerable public transport travel. This is shown in Table Two.

Table 2: Transport Sector Emissions

Transport Sector	**Increase in CO2-e emissions** (1990-2020)	**2020 Emissions Forecast** (million tonnes CO_{2-e})
All Modes		
Motor Vehicles	74.7%	92892
Rail	44.9%	2523
Maritime	-7.6%	2119
Aviation	239.9%	8716
Road Transport Sectors		
Passenger Vehicles	50.2%	53518
Cars	50.6%	51510
Buses	42.6%	1684
Motor cycles	35.1%	323
Road Freight	124.6%	39298
Light commercial vehicles	139.3%	16787
Articulated trucks	165.0%	14760
Rigid and other trucks	57.9%	7751

In 2000 all Australian transport emissions totalled 75Mt per annum, which is forecast to rise to 106Mt in 2020. If the forecast is extrapolated by the rates of later years, the transport emissions reach a total 145Mt in 2050. However the total Australian national GHG emissions target is only 222Mt. Therefore, if the Australian transport system continues as it has in the past, including continuing to achieve improvements through policy and investment and operations, by 2050 transport will contribute more than two-thirds of the total Australian emissions target.

Clearly, substantial changes to the transport system will be required if transport is to make its contribution to reducing national GHG emissions. While the government intends to introduce an emissions trading scheme to manage and limit emissions we shall see later that market failures question whether sufficient reductions in emissions will occur to meet the target and objectives.

Our Transport

Particularly since transport is not an end in itself its performance should be considered to ensure that it is efficient and effective. The following indicators reflect a variety of aspects of the current performance of the Australian transport system[3]:

- Australian transport fuel use, emissions and transport infrastructure are amongst the highest per capita in the world,
- more than 1,600 people die on our roads and another 30,000 are injured and road crashes cost over $20 billion annually,
- traffic congestion in cities costs more than $10 billion annually
- transport emissions are responsible annually for (BITRE 2005):
  - the deaths of over 1,500 people,
  - over 4,500 cases of asthma and other sickness,
  - cost of death and sickness by transport emissions exceeds $2.3 billion annually,
- personal transport times and costs are increasing as a proportion of available time and disposable income, contributing to family pressure and other social degradation
- there has been no significant move towards more sustainable modes of transport, until recent years,
- fuel usage of passenger cars has not decreased.

This assessment of transport shows that the costs and effects of transport are already high. Many of these impacts are understated. For instance, the impacts of transport emissions on health are midrange figures and could be 40 percent higher. The costs of road crashes follow a conservative methodology and do not take full account of personal pain trauma and disruption. In addition, these figures do not include many other effects such as noise and carbon emissions. Some indicators, such as transport emissions and family impacts of travel times are not well accounted or in transport policy and planning since they are not assessed.

Some of these effects are graphically illustrated in the charts from the assessments of vulnerability to fuel, inflation and mortgage cost increases (Dodson & Sipe, 2008). These assessments, completed for small zones in each of the capital cities, demonstrate that outer areas of cities are more at risk when costs increase, including transport. An assessment of travel time would show similar patterns. Yet these are the growth areas for our cities. The estimates for later years show that these areas will deteriorate in future as costs and the system increase, and the deterioration again more marked in outer areas. In other words, *we are consigning more and more people buying their homes to areas which*

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[3] These statistics are extracted mainly from government reports, particularly the Bureau of Industry and Regional Economics (BITRE, formerly BTRE), Department of Industry Transport Regional Development and Local Government (DITRDLG), Australian Transport Safety Bureau (ATSB).

are more and more vulnerable to future transport pressures of congestion and fuel price, and these areas will degrade faster in future.

Our Transport Future

Transport agencies and business are investing considerably in transport systems (particularly infrastructure). Policy and operational improvements continue to be implemented, so it is worthwhile considering whether the performance of the transport system will improve. The indicators for the future, similar to those identified above, include:

- by 2050 transport emissions will comprise more than 66 percent of Australia's entire greenhouse gas emissions target,
- transport congestion costs are increasing at a faster rate than traffic is increasing:
  - heavy vehicle transport congestion costs will increase by an additional 100 percent,
  - traffic congestion in cities will cost $20-30 billion annually by 2020,
- road trauma will deteriorate:
  - road deaths are not decreasing,
  - serious injuries caused by road crashes is rising,
  - deaths caused by articulated vehicles is increasing,
  - serious injuries caused by articulated vehicles is not decreasing,
- other factors such as health effects, transport costs and travel time are certain to increase.

In other words, transport in Australia is getting worse, not better. Addtionally, the rate of deterioration for some of these indicators, such as congestion, is deteriorating at an ever increasing rate, as demand approaches capacity. Over the 15 years from 1990 to 2005, heavy vehicle congestion costs increased by 53 percent, but over the following 15 years to 2020, the costs are estimated to increase by a further 118 percent (BTRE 2007).

These figures assume that policy, infrastructure and operational improvements will continue to occur, with the same benefits and costs as in the past. However this is exceedingly unlikely:

- infrastructure construction costs are increasing
  - the unit rates over recent years (as demonstrated by tender prices and the Road Construction and Maintenance Price Index) has been increasing at a greater rate than inflation
  - projects are becoming more complex to implement (for instance as road widening becomes more expensive, as houses need to be demolished to make for wider roads),
- benefits of transport projects are diminishing as projects realise successively lower relative benefits (including accounting for inflation).

Therefore the value for money proposition for transport infrastructure projects continues to dwindle. The ultimate consequence is that the future performance of Australian transport is likely to be even worse and more expensive than forecast for governments, industry and the community.

While the data is available, it appears to be largely ignored in government transport policy and planning. It is apparent that Keynes words are being fulfilled:

"There is nothing a Government hates more than to be well-informed; for it makes the process of arriving at decisions much more complicated and difficult."[4]

Rail's Energy and Environmental Advantage

All transport modes which are used have a role depending on their characteristics and the environment in which they operate. Rail transport suits situations which have higher density of demand, longer distances and homogeneity (i.e. much the same product, be it bulks, containers or passengers). Obviously rail is preferred for transport such as Pilbara iron ore, and inappropriate for small packages around cities. Rail is preferred due to lower costs and higher performance (such as safety). Clearly, is important that the best mode of transport be used for the task

Rail has a particularly important advantage in the future where fuel costs will continue to rise, and environmental issues become more sensitive, particularly carbon emissions. Rail's energy and environmental advantages are illustrated in the following table for passenger and freight transport (Australasian Railway Association, 2009).

Rail's advantages for passenger transport are more marked during peak travel. At such times, public transport is heavily utilised, reducing the energy use and emissions per unit of travel. At the same time, high road demand results in the opposite, where congestion increases the energy use and emissions per unit of travel. This is shown in Table Three.

Table 3: Fuel Intensity by Transport Mode

Transport Mode	Fuel Intensity
Passenger Transport	*(Passenger-km/GJ-FFC)*
Ferries	220
Passenger vehicles	340
Domestic airlines	410
Motorcycles	420
Light Rail	460
Buses	590
Heavy Rail	650
General aviation	880
Freight Transport	*(Tonne-km/GJ-FFC)*
Light commercial vehicles	45
Rigid trucks	310
Coastal shipping	410
Articulated trucks	990
Pipelines	1020
Hire and reward heavy rail (including intermodal container transport)	3130
Ancillary Rail (including bulk ores)	11100

[4] Quoted in Banks (2009) p19.

Note: FFC - Average Full Fuel Cycle which means the whole fuel use for the transport mode including idling, maintenance running, dead running to depots, etc.

Climate Change Management

Climate change has the potential to impact transport in a variety of ways, which are mostly not well understood. There are innumerable activities undertaken by governments, business and the community which may be altered by climate change. Examples of these include:

1. Transport demand
   - e.g. changed agricultural production, more environmentally sensitive transport choices by travellers
2. Transport infrastructure and networks
   - damage due to track buckling, flooding or bushfires
3. Operations
   - locomotive emissions which change with ambient temperature, air-conditioned failures caused by overheating.

As these effects occur, governments, companies and individuals will respond in ways which they consider appropriate. The Australian Commonwealth Government's principal response is an emissions trading scheme (the Carbon Pollution Reduction Scheme - CPRS), which additional elements such as Mandatory Renewal Energy Targets (MRET). However, as described later, it is questionable whether these arrangements are either sufficient or efficient. These responses either mitigate against increasing climate change further by reducing greenhouse gas emissions, or are adaptations to a changed environment. Almost none of these consequences have been examined and quantified for the transport system as a whole or for railways. In other words, transport in Australia is simply unprepared for climate change and does not know how it should respond appropriately

Transport and the Carbon Economy

In the simplest terms, transport can contribute to a low carbon economy by reducing travel or transport demand, or by burning less carbon while travelling. Transport demand management has been around for several decades, although in practice, some techniques actually properly fall into the category of supply management. Others are cross modal, where one mode substitutes for another. Less carbon is emitted when more efficient transport or modes of transport are used, more efficient vehicles are used, or more efficient energy sources are used (such as hydro power instead of brown coal to power electric railways).

Market Issues of an Emissions Trading Scheme

Economists describe that markets work when certain conditions exist. Conversely, markets fail when the following conditions occur:

- there is inadequate information between buyers and sellers,
- there is a natural monopoly of buys or sellers,
- externalities to the transaction result (i.e. impacts experienced by those external to the transaction), and/or

- other social objectives are required to be met (e.g. income distribution or service quality).

As described above the Australian Commonwealth Government's principal response to Climate Change is the CPRS, which is a market based scheme to limit the total amount of greenhouse gas emissions. In its presently proposed form, the CPRS has numerous flaws, compared with the requirements for a market to operate properly, including:

- car driver's costs will not change since the emissions permit cost will be rebated from the fuel price,
- rail public transport costs will increase since operators will pay higher electricity or diesel fuel costs,
- road freight charges will not change, but rail freight costs will increase (for the same reasons as above),
- CPRS charges are not market linked to public transport,
  - pricing (fares) which may be constrained by political choices and economic regulation,
  - infrastructure charges and provision (i.e. users pay for infrastructure but don't have choices about where improvements are made).
- car owner's costs are discounted by tax rebates or payments by others (business).
- governments, as purchasers (and business to a lesser extent), are not responding to the market by purchasing small cars, while the general community has responded by predominantly purchasing four cylinder cars,
- businesses will transfer their increased costs to consumers who have no influence over business costs ("Take it or leave it"), so business does not always have much incentive to reduce emissions costs. Governments have even less management incentive,
- commercial drivers are often distant from the usage costs. So a truck or light commercial vehicle driver can drive in a very fuel inefficient manner and receive no penalty so there is no incentive to change,
- car and truck emission trading charges are proposed to be rebated, but freight and passenger railways pay full costs,
- road freight pricing is flawed so trucks do not pay efficient prices for the use of the road infrastructure,
- road user charges are not market linked to infrastructure supply.

Professor Ross Garnaut, has described that governments must take a variety of actions in response to climate change, including (Garnaut, 2008, p. 44)[5]:

> *"Governments have a major role to play in lowering the economic costs of adjustment to higher oil prices, an emissions price and population growth, through planning for* ***more compact urban forms*** *and* ***rail*** *and* ***public transport****.*
>
> ***Mode shift may account for a quarter of emissions reductions*** *in urban passenger transport, lowering the cost of transition and delivering multiple benefits to the community".*

[5]My emphasis added.

These statements describe that governments must do more, and the transport system must develop, in order to meet the needs of Australia in future.

Transport Policy Development

Typically the transport system is assessed according to certain performance criteria, such as capacity, utilisation, speed or safety. The question arises as to whether these are the appropriate criteria for assessment.

Infrastructure Australia summarised key objectives for funding of infrastructure by government, including (Infrastructure Australia, 2009, p6):

> *"A national rail freight network development of our rail networks so that more freight can be moved by rail.*
>
> *Transforming our cities increasing public transport capacity in our cities and making better use of existing transport infrastructure."*

It is possible to meet such measureable criteria and improve micro efficiency, but fail to achieve macro effectiveness. For instance a passenger transport system would be completely safe, if it carried no passengers, and therefore there would be no injuries. However it would obviously be completely ineffective.

One might think of travelling from Melbourne at good speed, without incident, and using reasonable amounts of fuel. The performance according to these criteria might well be very good. However if the objective is to arrive in Sydney, no amount of performance improvement in these criteria will achieve the required result.

Once the transport system can be adequately assessed for both efficiency and effectiveness, good decisions can be made about how best to achieve the objectives. Typically, policy makers promote policies from their fields of experience and expertise; their comfort zone. So, regulators propose legislation, engineers propose construction, and economists propose charges and markets. But transport is complex with a diversity of alternatives, opportunities and effects.

A New Planning Paradigm

The current transport policy development, transport system planning and project assessment is based on the following perspectives:

- microanalysis,
- short term,
- narrow focused,
- detailed / fragmented,
- historical,
- quantitative,
- separate mode view,
- infrastructure solutions,
- commodity view,
- incremental & evolutionary,
- environmental and social benefits are largely ignored.

This type of analysis has been helpful in answering the question "*How do we improve what we have?*", which is incremental.

The existing transport system performance, future demands and likely performance in future described above illustrate that Australia needs to fundamentally and structurally transform its transport system. It needs to respond to the question "*How do we provide what we need?*", which requires the following, quite different perspectives:

- strategic,
- holistic,
- long term,
- broad,
- integrated,
- multifaceted,
- future oriented,
- qualitative and quantitative,
- customer view,
- logistics chain analysis,
- quantum change & revolutionary,
- environmental and social benefits described and included.

While recognising that rail transport is not for its own sake and must be justified against alternatives, under a new planning paradigm rail would take a greater share in contributing to a sustainable and productive transport system. Passenger and freight rail provides a numerous benefits to the Australian community, business and the environment including:

- supporting regional communities,
- reducing community health effects,
- minimising environmental consequences,
- reducing the road toll by reducing crashes,
- limiting local government road maintenance,
- limiting road investment demands on Treasuries,
- improving international competitiveness for agriculture,
- reducing road infrastructure costs for state government road authorities, and
- maintaining robust transport systems to suit a variety of futures, including reduced oil availability.

An efficient, effective, safe transport system is required to meet Australia's short and long term needs. Therefore, compared with historical practice, passenger and freight rail must take a much larger proportion of land transport in Australia. To do so requires many and diverse industry and government activities at substantially higher levels than have occurred previously.

Rail System Structure

The rail system is primarily comprised of :

- Infrastructure (track, signals, land use, information & ticketing systems, etc),
- Rolling Stock (passenger cars, locomotives, wagons), and

- Users (passengers and staff).

In this form railways are large and still quite complex. However, the system exists within a much larger and even more complex milieu which includes:

- the environmental context,
- education and training issues,
- technology development and deployment,
- divergent and sometimes incoherent or conflicting business and community requirements and expectations,
- inadequate data, information, and research, together with uncertain innovation,
- funding restrictions and competition,
- industry culture and practice,
- integration and interaction with other systems,
- a multitude of business, safety, environment, economic and workplace safety regulation,
- and three levels of government with different policies, aspirations and effects.

At different times these may sometimes be collaborative, while at other times they may be very competitive.

In addition (or perhaps as a consequence), there appears to be a lack of leadership resulting in a lack of vision and direction resulting in a transport policy vacuum. The last major policy reforms in Australia were to heavy vehicle charges in the early 1990's and commercialisation of government freight railways in the late 1990's. So there has been no significant transport reform in Australia for a decade (perhaps that's why it was called the 'noughties').

Rail Needs and Opportunities

For rail to make a greater contribution to Australia changes to investment, incentives, taxation, regulation and other legislation are required. In particular:

- continue government investment in infrastructure and rolling stock,
- reform of transport system policy to ensure incentives to achieve public outcomes
- reform taxation by
  - removing the fringe benefits tax (FBT) financial incentives encourage more road travel, and
  - provide incentives for promoting public transport use,
- introduce a more efficient mass-distance-location charging system for road use, particularly for freight transport,
- introduce taxation incentives for environmentally friendly rolling stock and infrastructure,
- neutralise the negative effects of the Carbon Pollution Reduction Scheme on transport, as described above.

Benefits from Rail Investment

The CRC for Rail Innovation has researched aspects of the Carbon Pollution Reduction Scheme which relate to railways and transport generally. This work (CRC for Rail

Innovation, 2009) concludes that substantial benefits can be realised from investing in railways, including:

- annual reductions of CO_{2-e} emissions of 3.8 to 6.2 Mt,
- 11% lower transport emissions by 2030,
- Total benefits of $27.4 to 41.7b (NPV 2010 -2020).

These benefits could be realised by an investment of $2 billion per annum for 10 years, with the benefits continuing to accrue indefinitely.

Conclusions

This paper describes weaknesses in the current Australian transport system which will continue to deteriorate over time to the disadvantage of Australian business, the community and the environment. Rail must take a greater role in transport in order to meet the future needs. A different decision making model is needed and substantial changes to policy is required to improve the transport system.

Bibliography

Australasian Railway Association (2009) *Rail Industry Report 2008*, Canberra, http://www.ara.net.au/UserFiles/file/Publications/ARA%20Industry%20Report%202008.pdf

Banks, G. (2009), *Evidence-based policy making: What is it? How do we get it?* (ANU Public Lecture Series, presented by ANZSOG, 4 February), Productivity Commission, Canberra, http://www.pc.gov.au/__data/assets/pdf_file/0003/85836/20090204-evidence-based-policy.pdf

Bureau of Transport and Regional Economics (2007) *Estimating Urban Traffic and Congestion Cost Trends for Australian Cities*,Working Paper 71, Canberra, http://www.bitre.gov.au/publications/49/Files/wp71.pdf

BTRE (2005) *Greenhouse Gas Emissions from Australian Transport: Base Case Projections to 2020*, Report for the Australian Greenhouse Office, Department for Environment and Heritage, Canberra, http://www.bitre.gov.au/publications/34/Files/BTRE_AGO_05.pdf

BTRE (2005) *Health Impacts of Transport Emissions in Australia: Economic Costs*, Working Paper 63, Canberra, http://www.bitre.gov.au/publications/94/Files/wp63.pdf.

CRC for Rail Innovation (2009), *Transforming Rail: A Key Element in Australia's Low Pollution Future*, http://www.railcrc.net.au/publications/downloads/03032009Final-Report-27-February-2009.pdf

Dodson, J. and Sipe, N. (2008) *Unsettling Suburbia: The New Landscape of Oil and Mortgage Vulnerability in Australian Cities*, Griffith Uni. Urban Research Program, Research Paper No. 17, http://www.griffith.edu.au/__data/assets/pdf_file/0003/88851/urp-rp17-dodson-sipe-2008.pdf

Garnaut, R., (2008) *The Garnaut Climate Change Review: Final Report*, Cambridge University Press, Melbourne, http://www.garnautreview.org.au

Infrastructure Australia (2009) *Infrastructure Australia – National Infrastructure Priorities*, Infrastructure Australia, Canberra, http://www.infrastructureaustralia.gov.au/files/National_Infrastructure_Priorities.pdf

Appendix: Presentation Slides

Australia's Transport System:

Railway challenges, realities and business opportunities

Australian Railway Business Economics Conference
PATREC, Perth, July 2009

Brett Hughes
Director Policy

Australasian Railway Association

Overview

- Transport Challenges
- Transport Future
- Transport and Climate Change
- Rail in Transport
- Rail Opportunities

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Transport Challenges

- **Congestion**
- **Fuel price**
- **Emissions**
  - greenhouse gases
  - NOx, SOx, etc
  - particulates
- **Transport Demand**
  - Passenger (population)
  - Freight (economy)

- GFC
- Climate Change
  - Infrastructure impacts
  - Demand changes
- Accessibility
  - equity
- Workforce Attraction & Retention
- Community & Business Expectations

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The government's view of the economy could be summed up in a few short phrases:

If it moves, tax it.

If it keeps moving, regulate it.

And if it stops moving, subsidize it.

