Promoting technological investment in the Australian rail freight sector: evaluating the feasibility of accelerated depreciation

Nattawoot Koowattanatianchai

Southern Cross University

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PROMOTING TECHNOLOGICAL INVESTMENT IN THE AUSTRALIAN RAIL FREIGHT SECTOR: EVALUATING THE FEASIBILITY OF ACCELERATED DEPRECIATION

Nattawoot KOOWATTANATIANCHAI

A thesis
Submitted to the Southern Cross University
in partial fulfilment of the requirements for the degree of

Doctor of Business Administration
STATEMENT OF ORIGINAL AUTHORSHIP

I certify that the substance of this thesis has not been submitted either in whole or in part for any degree.

I also certify that to the best of my knowledge and belief, that any help received in preparing this thesis and all sources used have been acknowledged.

Signature: ____________________________

Nattawoot KOOWATTANATIANCHAI

Date: _______________________________

January 1, 2011
For Mum and Dad
ACKNOWLEDGMENTS

Many incidents delayed the completion of this thesis, most of which was my inability to stay away from basketball and associating with my good friends; especially Apichai, Sutket, Jo, Junior, June, Gibsy, Tik, Mo, To, David, Ryota, Jonathan, and Pear. I must specially thank them for their love and support.

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I would like to thank Ian especially for his assistance in the development of the extended asset replacement model. His expertise in finance and accounting also facilitated my collection of the relevant literature.

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Special thanks to Mom and Dad who have been significantly involved in my upbringing and education to date. This thesis is dedicated to both of them.
ABSTRACT

Although regulation for emissions, pollution, etc., is becoming stricter, the Australian rail freight industry is still locked in to using large numbers of existing rolling stock, e.g., locomotives and wagons. Much of this rolling stock is no longer efficient. Largely as a result of infrastructure constraints, it is not feasible for operators to dispense with their old technology at regular intervals, even though they will need to pay more to use older technology if a carbon price eventuates.

This thesis seeks to ascertain the viability of promoting investment incentives for newly acquired locomotives, wagons and other equipment. It analyses the impact of an accelerated depreciation scheme on the investment behaviour of above-rail operators and offers a comparison with alternative incentives or mechanisms. These schemes, if their efficacy is demonstrated, could potentially provide tools to encourage re-equipment of the aging rail fleet and facilitate the provision of sustainable rail freight growth in Australia.

A three-stage sequential mixed methods approach was designed to investigate the investment implications of accelerated depreciation in the rail freight sector. In the first stage, an in-depth interview technique was employed to contextualise the rolling stock replacement decisions among rail freight firms. In the second stage, an extended asset replacement model exclusively was developed to examine whether accelerated depreciation and other tax concessions could significantly reduce the optimal time to replace rolling stock in the Australian rail freight industry. In the final stage, a focus group technique was applied to examine the findings from the first two stages and provide in-depth expert assessments of their implications.

This thesis concludes that accelerated depreciation alone is unlikely to be sufficient to assure a desired level of investment in cleaner technologies. The scheme should be part of a whole suite of initiatives to stimulate investment, and should not be the primary mechanism. The main obstacle is the incompatibility between the existing below-rail infrastructure in Australia and the modernised above-rail equipments. This implies that even though accelerated depreciation successfully offers them the incentive to replace their old fleets with newly acquired rolling stock, it is impossible, for example, to run the new train on the existing track.
Improving the below-rail infrastructure therefore has been identified as the only way to ensure the ongoing sustainability of the rail freight sector in terms of overall energy efficiency. Nevertheless, upgrading the infrastructure is a difficult task. To encourage greater energy efficiency within the rail freight sector in the short term, some other instantaneous initiatives should be provided. A two-pronged approach to energy efficiency in the rail freight sector has been proposed. In particular, some incentives to buy new equipment combined with a ‘cash for clunkers’ scheme with a refurbishment option to make existing assets more energy efficient are needed to deliver appropriate outcomes in the short term. Incentives aimed at buying new equipment are particularly crucial for regions where the rail networks have already been upgraded to suit modern energy-efficient equipment, whereas programs targeting the refurbishing of older assets are necessary for track that is not suitable for modern equipment, which is generally heavier than the older equipment.

Apart from its implications for managerial practices within the rail freight sector and implications for policies pertaining to rail freight operation, another major highlight of this thesis is the derivation of the extended asset replacement model under taxation, inflation, and technological progress environment. The novelty of this model is its comprehensiveness. The effects of technological advancement, taxes, and inflation have been analysed by previous replacement studies. The literature, however, indicates that these three factors have not been incorporated into the replacement model simultaneously. This thesis also makes a significant contribution to the research methodology in finance. Combining a qualitative method and a quantitative approach, or in other words, using mixed methods in finance has not proved to be very popular. This thesis shows that it is justifiable in instances where the likelihood of a policy being useful to stakeholders is being assessed, and where the context of the policy and the context of the area in which it is applied are important.
A paper relating to the research in this thesis has been presented at the following refereed conference:


A paper relating to the research in this thesis has been published in the following refereed industry report:

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## LIST OF ABBREVIATIONS AND ACRONYMS

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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ACRS</td>
<td>Accelerated Recovery System</td>
</tr>
<tr>
<td>ADR</td>
<td>Asset Depreciation Range</td>
</tr>
<tr>
<td>ARA</td>
<td>Australasian Railways Association</td>
</tr>
<tr>
<td>ARTC</td>
<td>Australian Rail Track Corporation</td>
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<tr>
<td>ATO</td>
<td>Australian Taxation Office</td>
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<tr>
<td>BIE</td>
<td>Bureau of Industry Economics</td>
</tr>
<tr>
<td>BTRE</td>
<td>Bureau of Transport &amp; Communications Economics</td>
</tr>
<tr>
<td>btkm</td>
<td>billion tonne kilometres</td>
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<tr>
<td>CEO</td>
<td>Chief Executive Officer</td>
</tr>
<tr>
<td>CFO</td>
<td>Chief Financial Officer</td>
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<tr>
<td>CPRS</td>
<td>Carbon Production Reduction Scheme</td>
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<tr>
<td>DCC</td>
<td>Department of Climate Change</td>
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<tr>
<td>EBS</td>
<td>Environmental Benefit Scheme</td>
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<td>ETS</td>
<td>Emission Trading Scheme</td>
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<tr>
<td>IE Aust</td>
<td>Institution of Engineers, Australia</td>
</tr>
<tr>
<td>IRR</td>
<td>Internal Rate of Return</td>
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<tr>
<td>LCC</td>
<td>Lifecycle Costing</td>
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<tr>
<td>MACRS</td>
<td>Modified Accelerated Recovery System</td>
</tr>
<tr>
<td>NPV</td>
<td>Net Present Value</td>
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<tr>
<td>NSW</td>
<td>New South Wales</td>
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<tr>
<td>NTC</td>
<td>National Transport Commission</td>
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<tr>
<td>ntk</td>
<td>net tonne kilometres</td>
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<td>PSC</td>
<td>Project Steering Committee</td>
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<tr>
<td>PV</td>
<td>Present Value</td>
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<td>QR</td>
<td>Queensland Rail</td>
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CHAPTER 1

INTRODUCTION

1.1 Overview
This thesis seeks to determine the viability of accelerated depreciation as a means to provide incentives for rail freight operators to invest in more efficient and environmentally friendly technology. This chapter sets the overall theme of this thesis. I begin with a discussion about the background of this research. Following this, its objectives, justifications, methodology, potential limitations, and structure are outlined.

1.2 Research Background
1.2.1 The challenge
Integrating sustainability into Australia’s transport systems is especially important in the face of concerns regarding potential climate change policy, ensuring energy security, and realising a low-carbon future. Economic development must be undertaken in an environmentally sustainable way, while taxes should provide a means of improving environmental amenity through the incentives that they create. There are opportunities for government to replace existing tax regimes with more targeted taxes that will promote the efficient use of transport networks such as rail and reduce the social costs of motoring such as particulate air pollution, greenhouse gas emissions, noise, and road accidents, in addition to ongoing damage to publicly funded roads.

The Australian transport task is expected to continue to grow strongly over the next 20 years. The National Transport Commission (NTC) paper “Twice the Task” predicts that freight transport demand will grow in volume from 375 billion tonne kilometres (btkm) in 1999-2000 to 648 btkm by 2020 (NTC, 2008a). Rail has been steadily losing market share in the area of non-bulk freight since the 1970s (CRC for Rail Innovation, 2009). Whether the future volumes will be carried on rail will depend on rail being able to provide a competitive level of service and price. If rail is unable to perform the task, the forecast additional freight will be carried on the road system by a large numbers of B-double truck movements, with all the negative externalities that will potentially ensue. Even so, such a huge growth in freight
volumes cannot reasonably be expected to be carried on the road system, at least without significant social, economic and environmental repercussions. The rail freight system will therefore need to play a major part in carrying the increased volumes, and intermodal freight in particular. Rail can only play that part if adequate and efficient infrastructure exists both above and below rail.