- Ronald Reagan

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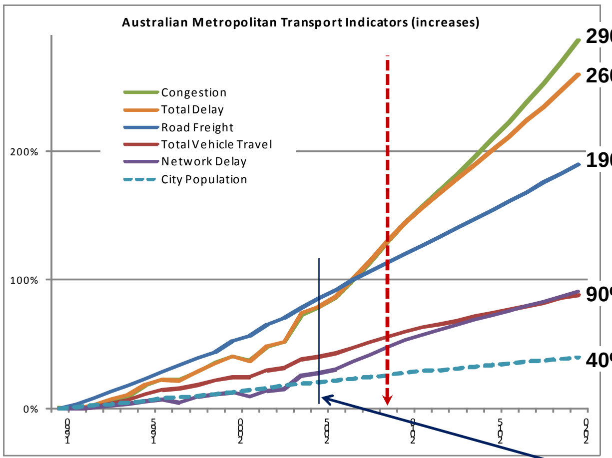
Land Transport Performance



290%

260%

190%

90%

40%

Our best transport planning and policy gets us ***HERE!***

Australian City Heavy Vehicle Congestion Cost Increases

1990 - 2005: 53%

2005 to 2020: 118%

1990 to 2020: 234%

Source: from BITRE WP71 data

Passenger Transport Forecasts

Average Growth 2000-2004

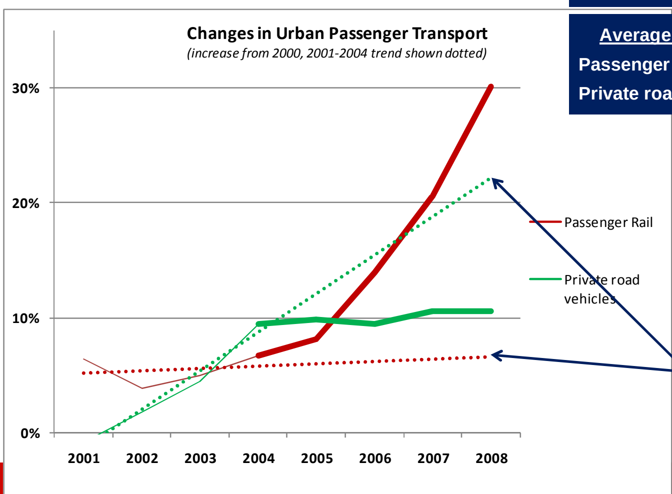
Passenger Rail: 1.6%

Private road vehicles: 2.3%

Average Growth 2004-2008

Passenger Rail: 5.1%

Private road vehicles: 0.3%



Transport planning and policy is based on these forecasts.

Source: from BITRE IS31 data

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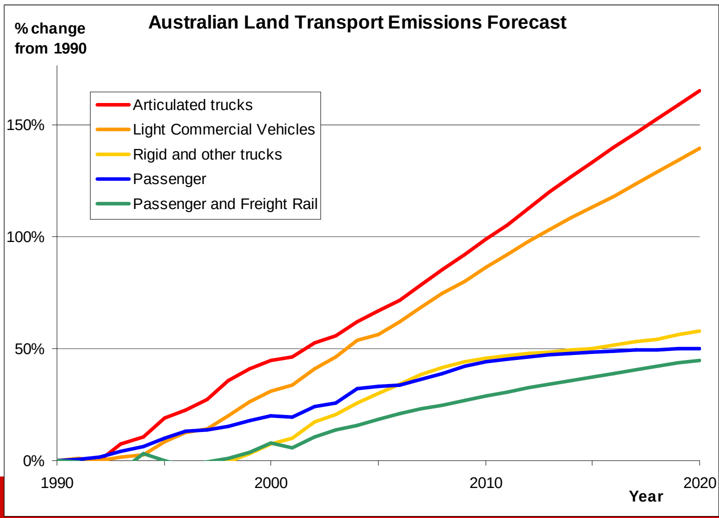
Land Transport Emissions



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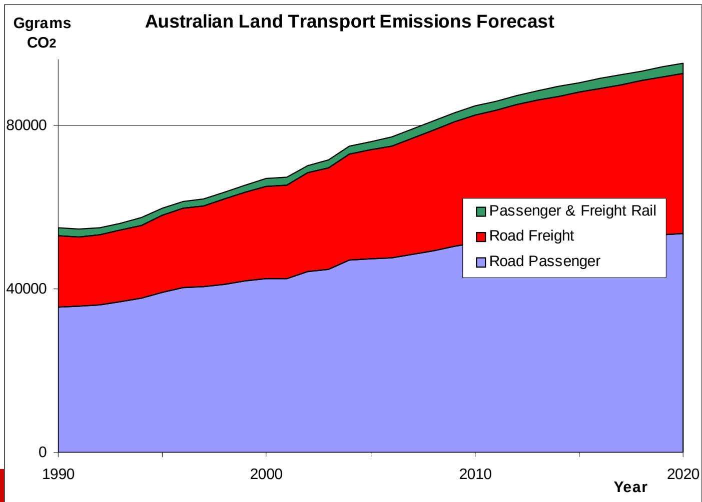
Land Transport Emissions



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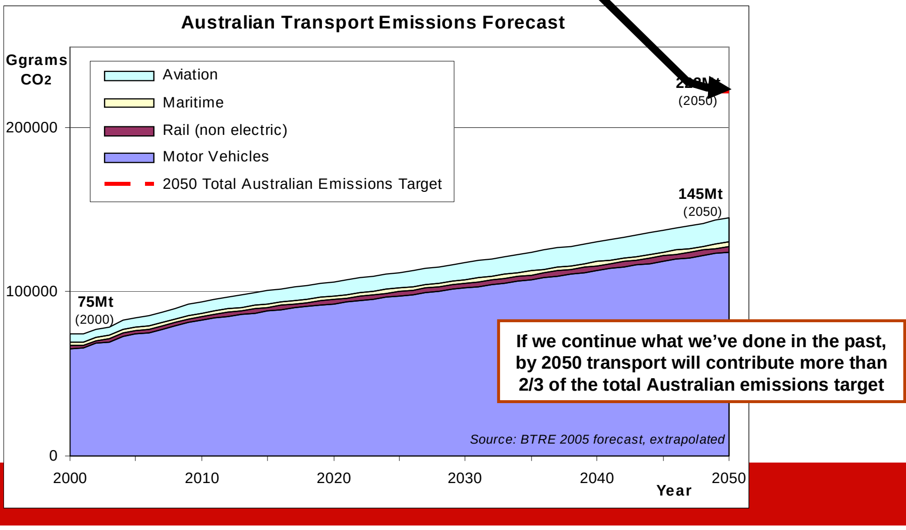
The Future of Transport Emissions



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Our Transport

- Australian transport fuel use, emissions and transport infrastructure are amongst the highest per capita in the world
- More than 1600 people die on our roads and another 30,000 are injured and road crashes cost over $20billion annually
- Traffic congestion in cities costs more than $10 billion annually
- Transport emissions are responsible annually for:
  - the deaths of over 1500 people
  - over 4,500 cases of asthma and other sickness (but could be 40% higher)
  - cost of death and sickness by transport emissions exceeds $2.3 billion annually
- Personal transport times and costs are increasing as a proportion of available time and disposable income, contributing to family pressure and other social degradation
- There has been no significant move towards more sustainable modes of transport, until the last two or three years
- Fuel usage of passenger cars have not decreased

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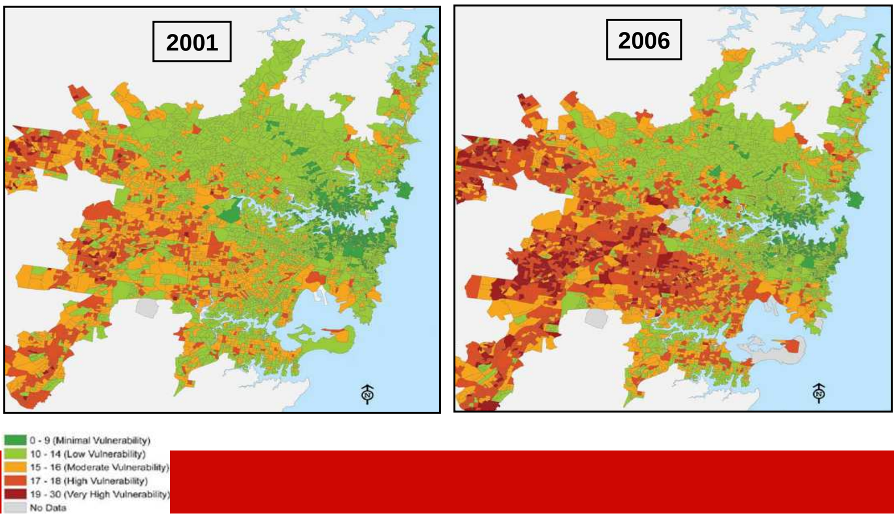
Oil and Mortgage Vulnerability (Sydney)



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Our Transport Future

- by 2050 transport emissions will comprise more than 66% of Australia's entire greenhouse gas emissions target
- transport congestion costs are increasing at a faster rate than traffic is increasing
  - heavy vehicle transport congestion costs will increase by an additional 100%
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  - deaths caused by articulated vehicles is increasing,
  - serious injuries caused by articulated vehicles is not decreasing
- Other factors such as health effects, transport costs and travel time are certain to increase

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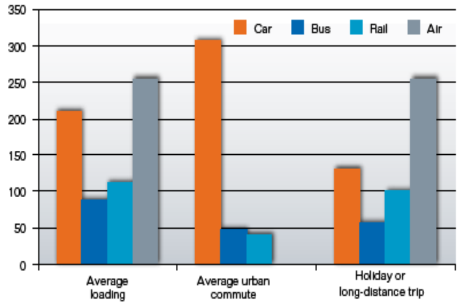
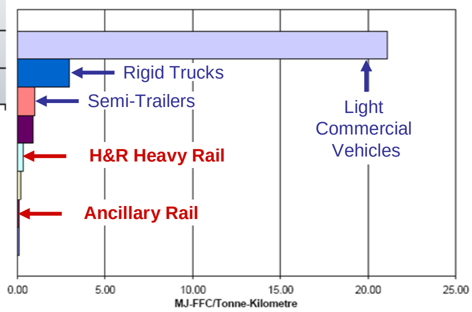
Rail’s Energy and Environmental Advantage



Passenger Transport Energy Intensity

Freight Transport Energy Intensity



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There is nothing a Government hates more than to be well-informed;

for it makes the process of arriving at decisions much more complicated and difficult.

Keynes

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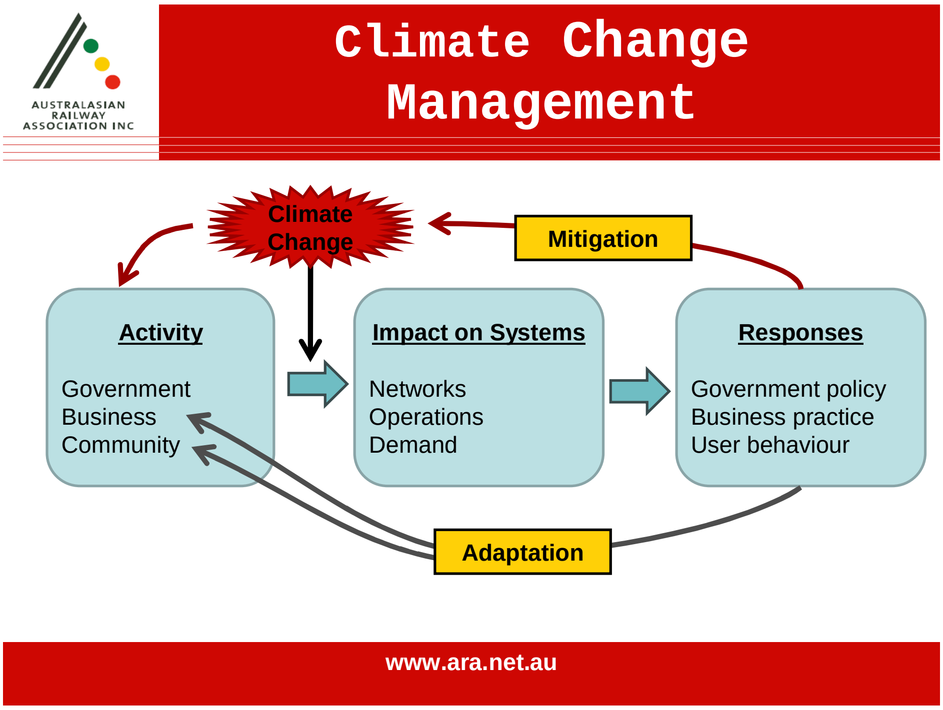
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Government
Business
Community
Impact on Systems
Networks
Operations
Demand
Responses
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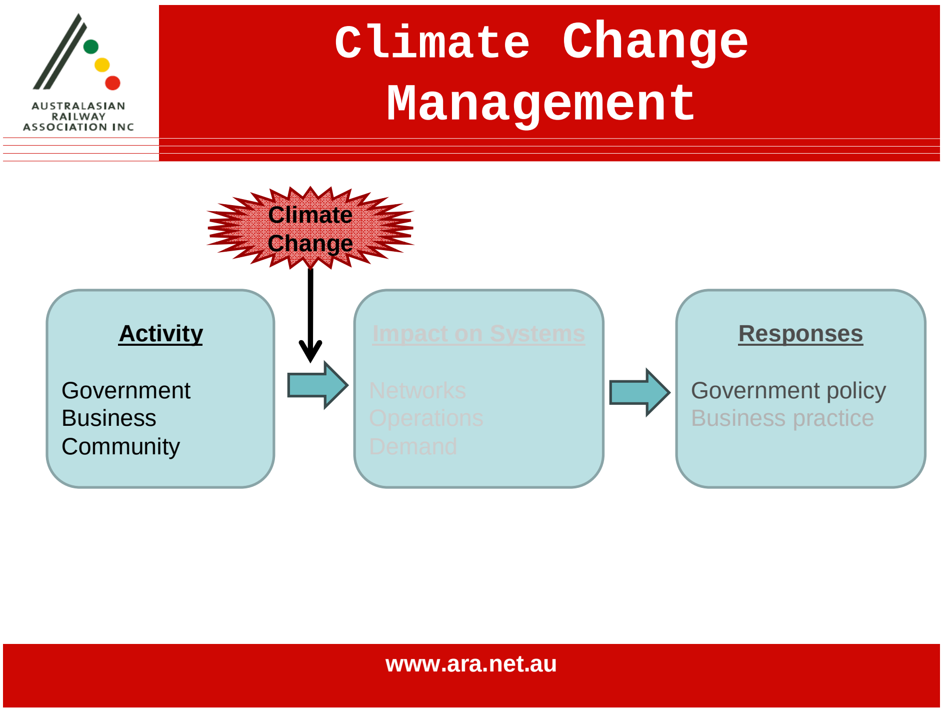
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Transport and the Carbon Economy

- Travel / Transport less
- Burn less carbon
  - more efficient transport & modes
  - more efficient vehicles
  - more efficient energy sources

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Market Issues of an Emissions Trading Scheme

- Market principles
- Market failures
  - ✓ Poor information
  - ✓ Natural monopoly
  - ✓ Externalities
  - ✓ Social objectives (eg income distribution or service quality)

So, other strong policies are needed to complement the Emissions Trading Scheme
CRC for Rail Innovation, 2009

Emissions trading on its own does not work; it needs other actions
Allan Jones - CEO, London Climate Change Agency

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Transport Emissions Market Distortions

- Car driver's costs will not change, but rail public transport costs will increase
- Road freight charges will not change, but rail freight costs will increase
- ETS charges are not market linked to public transport
  - pricing (fares) which may be constrained by political choices and economic regulation
  - infrastructure charges and provision (ie users pay for infrastructure but don't have choices about where improvements are made)
- Car owners costs are discounted by tax rebates or payments by others (business)
- The general community has responded to the market by purchasing small cars, while government (and business to a lesser extent) has not. In other words governments are not responding to the market.
- Businesses will transfer their increased costs to consumers who have no influence over business costs ("Take it or leave it"). So business does not always have much incentive to reduce emissions costs. Governments have even less management incentive
- Commercial drivers are often distant from the usage costs. So a truck or LCV driver can drive in a very fuel inefficient manner and receive no penalty so there is no incentive to change
- Car and truck ET charges are rebated, but freight and passenger railways pay full costs
- Road freight pricing is flawed
- Road pricing not market linked to infrastructure supply

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Emissions Adaptation and Transport

*Governments have a major role to play in lowering the economic costs of adjustment to higher oil prices, an emissions price and population growth, through planning for **more compact urban forms** and **rail** and **public transport**.*

***Mode shift may account for a quarter of emissions reductions** in urban passenger transport, lowering the cost of transition and delivering multiple benefits to the community.*

Professor Ross Garnaut, Final Report, Sept 2008

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Government Objectives

- **A national rail freight network**
  development of our rail networks so that more freight can be moved by rail
- **Transforming our cities**
  increasing public transport capacity in our cities and making better use of existing transport infrastructure
  (Infrastructure Australia, May 2009)

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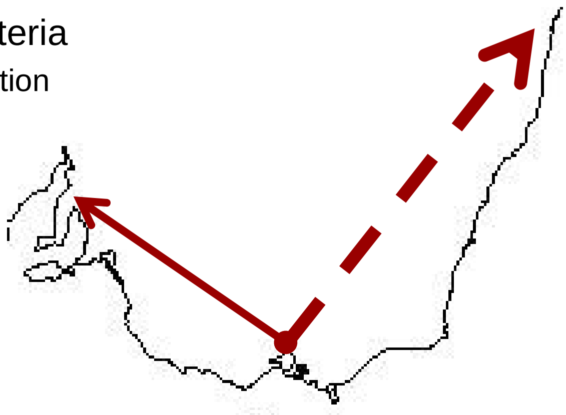
Where is Australian Transport Going?

- Performance Criteria
  - Capacity / utilisation
  - Speed
  - Safety



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Policy Tool Selection

Desirable? Necessary?
Valuable? Sufficient?
Integrated, complementary or conflicting?
Are there better alternatives?

A New Planning Paradigm

Current Perspective

- microanalysis
- short term
- narrow focused
- detailed / fragmented
- historical
- quantitative
- separate mode view
- infrastructure solutions
- commodity view
- incremental & evolutionary
- environmental and social benefits largely ignored

How do we improve what we've got?

New Planning Paradigm

- strategic
- holistic
- long term
- broad
- integrated
- multifaceted
- future oriented
- qualitative and quantitative
- customer view
- logistics chain analysis
- quantum change & revolutionary
- environmental and social benefits described

How do we provide what we need?

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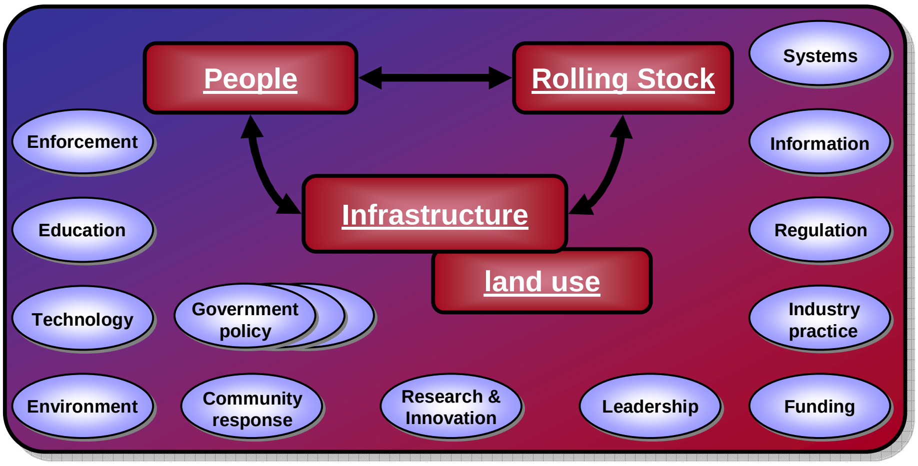
Rail System Structure



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Rail Needs and Opportunities

- Continuing **government investment**
- **Transport system reform** with incentives to achieve public outcomes
- **Reform FBT**
  - Remove FBT incentives for non-sustainable fuel use and
  - provide incentives for promoting public transport use
- **Mass-distance-location** charging for road use
- **Accelerated taxation depreciation** for rolling stock and infrastructure.
- **Neutralise the negative effects of the Carbon Pollution Reduction Scheme** on transport

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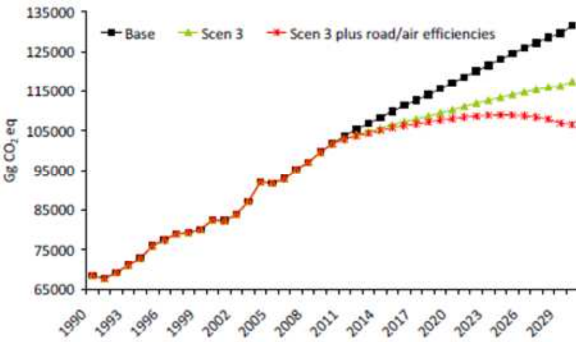
Economic Opportunities

- Investment
- Incentives & taxation
- Reducing regulatory burden
- Legislation

Benefits from Rail Investment

- Annual 3.8 to 6.2 Mt $CO_{2\text{-}e}$ emissions reductions
- 11% lower transport emissions by 2030
- Total benefits
  $27.4 to 41.7b
  (NPV 2010 -2020)



Source: CRC for Rail Innovation 2009 www.railcrc.net.au
Transforming Rail: A Key Element in Australia's Low Pollution Future

Workforce Analysis of the Australian Rail Transport Industry (ARTI)

Anusha Mahendran

Research Associate - Centre for Labour Market Research, Curtin Business School, Curtin University of Technology

Abstract

Despite a slowing in economic activity both internationally and nationally, the Australian rail transport industry (ARTI) is still reporting the existence of skill shortages amongst specified professions. This paper explores this interesting phenomenon more closely by analysing the ARTI workforce and providing a contemporary profile of its major employment trends and characteristics, using the most recently released ABS Census data. Like other industries the ARTI experienced substantial rationalisation of its workforce during the 1990's which resulted in considerable downsizing of employee numbers, reduced intake of young recruits and a significant decrease in training investment and skills development. The combined effect has left the ARTI facing several personnel problems including widespread labour shortfalls, an aging workforce and difficulties in relation to staff attraction and retention. The ARTI's heavy reliance on the skills of its personnel therefore means that such labour issues are likely to have important implications for the industry's prospective output capacity.

Keywords: Railways, Employment, Workforce Composition.

Introduction

Adequate transport infrastructure and an efficient transport industry are critical if any economy is going to achieve production at or near its capacity. The timeliness and cost efficiency with which raw materials and intermediate goods are brought to the production process and the delivery of final goods has a significant bearing on competitiveness in terms of both cost-structure and service quality. Equally, passenger transport is a major determinant of the liveability and functionality of cities and of the commercial connectedness between cities and regional areas. The transport sector takes on an even greater significance for a country such as Australia for various reasons. Australia's large resource base requires extensive bulk haulage over long distances. Second, Australia has a vast land mass, but is also one of the most highly urbanised countries in the world, with around 64% of the population living in the capital cities (ABS 2006: p.2).

The rail industry has played a pivotal role in Australia's economic and social development and will continue to do so for the foreseeable future. Rail is a major provider of passenger transport, both in the form of inner city rail networks and regional as well as interstate networks. In addition, rail also figures prominently in the transport of freight. Rail accounts for around one-fifth of the value of output from transport, and a higher share as an intermediate input into other industries. It is predicted that the importance of the rail sector for the Australian economy will continue to grow and that the magnitude of the rail transport task will increase even more into the future. In the ten years to 2001, the rail freight task increased by an average of 4.4% per annum (BTRE 2006: p. 45) and passenger kilometres by 1.5% per annum (Apelbaum Consulting Group 2005).

However, the rail industry is currently facing significant constraints in the form of the availability of appropriately skilled and trained labour to meet its growth potential and this situation is set to worsen dramatically in the next two decades. As policy-makers begin to grapple earnestly with the potential implications of the ageing of the Australian population for labour supply and productivity, concern about emerging shortages of skilled rail labour and the constraints this may be placing on further economic growth within the rail sector has become widespread, as evidenced in policy statements, current political debate and frequent media reporting on the ‘skills crisis’.

The Australian rail industry is a prime example of an industry experiencing recruitment difficulties associated with a tight specialised or niche labour market. However, the synopsis of skills shortages in the rail industry is far more unique and complex than that of a generally tight labour market, where there is high a level of competition for skilled labour. On the one hand, the industry has undergone a lengthy period of restructuring that has seen total employment in rail transport fall by roughly half in the decade spanning from 1991 to 2001 (Affleck, Dockery & Mahendran 2006). From this perspective, the industry might be expected to be immune to some extent from the effects of rapidly growing aggregate labour demand. On the other hand, the long term reduction in the rail workforce has reduced the need to actively cultivate sources of new entrants and to minimise wastage among existing workers. This has exacerbated the ageing of the rail workforce. Further, where employment and growth opportunities are popularly seen to be strongest in emerging technology based occupations and industries, such as the information technology and telecommunications sector, and in tertiary services, such as health, business administration and other technical services, the rail industry suffers from being viewed as an ‘old economy’ sector, reducing its attraction to school leavers and graduates from post-secondary education and training.

The need for both industry and policy makers to effectively respond to the workforce challenges faced by the ARTI has thus arrived in order to secure the future of the rail industry and maximise its contribution to Australia’s ongoing economic development. One initiative that was undertaken to assist in this endeavour involved the Centre for Labour Market Research (CLMR) with support and funding from the Planning and Transport Research Centre (PATREC), undertaking research to profile the current national rail workforce. This involved accessing and analysing the latest (2006) release of ABS Census data relevant to the rail sector, in order to develop an accurate profile of the industry’s workforce.

Current Structure of the Australian Rail Industry

The Australian rail industry is very diverse in nature. The industry consists of suppliers, track access corporations, rail operators, (including those specialising in heritage, tourist, freight, passenger transport) and a diversity of other companies covering all sectors of the industry (TDT 2005). Although there are around 250 firms that are listed as being apart of the Australian rail industry, approximately ten large rail enterprises dominate the majority of the operating and infrastructure sectors.

The majority of the companies in the Australian rail transport industry are profitable private enterprises that operate in monopolistic domestic markets (RTBU 2004). Each sector of the rail industry has unique and different corporate and community objectives (TDT 2005). Urban and passenger rail service providers offer a range of community transport services that are largely financed by a combination of government funding and passenger fares. In contrast freight and track access providers are predominantly commercial organisations focussed on making profitable rates of return and being corporately accountable for their capital investments and capital stock. Most of the organisations that were principally focused on in this study include those that are associated with one or more of the following sectors within the Australian rail Industry;

Providers of Rail Infrastructure Access

These organisations either lease or own the track they control and thus administer track access to other parties. The category also includes companies that are involved in the provision of signaling and communications. In some Australian states rail access providers own and control major rail yards and sidings used for the assembling, maintenance and repair of trains. In addition, many of these organisations may also be responsible for controlling train movements to ensure that trains that may be sharing the same track are separated, thereby effectively securing “train control”. Such organisations may solely specialise in the provision of rail infrastructure access which would mean that they are ‘vertically separated’. Alternatively, these organisations may be ‘vertically integrated’ meaning that they have ownership of train operating services in conjunction with being rail infrastructure access providers (Affleck Consulting 2003).

Rail Train Operators

These organisations can be broadly classified as being involved in “Private Railways” or “Public Railways” within the Australian rail industry. The Private Railway group includes a small number of train operators whose rail services are not available for hire and reward (Affleck Consulting 2003). These rail operators often have operations integrated with the extraction, refining and transportation of natural resources and minerals. Public railway operators offer rail services for hire and reward. These rail operators may thus be owned by both private and public sector entities. Train operators may also be categorised according to whether they are involved in the transportation of freight or passengers or a combination of both. Rail operators are referred to as being “horizontally integrated” enterprises if they are involved in the operation of both passenger and freight rail services (Affleck Consulting 2003).

Passenger train operators specialise in the provision of commuter, regional and/or tourist train services for the transportation of passengers within metropolitan areas, between capital cities and regional areas and also across states and territories. Commonly inter-urban service and urban commuter operators also manage and control ticketing, passenger stations and reservation systems (Affleck Consulting 2003).

The majority of rail freight operators in Australia are engaged in the commercial transportation of cargo, most commonly primary agricultural products and mineral resources. Often rail freight operators own and manage major rail yards and sidings. These serve numerous functional purposes including allowing for the provisioning and fuelling of trains. The rail yards and sidings also provide a base for the storage, assembly and en route management of trains (Affleck Consulting 2003). In addition, many freight operators also own and control intermodal freight terminals. There is a prevailing trend for freight operators to be increasingly integrated into multimodal and logistics entities (Rail CRC 2006).

Maintenance and Other Related Service Providers

These organisations are involved in the assembly, repair and maintenance of rolling stock including the overhaul of passenger carriages, locomotives and wagons. Rail enterprises classified within this category may also be involved in the hire and lease of wagons and locomotives. It also includes organisations involved in the provision of services related to the development, maintenance and inspection of rail track and other rail infrastructure, as well as of signaling and communications systems. A small subsection of enterprises classified in this group are also responsible for providing services related to the training and recruitment of specialised rail personnel (Affleck Consulting 2003).

Economics of the Australian Rail Industry

Overview

It is clear that an efficient rail transport sector will deliver substantial and diverse benefits to the economy. However, unique aspects of the production and consumption of rail services mean that the market is far removed from that of the standard economic textbook. Some important characteristics of the rail industry are:

- High infrastructure (sunk) costs, meaning that variable costs are very low relative to average costs. That is, once the infrastructure is in place and maintained, the marginal cost of carrying additional freight or additional passengers is very small.
- As a result of its high fixed cost structure and relatively low variable costs, the economics of rail transportation are heavily dependent on economics of scale (Productivity Commission 2006).
- These ‘natural monopoly’ conditions tend to result in one viable operator providing services within a given area or network, rather than a competitive marketplace.
- There are positive externalities associated with consumption of rail services. In the case of rail passenger transport, for example, these are in the form of less pollution and reduced congestion for road transport users. Further, one passenger’s use of rail services generally does not limit the use of the service by other passengers - in fact greater demand leads to enhanced services by allowing more frequent schedules.

The development of an efficient rail sector, therefore, can not be left to private markets. Rather, governments must play a leading role in their structure and regulation while at the same time trying to harness benefits available from competition. How infrastructure is to be funded, the separation of activities (such as ‘above track’ and ‘below track’), regulation of access to infrastructure and the pricing of services are all highly contentious issues. This also has implications for the labour market. Once externalities are involved and prices are influenced by regulatory decisions, the textbook link between the marginal product of labour and wages also becomes tenuous. While this paper is mainly concerned with profiling the workforce of the industry and outlining some of the labour market issues facing the sector, it may be useful to first provide an overview of the evolving structure of the Australian rail industry. Indeed, such structural reforms over the past two decades have had lasting implications for the current rail workforce.

Rail Industry Reforms

Many rail sectors in Australia could be viewed as natural monopolies. This is because the level and nature of the demand that exists for these often means that, in most cases, a single operator can provide the required level of service at a lower cost than multiple operators would be able to achieve. As capital costs are so large, most rail operators often face the prospect of extremely low marginal costs and high fixed costs (Productivity Commission 2006, Bradshaw 1997). The implication of this is that average costs continue to fall as an incumbent provider expands in scale, making entry into the market of a second provider unviable. Consequently, the vast bulk of passenger and freight rail in each Australian state came to be operated through government owned monopolies.

In recent decades, however, Australia's railway sectors have undergone significant changes. Initiatives by the Commonwealth and State/Territory Governments to promote more competition and efficiency within the rail industry have resulted in an increase in private rail activity and a decline in government ownership and management of railways (TDT 2005, Hensher et al., 1994). These deregulation policies were part of a wider microeconomic policy framework and were designed to open the rail industry to more private sector competitive forces and remove the existence of state based government monopolies (Everett 2006).

The reforms involved significant deregulation of the industry following the publication of the 1991 Industry Commission inquiry into rail transport, the 1993 Hilmer Report as well as the National Competition Policy (Everett 2006, Productivity Commission 2000a). Many of the policies that were implemented were based on a fairly broad microeconomic reform framework and involved enforcing a more commercial focus on rail operators to improve cost recovery. The structure of railways in most Australian jurisdictions consequently changed with many of the previously integrated State rail authorities being vertically and horizontally separated.

Prior to the implementation of the reforms, most railways were controlled by State specific rail organisations which managed both below and above track operations within their jurisdiction (vertically integrated) and provided a combination of urban passenger, non urban passenger and freight services (horizontally integrated). Effectively, a single government agency controlled activities such as track provision, signalling, maintenance, train operations and timetabling. The implementation of rail reforms in the 1990's however resulted in several rail networks in Australia being structurally separated (Productivity Commission 2000a).

Deregulation paved the way for the establishment of “open access” regimes which allowed competition within the rail industry by enabling competitors to have access to below track infrastructure (Productivity Commission 2000c, Everett 2006). This provision was designed to allow competition and removed the ability of state government authorities to earn monopoly rents. Following deregulation and introduction of “open access” regimes, the number of rail operators within the Australian rail industry increased from 12 in 1991 to 27 in 1999. There are presently over 30 major private rail operators in Australia compared to the 8 that existed ten years ago (RTBU 2004). Deregulation also enabled rail enterprises to extend their operations more freely interstate and rail operators have increasingly moved towards the provision of integrated intermodal services (i.e. integration of rail with road, air and water transport services). As a result many operators have evolved from being simple linehaul operators in bulk freight or container markets, to focusing their operations on the provision of third party services in a range of integrated functions (Everett 2006).

Many commentators have also purported that the reforms have facilitated structural separation in the Australian rail sector which has enabled increased product differentiation and market segmentation within the interstate rail markets. Evidence indicates that such segmentation enhances the ability of rail operators to more effectively compete with the sea and air modes of transport. Vertical separation of the interstate rail network has enabled greater integration of niche players into the transport logistics chain and has enhanced competition between rail operators for train schedules. Vertical separation has also enabled some expansion in the geographic markets of above rail operators and allowed for improved coordination of freight flows across infrastructure networks (Productivity Commission 2000a, 2006).

Outcomes identified from the rail reforms introduced in the 1990’s have included reduced freight rates, improvements in service quality and increased productivity (Productivity Commission 2000a, 2000c). In turn, this has been credited with enabling productivity improvements estimated to be worth more than $2 billion (RTBU 2004). The development and implementation of new technologies has also strongly contributed to productivity growth within the Australian rail industry and it is likely that this trend will continue and accelerate in the future (Rail CRC 2006). The improvements in the levels of productivity and competition experienced within the Australian rail industry have contributed to an 18% decrease in freight rates over the period spanning from 1990 to 1997 and a 30% reduction in real national freight rates from 1989 to 1998 (Everett 2006, Productivity Commission 2000b).

Another consequence of the reform process and resulting labour productivity growth has been a large scale reduction in employment in the rail industry. Employment fell by around fifty percent between 1991 and 2001. The Productivity Commission estimated that the number of full time employees in the rail industry decreased from 88500 in 1986 to 36500 in 1998 (2000c). Analysis of ABS Census data also shows a halving of employment in the rail transport industry between 1991 and 2001 as reported in Affleck, Dockery & Mahendran (2006). Other factors believed to be responsible for the decline in demand for rail labour include increased competition from alternative transport modes; increased contracting/outsourcing of rail operations and the redefining of labour arrangements with greater emphasis on multitasking or multi-skilling. As an example of the latter, many train drivers are now responsible for a wider range of duties including inspecting locomotives, planning shunting work and completing minor repairs (TDT 2005, Productivity Commission 2000a).

The fall in rail employment in Australia may also have been partly due to the large increases in real average labour costs which were recorded by many rail operators following the introduction of Enterprise Bargaining Agreements in 1992-93 and 1996-97. One study reported that over the period spanning from 1990 to 1998 real average labour costs, as a proxy for remuneration, increased by 27% within the Australian rail industry (Productivity Commission 2000b). Research reveals that the losses in employment among rail workers was less pronounced in Australian capital cities than in less densely populated regions such as rural and outer-city areas. A "Progress in Rail Reform" Report released in 2000 revealed that approximately two thirds of the 60% reduction in railway employment that occurred since 1986, was concentrated in regional areas, with devastating economic implications for some rural communities (Productivity Commission 2000a). The greatest reductions were recorded for occupational groups relating to clerical and service staff, labourers, tradespersons and managerial staff, all of which experienced a decrease of more than 50% in the number of their workers.

Profile of the ARTI workforce based on Analysis of ABS Census Data

This section provides a thorough, contemporary analysis of the current profile of the Australian rail transport industry workforce and of recent employment trends in the sector. Specifically it examines data from the four most recent ABS Population and Housing Censuses including the 1991, 1996, 2001 and 2006 Census. Data on rail employment is available from a number of existing published reports. Estimates of employment vary according to the methodology that is used and depending on how the 'rail industry' is defined. The only existing data source on employment in the Australian rail transport industry (ARTI) that is comprehensive enough to enable a detailed analysis is the full population Census.

Aggregate Employment

The 2006 ABS Census data reveals that there were 29,383 workers employed in the Australian Rail Transport Industry (ARTI). This is a decrease from the corresponding 1996 Census figure of 33,295 and represents a significant fall from the 54,677 rail transport employees recorded by the 1991 Census. Collectively the Australian rail workforce was downsized by over 85 percent in the time span between 1991 and 2006. Total employment in all industries grew by almost 9 percent over the 15 year period. In contrast, between 1991 and 2006, the ARTI's share of employment more than halved, declining from 0.77 percent of total employment in 1991 to only 0.32 percent in 2006. Between 2001 and 2006, there was however a slight rise in employment within the rail transport industry across Australia of 1.7 percent.

Employment by Occupation

The 2006 Census Data indicates that there is still a predominant concentration of rail workers within the occupational category "intermediate production and transport workers", as was also apparent in the national rail workforce data from 2001 and 1996 Censuses. The most prevalent occupation within the "intermediate production & transport workers" category is that of drivers, representing over 70 percent of jobs in the occupational group and about one fifth of all jobs in the rail sector. "Intermediate plant operators" are another prominent group of professionals within the "intermediate production & transport workers" category, accounting for approximately 23 percent of employees within the occupational group. The 2006 Census data also reveals that more than 80 percent of trade personnel in the ARTI were employed within the fabrication engineering trades and the electrical trades.

Table 1: Employment shares by occupation, Rail and All industries, 2006

	Rail Industry					All Industries
	1996 share (1)	2001 share (2)	2006 share (3)	Change in share (3) - (2) % pts	Change in share (3) - (1) % pts	2006 Share
1. Managerial	2.9%	4.9%	5.7%	0.8%	2.8%	9.2%
2. Professionals	4.9%	7.4%	9.7%	2.3%	4.8%	19.6%
3. Associate Professionals	6.4%	8.7%	8.8%	0.1%	2.4%	12.2%
4. Tradespersons	14.2%	11.0%	11.0%	0.0%	-3.2%	12.3%
5. Advanced Clerical & Service Workers	1.5%	1.8%	1.7%	-0.1%	0.2%	3.2%
6. Intermediate Clerical & Service Workers	10.6%	11.4%	9.9%	-1.5%	-0.7%	17.2%
7. Intermediate Production & Transport Workers	31.7%	31.5%	30.2%	-1.3%	-1.5%	8.2%
8. Elementary Clerical, Sales & Service Workers	12.9%	13.6%	15.0%	1.4%	2.1%	9.6%
9. Labourers & Related Workers	15.0%	9.8%	8.0%	-1.8%	-7.0%	8.5%
Total	100.0%	100.0%	100.0%			100.0%

In absolute terms, the greatest falls in employment in the ARTI between 1996 and 2006 were within the "labourers and related workers" occupational group (down by 2587 workers) with the vast majority of the decline within this group being recorded amongst "other labourers & related workers" (loss of 2065 workers). A large decrease in employee numbers was also recorded in the period between 1996 and 2006 amongst "intermediate production & transport workers" (down by 1623 workers), with falls being recorded for all professions classified within this occupational group. The largest quantitative fall in employee numbers within the occupational group was however reported amongst "intermediate plant operators" (recorded a decrease of 758 workers) and "road and rail transport drivers" (down by 502 workers).

Large falls were also reported among the number of workers employed within trade professions (down by 1452 workers). The greatest declines in jobs within this occupational group were among mechanical & fabrication engineering tradespersons (reported a decrease of 494 workers), electrical & electronics tradespersons (recorded a fall of 423 workers) and construction tradespersons (down by 369 workers). Another occupational group in which a considerable decrease in employment was reported was amongst "intermediate clerical, sales & service workers" (decreased by 599 workers). Most of the decline in employment within this occupational group was recorded for intermediate clerical workers (down by 544 workers). The largest increase in employment in absolute terms within the ARTI between 1996 and 2006 was recorded for the occupational group “professionals” (increased by 1226 workers). Increases in employment over the decade between 1996 and 2006 were also reported for “managerial” staff (increased by 692 workers) and “associate professionals” (increased by 476 workers).

Employment by Qualification

Table 2: Employment shares by level of qualification, Rail and All industries, 2006

	Rail Industry					All Industries		
	1996 share (1)	2001 share (2)	2006 share (3)	Change in share (3) - (2) % pts	Change in share (3) - (1) % pts	2001 Share (4)	2006 Share (5)	Change in share (5) - (4) % pts
Postgraduate Degree	0.80%	1.6%	2.9%	1.3%	2.1%	2.9%	4.0%	1.1%
Grad Diploma & Grad Certificate	0.40%	0.9%	1.2%	0.3%	0.8%	2.2%	2.2%	0.0%
Bachelor Degree	4.20%	7.2%	10.3%	3.1%	6.1%	14.9%	17.1%	2.2%
Advanced Diploma & Diploma	3.40%	4.7%	6.7%	2.0%	3.3%	8.2%	9.5%	1.3%
Certificate Level	*24.5%	26.2%	29.8%	3.6%	5.3%	21.6%	22.7%	1.1%
No Recognised Qualification	66.60%	59.5%	49.1%	-10.4%	-17.5%	50.3%	44.5%	-5.8%
Total	100.0%	100.0%	100.0%			100.0%	100.0%	

**NOTE:* The 1996 figure for Certificate Level was derived by adding Certificate (skilled vocational) & Certificate (basic vocational)*

The 2006 Census data indicates that the rail transport sector has largely maintained its status as a relatively lowly skilled industry, a standing which is reflective of the formally recognised skill level of the great majority of workers employed in the Transport & Storage Industry (TDT 2005). According to the figures the vast majority of rail employees have no recognised qualification with almost half of the workers nationally, identified as falling into this category. This group of unskilled rail workers however was the only group to report a fall in employment share between 2001 and 2006 (recorded a decline of more than 10 percent). This decrease in employment share was almost double what was reported for the same category of workers for all industries over the same period. In the ten years from 1996, the employment share of rail transport workers without a recognised qualification fell by more than 17 percent.
However, caution must be taken in investigating the trends between the Censuses as the classifications of qualifications changed from 1996 to 2001. Most notably, in 2001 certificates were no longer distinguished as basic or skilled as they were in 1996. Irrespective of this, a general trend towards higher levels of qualification within the rail workforce was still evident.