The quality of the infrastructure and rolling stock differs sharply across the various components of Australian land transport. Road quality on the major freight routes has improved substantially in the past decade owing to funding provided by various Australian governments. However, investment in rail has not kept pace with road investment. One measure of expenditure on railway infrastructure is the value of engineering construction work done, and this has increased substantially since 2000-01, reaching A$2488 million in 2006-07 (see Figure 1.1). But this figure remains relatively low when projected freight demands are considered. Furthermore, it represents little more than 20% of the comparable figure for expenditure on roads and bridges.

Figure 1.1: Transport infrastructure construction engineering work by mode, 1986-87 to 2007-08 (A$ million, 2007-08 prices)

Source: Bureau of Transport & Regional Economics (BITRE) (2009), based on data from the Australian Bureau of Statistics.

1.2.2 Issues with the Australian fleet

The rail industry operates under very large long investment periods for rolling stock. The locomotive and wagon fleet currently employed by the Australian rail industry is one of the oldest in the developed world. The intermodal fleet currently comprises around 200
locomotives and 2,500 wagons (ARA, 2007a). Most of the modernised fleet are rebuilt locomotives that were originally built in the 1970s (Booz Allen & Hamilton, 2007). The average age of diesel-electric locomotives in Australia is 34.8 years, while half the wagons are more than 26 years old; by way of contrast, the average age of the US fleet is 8 years (Philip, 2008; Booz Allen & Hamilton, 2007). Figures 1.2-1.3 illustrate the age distribution of the Australian locomotive and wagon fleets. According to 2007 data, more than 50% of the locomotive fleet was aged 17 years or higher, while 24% of the diesel-electric locomotive fleet is more than 32 years of age. The aging wagon fleet in Australia is more prominent in the case of bulk wagons, of which more than half are aged 25 years or more.

The ARA, the peak advocacy body of the Australian rail industry, claims that this aging fleet is largely a function of the low or negative return on the cost of new locomotives (about $6 million each) (ARA, 2007b). The intermodal business is an extremely low return business, which is particularly evident on the East Coast (Booz Allen & Hamilton, 2007). Its current
and projected returns are such that there is no compelling commercial case for new
locomotives. Unless commercial returns from the east coast intermodal business improve or
there is external intervention, this situation is unlikely to change. Although the alternative of
using rebuilt or even ‘re-birthed’ locomotives has the potential to fill a cap, and will be
necessary in cases where new locomotives cannot be deployed owing to infrastructural
constraints, it cannot be regarded as a sustainable solution in the long term (ARA, 2009a). At
some point in time, further rebuilding and adaption will become uneconomic, more so since
many already rebuilt locomotives, using now outdated technology, are still operating on
Australian tracks. New locomotives with the modern low-emission technologies are being
developed in the United States and Europe. As a result, there are continuing opportunities to
invest in this modern equipment. It is estimated that a failure to take up these opportunities
will cost Australia the opportunity to reduce current locomotive greenhouse gas emissions by
40% (Booz Allen & Hamilton, 2007).

1.2.3 Potential need for investment incentives

In a fully competitive market, transport service providers take decisions on the basis of price,
and in the face of demand and supply functions. However, when market failures occur, these
results cannot be achieved. The transport system is riddled with market failures, especially
externalities. A report produced by the rail industry claims that there is a role for government
to assist the industry through measures such as direct funding, tax credits or incentives
through changes in marginal tax rate (ARA and Booz Allen & Hamilton, 2007).

One of the main justifications for government interventions to rail infrastructure and rolling
stock investment is the fact that social rates of return (private return plus externalities) are in
excess of private rates of return (Figure 1.4). Rail operators’ decisions to undertake
investment are based only on their private return to investment. These are lower than the
return to society as a whole, but the industry cannot internalise social benefits since these
have no commercial values. This results in under-investment in rail infrastructure and modern
environmentally efficient rolling stock. Moreover, there are market imperfections in loan and

---

1 Externalities are social costs that are not borne by those who are responsible for them, but rather other
members of society.
equity markets that hamper financing of infrastructure investment (Stiglitz and Wiess, 1981). As has been argued elsewhere, to achieve the optimal level of infrastructure investment, government policy should introduce incentives to include the social benefits into commercial and government decisions and activities (Clark and Arnold, 2005).

**Figure 1.4: Intervention logic for investment incentive**

It is not likely that rail freight firms, especially those operating in the intermodal areas, will have the financial resources to carry out the investment in new rolling stock. As a result, the introduction of accelerated depreciation schedules has been mooted by the industry stakeholders (as evidenced by various industry reports, e.g., Booz Allen & Hamilton 2007; ARA, 2009b; and Sheehan, 2009a) as an instrument to shift industry away from carbon-intensive technologies, including older generation and evenly previously rebuilt diesel-electric locomotives, which could be replaced by more efficient locomotives. These could even be electric locomotives if the supporting infrastructure was simultaneously put in place, though this would be a massive and very long-term investment.

Changes to reduce current depreciation times of 25 years for locomotives and 30 years for wagons to much shorter periods have been argued by the ARA to have the potential to improve financial justification for earlier technology change (ARA, 2008a). This belief stems from the classic example in the late 1980s when accelerated depreciation was implemented in order to bring about a younger Australian shipping fleet. The scheme made the Australian

---

2 Market imperfections often arise when there is asymmetric information, i.e., lenders do not know nearly as much about a borrower’s business prospects and likelihood of repayment as the actual borrower does. As a result, banks may require substantial collateral and they may charge higher interest rates to offset this risk.
PROMOTING TECHNOLOGICAL INVESTMENT IN THE AUSTRALIAN RAIL FREIGHT SECTOR: EVALUATING THE FEASIBILITY OF ACCELERATED DEPRECIATION

shipping fleet more cost competitive than foreign ships and competing land transport (Gillies and Cleworth, 2008). Yet the value of such schemes has also been criticised since not only does accelerated depreciation bring about benefits, but also incurs significant financial and social costs that might not be sufficiently counterbalanced by the scheme’s positive attributes (Forte, 1966; Furstenberg and Malkiel, 1977). In many instances, accelerated depreciation schemes were discontinued, and alternative mechanisms implemented.

1.3 Research Objectives

This research takes its cue from the research signalled by the ARA, as alluded to above. The claim made by the ARA is that accelerated depreciation, if permitted for newly acquired locomotives, wagons, and other rolling stock equipment, could provide incentives for rail freight operators to invest in more efficient technology and provide opportunities to further enhance rail’s existing environmental and social benefits. This thesis seeks to examine the feasibility of this claim.

The central question addressed here is whether accelerated depreciation holds a particular promise for addressing the large long investment periods for rolling stock in the Australian rail freight sector. To answer this, it is essential to discover the actual causes of the vehicle fleet age problem within the sector and whether accelerated depreciation is really the right instrument to deal with these issues. It is also necessary to ascertain the investment outcomes to the rail industry if accelerated depreciation is to be introduced for new locomotives and rolling stock.

This thesis aims to provide an historical overview of issues pertaining to accelerated depreciation. This is in order to: (1) analyse stated rationales for accelerated depreciation and the broader contexts in which such schemes are implemented; (2) consider evidence of the scheme’s impact on economic activity and how this evidence squares with initial predictions; and (3) extrapolate whether there are any clear lessons to be learned for future application of accelerated depreciation schedules, or whether other tools that could have the same effect, or better outcomes, should be used in cognate contextual circumstances.

Another objective is to use appropriate economic analysis, together with proper modelling, to evaluate the merits of accelerated depreciation with respect to addressing the lack of
technological investment, and then compare the outcomes with other alternative incentive schemes. It is therefore essential to explore previous research that deal with similar issues, i.e., the impact of tax concessions on firms’ investment behavior. This is so as to identify suitable analytical frameworks that can be used to rigorously answer the central research question established above.

The final task is to translate the research outcomes into meaningful policy advice. It is important to remind readers that this thesis is not meant to demonstrate the utility of accelerated depreciation. The real purpose is to conduct a feasibility study of implementing accelerated depreciation in the rail freight sector in an Australian industry context, and ascertain the conditions that would be required for it to work in an efficacious manner.

1.4 Justification for the Research

A major source of justification for conducting this study is its contributions to theory and practice, which will be clarified in later chapters. Apart from this, substantial benefits for the rail industry could be brought about by this research. The analytical frameworks established for the thesis is expected to maximise rail operators’ understanding of investment implications of the accelerated depreciation scheme. Given operators’ long-term ‘lock in’ to using existing infrastructure, e.g., locomotives and rolling stock, accelerated depreciation schedules (if its efficacy is proved), or indeed alternative (better) initiatives identified from this research, could provide significant incentives for operators to dispense with their old technology and re-invest in more efficient equipment. This research could thus further enhance rail’s existing environmental and social benefits, in addition to minimising the carbon footprint of the overall Australian transport sector.

Rail customers and associated stakeholders will benefit from efficient and low-emissions rail hardware, such as reduced costs, improved efficiency and safety, and favourable environmental impacts, including a reduction in particulate emissions and an amelioration of noise outputs. In addition, the ARA and other members of the Australian rail industry will be provided with an enhanced capability to handle issues pertaining to investment in rail hardware and the provision of concomitant policy advice. Development and implementation of economic modelling tools will also enhance the capability of rail authorities and researchers to evaluate impacts of increased technological investment. The research outcomes
also have important implications for suppliers of locomotives, rolling stock, and handling equipment. A suite of appropriate policies implied from this research could potentially result in increased technological investment, which in turn, would lead to revenue growth for rail hardware manufacturers and maintainers.

The research would also be of interest to other transport sectors (and potentially even infrastructure associated with energy generation and supply) looking to promote technological investment.

1.5 Methodology
A three-stage sequential mixed methods approach was designed to investigate the investment implications of accelerated depreciation in the rail freight sector. I proceeded in chronological order. First, an in-depth interview technique was conducted to gain a deep understanding of complexities surrounding how decisions are made regarding rolling stock replacement among rail freight firms. Then, I considered whether accelerated depreciation and other tax concessions can significantly reduce the optimal time to replace rolling stock in the Australian rail freight industry using an extended asset replacement model exclusively developed for this research. Finally, I employed a focus group technique to examine the findings from the first two stages and provide in-depth expert assessments of their implications.

1.6 Potential Limitations
Two potential limitations of the study relate to assumptions required to build the analytical frameworks and generalisability of the research findings. Formulating analytical frameworks unavoidably brings with it a set of assumptions. An attempt will be made to ensure that all required assumptions fit the Australian rail freight industry characteristics as much as possible. However, some compromises might need to be made if necessary, especially when the data required to conduct the analysis is not obtainable. As explained in the above section, some qualitative research methods will be required to undertake careful analysis of the qualitative data collected for the thesis. Despite this, qualitative research findings cannot be generalised statistically, although they can be compared with previously established theory and other studies.
Furthermore, operators’ investment policies are dynamic, but this predictive study relies heavily on historical data and is cross-sectional, rather than longitudinal. Therefore, an issue of dynamic inconsistency might arise. It is acknowledged that future revisitation might be desirable as a means to test the validity of the ultimate research outcomes. Finally, this research is primarily concerned with investment behaviour of rail freight organisations, but individuals will provide much of the data and research protocols required to control the effects of individuals’ personal characteristics.

1.7 Structure of the Thesis

This thesis is divided into five chapters, using the same format developed by Perry (1998). This chapter sets the overall tone of this thesis, beginning with a discussion about the background of this research, following by an outline of its objectives, its justifications, its intended methodology, and its scope. In Chapter 2, the review of the literature closely related to the main theme of the research is presented. The research questions are then developed and expected contributions of this study discussed. Chapter 3 deals with methodology choices and rationale with respect to the methods used in each stage of the research. Having clarified the approach to research design, in Chapter 4, I report the findings emerging from the data collected in each stage of the research. Chapter 5 concludes with a summary of what has been found, and an indication of future research directions.

1.8 Summary

The inspiration of this thesis has been established in this chapter. In particular, this thesis is motivated from an observation that although regulation for emissions, pollution, etc., is becoming stricter, while the Australian rail freight industry is still locked in to using large numbers of existing rolling stock, much of which is no longer efficient. Largely as a result of infrastructure constraints, it is not feasible for operators to dispense with their old technology at regular intervals, even though they will need to pay more to use older technology if a carbon price eventuates. This thesis seeks to ascertain the viability of promoting investment incentives for newly acquired locomotives, wagons and other equipment. It intends to analyse the impact of allowing accelerated depreciation on the investment behaviour of above-rail operators. This scheme, if its efficacy is demonstrated, could be a powerful tool to encourage re-equipment of the aging rail fleet and facilitate the provision of sustainable rail freight growth in Australia.
PROMOTING TECHNOLOGICAL INVESTMENT IN THE AUSTRALIAN RAIL FREIGHT SECTOR: EVALUATING THE FEASIBILITY OF ACCELERATED DEPRECIATION
CHAPTER 2

LITERATURE REVIEW

2.1 Overview

In Chapter 1, the theme of this research was established; that is, to ascertain the viability of accelerated depreciation of newly acquired locomotives, wagons, and handling equipment in the rail freight sector in Australia. In particular, this thesis aims to ascertain whether the implementation of accelerated depreciation will change rail freight operators’ investment decisions and result in more efficient and environmentally friendly technology. In this chapter, an overall contextual framework for this research is developed. This will be achieved by reviewing literature relevant to the research’s main theme. As a result of this literature review, issues worth investigating can be identified (Perry, 1998). Furthermore, the review establishes an analytical framework that allows systematic investigation of the research topic (Baker, 2000), and will thus provide broader guidelines for the following methodology and data analysis chapters (Hart, 1998). By reviewing the literature, we also avoid the calamities of ignorance and the reinvention of what is already known (Baker, 2000). In view of this, academic contributions made by this research can be more readily identified.

The literature review includes academic research papers, conference proceedings, and a series of industry reports relating to the main theme of the research. Three main areas of the literature are explored. The first investigation aims to determine the overall characteristics of the Australian rail freight industry, especially regarding its role, its contribution to Australia’s rural and regional economies, and the problem of an aging rolling stock fleet. A discussion of what needs to be done in order to maximise the growth of freight rail in Australia so as to reduce the environmental consequences of transport will be provided. Reasons as to why the sector proposes that competitive tax arrangements, such as accelerated depreciation, should be implemented will be raised. Note that the literature in this part of the review largely consists of the industry reports. The reason is that there are not many refereed papers that study the Australian rail freight industry, especially the matters of specific interest to this research.
PROMOTING TECHNOLOGICAL INVESTMENT IN THE AUSTRALIAN RAIL FREIGHT SECTOR: EVALUATING THE FEASIBILITY OF ACCELERATED DEPRECIATION

Carbon-constrained and post-carbon economies potentially necessitate economic and financial instruments to facilitate the uptake of new technologies designed to limit environmental impacts and reduce cost intensity. One of the proposed methods to achieve this is the introduction of accelerated depreciation schedules (Richardson, 2008). The second consideration of the literature review is the academic debate regarding whether accelerated depreciation schemes are really effective tools with respect to promoting technological investment. In view of this, there is a need to ascertain whether accelerated depreciation has had a historical application in industries where there was also a need to acquire new technologies rapidly, as there now is in the case of carbon-emitting/carbon-constrained sectors such as transportation and stationary energy. Very little cohesive work has been attempted on this theme from a historical perspective, with most critiques of accelerated depreciation having taken a firmly theoretical viewpoint, e.g., Goode (1955), Barritt (1959), Hall and Jorgenson (1967), Coen (1969), Eisner (1969), and Margalioth (2008).

The value of sympathetic taxation arrangements, such as accelerated depreciation, obviously depends on whether they would influence operators to adopt newer, cleaner transport infrastructure. In particular, the intention is that operators will replace their aging rolling stock with new rolling stock equipped with modern and environmentally friendly technology, if appropriate arrangements are made to facilitate their uptake. The third task of the literature review is therefore to focus on firms’ capital item replacement decisions. General factors driving capital item replacement decisions and the influence of taxation arrangements (such as accelerated depreciation) on these decisions are explored. A description of the behaviour of a number of replacement models used in practice to model replacement decision problems is provided. Of particular interest is how tax elements are incorporated into these models. This part of the literature review will form a basis for the development of an alternative capital asset replacement model, which is exclusively used by this research to investigate the investment implications of accelerated depreciation.

An overall structure of the literature review presented in this chapter is illustrated in Figure 2.1.
2.2 Australian Rail Freight Industry

Rail industry overview

Rail in Australia represents a diverse industry and is widely regarded as a key element in the nation’s increasingly integrated logistics supply chain (IE Aust, 2001). The rail sector broadly comprises freight and passenger train operators, infrastructure providers and maintainers, rolling stock manufacturers and maintainers, and other supply chain and logistics operators.

Rail contributes significantly to Australia’s rural and regional economies. It produces economic benefits worth around AUS$7.7 billion a year (ARA, 2007b). Additional benefits and jobs are provided by supporting industries, such as rolling stock manufacturers, track and equipment suppliers, and the tourist sector. The industry currently consists of over 250 private and public companies employing around 70,000 people in urban and regional Australia (ARA, 2007b). In many regional centres, employment in the rail industry, or indeed rail-related sectors, comprises a major source of employment. In environmental and resource-use terms, rail is superior to road (see evidence provided in, e.g., QRNA, 2002; and Rasmussen and Welsh, 2009). Past estimates of the external costs of road freight have
allowed for road maintenance costs, together with air pollution, greenhouse gas emissions, congestions, and accident costs (ARA, 2007a). Another form of spill-over benefits produced by rail is the reduction in these negative externalities. All of these benefits suggest that the rail industry has an important societal value across the nation.