The 2006 Census data revealed that approximately 30 percent of rail workers possessed certificate level qualifications, thereby representing the qualification that most rail employees were likely to have. The Census figures also indicate that the rate of growth in the proportion of employees with certificate level qualifications was also higher between 2001 and 2006 for the ARTI compared to all industries (with the rate of growth for the rail industry being more than three times what was recorded for all industries). The employment share of rail workers with bachelor degrees and or advanced diplomas & diplomas also increased between the two most recent Census periods. However despite growth in these groups of workers between 2001 and 2006 being higher in the ARTI compared to what was reported for all industries, the proportion of rail employees with either of these qualifications was still noticeably lower than the average recorded for employees in all industries. Workers with postgraduate degrees and/or graduate diplomas & graduate certificates had the lowest employment share, accounting for less than 5 percent of the national rail workforce.

Age Profile

Figures 1 and 2 clearly indicate the aging phenomenon which has occurred within the Australian rail workforce. In the comparison of the age profiles for the ARTI between 1991 and 2006 presented in Figure 1, the significantly lower representation of workers aged 15-34 years in 2006 is clearly evident. The percentage of rail transport employees aged less than 35 years in 1991 was 40 percent. However 15 years later, the figure representing rail workers belonging to the same age group was only about 24 percent. This is indicative of a disturbing fall in the recruitment of entry level workers within the industry.

Figure 1: Age profile of the rail workforce; 1991 and 2006

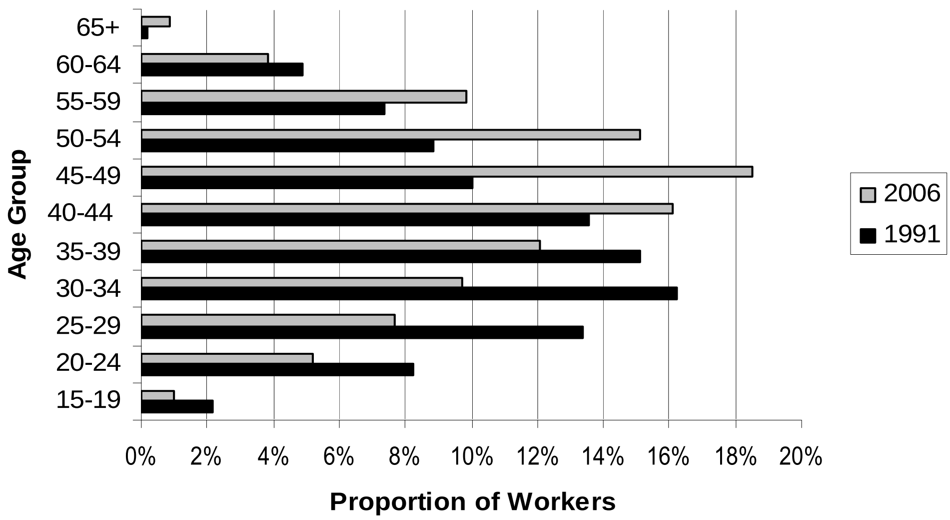
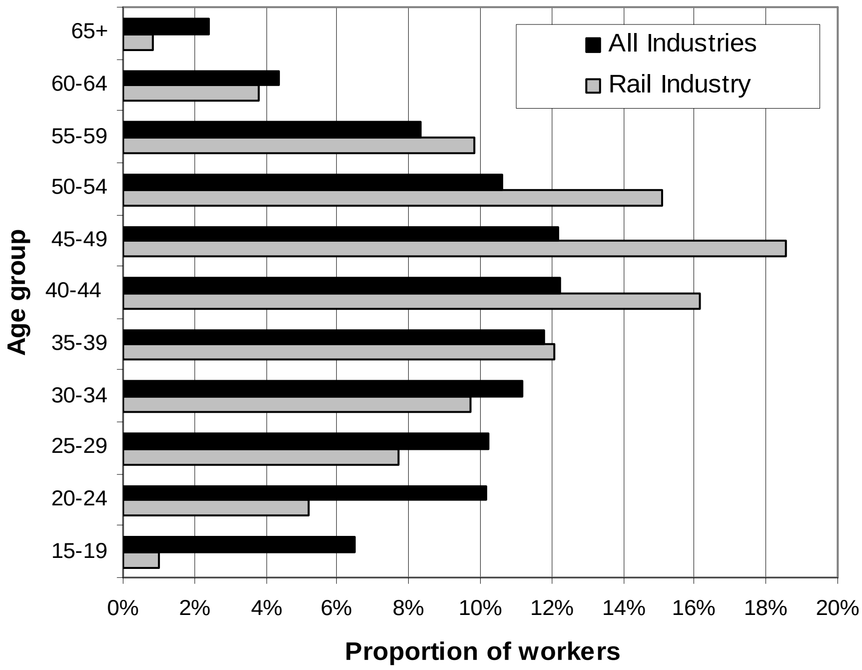


Figure 2: Age profile of the workforce; rail industry and all industries, 2006



The higher proportion of workers in the 35-59 age group and the under-representation of employees younger than 35 in the rail industry relative to all industries nationally in 2006, is clearly depicted in Figure 2. According to the 2006 Census data, workers aged less than 35 comprised approximately 38 percent of the overall Australian workforce compared to 24 percent in the rail transport sector. The rail industry also had a considerably higher percentage of employees aged between 35-59 years with this age group constituting almost 72 percent of its total workforce, while the corresponding figure for workers in this age group in all industries was only 55 percent.

The 1991 Census figures revealed that the average age of employees in the rail sector was 39, compared to 37 for workers in all Australian industries. By 2006 the average age of rail transport workers had rose to 42.9 years, which was almost 3.5 years older than the average age of employees in all industries. A comparison of the average age of workers in the rail industry and the wider Australian workforce by occupational group based on 2006 Census data, is presented in Table 3. The figures indicate that male rail employees in each occupational category are on average older than their counterparts in other industries. Consistent with findings from the 2001 Census, the average age of female rail employees was less than was the case in the general workforce in all occupational groups with the exception of intermediate and elementary clerical, sales and service workers and labourers and related workers. However due to the relatively small proportion of female rail employees in the ARTI, this finding has little bearing on the overall age profile of the rail workforce.

Table 3: Average age by occupation and gender, rail industry and all industries, 2006

	Males		Females	
	Rail	All Industries	Rail	All Industries
Managers	45.8	45.6	39.5	44.0
Professionals	42.2	41.8	34.6	40.3
Associate Professionals	44.8	41.2	38.0	39.9
Tradespersons & Related Workers	40.4	37.5	32.6	36.8
Advanced Clerical & Service Workers	45.0	41.5	37.1	41.9
Intermediate Clerical, Sales & Service Workers	45.2	38.5	38.1	38.1
Intermediate Production & Transport Workers	44.8	40.8	37.2	40.0
Elementary Clerical, Sales & Service Workers	42.2	34.0	39.1	33.0
Labourers & Related Workers	43.5	37.1	44.4	41.1
Total all Occupations	43.7	40.0	38.0	38.9

Employment by Gender

Data from the 2006 ABS Census revealed that female employees comprised approximately 15 percent of all rail workers nationally. This represented a slight increase of 3 percent from the figure for female representation derived from the 2001 ABS statistics. The Census figures also indicated that there was an increase in the percentage of female rail workers recorded for all occupational groups between 2001 and 2006. This was most pronounced amongst professional personnel, which as an occupational group experienced an almost 7 percent increase in the representation of females. Other occupational groups where growth in the proportion of women workers was evident was in relation to managers, associate professionals & intermediate clerical and sales workers for whom a 3-4 percent rise was reported. These findings seem to indicate a trend towards the increased employment of women in intermediate to highly skilled professions within the rail industry between 2001 and 2006.

It is evident from Table 4 that approximately 56 percent of all female rail workers were employed in clerical, sales and service positions. The total percentage of males employed in occupations within the advanced, intermediate or elementary clerical, sales and service occupational group was less than half that of females at around 22 percent. The occupational categories that did have a high proportion of male employees included the trade professions, intermediate production and transport workers and labourers and related workers. Looking at specific occupations more closely, women workers represent just over 1 percent of trade workers, 2.4 percent of transport drivers, 2.6 percent of intermediate plant operators and more than 98 percent of secretaries and personal assistants. The Census also indicated that the high degree of occupational segregation by gender has remained relatively unchanged between 1991 and 2006.

Table 4: Employment by occupation and gender, 2006, Australian rail industry

	Number Employed		%	Share of Employment	
	Male	Female	Female	Male	Female
Managers	1402	241	14.7%	5.7%	5.7%
Professionals	2112	699	24.9%	8.6%	16.5%
Associate Professionals	2064	492	19.2%	8.4%	11.6%
Trades & Related Workers	3138	36	1.1%	12.7%	0.8%
Adv. Clerical & Service Workers	169	321	65.5%	0.7%	7.6%
Interm. Clerical, Sales & Service Workers	1905	941	33.1%	7.7%	22.2%
Interm. Production & Transport Workers	8491	231	2.6%	34.5%	5.4%
Elem. Clerical, Sales & Service Workers	3247	1090	25.1%	13.2%	25.7%
Labourers & Related Workers	2115	195	8.4%	8.6%	4.6%
Total all Occupations	24643	4246	14.7%	100.0%	100.0%

Conclusions

The rail sector is thus having to contend with an aging workforce and further labour shortages that are likely to result from the imminent retirement of senior staff and older workers. The ageing of the industry's workforce is also likely to mean more workers in the sector will face a range of health issues. This includes such things as diminished hearing, sight, reactivity, impaired movement and the increased prevalence of age related diseases such as Type 2 Diabetes. All these may adversely impede the ability of employees to work efficiently, thereby contributing to reduced productivity and other labour problems. The relevance of this is particularly pertinent to the rail transport industry due to the physical nature of the work undertaken by the majority of employees, the stringent health and safety standards that have to be met and the often high risk work environment that much of the workforce is exposed to.

Due to the high proportion of older rail workers occupying positions of seniority, their eminent departure from the workforce due to retirement or other reasons is likely to result in a substantial loss of industry experience and expertise. This is of particular concern in a number of key rail occupations and is especially pertinent considering that there is likely to be an insufficient pool of adequately experienced and skilled workers available to replace them. The loss of experienced workers will also mean there will be a lack of mentors to effectively train and develop the younger workers. A lack of effective workforce planning and training of younger rail workers by Australian rail operators can thus be identified as having contributed to the skilled labour shortages currently being experienced by the industry nationally.

The skills crisis facing the rail sector is likely to be further exacerbated by the realisation that the industry has been largely unsuccessful in attracting new recruits. The problem is also complicated by the fact that over past decades the rail sector has enjoyed the benefits of having a very loyal, passionate and dedicated workforce who maintained a largely "cradle to grave" perspective in relation to their careers within the industry. This combined with the prevalence of traditional rail families helped to ensure sufficient numbers of recruits could be attracted and retained to continue working within the industry on a long term basis. However in recent times with the decline in traditional rail families and the changing employment attitudes of younger workers, much of the appeal that was once associated with a career in the rail industry has been diminished.

As has been identified elsewhere (see, for example, Department of Education, Science and Training 2006), the task of enticing more younger workers into embarking on and pursuing employment within the rail sector would be made easier if the image of careers within the rail industry could be markedly improved. Factors identified as negatively impacting the attraction and recruitment of workers into the rail transport sector included such things as the lack of clear career pathways, the industry image (i.e. as old, dirty and unsophisticated) and specific issues relating to the employment of younger workers (such as the attitudes of most "Generation Y" employees concerning the traditionally hierarchical nature of most rail workplaces).

It would also be prudent for the industry to address the entrenched gender segregation that exists with regard to the major semi-skilled occupations in the sector. Currently, half of the potential supply of young workers is effectively excluded from major rail occupations, such as driver and intermediate plant operator positions, due to the almost complete domination of males within these occupations. Policies to address this imbalance would likely require the inclusion of greater flexibility with regard to working hours, combined with other family-friendly working arrangements and a visible antidiscrimination regime.

One potential strategy rail operators could attempt to implement to mitigate some of their workforce problems would be to try to encourage older rail workers to delay retirement. This is likely to involve offering older employees more flexible working conditions and improved financial incentives in an effort to encourage them to continue working. Such measures have been perceived as necessary, to address the challenges of population ageing in the wider Australian economy. If this could be achieved in the ARTI, it would smooth the anticipated spike in wastage rates associated with the concentration of workers in the older age groups and at least delay emerging skills shortages, thus allowing greater time for human resource adjustments to be made.

Rail operators could also offer and sponsor more training opportunities for employees in order to further minimise the skills shortages they face. This would be particularly pertinent to rail employers who have previously not trained workers. For example in occupations that don't require a tertiary qualification, promoting more apprenticeship programs would be an effective method of training employees for specialised roles through a combination of classroom and on the job training. Rail employers could thus boost their efforts to deliver more internal training to new recruits and existing workers. Other training options available to rail operators would be to develop more collaborative training programs in cooperation with affiliated training organisations and educational institutions such as universities and TAFEs. In some cases, rail employers may not even have to bear the full cost of such training because it may be partially funded and supported by government bodies, workers and/or industry groups.

Many competing industries have already made significant progress towards ensuring their skill needs are met and so in this regard the rail industry could be viewed as being behind in developing effective strategies to tackle the issue. As other competing industries seek to improve their practices and strategies for attracting and retaining workers in the future, the challenge facing the rail sector to ensure it has an adequately qualified and trained workforce is likely to become even more difficult. Therefore unless effective action is taken to address current and emerging workforce issues within the sector, the ARTI may well have to contend with being in the arduous predicament of having to compete for a declining portion of the skilled labour available in the market, in addition to having to tackle the potentially adverse implications that the workforce issues it faces may have on the productive capacity of the industry.

Bibliography

Affleck Consulting (2003), *The Australian Rail Industry: Overview and Issues,* Report prepared for the National Road Transport Commission.

Apelbaum Consulting Group (2005), *Australian Rail- The 2004 Productivity Report,* Canberra: Australasian Railway Association.

Australian Bureau of Statistics (ABS) (2006), *Australian Social Trends 2006*, ABS Cat. no. 4102.0, ABS, Canberra.

Bradshaw, W. (1997), 'Competition in the Rail Industry', *Oxford Review of Economic Policy,* **13(1),** 93-103

Bureau of Transport and Regional Economics (BTRE) (2006), *Freight Measurement and Modeling in Australia*, BTRE Report 112, Department of Transport and Regional Services: Canberra.

Everett, S. (2006), 'Deregulation and Reform in Australia: Some emerging constraints', *Transport Policy*, **13(1),** 74-84.

Hensher, D.A, Daniels R., DeMellow I. (1994), *Revisions and Update: Productivity of Australian Railways 1971/71 to 1991/92*, Institute of Transport Studies, Graduate School of Business, University of Sydney.

Affleck, F. Dockery, A.M & Mahendran, A. (2006), 'Skill Shortages in the Australian Rail Industry', in Wrightson, G (ed), *8th Path to Full Employment Conference and 13th National Conference on unemployment*, Centre of Full Employment and Equity (CofFEE): Australia.

Productivity Commission (2000a), *Progress in Rail Reform*, Canberra: Productivity Commission.

Productivity Commission (2000b), *An Assessment of the Performance of Australian Railways 1990-1998,* Canberra: Productivity Commission.

Productivity Commission (2000c), *Draft Report- Progress in Rail Reform (Media Release),* Canberra: Productivity Commission.

Productivity Commission (2006), *Road and Rail Infrastructure Pricing*, Canberra: Productivity Commission.

Rail Collaborative Research Centre (Rail CRC) (2006), *Research: Theme 6 Industry Skills Development (Education and Training),* Australia: Rail CRC.

Rail, Tram & Bus Union (RTBU) (2004), 'Skills Crisis in Australia's Railways', *Rail, Tram & Bus Worker*, **12(3),** 1

Transport and Logistics Industry Skills Council (TDT) (2005), *Industry Skills Report*, Australian National Training Authority, February, pp. 9-28.

A Cost Function for Australia's Railways

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Abstract

This paper utilises a unique dataset comprising of a hundred years of Australian railway history to develop a cost function for Australia's railways. It explores two different functional forms, highlighting the advantages and disadvantages of each, and explores some of the ramifications of the cost models, both in terms of the economics of Australia's railways and their economic regulation.

Keywords: Railways, Cost Functions

Introduction

This paper endeavours to construct a cost function for Australia's seven government-owned railways, covering the period from 1900 to 1992. It explores both translog and Symmetric Generalised McFadden (SGM) functional forms, and finds that the former provides a more robust set of estimates of the railways' costs. The paper also explores issues of economies of density, scale and scope for Australia's railways, and provides estimates of long run marginal cost.

Section Two of this paper provides some background literature review on the estimation of railway cost functions. Section Three describes the data used, whilst Section Four describes the models and modelling results. Section Five explores some implications of the modelling results, and Section Six concludes.

Railway Cost Functions

US railways have been regulated for more than one hundred years, and their economic regulators have, for most of that time, collected detailed, consistent data on their operating characteristics. The ready public availability of this data has meant, in turn, that most of the advances in railway cost function construction and development have been based upon US data. Winston (1985), Bitzan (2000) and Waters (2007) provide three historical overviews of the development of the literature, with the first and last beginning their analyses in the 19th Century and covering railway economics more generally, and Bitzan (2000) focusing on cost functions developed since World War Two.

One can divide the development of the literature into three parts. Prior to World War Two, there was a major focus on what drove railway costs, with early authors (Wellington, 1887 and Ripley, 1912) suggesting that up to half of railway costs were unrelated to traffic, a misconception which was not remedied until the 1920s, when more sophisticated statistical methods began to be used for the first time (Lorenz, 1923, Clark, 1923). In the post-war period, econometric analyses began to be undertaken, notably by Borts (1952, 1954, 1960) and Klein (1953), who focused upon cost and production functions, and the measurement of scale economies where over-capacity prevailed. However, as Keeler (1974) pointed out, many of these models were prone to error due to their linear construction, which meant a fixed relationship between inputs and outputs, regardless of scale. Keeler (1974) used a Cobb-Douglas function, to obviate these concerns, estimating short-run cost functions and using their envelope to construct a long-run function. He also distinguished between economies of scale, where above-rail output and track both increase, and economies of density, where greater above-rail traffic is accommodated on the same track. However, the Cobb-Douglas function has problems of its own, in terms of flexibility, and thus the third stage of progress arguably did not begin until the advent of flexible functional forms; first the translog, and later the SGM.

Translog functional forms, as noted by Waters (2007) first entered the railway cost function literature in the early 1980s, with work by Spady (1979), Friedlander & Spady (1981) and Cave Christiansen & Swanson (1980,1981a,b). The studies were interested in productivity gains, but also explored more deeply the differences between economies of scale and economies of density. Caves, Christiansen, Trethaway & Windle (1985) point out that the use of firm dummies can distort measures of scale and density, because the dummies can often be correlated with these measures. Brauetigam, Daugherty & Turnquist (1984) use data from a single firm to avoid these difficulties, but this is rare, because there are rarely enough observations from a single firm to render robust estimations of complex cost functions like the translog.

One problem associated with the use of the translog is that the log of zero is not defined; meaning firms with zero output within a particular class (say passenger trips) in a particular year are difficult to incorporate into the model. Caves, Christensen, & Trethaway, (1980) addressed the issue of zero outputs by using a Box-Cox transformation. They then applied this model to a cross-section of US railways from 1963, consisting of 56 firms, 41 of which produce passenger and freight outputs and 15 of which produce either on or the other alone.

A broader issue than outputs of zero is the diversity of output commonly seen in railways, which can be obscured by narrow measures such as net tonne kilometres for freight or passenger journeys for passenger rail. DeBorger (1991) presents what he claims is the first application of an hedonic output aggregation model to the railway industry, focussing on the railways of Belgium. He uses a short-run translog cost function, whereby each output is a function of its attributes, and the hedonic output aggregator and the cost function are estimated jointly. The approach allows for the incorporation of diversity without greatly expanding the number of parameters estimated, but for it to be appropriate each of the aggregators must be separable from all of the other arguments in the cost function; something which the author admits is empirically rare in transportation industries. Each aggregator is a summation of the log of the relevant output, such as freight, and the sum of a vector of operating characteristics relevant to that output.

The translog functional form is very versatile in that it can be adapted to accommodate outputs of zero, or a wide range of outputs. It is also relatively easy to estimate, and its coefficients have an easily-understood meaning; they are elasticities. It has thus proven popular. In addition to the above studies, Friedlaender, Berndt, Shaw-Er Wang Chiang, Showalter and Vellturo (1993) use the translog to explore capital stock adjustments subsequent to industry deregulation in the US, finding that overcapacity still prevailed, whilst Wilson (1997) uses the model to explore cost reductions and productivity gains over the same period. Bitzan (2000, 2003) uses the translog to explore cost subadditivity, and hence the impacts of vertical and horizontal separation, highlighting both the cost and welfare impacts. Wills-Johnson (2008) performs a similar analysis for Australian railways, using a much shorter version of the dataset used in this paper. Bitzan & Keeler (2003) use the translog to narrow down sources of technical improvements since (US) industry deregulation, focusing on the consequences of removing cabooses from trains, whilst in a 2007 paper, the authors explore the effects of increased traffic density possible since deregulation, by developing a counterfactual translog cost function (Bitzan & Keeler, 2007). Mizutani (2004) presents a rare example of the use of a translog model for urban passenger railways, into which he incorporates DeBorger's (1991) hedonic approach, in order to compare the costs of public and private railways in Japan. Finally,[1] Ivaldi & McCullough (2001) utilise the translog to examine vertical separation, using an ingenious characterisation of below-rail output; replacement ties.[2]

However, in more recent times, some authors have begun to move away from the translog. Crafts, Leunig & Mulatu (2008), estimate an efficient cost frontier for British railways around the turn of the 20th Century, and use a Cobb-Douglas function in preference to the translog because their statistical tests suggest that the added complexity of the translog is unwarranted. More often, however, the move is to more complexity, and most particularly to the SGM. This literature is still small. Ivaldi & McCullough (2005, 2006) us the SGM to explore subadditvity, finding greater evidence of inefficiencies from vertical and horizontal separation than Bitzan (2000,2003), and also to explore the welfare effects associated with the many mergers that have characterised the US industry in recent decades. Christopolous, Loizides & Tsionas (2001) use a single-output version of the SGM to explore the sources of inefficiency in European railways, by decomposing the error in each factor-demand equation into a random component, and one associated with the relevant factor. This paper, to the knowledge of the author, thus represents the fourth paper to use the SGM in the context of the railways.

Description of the Data

Australian railway data are not as comprehensive as those from the US, but the Australian Bureau of Statistics has collected reasonably consistent data on Australia's railways for almost 100 years (from 1900 to the mid 1980s), and the author has used this data, along with annual reports and a small number of other studies (notably Hensher, Daniels & DeMellow, 1995 and BTRE, 2006) to construct the Australian Railways Database (http://tiny.cc/ozrail).

Inputs

The Database has operating expenditure divided as follows:

- **Maintenance of Ways and Works:** upkeep of the permanent way (tracks), buildings, fences, signals and bridges.

[1] See the three historical studies mentioned previously for more examples.
[2] That is, the clips which connect the track to the sleepers.

- **Motive Power and Maintenance of Rolling Stock:** fuel and lubricants for locomotives, wages for locomotive crews, maintenance of rolling stock.
- **Traffic:** wages in stations and yards, vehicle cleaning, gate-keeping and train supplies.
- **Other Charges:** refreshment room services, generation of electric power, administration and payroll expenses and stores.

I roll traffic and other charges into a single category called "incidental expenses", which roughly correlates with the "materials" category used by many models of the US railways, in that it is a catch-all for expenses not covered elsewhere. Since labour numbers and costs are provided in the Database, I also add labour as an input, reducing each of the four cost categories above (which include labour expenses) by the proportion of labour costs in total expenses, which implicitly assumes unit labour costs are equal. The fifth input is fixed capital. For this, I use a perpetual inventory method whereby the value of the asset base in the previous year is divided by 50 (to reflect straight-line depreciation over a 50-year period, not unreasonable for fixed capital in rail) and the capital expenditure in the given year is added to this figure, with the result multiplied by the long-term Treasury bond yield.[3] Unlike most US models, I do not separately identify fuel costs as, whilst data exist for these in some years, they do not exist in enough years to make this a viable input. To turn my five input categories into prices, I divide fixed capital and below-rail maintenance by route kilometres, rolling stock operations and maintenance and incidentals expenditure by train kilometres and staffing costs by total numbers of staff. This gives five input prices:

- **PCAPM:** the price of fixed capital.
- **PRS:** the price of rolling stock operations and maintenance.
- **PINFM:** the price of below-rail maintenance.
- **PL:** the price of labour.
- **PINC:** the price of incidentals.

The division of prices is not as exact as it may appear. Australian railways funded their operations and maintenance out of retained earnings and their capital expansion from government grants. Earnings greater than operating expenditure were to be returned to government. Since capital grants were often not forthcoming, the railways had an incentive to try and maintain rolling-stock rather than buy it anew, and also to put as much expenditure into operating expenditure accounts as they could. For example, sleeper replacement was usually classed as maintenance even when replacing wooden sleepers with concrete ones. The boundary was further blurred by the fact that rolling stock was often constructed in the same yards it was maintained in. It is thus difficult to draw a distinct line between maintenance and capital expenditure. Moreover, since the railways were government-owned, they never went bankrupt and capital assets stayed on the books based on their construction cost even when subsequent history proved that a particular line was worth nothing due to shifting demand. In the US, such lines might have been sold, or written off, but, with the exception of a series of capital write-downs in the late 1920s and 1930s, this rarely happened in Australia. Not much can be done

[3] Sourced from http://www.wrenresearch.com.au/downloads/index.htm and based on Reserve Bank of Australia historical data.

about these data difficulties, but they may, for example, go some way to explaining why many of the model results point towards over-capitalisation.

Outputs

In the models below, I separate output into passenger and freight outputs. The way in which I count passenger and freight output is a little different from measures used elsewhere. Although I have some data on net tonne kilometres (ntk) of freight, I do not have any similar measure for passengers, such as passenger kilometres. However, I have data on passenger journeys, passenger train kilometres, freight tonnes and freight train kilometres. My measures are thus passenger journeys multiplied by passenger train kilometres (*PASS*) and freight tonnes multiplied by freight train kilometres (*FRGT*). The latter is perfectly correlated with freight ntk in the years for which I have data, and is thus simply a scalar multiple of this variable.

Technical and Dummy Variables

I provide three technical variables in each model; the number of train kilometres per route kilometre (*DEN*), the number of years since dieselisation extended to cover 90 percent of locomotive kilometres (and thus became pervasive – denoted *DIES*) and the proportion of minerals freight tonnes in total freight tonnes (*MINP*). The first of these captures the increased efficiencies which are possible through greater network utlisation. The second attempts to capture the rather profound impact that changing from steam to diesel can have on the efficiency of rail operations. Previous work (Mills & Wills-Johnson, 2008) suggests that this does not occur straight away, but rather that it can take some time for existing railway operations to adapt to a transformational new technology such as diesel, particularly when long-lived assets such as track are configured for steam. Thus, rather than considering a simple dummy variable, I use what is in essence a time trend. The final technical variable, also used in Freidlander et al (1993) is intended to capture the efficiency gains associated with the use of unit trains devoted to minerals traffic, which move large amounts of a single product from a mine to (usually in Australia) a port.

I also have a dummy variable for each of the state railways. In general, the models are not sensitive to which of these dummy variables is omitted. As the models are estimated in first differences (see below) the effect of each of these dummies is to act as a time trend for each railway, and thus capture technological change not elsewhere captured.

Stationarity

Before undertaking any modelling, it is important to ascertain whether the relevant variables are stationary or not. Table One presents the results of a Phillips-Perron unit root test, undertaken on the logged variables. The variables are all as named above, except for TC, the total cost. This form of unit root test is undertaken has higher power in the presence of serial correlation and heteroscedasticity, which the data exhibit.[4]

[4] A simple OLS regression of the cost function, undertaken in levels, has a Durbin-Watson test statistic close to zero, whilst the Breusch-Pagan (1979) test statistic is 115.

Table 1: Unit Root Test Results

State	Variable	*t no trend (crit value -2.57)*	*t trend (crit value -3.13)*	*z no trend (crit value -11.2)*	*z trend (crit value -18.2)*
NSW	TC	-1.645	-3.408	-2.220	-21.262
	PINFM	-2.249	-3.968	-10.462	-26.260
	PRS	-3.035	-4.205	-17.142	-29.588
	PCAPM	-0.035	-1.368	-0.071	-3.833
	PL	-0.132	-4.434	-0.256	-29.935
	PINC	-2.091	-4.098	-8.956	-27.889
	FRGT	-1.751	-3.278	-2.871	-18.172
	PASS	-4.277	-1.921	-3.866	-2.933
	PJ	-4.269	-2.223	-4.077	-3.500
	DEN	-1.408	-3.338	-4.063	-20.033
	MINP	-1.981	-2.025	-8.415	-8.596
Vic	TC	-0.917	-3.557	-1.750	-21.768
	PINFM	-0.899	-4.164	-3.254	-28.458
	PRS	-1.869	-3.373	-9.735	-22.138
	PCAPM	-0.342	-1.292	-0.670	-3.095
	PL	-0.287	-4.322	-0.641	-29.812
	PINC	-0.770	-3.242	-2.582	-19.367
	FRGT	-2.250	-1.089	-6.406	-4.421
	PASS	-2.536	-1.593	-5.139	-3.767
	PJ	-2.583	-2.205	-5.292	-4.325
	DEN	-1.348	-2.963	-3.519	-16.463
	MINP	-2.153	-2.196	-8.917	-9.167
Qld	TC	-1.075	-2.894	-1.436	-15.702
	PINFM	-1.605	-4.404	-6.102	-26.878
	PRS	-2.591	-4.885	-13.799	-37.634
	PCAPM	-0.120	-1.444	-0.221	-3.483
	PL	-0.531	-4.515	-1.105	-30.472
	PINC	-2.094	-4.954	-9.672	-37.973
	FRGT	-0.518	-1.870	-0.568	-6.839
	PASS	-2.231	-1.783	-3.894	-4.832
	PJ	-2.508	-2.112	-4.488	-5.740
	DEN	-1.193	-2.950	-3.018	-14.641
	MINP	0.048	-1.860	0.083	-3.612
SA	TC	-1.364	-3.289	-3.501	-18.575
	PINFM	-3.411	-4.197	-20.793	-27.303
	PRS	-3.263	-3.822	-18.601	-24.180
	PCAPM	0.277	0.576	0.861	1.695
	PL	-0.870	-4.217	-2.532	-28.523
	PINC	-2.117	-3.759	-9.015	-22.924
	FRGT	-1.679	-2.593	-5.670	-12.638
	PASS	-2.794	-2.014	-6.524	-5.247
	PJ	-2.404	-2.375	-6.963	-6.488
	DEN	-1.928	-1.296	-7.982	-5.999
	MINP	-3.484	-3.397	-17.949	-19.180

State	Variable	*t no trend (crit value -2.57)*	*t trend (crit value -3.13)*	*z no trend (crit value -11.2)*	*z trend (crit value -18.2)*
WA	TC	-1.371	-2.297	-2.320	-13.373
	PINFM	-1.351	-2.435	-3.645	-8.578
	PRS	-2.180	-2.646	-9.000	-13.746
	PCAPM	-0.878	-2.048	-1.933	-5.790
	PL	-0.365	-3.234	-0.789	-17.172
	PINC	-1.245	-2.984	-3.301	-14.413
	FRGT	-0.548	-2.105	-0.741	-8.344
	PASS	-3.297	-4.046	-17.850	-23.117
	PJ	-2.696	-4.171	-11.459	-19.797
	DEN	-2.354	-3.072	-6.642	-8.424
	MINP	-1.200	-2.933	-3.572	-15.652
Tas	TC	-1.005	-4.412	-2.374	-30.348
	PINFM	-1.297	-4.468	-4.219	-29.542
	PRS	-2.102	-5.915	-8.367	-47.559
	PCAPM	-1.225	-1.426	-4.215	-4.783
	PL	-0.724	-3.959	-1.989	-25.098
	PINC	-1.496	-5.063	-5.126	-38.439
	FRGT	-1.647	-3.151	-3.671	-17.704
	PASS	1.182	1.586	3.082	3.446
	PJ	1.805	2.156	4.947	4.820
	DEN	-1.285	-1.340	-3.272	-4.511
	MINP	-0.967	-1.762	-2.707	-5.639
Cwlth	TC	-1.389	-1.983	-1.827	-7.487
	PINFM	-2.805	-2.947	-14.472	-16.175
	PRS	-4.900	-5.036	-39.159	-40.395
	PCAPM	-2.289	-2.121	-9.022	-8.471
	PL	-0.303	-3.938	-0.709	-25.726
	PINC	-2.878	-3.902	-16.364	-25.978
	FRGT	-1.558	-2.820	-2.941	-14.947
	PASS	-2.120	-1.806	-4.751	-7.026
	PJ	-1.930	-1.634	-4.266	-6.054
	DEN	-2.425	-2.084	-8.444	-8.331

In most cases, the null hypothesis of a unit root is not rejected. A similar test undertaken on the first difference of each of the variables rejects the null in every case. Due to the difficulties of fitting an error correction model to the complex functional forms used in the models here, I have instead chosen to undertake modelling in first differences. The coefficients of this model, with the exception of the intercepts, are the same as would be the case in a levels model. Due to the models using data in first differences, I have turned the DIES variable into a dummy, rather than a trend, which means that it can be interpreted as a trend in levels form. The same conclusion holds for the state dummies.

Models and Model Results

Ideally, one would like a cost function which accords with theory, is flexible (in that it can approximate a wide range of true functional forms) and has a wide range of applicability. Lau (1986) suggests that it is impossible to achieve all three; there is no "perfect" functional form, and each has its own restrictions in use. It is for this reason that I use two different functional forms; the translog and the SGM. The translog is an extension of the Cobb-Douglas production function, whilst the Symmetric Generalised McFadden production function extends the Leontieff production function.

The translog was developed by Christensen, Jorgenson & Lau (1973). It is a second-order flexible meaning that it imposes no restrictions on levels or on the first or second derivatives itself (like, say, the Cobb-Douglas does) allowing any such restrictions to be imposed solely by theory. It thus allowing the approximation of any arbitrary transformation function, provided concavity criteria are satisfied. Moreover, it allows for freely variable elasticities between factors, meaning that economies of scale, density and scope are dependent upon the data, rather than having to be imposed. It is also relatively simple, and has readily interpretable results; the coefficients are elasticities.

The SGM was first posited by McFadden (1978), then extended by Diewert & Wales (1987) to render it symmetric, and finally, extended to the multi-output case by Kumbhakar (1994). It is also second-order flexible and allows one to handle outputs of zero. It is, however, computationally more complex, and its coefficients are not as easily interpretable as the translog.

Diewert & Wales (1987), Terrell (1996) and Sauer, Frohberg & Hockmann (2004) provide detailed comparisons between these two, and other flexible functional forms. However, the main practical difference between the two is concavity. If a cost function is not concave in input prices, then their factor input demand functions are not well-behaved (if indeed they exist at all) and the firm in question cannot be said to be cost-minimising. Whilst both the translog and the SGM can suffer from concavity issues in a given empirical application, and whilst both can have this shortfall remedied by imposing concavity, imposing concavity on the SGM does not influence its flexibility, whilst it renders the translog inflexible. This is an important reason to favour the SGM over the translog but, as Terrell (1996) points out, imposing concavity means that, whilst one is flexible at the set of prices where the cost function is estimated, this is not a guarantee that it will remain flexible over a range of prices.

Testing for concavity in each case is relatively simple. Referring to Equations One and Two below, the translog is concave if the matrix $\Lambda - \hat{s} - s.s'$ is negative semi-definite, where $\hat{s}$ is a diagonal matrix containing the factor shares down the main diagonal and zeroes elsewhere, whilst s is a vector of factor shares. The matrix is tested for each factor share in a dataset, meaning 592 such tests for each model analysed here. For the SGM, referring to Equations Three and Four below, there is a single test of concavity for each model; an examination of whether the Λ matrix is negative semi-definite or not. If it is not, then concavity can be imposed on the SGM without loss of flexibility by substituting *Λ* for $-A.A^T$, where is *A* is a lower triangular matrix (Diewert & Wales, 1987). [5]

Both the translog and the SGM can be expressed compactly in matrix form. The translog is expressed thus:

$$\ln C(y,w,t,D) = \alpha_0 + \alpha' w + \beta' y + \gamma' t + \kappa' D + w'\Lambda w + w'\Delta y + w'\Theta t + y'\Sigma y + t'\Gamma t \qquad (1)$$

Where *y* refers to the two outputs, *w* refers to the five inputs, *t* refers to the three technical variables and *D* to the seven dummy variables for each state plus the Commonwealth. The lower case Greek letters refer to vectors of coefficients, whilst the upper case Greek letters refer to appropriately dimensioned matrices of coefficients. Note that *Λ, Σ* and *Γ* are symmetric whilst *Δ* and *Θ* are not.

Applying Shephard's Lemma gives the five factor share equations, which can again be written in matrix form as:

$$S_w = \alpha + \Lambda w + \Delta y + \Theta t \qquad (2)$$

As is standard practice in such analyses, to avoid a singular covariance matrix, one factor share equation is dropped, and a system of the cost function plus four factor share equations is estimated. Also, to simplify the system, price homogeneity is imposed, meaning that the α vector sums to one and that the rows of *Λ, Δ* and *Θ* sum to zero.

The generalised McFadden can also be summarised rather neatly in matrix form thus (Ivaldi & McCullough, 2005):

$$C(w,y,t) = \alpha' w + \frac{1}{2}\frac{w'\Lambda w}{\varphi' w}(\beta' y)^2 + w'\Delta z + \frac{1}{2}(\varphi' w) z'\Gamma z \qquad (3)$$

Here, *α* and *β* are again a vectors of coefficients, whilst φ is a vector of fixed parameters set at the average of each input price for each railway (following general practice, see for example, Ivaldi & McCullough, 2006). The matrices *Λ* and *Γ* are symmetric, whilst *Δ* is not. As previously, *w* refers to the input prices and *y* to outputs, whilst *z* is a vector which includes both *y* and the technical variables *t*. Since this cost function is in ordinary numbers, rather than logs, the application of Shephard's Lemma gives the factor demand equations, rather than the factor share equations, thus:

$$X_w = \alpha + \left(\frac{\Lambda w}{\varphi' w} - \frac{1}{2}\frac{(w'\Lambda w)\varphi}{(\varphi' w)^2}\right)(\beta' y)^2 + \Delta z + \frac{1}{2}\varphi(z'\Gamma z) \qquad (4)$$

The five factor demand equations contain all of the variables of interest. Thus one can simply estimate all of them in a system, without estimating the cost function. Note that,

[5] The translog has concavity imposed by replacing the Hessian matrix with its Cholesky decomposition, but this is rarely done, because it renders the model inflexible.

although similar Greek letters are used in the translog and McFadden cases, their meanings are not exactly the same.

In both the translog and McFadden cases, the resultant models are estimated via Zellner's (1962) Seemingly Unrelated Regression approach, using SHAZAM (2004).[6]

In order to explore the cost functions in some detail, apart from experimenting with two functional forms, I also used four different manifestations of the input data (one in ordinary numbers, plus three indices; Paasche, Laspeyres and average), five different translog model forms based on omission of each of the factor share equations and seven different versions of each translog and SGM model based upon omission of one of the firm dummies. Moreover, the maximum likelihood solution algorithm used by SHAZAM (2004) allows one to specify the starting values for each coefficient to be estimated, or use its default value of one. I did both, for the index forms of the model, basing the chosen starting value on the results of an initial run where the starting value was one. Finally, to provide some indication of how results might change when the SGM models were constrained to be concave, I chose six different Λ matrices to use as fixed values. This gave rise to 280 different translog models, 64 different SGM models where Λ is not fixed, and 384 where it is; a total of more than 700 models, of which I present only the highlights below. The full set is available from the author upon request.

Translog Models

I begin with the ordinary numbers cases. Overall, this form of the model gave the best results, in terms of statistical significance. Indicative results are provided in Table Two, which shows the results from the model form where *PL* is the omitted share equation and Commonwealth Railways the omitted state railway dummy. Changing the omitted share equation influences coefficients (removing *PL* gives the best results in terms of the statistical significance and sign of coefficients), but changing the omitted dummy does not. Note that, with *PL* removed, *A1* refers to *PINFM*, *A2* to *PRS*, *A3* to *PCAPM* and *A4* to *PINC*. The coefficients for output and technical variables do not change in Tables Two through Eight, and *B1* refers to freight, *B2* to passenger, *G1* to density, *G2* to the diesel dummy and *G3* to the proportion of mineral freight traffic. The dummy variables refer to each of the state railways, with *D1* being NSW, *D2* being Victoria, *D3* being Queensland, *D4* being South Australia, *D5* being WA, *D6* being Tasmania and *D7* (here omitted) being the Commonwealth Railways. These dummy variables are also defined similarly in Tables Two through Eight. The double-subscripts and compound coefficients refer to the relevant second order effects. Thus, *A11*, for example, refers to the impact of *PINFM* on itself, whilst *B2G1* refers to the interaction between passenger outputs and the diesel dummy.