According to data from 2007 (ARA, 2008b), Australian rail systems carry approximately 667.09 million passengers for a total of 12.31 billion passenger kilometres. The Australian rail freight task for the same year was 665.64 million tonnes carried for 198.65 billion net tonne kilometres. There were approximately 1,829 locomotives and 39,169 wagons. Table 2.1 presents highlights of the sector from 2007.

Table 2.1: Highlights of Australian rail transport in 2007. The number of passengers, carriage amount, and number of rolling stock equipment are reported in this table.

| Total Passenger- Kilometres (billion) | 12.31 |
| Total Passenger Journeys (million)  | 677.09 |
| Tonnes Carried (million)            | 665.64 |
| Net Tonne Kilometres (billion)      | 198.65 |
| Number of Locomotives               | 1,829 |
| Number of Wagons                    | 39,169 |


The Freight Market

Australia’s railways haul over one third of the rail, road and domestic sea freight task in net tonne kilometres (ARA, 2001). Of the land freight task, 53% is currently carried by railways (approximately 183 billion tonne-kilometres as estimated by ARA, 2008a). The rail freight sector currently comprises 22 freight operators, 4 of which are government-owned enterprises. 8 of the freight operators might well be regarded as major operators since they individually carry more than 10 million tonnes per annum (IE Aust, 2001). The Australian rail freight market can be divided into bulk and non-bulk markets, where the former is the dominant of the two (representing 84.4% of the total tonne-kilometre rail task according to Rasmussen and Welsh, 2009) and consists of predominantly mineral and agricultural products. It serves a market that requires the transportation of a single product from the hinterland to a seaport.
According to BTRE (2006a), the primary bulk cargoes that rail carries include iron ore, coal, minerals, grain, and sugar. The same industry report indicates that this has steadily grown from 559.8 million tonnes to 647.1 million tonnes in the five years to 2006-2007. The above figure is closely related to export demand and is expected to grow at a rate of around 2% a year to 2020. Rail is the main transport mode of choice for bulk cargoes and faces little competition from road (ARA, 2007a). This largely reflects the competitive advantage that railways have with respect to transporting bulk commodities over long distances (Productivity Commission, 1999). While some of this market is served by privately owned railways, such as BHP Billiton’s Iron Ore Rail and Pilbara Rail, a large proportion has become contestable between rail operators, thereby leading to competition between QR National and Pacific National for bulk contracts (Rasmussen and Welsh, 2009).

The remaining 15.6% of the market share belongs to the non-bulk freight (Rasmussen and Welsh, 2009). The non-bulk market is divided between general and containerised freight, most of which is moved interstate and competes directly with road transport. Trucks move approximately 80% of domestic non-bulk freight and dominate every major inter-capital route except the Eastern States–WA and Adelaide–Darwin corridors (BTRE, 2003). Rail has been steadily losing market share in this area of transportation since the 1970s (CRC for Rail Innovation, 2009). These trends are more pronounced on shorter routes, e.g., Sydney to Melbourne than Melbourne to Perth (BTRE, 2003). The major reason contributing to low market share of rail relative to road for the non-bulk freight task is the lower reliability of freight trains, including failure to run on time, and other problems regarding service quality (BIE, 1995; Productivity Commission, 1999).

There is a continuing discussion about whether road users are paying the full economic costs of using road infrastructure. A report by Port Jackson Partners suggests that the failure to charge trucks on a mass distance basis results in serious undercharging for heavy vehicle transportation (Port Jackson Partners, 2005). Other industry reports (Back on Track, 2001; Tracking Australia, 1998) also indicate that road freight is being subsidised, which is in stark contrast to rail. Between 1975 and 2001, government investment in roads was over 20 times that of rail ($43 billion on roads and $2 billion on rail according to ARA, 2001). Since 1975, rail’s share of interstate non-bulk freight has declined from 60% to 35% despite the interstate non-bulk freight task more than tripling over that period (IE Aust, 2001). This has been partly due to the lack of investment in rail infrastructure (Rural Industries R&D Corporation, 1999).
The ARTC (2001) estimates that a $507 million investment would generate $1.5 billion of benefits to the community and increase the share of interstate freight carried by rail, by 38%.

Two sets of costs for the major North–South links are shown in Table 2.2. These costs include pickup and delivery and an estimate of negative externalities. This table has been taken directly from the study of Port Jackson Partners (2005). It is important to observe that the full cost of rail for the all important Melbourne–Sydney route is approximately 15% higher than that of road. This is largely owing to the deficiencies on the Australia’s rail infrastructure and services. The cost of rail on the Melbourne–Sydney link has the potential to be reduced from 6.9 cents per net tonne kilometres (ntk) to 5.5 cents per ntk, with suggested efficiency improvements.

The table also highlights the necessity for significant industry reforms and new investment so as to reduce rail freight costs on the North–South corridor to levels comparable with the East–West corridor. Furthermore, doing so would make rail more competitive vis-à-vis road. Without substantial investment in rail infrastructure, there are potentially enormous costs to be faced as a result of diminished or defunct rail services between major cities on the North–South corridor, including increased road construction and maintenance, and the negative externalities associated with large and growing volumes of road traffic. Despite this, there seem to be a disagreement regarding the view that rail infrastructure requires substantial investment, and considerable effort on the part of the Commonwealth (Rural Industries R&D Corporation, 1999).

Table 2.2: Total cost comparison: road and rail freight (c per ntk). The total cost comprises of pickup and delivery, and an estimate of negative externalities. The comparison is made between road and rail major north-south routes in Australia.

<table>
<thead>
<tr>
<th>Route</th>
<th>Road</th>
<th>Rail (current)</th>
<th>Rail (reduced)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sydney–Brisbane</td>
<td>6.4</td>
<td>6.6</td>
<td>4.3</td>
</tr>
<tr>
<td>Melbourne–Sydney</td>
<td>6</td>
<td>6.9</td>
<td>5.5</td>
</tr>
<tr>
<td>Melbourne–Brisbane</td>
<td>5.8</td>
<td>5.9</td>
<td>3.8</td>
</tr>
<tr>
<td>Melbourne–Adelaide</td>
<td>6.6</td>
<td>3.8</td>
<td>3.8</td>
</tr>
<tr>
<td>Adelaide–Perth</td>
<td>6.3</td>
<td>2.6</td>
<td>2.6</td>
</tr>
<tr>
<td>Melbourne–Perth</td>
<td>6.1</td>
<td>2.8</td>
<td>2.8</td>
</tr>
<tr>
<td>Sydney–Perth</td>
<td>5.7</td>
<td>3.5</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Source: CRC for Rail Innovation 2009.
The key players in rail freight
As indicated in Table 2.3, two national rail operators, viz., QR National and Pacific National, dominate almost two thirds of the intermodal rail freight. Other smaller players include SCT Logistics, Genesee & Wyoming, and FreightLink. QR National, while Queensland based, is becoming an integrated national carrier and retains significant state government support. According to IBISWorld (2008), QR National is currently earning almost 40% of intermodal rail freight industry revenue. Pacific National is part of the Asciano Group, which also has interests in stevedoring. A recent industry report by the ARA (2009) indicates that Pacific National is saddled with high debt levels following its split with Toll Holdings in 2007 (ARA, 2009c). Moreover, its future has been the subject of continuing discussion in the financial press. Pacific National represents 27% of the intermodal rail freight transport industry. SCT Logistics, with an intermodal rail freight market share of 3.7%, is a niche operator specialising in the Melbourne to Perth link. It has experienced very high rates of growth, over 20% per annum for the period 2002/03 to 2006/07. Genesee & Wyoming, a US-owned company, handles South Australian intrastate traffic and has an intermodal rail freight market share of 1.6% (Rasmussen and Welsh, 2009). FreightLink, which operates the Adelaide–Darwin link, enjoys a 1% share of the total intermodal rail freight market (Rasmussen and Welsh, 2009).

The majority of the Australian rail freight network is owned and managed by the Commonwealth-owned ARTC, which has integrated the key interstate rail links under its control, and is now responsible for access to and maintenance of the interstate network linking Brisbane to Perth via Sydney (Rasmussen and Welsh, 2009). In Victoria, the state government infrastructure owner is VicTrack. In New South Wales, it is the Rail Infrastructure Corporation that owns the country regional network. The NSW suburban network is owned by RailCorp. In Western Australia, the Kalgoorlie–Perth link is owned by the State Government and leased to Westnet rail, while BHP Billiton’s Iron Ore Rail and Pilbara Rail are privately owned and operated. Third-party access recently has been granted by the High Court for these lines (Rasmussen and Welsh, 2009). In addition, the track from Kalgoorlie to Adelaide is owned by ARTC, while, in South Australia, the interstate track is also owned by ARTC. Genesee & Wyoming manages the intrastate track, while FreightLink

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3 Private operators such as BHP Billiton and Pilbara Rail have been excluded from this data.
owns and operates the track from Adelaide to Darwin. FreightLink also owns the Darwin–Tarcoola link, where the line joins the main Adelaide–Perth link. In Tasmania, the track is owned by the state government and operated by Pacific National (NTC, 2008b). In Queensland, the network is owned and operated by Queensland Rail (formerly joined together with QR National), subject to access provision agreements.