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[6] As noted previously, the data exhibit heteroscedasticity, which can be addressed via GLS if the error structure is known. SHAZAM does not allow for GLS within its linear systems command. It does, however, allow a non-linear regression with an option (called ACROSS, see SHAZAM, 2004, p249) which estimates a SURE model with vector autoregressive errors. This allows for maximum likelihood estimation of the regression parameters, provided the model converges, and provides efficient and consistent estimates of the coefficients. The model estimated is a linear model, but due to the nature of SHAZAM, it was estimated using a non-linear approach. For this reason, some diagnostic results normally associated with linear models are not available.

Table 2: Levels Translog Results – PL Removed

	Coefficient	t-ratio		Coefficient	t-ratio
A1	0.1322	4.4288	A1G1	-0.0248	-10.7620
A2	0.6471	3.8960	A1G2	0.0003	0.8152
A3	3.4278	26.3220	A1G3	0.0011	0.8950
A4	0.1962	1.1891	A2G1	0.0329	8.6949
B1	0.2277	1.5807	A2G2	0.0006	0.8766
B2	0.1907	2.0977	A2G3	-0.0006	-0.3177
G1	-1.7567	-3.4385	A3G1	-0.1468	-21.2020
G2	-0.0161	-2.4589	A3G2	0.0016	1.2646
G3	0.4796	3.0917	A3G3	0.0075	2.2043
D1	0.0020	0.3189	A4G1	0.0371	11.5410
D2	-0.0003	-0.0373	A4G2	0.0005	0.8827
D3	0.0000	0.0072	A4G3	-0.0035	-2.0827
D4	0.0006	0.0805	B11	0.0217	4.3848
D5	-0.0040	-0.5775	B12	-0.0342	-5.5487
D6	0.0022	0.2975	B1G1	0.0085	0.4761
A11	0.0384	39.1890	B1G2	-0.0053	-0.2654
A12	-0.0080	-8.0800	B1G3	-0.0382	-3.2224
A13	-0.0083	-10.6210	B22	0.0046	1.8858
A14	-0.0123	-13.8960	B2G1	0.0525	5.1840
A22	0.0644	41.9550	B2G2	0.0102	0.7741
A23	-0.0128	-11.2620	B2G3	0.0278	3.8436
A24	-0.0213	-17.6770	G11	0.0016	0.0448
A33	0.1727	49.5450	G12	-0.0043	-0.1772
A34	-0.0114	-10.0410	G13	-0.0449	-2.2724
A44	0.0615	41.3100	G23	0.0447	1.2821
A1B1	0.0002	0.4451	G33	0.0012	0.8473
A1B2	0.0012	1.5794			
A2B1	0.0044	0.4526			
A2B2	0.0030	2.4952			
A3B1	0.0056	0.8377			
A3B2	-0.0018	-0.8598			
A4B1	0.0228	2.3755			
A4B2	0.0025	2.4377			

Diagnostics - Cost Function	
GtH^(-1)G	2.4609E-09
Durbin Watson	2.1901
Rho	-0.0999
R-squared between obs and predicted	0.8533
Runs Test	290.0000
Normal Statistic	-0.5319

Share Functions	*PINFMS*	*PRS*	*PCAPMS*	*PINCS*
Durbin Watson	2.0692	2.0848	2.0986	2.0474
Rho	-0.0353	-0.0433	-0.0495	-0.0257
R-squared between obs and predicted	0.7383	0.7222	0.8748	0.7251
Runs Test	288.0000	256.0000	279.0000	276.0000
Normal Statistic	-0.6917	-3.3347	-1.3999	-1.6171

The coefficients shown in Table Two are largely as expected; all of the inputs and outputs have positive coefficients, although PINC is not significant. Note that the responsiveness of total costs to fixed capital is much larger than for any other input variable, highlighting the importance of fixed capital costs to the railways. Note also that freight and passenger traffic imposes roughly similar costs (although freight is not statistically significant). The technical variables are mostly as expected; density and dieselisation have reduced costs, but the proportion of minerals traffic here points to a cost increase, when one would expect a cost decrease if more traffic were hauled in unit trains with few origin and destination points, as minerals traffic commonly is. The explanation for this anomaly might be that, early in the 20th Century, minerals were not hauled in unit trains and had many origins and destinations. In other models, minerals traffic is often not significant, and hence it may be better to omit this from the model. I have not done so, as I want to compare like model specifications across a number of different model types. The second-order effects are mostly as expected as well, with own-price elasticities (for example, A11, B11 and G11) generally being positive and significant and cross price elasticities generally being negative and significant. Finally, the limited model statistics afforded by SHAZAM in its non-linear mode all suggest that the model performs reasonably well.

Although the ordinary numbers versions of the model perform well in terms of the statistical significance of their coefficients, they perform less well in terms of concavity. The version with *PL* removed shown in Table Two had only 51 of the 592 factor share equations available where the $\Lambda - \hat{s} - s.s'$ matrices which were negative semi-definite. The best performing of these models from the perspective of concavity, coincidentally the worst from the perspective of the accordance of the coefficient values with theory, was the model with *PINFM* removed, and this only had negative definiteness in 219 cases, fewer than half of the total.

Turning now to the index forms of the translog models, the best of these significantly outperformed the ordinary numbers versions above in terms of concavity. The best models were those using the Paasche index form, with the *PRS* factor share equation omitted. Of the total of 592 factor share equations available, 560 of these had negative semi-definite $\Lambda - \hat{s} - s.s'$ matrices when the starting point of the maximum likelihood algorithm was one, and 532 when it was the result of such a regression. However, the coefficients are generally less robust than in the ordinary numbers version, as is shown in Table Two. Note that, in this case, *A2* refers to *PCAPM* and *A3* refers to *PL*, whilst other variables are defined as previously.

Table 3: Paasche Index Form Translog Results – PRS Removed

Coefficient Start Points = 1						Coefficient Start Points = Translog Levels Results					
	Coefficient	*t-ratio*		*Coefficient*	*t-ratio*		*Coefficient*	*t-ratio*		*Coefficient*	*t-ratio*
A1	-0.0211	-0.0298	A1G1	0.0315	6.8554	A1	3.8212	0.9157	A1G1	0.0316	6.8505
A2	0.3766	13.3470	A1G2	0.0000	0.7311	A2	0.3690	13.3300	A1G2	0.0000	0.7123
A3	0.5257	16.1260	A1G3	0.0006	0.2401	A3	0.5363	16.7280	A1G3	0.0005	0.2280
A4	-0.0217	-0.0306	A2G1	0.0113	3.2891	A4	-3.8798	-0.9298	A2G1	0.0114	3.3157
B1	0.1336	7.3104	A2G2	0.0000	0.7651	B1	0.1157	5.5789	A2G2	0.0000	0.7591
B2	0.1270	5.6312	A2G3	0.0031	1.8355	B2	0.1189	5.2109	A2G3	0.0031	1.7970
G1	-0.0195	-0.3178	A3G1	0.0824	6.8289	G1	-0.0180	-0.2927	A3G1	0.0828	6.6919
G2	-0.0001	-0.3820	A3G2	-0.0002	-0.8023	G2	-0.0004	-0.9104	A3G2	-0.0002	-0.8088
G3	-0.0488	-1.8457	A3G3	-0.0195	-2.8721	G3	-0.0379	-1.4086	A3G3	-0.0198	-2.8782
D1	-0.0134	-1.2439	A4G1	-0.0031	-0.2280	D1	-0.0132	-1.2387	A4G1	-0.0041	-0.2929
D2	0.0007	0.1351	A4G2	0.0000	-0.2781	D3	0.0004	0.0760	A4G2	0.0000	-0.2454
D3	-0.0002	-0.0469	A4G3	-0.0132	-1.6683	D4	0.0030	0.4758	A4G3	-0.0130	-1.6344
D4	0.0028	0.4605	B11	-0.0044	-1.2757	D5	0.0043	0.7841	B11	-0.0052	-1.4899
D5	0.0033	0.6265	B12	-0.0035	-0.5516	D6	-0.0027	-0.4544	B12	-0.0048	-0.7760
D6	-0.0021	-0.3687	B1G1	0.0784	5.0414	D7	-0.0023	-0.3828	B1G1	0.0773	5.0037
A11	-0.0500	-2.0755	B1G2	0.0040	2.7685	A11	-0.0427	-1.7463	B1G2	0.0048	3.2101
A12	-0.0389	-10.5360	B1G3	-0.0022	-0.3776	A12	-0.0390	-10.5620	B1G3	-0.0009	-0.1444
A13	0.0028	0.6863	B22	0.0008	0.1645	A13	0.0029	0.7041	B22	0.0035	0.6796
A14	0.0039	0.1704	B2G1	-0.0157	-0.8984	A14	-0.0034	-0.1451	B2G1	-0.0166	-0.9698
A22	-0.0187	-6.8140	B2G2	0.0027	2.4634	A22	-0.0188	-6.8199	B2G2	0.0028	2.6015
A23	0.0002	0.0705	B2G3	-0.0211	-2.3784	A23	0.0003	0.1023	B2G3	-0.0225	-2.5275
A24	0.0222	4.6754	G11	0.0018	0.0723	A24	0.0222	4.7083	G11	-0.0010	-0.0412
A33	0.0170	4.0839	G12	-0.0121	-3.6679	A33	0.0164	3.9293	G12	-0.0118	-3.5742
A34	0.0165	2.3152	G13	-0.0467	-2.7837	A34	0.0166	2.2940	G13	-0.0486	-2.9288
A44	0.0224	1.0364	G23	0.0055	2.1419	A44	0.0296	1.3398	G22	0.0001	1.7727
A1B1	0.0019	2.0278	G33	0.0013	0.4863	A1B1	0.0019	2.0333	G23	0.0050	1.9634
A1B2	0.0052	2.9173				A1B2	0.0050	2.8103	G33	0.0021	0.6987
A2B1	-0.0450	-5.6695				A2B1	-0.0452	-5.5839			
A2B2	0.0022	1.7373				A2B2	0.0022	1.6780			
A3B1	0.0351	4.1621				A3B1	0.0357	4.1353			
A3B2	-0.0200	-5.2418				A3B2	-0.0199	-5.1529			
A4B1	0.0218	1.6578				A4B1	0.0146	1.0612			
A4B2	0.0073	1.3825				A4B2	0.0084	1.5355			

Diagnostics - Cost Function		*Diagnostics - Cost Function*	
GtH^(-1)G	1.65E-06	GtH^(-1)G	2.58E-08
Durbin Watson	2.0029	Durbin Watson	2.0029
Rho	-0.0015	Rho	-0.0015
R-squared between obs and predicted	0.9554	R-squared between obs and predicted	0.9556
Runs Test	265.0000	Runs Test	261.0000
Normal Statistic	-2.5861	Normal Statistic	-2.9156

Share Functions	*PINFMS*	*PCAPMS*	*PL*	*PINCS*	*Share Functions*	*PINFMS*	*PCAPMS*	*PL*	*PINCS*
Durbin Watson	2.0813	2.0479	2.0052	2.0301	Durbin Watson	2.081	2.0479	2.0047	2.0296
Rho	-0.0406	-0.0240	-0.0026	-0.0162	Rho	-0.04052	-0.02393	-0.00234	-0.01598
R-squared between obs and predicted	0.6805	0.5001	0.0940	0.2517	R-squared between obs and predicted	0.6802	0.4997	0.0965	0.2528
Runs Test	254	267	322	288	Runs Test	256	269	318	288
Normal Statistic	-3.4946	-2.4259	2.1331	-0.6917	Normal Statistic	-3.3274	-2.2592	1.8033	-0.6966

The first-order coefficients are roughly the same, in terms of significance, as in Table Two, with the exception of *PINFM*. However, the size of the *PCAPM* coefficient relative to the others has now decreased markedly, and it is roughly the same as that for labour, suggesting both influence costs roughly equally. Again, both outputs have similar coefficients (but they are both statistically significant), which is interesting in the light of subsequent railway policy that saw horizontal separation in many states. The second-order coefficients perform much less well, which suggests these models do not estimate own and cross price elasticities particularly well.

Crafts et al (2008) suggest that the additional complexity of the translog is not warranted in their examination of British railways in the early part of the 20th Century, a suggestion they make after testing whether the second-order coefficients are statistically different from zero in the translog functional form. Undertaking the same test here highlights the fact that the same does not hold. An F-test of the second-order coefficients being set to zero in the model in Table Two returns a chi-squared test statistic of 346, whilst for the models in Table Three, the chi-squared test statistics are 2021 and 2031. Clearly, the translog is adding explanatory value to the understanding of Australian railways.

Whilst the index forms of the models perform better in terms of concavity, they are not globally concave, and it is therefore useful to explore the SGM to see if global concavity exists for this model form, or can be imposed. Before doing so, however, it is useful to explore whether there are some differences between the factor share combinations for which the $\Lambda - \hat{s} - s.s'$ matrix is negative semi-definite, and those for which it is not. Table Four shows the results of an analysis which splits the sample of (592) factor share observations in three of the models for each of the two different sets of starting points with the highest share of negative semi-definite results into those factor shares which are negative semi-definite and those which are not.

Table 4: Concave and Non-Concave Factor Shares

			PINFM	PRS	PCAPM	PL	PINC
Start coefficient based on previous translog	PINFM Out - Paasche	test stat		20.556109	-19.239268	9.603477	9.9525452
		difference		0.0391204	-0.1952555	0.1076973	0.0331366
	PRS Out - Paasche	test stat	12.473405		-12.782877	3.6956352	32.216914
		difference	0.0228211		-0.1691733	0.0527312	0.050452
	PINC Out - Average	test stat	10.815224	10.574414	-6.6953818	1.0922061	
		difference	0.015341	0.0252784	-0.0696535	0.0097417	
Start coefficient vector of ones	PINFM Out - Average	test stat		21.192681	-18.445633	9.0887796	9.6914926
		difference		0.0397955	-0.1922074	0.1040221	0.0328968
	PINFM Out - Paasche	test stat		21.56013	-21.993621	12.059076	10.574016
		difference		0.0370972	-0.1829533	0.1041417	0.0284178
	PRS Out - Average	test stat	16.628305		-11.251238	2.2317018	33.177265
		difference	0.028581		-0.1701655	0.0369969	0.0539958

In almost every case, the differences between the averages for the concave and non-concave factor shares are statistically significant. Moreover, the results are surprisingly consistent; in every case the non-concave set has a larger share of fixed capital and a smaller share of all other inputs, whilst the converse is true for the concave set. This suggests that where railways have over-capacity in track, they are unlikely to be cost minimising; a not unreasonable conclusion. Alternatively, it could reflect poor accounting of track infrastructure, which was generally recorded at its construction cost rather than its value in use. Many branch lines were expensive to build, but later transpired to be practically worthless to their owners. Thus, over-capitalisation could be an accounting issue, rather than one associated with levels of physical assets. Whichever is the case, the models highlight problems with below-rail capital for Australian railways; problems which are far from unknown to the industry.

SGM Models

I now turn to the SGM models, looking first at the 64 models whereby concavity is not imposed. For SGM models, the problem occurs one step before the estimation of coefficients and the determination of concavity, in model closure; very few of the 64 models actually closed adequately (as measured by the $G^TH^{-1}G$ score). These results are shown in Table Five, with the models that closed adequately highlighted.

Table 5: McFadden Model Closure Adequacy

				$G^TH^{-1}G$					$G^TH^{-1}G$
Ordinary Numbers	No state dummies		no start pt	91194	Paasche	No state dummies		no start pt	484.75
			start pt	1.41E+05				start pt	1.37E-07
	state dummies	no start pt	Cwlth out	1411.8		state dummies	no start pt	Cwlth out	1454.9
			Tas Out	6609.4				Tas Out	821.61
			WA Out	5952.8				WA Out	90.212
			SA Out	859.43				SA Out	513.11
			Qld Out	7748.8				Qld Out	629.87
			Vic Out	1482.6				Vic Out	142.13
			NSW Out	2620				NSW Out	261.25
		start pt	Cwlth out	2.53E+08			start pt	Cwlth out	6.14E-02
			Tas Out	1.90E+07				Tas Out	1.28E-06
			WA Out	3.70E+05				WA Out	1.55E-07
			SA Out	1.55E+07				SA Out	2.00E-08
			Qld Out	1.96E+07				Qld Out	2.54E-07
			Vic Out	1.96E+07				Vic Out	8.16E-05
			NSW Out	2.27E+08				NSW Out	1.94E-07
Laspeyres	No state dummies		no start pt	1.75E+09	Average	No state dummies		no start pt	372.69
			start pt	1.26E+05				start pt	2.48E-09
	state dummies	no start pt	Cwlth out	1.75E+09		state dummies	no start pt	Cwlth out	138.25
			Tas Out	1.75E+09				Tas Out	3726.3
			WA Out	1.75E+09				WA Out	483.16
			SA Out	1.75E+09				SA Out	438.82
			Qld Out	1.75E+09				Qld Out	449.4
			Vic Out	1.75E+09				Vic Out	55.535
			NSW Out	1.75E+09				NSW Out	153.74
		start pt	Cwlth out	1614.3			start pt	Cwlth out	7.89E-09
			Tas Out	288.35				Tas Out	5.75E-09
			WA Out	1270.4				WA Out	3.39E-09
			SA Out	1801.4				SA Out	3.91E-09
			Qld Out	942.23				Qld Out	1.10E-09
			Vic Out	3.17E+06				Vic Out	3.15E-09
			NSW Out	898.54				NSW Out	1.29E-09

Only those models which have used Paasche or Average indices, and begun with a start-point garnered from the relevant translog model above have adequate closure, and it is thus these that I consider further in Table Six.

Table 6: McFadden Models Statistical Significance

		A1	A2	A3	A4	A5	B1	B2
Paasche	no state dummy	0.5413	0.2661	-0.0293	0.7208	0.4400	6.4547	3.7298
	Cwlth out	-9.2016	0.2230	-45.5720	-30.8870	-23.9610	-0.1101	3.8439
	Tas Out	0.3757	0.3010	-0.0507	0.6494	0.3546	-7.2985	1.1767
	WA Out	0.6858	0.3883	0.0018	0.5940	0.4457	5.0171	-6.0501
	SA Out	0.6365	0.3649	0.0975	0.7976	0.5445	-6.8264	-3.8930
	Qld Out	0.6007	0.3573	0.1149	0.7693	0.4985	-6.2611	-3.6447
	Vic Out	-0.1800	0.3107	-12.4310	-6.9911	-1.6383	-7.4059	6.1448
	NSW Out	0.4889	0.2583	-0.0120	0.6454	0.3076	-6.3917	-3.6976
Average	no state dummy	-0.3928	0.3290	0.6132	1.4411	0.3563	1.9866	14.8740
	Cwlth out	1.7107	1.1556	1.2826	1.8594	1.2899	11.0540	8.5911
	Tas Out	1.2269	0.9514	1.1853	1.5969	1.0724	8.5509	12.6680
	WA Out	1.0831	0.8513	1.0438	1.8378	0.9528	2.4438	13.8400
	SA Out	0.9626	0.8866	1.0829	1.9266	1.0196	2.3756	14.7340
	Qld Out	1.0139	1.4323	1.5981	2.1592	1.6046	10.3770	9.7789
	Vic Out	1.5410	1.2896	1.3976	2.2371	1.4529	2.3842	15.3030
	NSW Out	1.3854	0.5129	0.7671	1.4326	0.5588	2.0195	15.4420

		G11	G12	G13	G14	G15	G22	G23	G24
Paasche	no state dummy	-5.9900	5.2848	2.5853	4.1023	5.2661	-0.6001	-2.9644	1.3581
	Cwlth out	-17.5880	-9.3540	-13.9520	24.1190	20.5080	23.4230	22.5230	16.7420
	Tas Out	-11.3960	1.6546	34.8960	-7.0339	4.5346	4.3454	-4.1293	-0.1723
	WA Out	-4.0128	0.3223	-0.5269	1.8738	2.5454	0.7804	-0.3254	-1.0979
	SA Out	-10.0430	5.8935	1.7779	4.6605	8.0362	-0.6719	-3.0059	1.0891
	Qld Out	-4.8328	4.1449	1.6605	3.4790	5.3740	-0.4301	-3.3742	1.2440
	Vic Out	-5.4204	0.3711	-0.9362	1.8007	3.0575	0.5428	-0.4815	-1.4179
	NSW Out	-5.3685	4.5732	1.4994	3.5082	4.6672	-0.5935	-2.8398	1.0554
Average	no state dummy	-0.8737	0.6225	-1.3329	2.1397	2.1046	-1.3613	0.8456	-0.0321
	Cwlth out	-0.1508	-0.5414	-2.0535	1.9395	1.0820	-3.1778	6.2883	-4.1466
	Tas Out	-0.1002	-0.3401	-1.1068	1.3449	0.6021	-0.8729	3.3555	-2.4796
	WA Out	-0.8872	0.7189	-2.0481	2.6070	2.7710	-1.9153	0.8509	0.0323
	SA Out	-1.2647	0.9781	-1.5407	2.5529	3.1089	-4.2600	0.9119	-0.0047
	Qld Out	-0.0980	-0.3960	-1.1461	1.4029	0.6295	-1.1687	4.2389	-3.0617
	Vic Out	-1.3451	0.9008	-1.9690	2.7886	4.3205	-3.2968	0.9899	0.0004
	NSW Out	-0.9691	0.6498	-1.5147	2.3489	2.5768	-1.4036	0.8526	-0.0142

		G25	G33	G34	G35	G44	G45	G55
Paasche	no state dummy	-3.7023	2.9599	-1.7519	0.8839	-2.4477	-3.4095	-3.4927
	Cwlth out	22.9090	29.3760	-10.5170	17.2200	-26.4290	-23.8510	-26.4680
	Tas Out	-3.2309	-50.0240	6.4480	-6.5337	-24.8700	6.7887	4.2367
	WA Out	-1.3870	-0.7828	-2.2512	0.0888	-2.0804	-2.8217	-0.3050
	SA Out	-4.1033	2.3263	-1.5348	0.6156	-2.3950	-5.1541	-4.3462
	Qld Out	-3.1222	2.7815	-1.1954	1.1987	-2.6746	-4.6822	-3.4298
	Vic Out	-1.0565	-1.0465	-3.1307	-0.7132	-4.8244	-3.3474	-0.4098
	NSW Out	-3.2791	2.0261	-1.4560	0.6919	-2.3293	-3.6663	-3.3563
Average	no state dummy	1.9982	-0.7579	-3.6143	1.4659	0.4407	-1.4847	-1.8686
	Cwlth out	1.0401	-2.5616	-6.4710	7.0514	5.2251	-1.1344	-2.1145
	Tas Out	0.7766	-1.1268	-3.8327	2.3819	3.9970	-0.7836	-2.1566
	WA Out	2.0779	-1.7851	-3.2916	1.7114	0.3437	-2.5985	-2.2004
	SA Out	3.0758	-0.9754	-3.8551	2.0072	0.3732	-1.7612	-3.0909
	Qld Out	0.8268	-1.8979	-5.6197	2.7231	4.5832	-0.7641	-2.2923
	Vic Out	3.0970	-1.3707	-3.9715	2.3473	0.4197	-1.7151	-3.6330
	NSW Out	2.1551	-1.0861	-4.0825	1.9375	0.4475	-1.7337	-2.6170

The coefficients *Ai* are the five inputs (*PINFM, PRS, PCAPM, PL, PINC*), the *Bi* coefficients are the two outputs, whilst the *Gi* coefficients are the elements of the Λ matrix from Equation Three. Cells coloured green are those which have the correct sign and are significant. Those coloured red are significant with the incorrect sign. There are no cases where all of the coefficients in a model are green. This suggests that even models which close do not actually fit the data well. It remains, then, to see if the SGM models are concave. This requires one to examine whether the *Λ* matrices from Equation Three are negative semi-definite or not, which will hold if all the eigenvalues of these matrices are zero or negative. Table Seven summarises these eigenvalues.

Table 7: Eigenvalues of McFadden Models

		Eigenvalues				
Paasche	no state dummy	-4644.020	-1019.130	807.876	224.566	-123.989
	Cwlth out	-2931.910	1295.640	1129.990	-568.826	10.149
	Tas Out	-16198.800	4891.420	-2847.710	1158.830	-307.989
	WA Out	-1873.250	-648.253	290.541	169.652	25.660
	SA Out	-1049.240	-224.170	190.634	50.047	-29.326
	Qld Out	-3107.720	-747.677	579.774	155.892	-110.243
	Vic Out	-1659.800	-851.683	280.556	135.895	30.045
	NSW Out	-1585.610	-339.200	288.759	75.931	-44.223
Average	no state dummy	-15.356	14.589	-7.255	-1.825	1.679
	Cwlth out	434.696	-261.273	-108.049	-38.644	12.870
	Tas Out	-20.288	3.288	-2.032	-0.797	-0.070
	WA Out	-27.045	21.257	-17.972	-14.744	9.489
	SA Out	-55.315	45.984	-37.565	-31.359	18.754
	Qld Out	93.300	-56.316	-23.045	-8.799	2.814
	Vic Out	-28.154	22.964	-19.089	-13.818	9.307
	NSW Out	-46.640	45.092	-36.802	-16.817	11.744

Clearly, none of the models is globally concave, so the SGM models do not perform better than the translog models either from the perspective of concavity or from the robustness of the estimation of their parameters. However, concavity can be imposed upon the SGM without sacrificing flexibility. This I do below.

In order to render the SGM model globally concave one must substitute the *Λ* matrix for $-A.A^T$, where is *A* is a lower triangular matrix. The elements of *A* are arbitrary, provided that if fulfils the relevant definiteness criteria. I choose six different matrices *A*, based upon the best performing translog models. Three of these come from the translog models in ordinary numbers form, and one from each of the three index forms. Since in the translog form, one of the factor share equations must be removed in order that the system can be reliably estimated, I had to combine models. In levels form, more of the variables were statistically significant, which is why I have three estimates based on this family of five models, and only one each from the index forms. In each case, I endeavoured to find the best coefficients; those which had the correct sign and were significant. I also tried to obtain as many as possible from a single translog model. There is no rigorous defence of why this approach was chosen to obtain elements of the *A* matrix. It is merely an attempt to base the arbitrary matrices on extant knowledge about the coefficients.

The results in terms of model closure adequacy (as measured by the $G^TH^{-1}G$ matrix) are much the same as those shown in Table Seven above in that only the Paasche and Average index models which use coefficients from the relevant translog models as starting points in the solution algorithm perform in any way adequately.

The results in terms of the significance of the parameters of each of these models are shown in Table Five. Note that, since the coefficients in the Λ matrix are fixed, there are no *Gi* results as there were in Table Six

Table 8: McFadden Models Statistical Significance – Fixed *Λ* Matrix

Fixed Sets Based on Translog Levels Models

Fixed set	Weights	Specification	A1	A2	A3	A4	A5	B1	B2
First Fixed Set	Paasche	No state dummies	0.3326	0.3393	-0.0845	0.6365	0.5279	0.0000	0.0000
		Cwlth out	0.2576	0.2970	-0.1015	0.5409	0.3033	-0.0001	0.0003
		Tas Out	0.2877	0.3262	-0.0788	0.5635	0.3426	0.0000	0.0000
		WA Out	0.3836	0.3739	0.0018	0.6696	0.5416	0.0001	-0.0001
		SA Out	0.3259	-0.5365	13.1050	4.5513	1.5757	0.0000	0.0000
		Qld Out	0.4127	0.4057	0.0386	0.6638	0.5035	0.0000	0.0000
		Vic Out	0.4015	0.4008	0.0278	0.6533	0.4821	0.0000	0.0000
		NSW Out	0.7462	-1.1402	21.8570	6.9373	1.9856	0.0043	-0.0061
	Average	No state dummies	0.3796	0.3750	0.5097	1.2468	0.3867	-0.5058	-2.7137
		Cwlth out	1.0177	1.0697	1.0928	1.9405	1.2359	0.4806	2.6721
		Tas Out	0.8679	0.9013	0.9246	1.6536	0.9862	0.4873	2.7391
		WA Out	0.8708	0.8877	0.9445	1.7027	1.0006	0.5038	2.6285
		SA Out	0.8548	0.8888	0.9503	1.6858	0.9926	0.5001	2.6936
		Qld Out	1.2624	1.2956	1.3258	2.0447	1.4476	0.4756	2.8074
		Vic Out	1.2332	1.2615	1.2605	2.0044	1.4113	0.4904	2.6683
		NSW Out	0.5881	0.5837	0.6758	1.2717	0.6180	-0.4947	-2.7217
Second Fixed Set	Paasche	No state dummies	0.3353	0.3470	-0.0850	0.6422	0.5107	-0.0001	0.0005
		Cwlth out	0.2598	0.3027	-0.0994	0.5272	0.3081	0.0000	0.0000
		Tas Out	0.3035	0.3380	-0.0817	0.5673	0.3591	0.0000	0.0000
		WA Out	0.3851	0.3893	0.0018	0.6745	0.5189	0.0000	0.0000
		SA Out	0.4245	0.4138	0.0284	0.7007	0.5820	-0.0002	0.0004
		Qld Out	0.4169	0.4122	0.0383	0.6835	0.5162	0.0000	0.0000
		Vic Out	0.3895	0.3979	0.0274	0.6590	0.4759	0.0000	-0.0001
		NSW Out	0.2860	0.3156	-0.0897	0.5475	0.3110	0.0002	-0.0004
	Average	No state dummies	0.3845	0.3672	0.5078	1.2463	0.3774	0.5885	2.7132
		Cwlth out	1.0336	1.0604	1.0983	1.9464	1.2762	0.6085	3.0172
		Tas Out	0.8384	0.8616	0.9062	1.6827	0.9851	0.5995	2.9855
		WA Out	0.8953	0.9000	0.9436	1.6712	1.0016	0.6048	2.8150
		SA Out	0.8907	0.9074	0.9705	1.7078	1.0242	0.6406	2.8767
		Qld Out	1.2627	1.2708	1.2763	2.0580	1.4288	0.6207	2.9301
		Vic Out	1.2334	1.2615	1.2404	2.0004	1.3990	0.6024	2.9692
		NSW Out	0.5814	0.5807	0.7036	1.2753	0.6065	0.5882	2.9610
Third Fixed Set	Paasche	No state dummies	-0.4160	32.8870	-36.222	-38.707	-21.270	0.0432	-0.0815
		Cwlth out	0.2536	0.2864	-0.1015	0.5337	0.3047	0.0001	-0.0002
		Tas Out	0.2823	0.3213	-0.0830	0.5902	0.3513	-0.0003	0.0004
		WA Out	0.3803	0.3770	0.0018	0.6795	0.5193	0.0000	0.0000
		SA Out	0.4261	0.4293	0.0280	0.7255	0.5691	0.0000	0.0000
		Qld Out	0.3936	0.3998	0.0366	0.6897	0.4904	0.0000	0.0000
		Vic Out	0.3713	0.3997	0.0242	0.6050	0.4357	-0.0074	0.0070
		NSW Out	0.2791	0.3035	-0.0889	0.5462	0.3226	-0.0001	0.0001
	Average	No state dummies	0.3819	0.3717	0.5005	1.2729	0.3839	0.6838	2.4393
		Cwlth out	1.0574	1.0741	1.0724	1.8811	1.2357	-0.7146	-2.6158
		Tas Out	0.8625	0.8606	0.9391	1.6845	0.9901	0.7205	2.5129
		WA Out	0.8821	0.8922	0.9360	1.6857	0.9916	-0.7371	-2.4065
		SA Out	0.8757	0.9003	0.9440	1.6809	0.9897	-0.7241	-2.4446
		Qld Out	1.3233	1.3553	1.3052	2.0943	1.4675	0.6935	2.4096
		Vic Out	1.2182	1.2398	1.2406	1.9849	1.3641	0.6870	2.4734
		NSW Out	0.6008	0.5942	0.6742	1.2652	0.6250	0.7067	2.3466

Fixed Sets Based on Translog Index Models

Fixed set	Weights	Specification	A1	A2	A3	A4	A5	B1	B2
First Fixed Set	Paasche	No state dummies	0.3262	0.3369	-0.0855	0.6393	0.5087	0.0000	0.0000
		Cwlth out	0.2671	0.3065	-0.1047	0.5776	0.3185	0.0000	0.0000
		Tas Out	0.2949	0.3237	-0.0793	0.5844	0.3697	-0.0001	0.0001
		WA Out	0.3939	0.3876	0.0018	0.6833	0.5344	-0.0010	0.0011
		SA Out	0.3005	-0.7108	10.5350	4.3318	1.5360	0.0000	0.0000
		Qld Out	0.4000	0.3860	0.0372	0.6648	0.5000	0.0000	0.0000
		Vic Out	0.3996	0.3991	0.0283	0.6631	0.4970	0.0000	0.0000
		NSW Out	0.2767	0.3077	-0.0908	0.5606	0.3157	-0.0001	0.0001
	Average	No state dummies	0.3981	0.3390	0.5114	1.1443	0.3031	1.2988	1.5508
		Cwlth out	1.0880	1.0782	1.0942	1.9190	1.2507	1.3551	3.1162
		Tas Out	0.8986	0.8806	0.9178	1.6584	0.9845	-1.3719	-3.2284
		WA Out	0.8932	0.8927	0.9720	1.7297	1.0266	-1.3275	-3.2129
		SA Out	0.8799	0.8711	0.9477	1.6718	0.9977	1.3849	3.1427
		Qld Out	1.2861	1.3031	1.3134	2.0421	1.4783	1.3549	3.1939
		Vic Out	1.2630	1.2595	1.2512	2.0262	1.4005	1.3641	3.1491
		NSW Out	0.5969	0.5717	0.6911	1.2643	0.6360	-1.4050	-3.1757
Second Fixed Set	Paasche	No state dummies	-10.379	34.0440	-32.899	-41.722	-33.498	-0.5708	0.6379
		Cwlth out	-0.3756	2.6227	-43.709	-15.268	-10.281	0.7288	-0.8198
		Tas Out	1.0183	5.8400	-52.562	-18.127	-33.818	-1.1974	1.4685
		WA Out	0.3887	0.3746	0.0014	0.6756	0.5244	0.4911	-0.5306
		SA Out	0.4315	0.4432	0.0286	0.7190	0.5570	0.5277	-0.5726
		Qld Out	0.4187	0.4133	0.0393	0.6749	0.4885	0.5028	-0.5465
		Vic Out	0.4066	0.3854	0.0290	0.6501	0.4810	0.4913	-0.5333
		NSW Out	0.3195	-0.6481	14.6960	4.9128	1.6631	0.7115	-0.8104
	Average	No state dummies	0.3737	0.3692	0.4973	1.2299	0.3761	0.6005	2.1605
		Cwlth out	1.0163	1.0216	1.0630	1.9110	1.1682	0.6427	2.1854
		Tas Out	0.8295	0.8456	0.9319	1.6676	0.9635	0.6037	2.1836
		WA Out	0.8649	0.8762	0.9323	1.6522	0.9817	0.5918	1.9923
		SA Out	0.8776	0.9075	0.9696	1.7288	1.0111	0.6112	2.1626
		Qld Out	1.2749	1.3237	1.2857	2.0504	1.4441	0.6101	2.1101
		Vic Out	1.2077	1.2371	1.2512	2.0035	1.3645	0.6174	2.1678
		NSW Out	0.5764	0.5845	0.6633	1.2667	0.6097	-0.6112	-2.1788
Third Fixed Set	Paasche	No state dummies	0.3539	0.3669	-0.0920	0.6393	0.5017	-1.1120	1.3152
		Cwlth out	0.2991	0.3207	-0.0997	0.5458	0.2997	-1.0345	1.2448
		Tas Out	0.3181	0.3618	-0.0866	0.5522	0.3245	-1.0539	1.2558
		WA Out	0.4277	0.4050	-0.0040	0.6660	0.5027	-1.0610	1.2611
		SA Out	0.4663	0.4369	0.0296	0.7133	0.5580	1.0676	-1.2902
		Qld Out	0.4335	0.4311	0.0417	0.6752	0.4892	-1.0393	1.2490
		Vic Out	0.4373	0.4100	0.0315	0.6474	0.4716	-1.0863	1.3187
		NSW Out	0.3107	0.3162	-0.0858	0.5437	0.3028	-1.0840	1.2946
	Average	No state dummies	0.3797	0.3694	0.5001	1.2683	0.3829	-0.6920	-2.3500
		Cwlth out	1.0460	1.0558	1.0055	1.8182	1.1984	0.7211	2.3736
		Tas Out	0.8340	0.8421	0.8916	1.5913	0.9569	-0.7056	-2.3215
		WA Out	0.8786	0.9019	0.9450	1.6735	1.0087	-0.6802	-2.2252
		SA Out	0.9046	0.9183	0.9959	1.7469	1.0293	-0.7089	-2.3638
		Qld Out	1.3277	1.2989	1.2914	2.0960	1.4258	0.6817	2.2609
		Vic Out	1.2419	1.2681	1.2654	2.0463	1.4017	0.6893	2.3134
		NSW Out	0.5885	0.5864	0.6936	1.2082	0.6151	0.7050	2.2753

The 48 models presented here perform far worse than their counterparts where the Λ matrix was not fixed. There are no versions of the model where more than a handful of coefficients are both significant and have the same sign. That is not to say that it is not possible to find a lower-triangular matrix *A* such that the SGM model is both globally concave and has coefficients which conform to the theory behind the model. However, it does seem that finding this matrix might be very difficult. Overall, therefore, the SGM appears to have little to recommend it, compared with the translog, for this dataset.

Model Implications

To explore some of the implications of the models, I look at economies of density, scale and scope. I then explore the long run marginal cost in some detail, as this is of importance to economic regulators. In this section, I use the three best performing models from the previous section, detailed in Tables Two and Three.

The literature on railway cost functions has been characterised by a distinction between economies of scale and economies of density. Oum & Waters (1996) make the distinction between the two measures thus:

$$RTD = \frac{1}{\sum_{i=1}^{m} \varepsilon_{Y_i}^{C}} \quad (5) \qquad\qquad RTS = \frac{1}{\sum_{i=1}^{m} \varepsilon_{Y_i}^{C} + \varepsilon_{Y_i}^{N}} \quad (6)$$

Where RTD refers to returns to density, RTS to returns to scale, $\varepsilon_{Y_i}^{C}$ to the elasticity of the cost function with respect to each of the outputs, and $\varepsilon_{Y_i}^{N}$ to the elasticity of the cost function with respect to network size. In the models above, I do not include a variable for the quasi-fixed cost input of the network, but rather incorporate density directly into the cost function (see coefficient *G3*).

The returns to density from the model in Table Two is 3.1407 (0.0010), whilst the two models in Table Three have returns to density of 3.8373 (0.0010) and 4.2626 (0.0019).[1] All are larger than one, which suggests considerable economies of density in Australia's railways throughout the 20th Century. This, in turn, suggests rather under-used track capacity, a finding alluded to previously. It remains important today because, absent of certain bottlenecks, it suggests that Australia's railways could expand quite substantially before economies of density are exhausted and track capacity needs to be expanded.

In order to estimate returns to scale, it is necessary to re-estimate these models, using network size, rather than density as a technical variable. Since these re-estimations are not directly comparable to the models above, I re-calculate returns to density as well. Note that I have implicitly assumed here that the three models performing best with density as a technical variable will also be the three which perform best with network size in its place. The results are presented in Table Nine. Note that the figures in brackets are the variances associated with the relevant numbers.

[1] The numbers in the brackets are the variances of the estimates.

Table 9: Economies of Density and Scale (Route km Model)

Model		*Density*	*Scale*
Ordinary Numbers Translog Results – PL Removed		3.9473 (0.1431)	0.6222 (0.1431)
Paasche Index Form Translog Results – PRS Removed	Coefficient Start Points = 1	4.6979 (0.0033)	1.2303 (0.0033)
	Coefficient Start Points = Translog Levels Results	4.6979 (0.0033)	1.2303 (0.0033)

Here, the economies of density are even more pronounced than is the case in the models presented in Tables Two and Three. The more interesting result, though, is that for economies of scale. The ordinary numbers results suggest declining economies of scale, whilst the Paasche index models both suggest increasing returns to scale. It is not clear what to make of this anomaly; certainly the Paasche results would be more in line with the existing literature and, given that they are based upon models where the concavity is much better, they would appear to be the more believable results. Thus, it would seem that the Australian railways are subject to increasing returns to scale; meaning they could reduce their costs by both expanding track and increasing output.

As suggested by Baumol, Panzar & Willig (1988) economies of scope exist when the costs of producing two outputs together is less than the sum of the costs of producing them separately. That is:

$$C(Y_1, Y_2) < \{C(Y_1, 0) + C(0, Y_2)\} \qquad (7)$$

In order to assess this, one must evaluate the above function at every data point, including points where output is zero for one or the other of the outputs. Unfortunately, very few railways produce zero of either output, and they do not do so in the dataset used in this paper either. This means that estimates of the cost of producing some of one output and zero of the other are unlikely to be very accurate. Thus, as Oum & Waters (1996) point out, very few analysts actually calculate economies of scope in this fashion, at least in transport economics. Instead, most use inter-product cost complementarity, which is the second cross derivative of the outputs with respect to the cost function. That is:

$$\frac{\partial^2 C}{\partial Y_i \partial Y_j} \qquad (8)$$

If this is less than zero, then cost complementarity exists between the outputs, which is suggestive of economies of scope, albeit over a narrower range of outputs. Here, the derivative will simply be the B_{ij} terms from Tables Two and Three. The first of these B_{ij} terms is statistically significant, whilst the latter two are not. These are summarised in Table Ten.