Table 2.3: Key rail freight players: revenue and employees of key rail freight players, 2006–2007. The statistics for both major rail freight operators and major track providers are reported.

<table>
<thead>
<tr>
<th>Rail freight companies</th>
<th>Revenue</th>
<th>Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Queensland Rail</td>
<td>2413.9**</td>
<td>13920</td>
</tr>
<tr>
<td>Pacific National</td>
<td>1622.5</td>
<td>3398</td>
</tr>
<tr>
<td>SCT Logistics</td>
<td>240.0</td>
<td>800</td>
</tr>
<tr>
<td>Genesee &amp; Wyoming</td>
<td>105.8</td>
<td>200</td>
</tr>
<tr>
<td>Freight Link</td>
<td>68.3</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Track managers</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ARTC</td>
<td>534.3</td>
<td>1391</td>
</tr>
<tr>
<td>Rail Infrastructure Corporation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VicTrack</td>
<td>410.8</td>
<td>145</td>
</tr>
<tr>
<td>WestNet Rail</td>
<td>190.4</td>
<td>220</td>
</tr>
</tbody>
</table>

* Includes FreightLink employees, passenger rail and ARG in WA.
** Freight only.

Source: IBISWorld, 2008; company information.

Projected freight task
At a national level, the total freight task is expected to almost double in the next 20 years; that is, a growth in volume from 375.3 btkm in 1999/2000 to 648.5 btkm by 2020 (NTC, 2008a). While this rate of growth is similar to that experienced over the last 20 years, the different growth rates of bulk and non-bulk growth have significant implications. Road’s share of the bulk market is very likely to grow, with road traffic doubling to some 100 btkm by 2020. Non-bulk freight trends are characterised by a continuing increase in the dominance of road in both total and interstate traffic (ARA 2008a). Interstate rail freight for many demands has exhibited a declining trend, especially on the eastern seaboard and in regional areas. For long-distance intermodal transport, rail demand between Melbourne, Sydney and Brisbane has increased, but only marginally, while road transport has dramatically increased (BTRE, 2006a). The proportion of land freight carried by rail between major cities on the
eastern seaboard was 39% in 1972. This figure is expected to decline to 6.5% by 2020 if current directions and initiatives continue (ARA, 2008a). In particular, a lack of investment by the government in infrastructure coupled with a regulatory burden based on State-based jurisdictions silo based approaches with no appreciation of the need for a national network approach is a major reason for the inefficiencies within the rail sector (ARA, 2007a).

Over the period 1972-2020, rail freight is expected to increase by 21%. This growth pales in comparison with road freight, which is expected to increase by 1138% over the same period (ARA, 2007b). As mentioned in Section 1.2.1, the growth in rail future volumes will depend on whether rail can provide a competitive level of service and price. This is possible only if adequate and efficient infrastructure – both above and below rail – exists. Otherwise, significant social, economic and environmental negative repercussions associated with road transport will ensue.

Benefits of rail freight
In environmental and resource-use terms, rail is generally superior to road according to Booz Allen & Hamilton (2007). Opposite arguments are presented, however, by the Productivity Commission (2006); for example, that there are no externalities for truck use to other members of society and/or road users. The reason claimed by the Productivity Commission is that trucks largely pay their way overall. Furthermore, good road conditions, especially on the eastern seaboard, results in minimal truck-caused damage to other road users. These arguments are complex and beset by data and cost allocation problems, which make them highly debatable. Contrary reports, however, are provided, for example, by Booz Allen & Hamilton (2007) and Rasmussen and Welsh (2009).

Past estimate of an externalities differential between road and rail greenhouse gas emissions, noise and accident costs (only) within a rural environment by Booz Allen & Hamilton (2007) is 0.5c/ntk or $4.84/tonne (assuming the use of 2,000 tonne ‘Superfreighter’ train configuration on the Melbourne–Sydney route). This figure has already excluded road maintenance externalities that the Productivity Commission (2006) argues are internalised. A higher value of externalities is reported by Port Jackson Partners (2005), with the estimate of 0.6c/ntk with the upper bound of 0.8c/ntk and the lower bound of 0.4c/ntk. Externalities such as congestion and air pollution are not included in Port Jackson Partners’ estimates since these external costs apply only to urban environments. These figures would have been higher,
indeed by about 10%, had inter-capital services that traverse urban environments for some distance been included (Port Jackson Partners, 2005). In view of these considerations, there is strong evidence to support the choice of rail over road modes for inter-capital routes.

Rail freight transport is at least three times more energy efficient than road freight and at least twice more efficient for moving people (IE Aust, 2001). These efficiencies are much higher for tasks with higher demand. Rail is cheaper for all inter-capital freight transport. If Australia is to achieve its transport tasks, a significant increase in rail transport must be part of the solution. Despite this, the Productivity Commission (2006) has argued that a modal shift from road to rail could potentially reduce the overall efficiency of freight transport. While this argument is complex and rests on data interpretation, there is no question about the market need for a significant increase in the handling capacity of rail in order to bear future freight task forecasts.

Modal shift from road freight to rail freight could potentially provide numerous benefits to business, environment, and Australian community. These benefits may be articulated as follows:

- Supporting regional communities;
- Reducing community health effects;
- Minimising environmental consequences;
- Reducing road toll by reducing crashes;
- Reducing 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.

**Taxes, transport and the environment**

As discussed in Section 1.2.1, integrating sustainability into Australia’s transport systems is especially important owing to potential climate change possibility and the need for a low-carbon future. Transport activities give rise to a range of other environmental and social costs, including road congestion, accidents, noise, and particulate emissions impacting on
urban air quality. Transport now comprises 14% of Australia’s total greenhouse gas emissions – an increase of 16% over its 1990 level – and is one of the fastest growing sectors of greenhouse gas emissions (DCC, 2008). At a national level, greenhouse gas emissions from the transport sector are expected to grow by 28.3% between 2005 and 2020, of which commercial and freight vehicles will be the fastest growing transport emissions source increasing 69.7% over this same period (BTRE, 2002). From 2005 to 2020, BTRE (2002) estimates that passenger vehicle greenhouse gas emissions will grow 9.6%, while commercial and freight vehicle greenhouse gas emissions will increase 37.7% over this same period. If there is no significant new intervention, emissions from the transport sector alone are expected to comprise over 66% of the target for all Australian emissions in 2050 (BTRE, 2005).

Approximately 2% of transport greenhouse gas emissions emanate from rail (IE Aust, 2001). In comparison with trucks and cars, rail produces significantly lower emissions and are approximately one third to a half of the greenhouse gas emissions per tonne of freight hauled (ARA, 2008b). Between 2010 and 2020, growth in emissions from road transport is projected to be seven times higher than all other forms of transport (ARA, 2008b). A significant opportunity therefore exists for reducing this road transport emissions growth through a shift to increased haulage of freight by rail. With the freight transport task set to almost double in the next twenty years (NTC, 2008a), more emissions cuts are required in the freight transport sector to meet national emissions reduction targets; a task which road transport is unlikely to be able to provide (ARA, 2008a). For the same quantity of goods moved, the following figure compares rail freight emissions with road freight and includes additional emissions for rail with road pickup and delivery of goods at the origin and destination. This figure illustrates that rail provides a marked emissions reduction benefit.

**Figure 2.2: Average Australian CO₂ emissions from road and intermodal rail freight.**

![Comparison of CO₂ emissions from road and rail](QRNA_2002.png)

Source: QRNA (2002).
PROMOTING TECHNOLOGICAL INVESTMENT IN THE AUSTRALIAN RAIL FREIGHT SECTOR: EVALUATING THE FEASIBILITY OF ACCELERATED DEPRECIATION

Australia has a tough task ahead of it with respect to reducing the forecast dramatic increase in transport emissions, while, at the same time, ensuring that economic activity is not constrained as a result of prohibitive transport costs (ARA, 2008a). There are opportunities for the Commonwealth to replace existing taxes with more targeted taxes and charges that promote the efficient use of transport networks and target the social costs of motoring such as air pollution, greenhouse gas emissions, and damage to publicly funded roads. It has been argued that taxes, if designed properly, have the potential to provide a means of improving environmental amenity, especially through the incentives that they create (Commonwealth of Australia, 2008). Unfortunately, a number of current tax schemes heavily subsidise car use and road freight, and therefore disadvantage users of more sustainable transport modes. An obvious example is the Fringe Benefit Tax scheme, under which an employer pays less tax if a private vehicle is used by an employee to travel a designated distance (ATO, 2009a). For example, the taxable value of car fringe benefits under the statutory formula method is proportional to the statutory percentage, which in turn, is inversely proportional to the total kilometres travelled during the year. The following table illustrates this issue.

<table>
<thead>
<tr>
<th>Total kilometres travelled during the year</th>
<th>Statutory percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 15,000</td>
<td>26</td>
</tr>
<tr>
<td>15,000 to 24,999</td>
<td>20</td>
</tr>
<tr>
<td>25,000 to 40,000</td>
<td>11</td>
</tr>
<tr>
<td>Over 40,000</td>
<td>7</td>
</tr>
</tbody>
</table>


Despite the massive benefits that rail transport provides, rail has been unable to increase its market share in the inter-capital general freight business along the eastern seaboard. This is a demand problem since rail’s performance has been lower than its competition, and also a supply issue because since operators are unable to continue operations, while the east coast services do not achieve adequate commercial returns (ARA, 2007a). In considering the impact of limitations in the growth of rail freight task, it is important to recognise that rail freight systems require considerable investment in fixed assets (e.g., track, signalling, yards, terminals, locomotives and wagons) to meet market service quality requirements (ARA,
The problem is that, at present, there is very little commercial incentive for operators to invest.

With a commitment from stakeholders within the transport sector, the government and end-users, sustainable growth in rail freight can be achieved. There are two major issues that key strategies must focus on in order for this increased freight volume to be realised:

1. Aspects such as reliability and cost (hence price) must be addressed. The AusLink/ARTC investment (predominantly track) will partly provide a reduction in delays and additional capacity and therefore encourage modal shift from road to rail, but it cannot be the whole answer. Other complementary parts of the rail system also need to be improved, including the regulatory and pricing regimes, where there are fundamental difference between road and rail (BTRE, 2006b; ARA, 2008a).

2. The realisation of increased market share for rail also depends on whether a sufficient supply of rail services can be provided. It is evident that this may not occur as a direct result of the poor commercial viability of existing non-bulk freight services (Booz Allen & Hamilton, 2007). Two key areas of the rail transport system that desperately require further investment are rolling stock and intermodal facilities (Jolley and Symons, 2009; Jolley et al., 2009).

**Issues with the Australian rail fleet**

This thesis chooses to primarily concentrate on how to address the issues pertaining to the vehicle fleet age in the rail freight sector. Section 1.2.2 provides details of these issues. Recall that the rolling stock fleet currently operated by the Australian rail industry is very old compared to that of the US rail industry. This problem is largely due to the low return business of the intermodal section. In the near future, the sector would need to invest in modern equipment as further rebuilding and adaption of old equipment will soon become uneconomical (BAH, 2007). This investment is also needed to reduce the sector’s locomotive greenhouse gas emissions.

**The public good argument**

There are public good arguments for reducing infrastructure constraints in light of the expected changes required for transport’s transition to a carbon-constrained future. It is not well recognised that freight railways generally operate with commercial and physical factors that are different from road transport (ARA, 2008a). Perhaps the single most important
difference for commercialised railways is that external benefits (e.g., reductions in road damage, crashes, pollution, etc.) have traditionally been excluded in the investment analysis, because the benefits do not accrue to the company (Government of WA, 2006). In contrast, all these non-commercial benefits, e.g., time saving, are included in road investment analysis as public good benefits. Governments therefore have a role to play in contributing to railways when non-commercial benefits occur at a non-commercial rate of return. Otherwise, rail infrastructure that has public good aspects may be underprovided because the private infrastructure provider is unable to capture the full benefits of its investment (Garnaut, 2008).

Recent research undertaken by the CRC for Rail Innovation (2009) uses the values from INFARS/IWW (2004) to calculate social costs from Australian road freight and rail freight for the year 2003–2004. Results are summarised in Table 2.5. For the Australian transport setting in the year 2003–2004 (the latest financial year where reliable data is available), the total social cost in 2004 from freight transport was AU$24.58 billion, including climate change costs. This is a substantial figure for Australia. As a consequence, the importance of these costs cannot be understated. It is notable from the table that these social costs are mainly the result of road transport, while rail contributes only 9% of these social costs. A modal shift from road to rail will significantly reduce these social costs. The ARA (2008a) argues that this modal shift can only be realised provided that significant investment is made in rail infrastructure to improve its service quality competitiveness. As mentioned above, this investment could only be provided from external intervention from the government given the public good aspects of rail infrastructure.

Table 2.5: Freight social total costs (AU$ billion, 2004 dollars). The figures reported are separated into the total social costs from road, the total social costs from rail, and the combined total social costs from two modes of transport.

<table>
<thead>
<tr>
<th></th>
<th>Road total</th>
<th>Rail total</th>
<th>Individual social cost total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accidents</td>
<td>2.78</td>
<td>0</td>
<td>2.78</td>
</tr>
<tr>
<td>Noise</td>
<td>2.7</td>
<td>1.18</td>
<td>3.88</td>
</tr>
<tr>
<td>Air pollution</td>
<td>6.52</td>
<td>3.06</td>
<td>9.58</td>
</tr>
<tr>
<td>Mode total</td>
<td>19.63</td>
<td>4.24</td>
<td>23.87</td>
</tr>
<tr>
<td>Climate change</td>
<td>0.64</td>
<td>0.06</td>
<td>0.7</td>
</tr>
<tr>
<td>Mode total (including climate change)</td>
<td>20.27</td>
<td>4.31</td>
<td>24.58</td>
</tr>
</tbody>
</table>

A possible role for accelerated depreciation

Although accelerated depreciation schedules have been in use in various contexts for the best part of a century, it is the increased attention being paid to what is widely regarded as anthropogenic climate change that has resulted in renewed interest in accelerated depreciation. Governments throughout the world have either introduced emission trading schemes (ETSs), such as has occurred in the EU, or intend to introduce them in the near future, such as Australia. Under the ETS or other similar carbon price mechanisms, assets heavily reliant on carbon-based fuel sources such as coal, natural gas or petroleum will be penalised, with the rate of penalty increasing with time so as to encourage an overall reduction in carbon emissions (Garnaut, 2008). In view of these constraints, firms relying on fossil fuels will either have to purchase increasingly expensive carbon credits, or invest in less carbon-intensive technologies, or preferably ones that do not emit carbon dioxide at all (HM Treasury, 2006).

The scenario described above represents a considerable challenge to the stationary energy and transport sectors in particular. These sectors involve huge sunk costs and have purchased infrastructure and equipment designed to operate over several decades (Betz, 1998). Take the rail freight industry as an example. The locomotives in this industry represent a considerable up-front investment. Furthermore, locomotives can be extremely long lived. In Australia, the average age of a locomotive is reportedly around 35 years (Philip, 2008; Booz Allen & Hamilton, 2007). Most of these locomotives are fully depreciated and do not, in the absence of emissions trading, incur any costs aside from maintenance and fuel. Some are also impaired since revenue from assets does not justify the current valuation of the asset. Yet older locomotives are not especially energy efficient and will thus incur penalties to their owners in a more carbon-constrained environment. As peak oil draws near, fuel costs will also rise and make older diesel-electric locomotives increasingly uneconomical. The diesel locomotives account for 88% of the locomotive fleet in 2007 (ARA, 2009b). This implies a huge operating cost saving for the rail freight sector if the modernisation takes place.

Investment in enhanced rail infrastructure (e.g., rail track, signalling systems, train control technologies and, in particular, modern rolling stock) involves a substantial sunk cost. Thus, the rail freight industry is unlikely to have sufficient financial resources to carry out such investment. In addition to high sunk costs, the lack of a business case for the industry (rail or end users) to invest for growth also stems from the currently distorted infrastructure pricing,
which prevents rail freight, especially east coast intermodal freight, to offer enough return on both asset and investment (ARA, 2009a and 2009b). If nothing is done, rail will be forced to step aside from intermodal services on the short-haul length, with the shortfall taken up by road transport. The consequences are, for example, a massive increase in greenhouse gas emissions and loss of external economic benefits (NTC, 2009). Accelerated depreciation has been considered by the ARA as a solution to prevent this scenario from taking place. The financial benefits that accelerated depreciation provides have been argued to have the potential to encourage new capital purchases, with associated social benefits in the form of less pollution and greenhouse gas emission from newer equipment (ARA, 2009a and 2009b). Newer equipment can also support high productivity trains, provide fuel efficiency gains, and improve current equipment reliability (ARA, 2009a and 2009b). Investment in this area arguably would allow the sector to become more competitive against its direct competitor; the road transport sector (Sheehan, 2009a), while increasing the volume of freight on rail will arguably provide major environmental benefits to the Australian community (ARA, 2007).

In the next part of the literature review, the theoretical and historical background of accelerated depreciation will be established. The objective of this exercise is to investigate the likelihood of more technological investment if accelerated depreciation were implemented in the Australian freight rail industry.