Table 10: Cost Complementarities

Model		B_{ij}
Ordinary Numbers Translog Results – PL Removed (Table Two)		-0.0342
Paasche Index Form Translog Results – PRS Removed (Table Three)	Coefficient Start Points = 1	-0.5516
	Coefficient Start Points = Translog Levels Results	-0.0048

The results suggest that there are indeed cost complementarities, and hence that economies of scope are also likely. However, the rather small size of the statistically significant result suggests that such economies are likely to be small. The result is interesting, however, for it suggests that Australia's railways were less costly when they produced passenger and freight services together. In the 1990s, reform many states implement horizontal separation, mainly to separate the generally unprofitable, subsidised passenger rail sector from the potentially profitable, largely unsubsidised freight sector. This policy decision can be supported on the basis of revenues and profits, but it is likely to have increased the costs of the relevant railways according to the results of the models presented here.

Calculating LRMC - Implications for Regulatory Models

Regulators commonly use a model for determining prices (in Australia, of rail access) which seek to replicate the costs of an efficient operator. Although the regulators routinely refer to long-run marginal costs in their determinations, they are in fact calculating average costs. That is, they take the projected costs of the (efficient benchmark of the) railway over a time period, including operating and capital costs and divide it by the expected future demand. This is not the same as estimating a cost function like those estimated above and taking its derivative, which is the correct way to determine marginal cost.

This matters because, in general, marginal cost curves are U-shaped. As marginal costs decrease, average costs will generally be above marginal costs, with the converse being true when marginal costs are increasing. They will only be equal at the minimum of the average cost curve.[2] Thus, depending upon the level of projected output, the regulator might over or understate its marginal cost estimates. If it understates marginal cost, then the regulated firm will not be able to cover its costs, and will reduce output. If the regulator overstates marginal costs, then the regulated firm will recover its costs, but pricing may be inefficient, and could be improved by properly estimating marginal costs, and then allowing the firm to recover the difference between marginal and average costs via a fixed fee. If, however, marginal costs are flat, the average costs will equal marginal costs at every output level, rather than just at the minimum, and then the proxy for marginal costs used by regulators will in fact be accurate.

In order to explore this further, I take the derivative of three of my translog cost functions, those shown in Tables Two and Three. I then use the data (input prices, output levels and technical variables) to make 592 point estimates of long-run marginal costs;

[2] Whilst regulators assume an optimal asset base and operating costs, they do not assume optimal output when determining price, but rather make assumptions about likely output over the coming regulatory period. Thus, price caps will generally not correspond with the minimum of the average cost curve.

one for each year of observation for each railway in the sample set. I then plot these point estimates against the relevant data on freight output, and fit a quadratic trend-line to the resulting scatter plots. I did not use a linear trend-line for the obvious reason that I would like to pick out any minima which exist. The results are shown in Figures One through Three.

Figure 1: LRMC Plot – PL Out, Levels Model

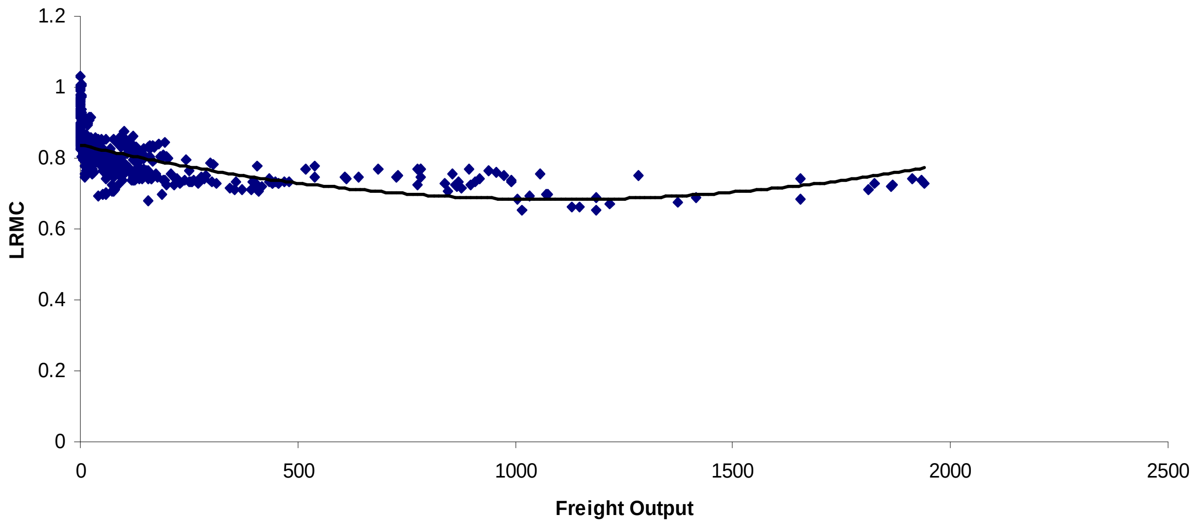


Figure 2: LRMC Plot – PRS Out, Paasche Model, Ones Start Point

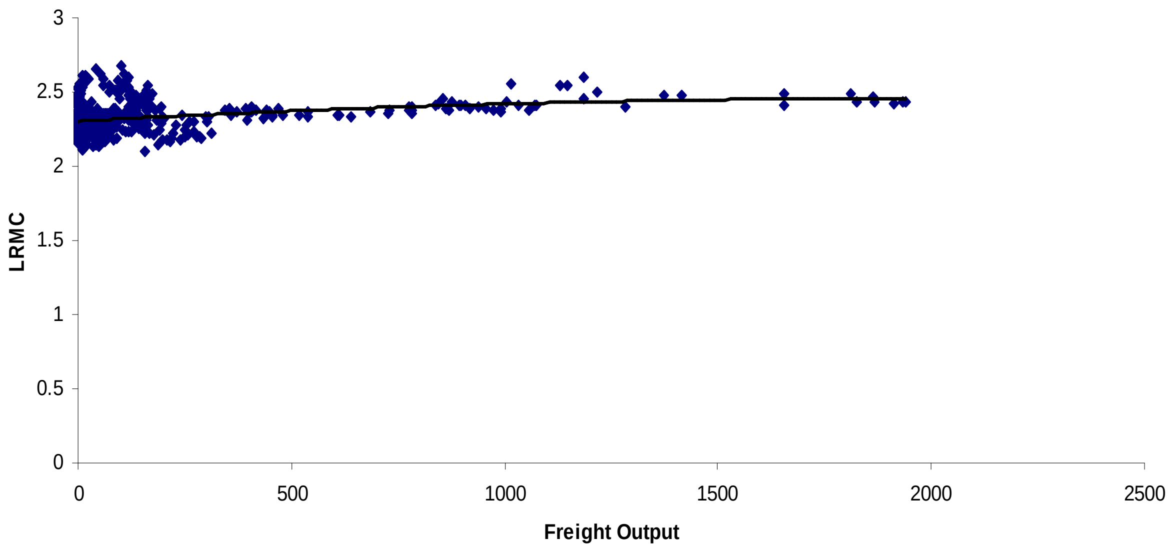
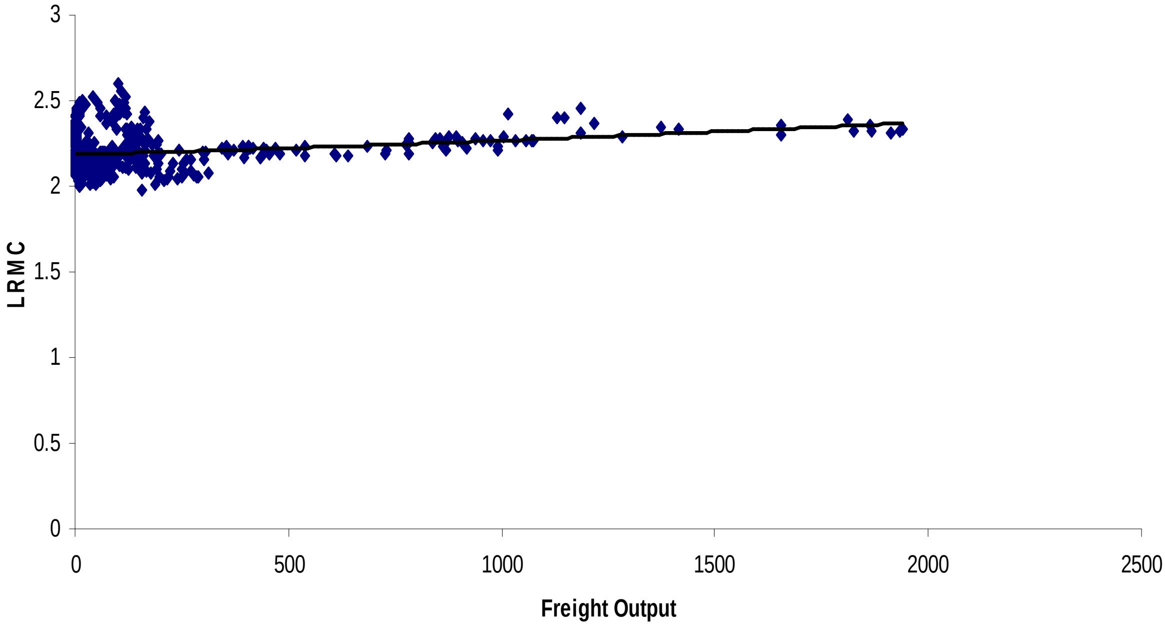


Figure 3: LRMC Plot – PRS Out, Paasche Model, Levels Results Start Point



Of these three, the two based upon the Paasche index suggest that long-run marginal costs are in fact roughly flat, which would suggest that the approach commonly used by regulators, although theoretically incorrect, gives results which are roughly correct. Figure One, however, based upon the ordinary numbers model, gives the familiar long run marginal cost curve, and suggests that the regulatory approach might give erroneous results. Moreover, since the minimum of the long-run marginal cost curve is much lower than current levels of rail output, it suggests that current pricing methodologies are unlikely to give railways sufficient revenues to recover their marginal costs, and also give prices that are inefficiently low.

Two caveats need to be made in relation to these three figures. The first is the obviously very large error band around each of the curves. In particular, most of the observations are bunched down around lower levels of output, and is it not clear how valid projections outward are. This is important as the outputs of railways today are generally larger than the historical figures used here.

A more important caveat is, of course, that Australian regulators do not regulate the price of rail services, but rather control the price of access to track. The models above do not provide any information on the marginal costs of providing below-rail services, for the obvious reason that there were no providers of these services on a stand-alone basis in the period under analysis, and it is generally not possible to separate out such costs from a model of an integrated railway. Thus, even though the marginal cost curve of an integrated railway might be flat (or curved), it is not necessarily the case that below rail services would have the same cost curve if operated on a stand-alone basis.

Conclusions

This paper has utilised a unique dataset to explore cost functions for Australia's railways through the 20th Century. It finds, overall, that translog cost functions give the best results, but there are clearly still some issues, most particularly associated with the treatment of below-rail capital. This might be ameliorated by utilising a more comprehensive cost-function estimation approach, whereby a short-run cost function is first estimated, and the long-run function is estimated from the envelope of the short-run, as in Keeler (1974). Such an extension would make for useful future work, as would changing the specification of inputs, to include more variety, perhaps through an hedonic approach such as that used by DeBorger (1991) and Mizutani (2004.

However, as a first pass, this paper delivers some interesting results. It highlights the importance of both fixed capital and labour to railway costs, and the relative equality of freight and passenger traffic in terms of their impact on costs. It also highlights some shortcomings in available data, particularly in relation to fixed capital accounting; a fact which is anecdotally well-known in the industry. The results for economies of density suggest that there is considerable scope for expansion of above-rail services on Australia's rail track infrastructure, but these aggregate figures do not take into consideration the impacts of bottlenecks. The results for economies of scope suggest that any decision to horizontally separate freight from passenger services could be based on revenue and profit considerations, but not on cost; separation actually makes both more costly to provide. The economies of scale results are somewhat ambiguous, but the more reliable models from the concavity perspective would seem to point towards increasing returns to scale.

Finally, calculation of long run marginal cost in a theoretically correct manner, apart from indicating that it can be done relatively easily, highlights the potential consequences of errors in the approach commonly used by regulators of proxying marginal costs with average costs. There are some indications from the work herein, that regulatory practices may in fact have lead to prices which are inefficiently low in the railway industry. There is therefore some utility in regulators developing models like those presented here to calculate long run marginal cost, rather than relying upon average cost models.

Bibliography

Baumol, W.J., Panzar, J.C. and Willig, R.D. (1988), *Contestable Markets and the Theory of Industry Structure*, San Diego: Harcourt Brace Jovanovich

Bitzan, J.D. (2000), *Railroad Cost Conditions: Implications for Policy*, Paper prepared for the Federal Railroad Administration, US Dept of Transportation, mimeo.

Bitzan, J.D. (2003), 'Railroad Costs and Competition: The Implications of Introducing Competition to Railroad Networks', *Journal of Transport Economics and Policy*, **37** 201-25.

Bitzan, J.D. and Keeler, T.E. (2003), 'Productivity Growth and Some of its Determinants in the Deregulated US Railroad Industry', *Southern Economic Journal*, **70(2)** 232-53.

Bitzan, J.D. and Keeler, T.E. (2007), 'Economies of Density and Regulatory Change in the US Railroad Freight Industry', *Journal of Law and Economics*, **50** 157-79.

Borts, G.H. (1952)'Production Relations in the Railway Industry', *Econometrica*, **20(1)** 71-79. .
Borts, G.H. (1954), 'Increasing Returns in the Railway Industry', *Journal of Political Economy*., **62(3)** 316-33.
Borts, G.H. (1960), 'The Estimation of Rail Cost Functions', *Econometrica*, **28(1)** 108-31.
Braeutigam, Daughety, A.F. and Turnquist, M.A. (1982), 'The Estimation of a Hybrid Cost Function for a Railroad Firm', *Review of Economics and Statistics*, **64(3)** 394-404.
Braeutigam, R.R., Daugherty, A.F. and Turnquist, M.A. (1984), 'A Firm-Specific Analysis of Economies of Density in the US Railroad Industry', *Journal of Industrial Economics*, **33(1)** 3-20.
Breusch, T.S. and Pagan, A.R. (1979), 'A Simple Test for Heteroscedasticity and Random Coefficient Variation', *Econometrica,* **47** 1287-94.
Bureau of Transport and Regional Economics (BTRE) (2006) *Freight Measurement and Modelling in Australia,* Report no 112, Canberra: BTRE.
Caves, D.W., Christiansen, L.R., and Swanson, J.A. (1980), 'Productivity Growth in U.S. Railroads', *Bell Journal of Economics,* **11(1)**166-81.
Caves, D.W., Christensen, L.R. and Swanson, J.A. (1981a), 'Productivity Growth, Scale Economies, and Capacity Utilization in US Railroads, 1955-74', *American Economic Review*, **71(5)** 994-1002.
Caves, D.W., Christiansen, L.R., and Swanson, J.A. (1981b)"Economic Performance in Regulated and Unregulated Environments: A Comparison of U.S. and Canadian Railroads," *Quarterly Journal of Economics*, **96(4)** 559-81.
Caves, D.W., Christensen, L.R. and Tretheway, M.W. (1980), 'Felxible Cost Functions for Multiproduct Firms', *Review of Economics and Statistics*, **62(3)** 477-81.
Caves, D.W., Christiansen, L.R., Trethaway M.W. and Windle, R.J. (1985) 'Network Effects and the Measurement of Returns to Scale and Density for US Railroads', in Daugherty, A.F. (ed) *Analytical Studies in Transport Economics,* Cambridge: Cambridge University Press.
Christensen, L.R. Jorgenson, D.W. and Lau, L.J. (1973), 'Transcendental Logarithmic Production Functions', *Review of Economics and Statistics,* **55** 28-45.
Christopolous, D., Loizides, J. and Tsionas, E.G. (2001), 'Efficiency in European Railways: Not as inefficient as one might think', *Journal of Applied Economics,* **4(1)** 63-88.
Clark, J.M. (1923), *Studies in the Economics of Overhead Costs,* Chicago Ill: University of Chicago Press.
Crafts, N. Leunig, T. and Mulatu, A. (2008), 'Were British Railways Well Managed in the Early Twentieth Century?', *Economic History Review*, **61(4)** 842-66.
DeBorger, B. (1991), 'Hedonic Versus Homogenous Output Specfications of Railroad Technology: Belgian Railroads 1950-1986', *Transportation Research A*, **25A(4)**, 227-38.
Diewert, W.E. and Wales, T.J (1987), 'Flexible Functional Form and Global Curvature Conditions', *Econometrica,* **55(1)** 43-68.
Friedlaender, A.F, Berndt, E.R., Shaw-Er Wang Chiang, J., Showalter, M. and Vellturo, C.A. (1993), 'Rail Costs and Capital Adjustments in a Quasi-Regulated Environment', *Journal of Transport Economics and Policy*, May 1993, 131-52.

Friedlander A.F & Spady, R. (1981) *Freight Transport Regulation*. Boston Mass: MIT Press.
Hensher, D.A. Daniels R. and DeMellow, I. (1995), 'A Comparative Assessment of the Productivity of Australia's Public Rail Systems 1971/72-1991/92', *The Journal of Productivity Analysis*, **6** 201-23.
Ivaldi, M. and McCullough, C.J. (2001), 'Density and Integration Effects on Class 1 US Freight Railroads', *Journal of Regulatory Economics*, **19** 161-82.
Ivaldi, M. and McCullough, G.J. (2006) *Welfare Tradeoffs in US Rail Mergers*, IDEI Working Paper no344, March 2005, http://idei.fr/doc/pap/2005/ivalid.pdf
Ivaldi, M. and McCullough, G.J. (2006), *Subadditivity Tests for Network Separation with an Application to US Railroads*, SSRN Working Paper 528542, http://ssrn.com/abstract=528542.
Keeler, T.E. (1974), 'Railroad Costs, Returns to Scale, and Excess Capacity', *Review of Economics and Statistics*, **56(2)** 201-8.
Klein, L.R. (1953), *A Textbook on Econometrics*, Evanston Ill: Row, Peterson & Co.
Kumbhakar, S.C. (1994), 'A Multiproduct Symmetric Generalized McFadden Cost Function', *Journal of Productivity Analysis*, **5** 349-57.
Lau L.J. (1986), 'Functional Forms in Econometric Model Building', in Griliches, Z. and Intriligator, M.D. (eds), *Handbook of Econometrics: Vol III*, Amsterdam: North Holland.
Lorenz, M.O. (1916), 'Cost and Value of Service in Rail- road Ratemaking', *Quarterly Journal of Economics*. **30(1)** 205-32.
McFadden, D.L. (1978), 'Cost, Revenue and Profit Functions' in McFadden, D.L & Fuss, M. (eds), *Production Economics*, Amsterdam: North Holland.
Mills, J.A. and Wills-Johnson, N.B. (2008) *Determinants of Australian Rail Productivity in the 20th Century*, Available at SSRN: http://ssrn.com/abstract=1309852
Mizutani, F. (2007), 'Privately Owned Railways' Cost Function, Organization Size and Ownership', *Journal of Regulatory Economics*, **25(3)** 297-322.
Oum, T.H. and Waters, W.G. (1996) 'A Survey of Recent Developments in Transportation Cost Function Research', *Logistics and Transportation Review*, **32(4)** 423-63.
Ripley, W.Z. (1912), *Railroads: Rates and regulation*, New York: Longmans Press.
Sauer, J., Frohberg, K. and Hockmann, H. (2004) *Black Box Frontiers and Implications for Development Policy – Theoretical Considerations*, Centre fro Development Research (ZEF), Bonn University Discussion Paper 92, available from www.zef.de
SHAZAM (2004), *User's Reference Manual Version 10*, Northwest Econometrics, Vancouver.
Spady, R. (1979), *Econometric Estimation for the Regulated Transportation Industries*, New York: Garland Press.
Terell, D. (1996), 'Incorporating Monotonicity and Concavity Conditions in Flexible Functional Forms', *Journal of Applied Econometrics*, **11(2)** 179-94.
Waters, W.G. (2007), 'Evolution of Railroad Economics', *Research in Transportation Economics*, **20** 11-67.
Wellington, A.M. (1887), *The Economic Theory of the Location of the Railways*, New York: John Wiley & Sons.

Wills-Johnson, N.B. (2008), 'Separability and Subadditivity in Australian Railways', *Economic Record*, **84(264)** 95-108
Wilson, W.W. (1997), 'Cost Savings and Productivity in the Railroad Industry', *Journal of Regulatory Economics*, **11** 21-40.
Winston, C. (1985), 'Conceptual Developments in the Economics of Transportation: An interpretive survey', *Journal of Economic Literature*, **23(1)** 57-94.
Zellner, A. (1962), 'An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests of Aggregation Bias', *Journal of the American Statistical Association*, **57** 500-09