2.3 Accelerated Depreciation

Accelerated depreciation regimes have been implemented in various industrial and economic contexts (such as regulated and deregulated markets) during the past century. Factors that have caused governments to implement accelerated depreciation schedules are varied. Different types and accompanying instruments/policies have been used, while varying methods of accelerating the depreciation have been applied. Furthermore, various sectors have been targeted, with the impact of accelerated depreciation on economic activity emerging as highly variable depending on the economic, institutional and other contextual circumstances. Indeed, the value of such schemes has also been criticised from several quarters since not only does accelerated depreciation bring about benefits, but also incurs significant financial and social costs that might not be sufficiently counterbalanced by the scheme’s positive attributes (Forte, 1966; Furstenberg and Malkiel, 1977). In many instances,
accelerated depreciation schemes were discontinued, and alternative mechanisms were implemented.

This section provides a historical overview of issues pertaining to accelerated depreciation. It analyses stated rationales for accelerated depreciation and the broader contexts in which such schemes were implemented. The section describes the major goals, types, and accompanying instruments/policies of individual schemes, and then considers evidence of the scheme’s impact on economic activity, and how this evidence squares with initial predictions. It also presents an overall evaluation of the respective schemes under investigation. The section concludes by extrapolating whether there are any clear lessons to be learned for future application of accelerated depreciation schedules, or whether other tools that could have the same effect, or better outcomes, should be used in cognate contextual circumstances.

2.3.1 What is accelerated depreciation?

Before we turn our attention to historical examples, it is important to provide a description of accelerated depreciation and the rationale behind it.

Depreciation is a term used in accounting, economics and finance, with reference to the fact that finite lived assets lose their value (i.e., depreciate) over time, and must be replaced. There are at least two factors causing depreciation: deterioration and obsolescence (Nelson and Caputo, 1997). Deterioration represents the combined effects of the reduction in the useful life of the asset, input decay (an increase in the input requirements necessary to maintain a given level of output), and output decay (a reduction in the output produced by a given asset, holding other inputs constant). Obsolescence represents the decline in the value of used assets resulting from technological improvements embodied in new assets.

Accelerated depreciation allows deductions for declines in the value of an asset to occur at a rate above what is expected in practice (Review of Business Taxation, 1999). The total amount of depreciation allowed over an asset’s life is the same under both the nominal and accelerated depreciation regimes. Accelerated depreciation only allows the amount of depreciation taken each year to be higher during the earlier years of an asset’s life. The benefit of accelerated depreciation is confined to tax deferral. Companies generally pay taxes on profits: revenues minus expenses. There are various types of expenses, and depreciation is
one of them. As a result, accelerated depreciation defers a company’s taxes during the earlier years of an asset’s life and increases them in later years. In many respects, as stated in the following paragraphs, this tax deferral property of accelerated depreciation will increase a firm’s demand for depreciable facilities and expand its financial capabilities for acquiring them (Ture, 1967).

The use of accelerated depreciation results in a greater flow of internal funds generated with respect to any given amount of depreciable facilities. This cash-flow benefit is not particularly meaningful for businesses acquiring assets in any one year, since the increase in cash flows in the asset’s earlier years will be exactly offset by the reduction in cash flows in the later years. However, for firms acquiring assets in more than one year, it will result in an increase in cumulated cash flows until these firms completely liquidate their depreciable asset account. For businesses whose purchases of depreciable assets are increasing, accelerated depreciation will continue to yield a larger cash flow than that resulting from the use of a non-accelerated method. The more rapid the growth in the stock of depreciable facilities, the greater will be the excess of the cash flow under an accelerated depreciation regime (as compared with the ordinary depreciation method).

Accelerated depreciation reduces the risk of investment in depreciable facilities and effectively transfers cash flows from later years to earlier years (Goode, 1955). Greater early cash flows mean that a greater proportion of the asset’s cost will be recovered within a short period, thereby benefiting firms relying on a short payoff period approach to allow for the risk of investment in depreciable assets. For firms relying on a discounting approach, cash flows received in the earlier years are subject to relatively slight discounting to cash flows received in the later years. Accelerated depreciation, in sum, reduces the average effective discount for risk and justifies earlier replacement of existing facilities (Ture, 1967).

Accelerated depreciation has the potential to reduce the optimum replacement cycle for depreciable facilities and therefore increase replacement investment rates (Lutz and Lutz, 1951; Edwards, 1961). In practice, firms comparing expected cash flows from existing facilities and that from replacements are likely to find that the more rapid reduction in existing facilities’ cash flows under accelerated depreciation will make earlier replacement more feasible.
There is, of course, a revenue cost to the government from the tax deferral aspect of accelerated depreciation. Accelerated depreciation is equivalent to the government providing an interest-free loan to the taxpayer, since it allows a deferral of tax payments to later years, with no increase in the amount due (Auerbach, 1982). Thus, the cost to the government is the interest on this loan less any extra income earned by the taxpayer as result of this loan (Review of Business Taxation, 1999). The impact on the government’s revenue flow will be significantly negative in the earlier years of the asset’s life (when the loan is first granted). If the stock of investment subject to accelerated depreciation is constant over time (in the case that the loan is not effective at boosting economic growth or, in this case, encouraging investment in cleaner technologies), the on-going cost to the government’s revenue from granting the scheme would be no more than the cost of the interest-free loan. If the stock of capital subject to accelerated depreciation grows (in the case that the loan is effective at achieving the desired outcomes), loan outlays would always exceed loan repayments and, as a result, the on-going cost of the scheme could be significant. This cost needs to be weighed against the benefit from higher economic growth, which obviously has the potential to yield higher tax revenues.

**Forms of accelerated depreciation**

Accelerated depreciation takes many different forms and is also known by other names. For the sake of cohesion and simplicity, the term ‘accelerated’ is characterised as any depreciation method allowing the taxpayer to charge off more of the depreciable cost of an asset in the early years than under an ordinary method, i.e., straight-line depreciation, which calculates an asset’s annual depreciation by dividing the difference between the purchase price and the salvage value of the asset by the estimated useful life of the asset (Margalioth, 2008).

A widely-accepted way to accelerate the depreciation deductions is to alter the pattern of the depreciation deductions so that a larger part of the depreciable amount is charged against income in the earlier years of the asset’s service life, while a smaller part is charged in the later years. Two popular methods that change the pattern of the depreciation deductions are the declining-balance method and sum-of-the-years-digits methods. In the former, the taxpayer could start deductions at usually 1.5 times or 2 times the amount allowed under the

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4 The salvage value is the value of the asset at the end of its useful life. It is usually assumed to be zero.
straight-line method (Hanchett, 1996); each year thereafter, the taxable value of the asset is computed by subtracting the amount already deducted from the initial value. In the latter method, a continually decreasing ratio is applied to the difference between the asset’s original cost and the asset’s estimated salvage value (Barritt, 1959). The numerator of the ratio in any year is the number of years of service life remaining (including the present year), whereas the denominator is the sum of the numbers representing the successive years in the estimated life of the asset. Suppose that the remaining life of the asset is 5 years. In the first year, the numerator would be 5 and the denominator would be the sum of $1 + 2 + 3 + 4 + 5$, which would provide the ratio of $5/15$. This ratio is the first year’s depreciation charge per dollar of the asset cost less savage. The annual sum-of-the-years-digits depreciation per dollar of the asset cost less savage is $4/15$ in the second year, $3/15$ in the third year, etc.). Annual depreciation allowances per dollar of the asset cost under straight-line, declining-balance, and sum-of-the-years-digits methods for assets of various service lives are shown in Figure 2.3 below.

Several features can be observed from looking at Figure 2.3. First, it shows that the declining-balance method dramatically curves the depreciation line, compared to the other two methods. Moreover, the declining-balance depreciation line is curvier when the service life of the asset is longer. Second, it demonstrates that both methods allow the amount of depreciation taking each year to be higher during the earlier years of the asset’s life, and smaller during the later years of the life of the asset than those produced by the straight-line method. As noted above, total deductions allowed under each of the three methods are virtually the same. Third, it illustrates that the number of years during which the accelerated allowances exceed the straight-line charge varies directly with the service life of the asset. Fourth, it shows that allowances under the sum-of-the-years-digits method exceed those under the straight-line method for a larger fraction of an asset’s service life than do those under the declining-balance method.
Figure 2.3: Annual depreciation allowances per dollar of the asset cost under straight-line (solid), declining-balance (broken), and sum-of-the-years-digits (dotted) methods for assets of various service lives (assuming no salvage value need to be taken into account in computing straight-line and sum-of-the-years-digits-allowances).

Another common form of accelerated depreciation, called the American system (Domar, 1953), is to maintain the straight-line depreciation system, but shorten the period of depreciation below the actual economic life of the asset. Suppose that the period of depreciation is reduced from the normal service life of 10 years to 5 years. Under this shortened service life method, a firm may claim $\frac{1}{5}$ in depreciation per dollar of the asset cost less salvage each year for the first 5 years, and nothing for the last 5 years.

Initial allowance is another form of accelerated depreciation. Here, a company is permitted to claim a specified extra proportion of the asset’s cost during the earlier years of the asset’s service life (Baritt, 1959). This supplementary allowance is deducted from the written-down
value for tax purposes, and so reduces the sum on which subsequent depreciation allowances are calculated. The initial allowance method, however, makes no change in the overall deduction. If there is an initial depreciation allowance of 10% of cost at the time of purchase, subsequent depreciation allowances are then based on 90% of the purchase price. A derivative of the initial allowance is free depreciation, under which corporate taxpayers are permitted to write off the full cost of assets in the first year after the acquisition (Ture, 1967). Thus, free depreciation is equivalent to a 100% initial allowance. Figure 2.4 graphs annual depreciation allowances per dollar of the asset cost under all depreciation methods discussed above. The asset’s life is assumed to be 20 years.

Figure 2.4: Annual depreciation allowances per dollar of the asset cost under straight-line, declining-balance, sum-of-the-years digits, shortened service life, and initial allowance methods for the asset with the service life of 20 years. It is assumed that no salvage value need to be taken into account in computing straight-line and sum of the years digits allowances. For the shortened service life method, it is assumed that the asset’s service life is reduced to 10 years. For the initial allowance method, it is assumed that 50% of the asset’s cost is depreciated over the first 5 years by the straight-line fashion, the rest is written off over the next 15 years, also by straight-line style.

Other closely-related taxation mechanisms
There are three other popular methods of liberalising the rules governing the determination of depreciation charges. One of these methods is to substitute replacement cost for original cost as the basis for the depreciation deduction. With the replacement cost method, it is possible to claim depreciation deductions of a sum greater than the original cost of the asset (Goode, 1955).
Another depreciation liberalisation method is known as the investment allowance. Like initial allowance, the investment allowance method also permits a firm to claim a specified extra proportion of the cost of the asset during the earlier years of the asset life (Goode, 1955). However, this supplementary allowance is not taken into account in the calculation of subsequent depreciation allowances. In effect, if accelerated depreciation acts like a loan provided by the government to the firm, investment allowances would represent subsidies for investment. Like replacement cost method, it is possible with investment allowances to claim depreciation deductions of a sum greater than the original cost of the asset. In Australia, newly acquired tangible depreciable assets are subject to different rates of investment allowances, as summarised in Table 2.6.

Table 2.6: Different rates of investment allowance rate permitted in Australia. Small businesses are entities with turnover of less than $2 million a year. Other businesses are entities with turnover of $2 million or more a year. Annual turnover includes all ordinary income the business earns in the ordinary course of business for the income year. Turnover means gross income, not net profit.

<table>
<thead>
<tr>
<th>Business Entity</th>
<th>Investment Commitment Time (Inclusive)</th>
<th>Date of First Use or Installed Ready for Use (Inclusive)</th>
<th>Minimum Investment Required</th>
<th>Rate Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small Business</td>
<td>13 December 2008 to 31 December 2009</td>
<td>By 31 December 2010</td>
<td>$1,000</td>
<td>50%</td>
</tr>
<tr>
<td>Other Business</td>
<td>13 December 2008 to 30 June 2009</td>
<td>By 30 June 2010</td>
<td>$10,000</td>
<td>30%</td>
</tr>
<tr>
<td>Other Business</td>
<td>1 July 2009 to 31 December 2009</td>
<td>By 31 December 2010</td>
<td>$10,000</td>
<td>10%</td>
</tr>
<tr>
<td>Other Business</td>
<td>13 December 2008 to 30 June 2009</td>
<td>1 July 2010 to 31 December 2010</td>
<td>$10,000</td>
<td>10%</td>
</tr>
</tbody>
</table>


Another liberalisation method is the price-index adjustment of depreciable basis. In particular, the depreciation allowance is calculated from the actual inflated replacement cost rather than the original cost (Barritt, 1959). In this study, the three methods discussed above are not considered accelerated methods since they may increase the overall deduction above what is allowed under ordinary depreciation practice.
Another tax mechanism that can be used to encourage greater investment is an investment tax credit. This provision permits a portion of the purchase price of specified assets to be utilised as a credit against income taxes (Bradford, 1980). For example, if a 30% investment tax credit is permitted to a newly acquired locomotive that costs $5.5 million, a credit worth of $1.65 million can be claimed against the tax payable. Normally a cap is set on the maximum amount of the credit. In particular, the maximum amount of the credit cannot exceed the tax liability of the company in the year the claim is made. Any unused credit is usually allowed to be carried forward to future tax years. The investment allowance and investment tax credit are very similar, with the difference being that the investment allowance reduces taxable income, whereas the investment tax credit is set against the tax payable. For example, if the relevant marginal tax rate is 40%, an investment allowance of 50% of the amount invested is equivalent to an investment tax credit of 20% of that amount. Unlike the US tax system, the investment tax credit scheme does not exist under the current Australian tax code.

Changes made to the marginal tax rate can also be used as incentive mechanisms. For example, a reduction in the marginal tax rate has two opposing effects. First, the tax cut increases the present value (PV) to the firm of the after-tax earnings from future assets (net of depreciation allowances). Second, it reduces the PV of the depreciation allowances associated with the asset. The incentive would be provided if the net effect is positive; that is, the first effect dominates the second effect. The opposite holds for an increase in the marginal tax rate. Later, it will be show that the sign of the net effect is largely dependent on the value of the discount rate.

### 2.3.2 Historical usage of accelerated depreciation

To understand the impact of accelerated depreciation, and whether it could prove useful in encouraging investment in more environmentally friendly technologies, it is important to look first at the background of depreciation law in several countries. The following section outlines the historical usage of accelerated depreciation in selected countries where accelerated depreciation has, at various times, been an integral part of taxation and economic policy.
The introductory period of accelerated depreciation: pre-Second World War

The first application of accelerated depreciation occurred during the First World War. Schemes of 100% initial allowances were adopted in Britain (in 1915) and the United States (in 1916), and were applied to war-related plant and machinery (Barritt, 1959). The first use of accelerated depreciation was not intended to be a progressive method of stimulating investment. Britain’s first provision of accelerated depreciation was adopted as an offset against the loss in the value of war-related plant and machinery arising from the postponement of renewals, or from repairs caused by exceptional depreciation or premature obsolescence owing to the war (Barritt, 1959). In the United States, the major reason leading Congress to introduce the scheme was that munitions makers’ profits were determined almost entirely from their performance of contracts with foreign governments. Accelerated depreciation was viewed as a method of securing a more equitable definition of taxable income for these munitions makers (Brown and Patterson, 1943).

With the United States’ entry into the war in 1917 came a need for expanded munitions capacity. A new accelerated depreciation scheme, called ‘reasonable deduction’, was incorporated into the Revenue Acts of 1918 and 1921; it aimed to provide an incentive to manufacturers of war goods to expand their plants (Brown and Patterson, 1943). Under the reasonable deduction provision, the loss in value of facilities used to produce articles contributing to the war effort was recognised in excess of ordinary wear and tear. Brown and Patterson (1943) contended that the reasonable deduction provision offered little investment incentive, especially in view of the delay in permitting the scheme – the law was not passed until three months after the hostilities had ceased. Uncertainties surrounding the length of time that the emergency demand was expected to last, in addition to uncertainties surrounding the amount that would be allowed to depreciate, further problematised the scheme. The total amount of costs that could be depreciated and the spreading of costs through time were determined by the Bureau of Internal Revenue (Brown and Patterson, 1943). The Bureau of Internal Revenue’s determination was based on its estimation of the post-war value of these facilities. As a result, firms did not know in advance what their depreciation allowance would be if they expanded their plants for war production.

During the Weimar Republic period in the 1920s, Germany underwent a period of hyperinflation (Widdig, 2001). Accelerated depreciation was not used by the German government as a tool to stimulate the economy and a replacement cost approach was
developed instead. This is not very surprising given that, in times of inflation, recovery of the nominal cost of investment will not be enough to match income and expenses. In particular, prices will increase rapidly during the hyperinflation period, as well as the income generated by the asset. By not adjusting the depreciation deduction to inflation, the firm’s tax liability will be a lot more than its real tax liability, and in times of hyperinflation, may be more than 100% tax on its real income. Moreover, in times of hyperinflation, an asset’s replacement cost will be considerably higher than its original purchase price. Combining these two incidences implies that, as long as the depreciation schemes are based on the original cost concept, investment incentives will be low during the hyperinflation episode. Even accelerated depreciation will not make much difference. To encourage investment, there is a need to express the costs incurred in generating that income in current dollars. This requires adjusting the historic cost of the asset for inflation (Margalioth, 2008).

Accelerated depreciation reappeared just before the Second World War. The free depreciation system was adopted by the Swedish government in 1938, and applied to equipment and machinery in general industry. The government hoped that the system would eliminate conflicts between taxpayers and tax administrators over correct depreciation rates (Muten and Faxen, 1966). The possible stimulus that the scheme might give to the consolidation of business firms was a secondary motive. Although the system was not adopted primarily as an investment-stimulating measure, it achieved a significant expansionary effect. Muten and Faxen (1966) contended that free depreciation increased corporate liquidity, or the availability of funds for new investment. Free depreciation had made self-financed investment in boom periods too easy for too many firms. As a result, the expansionary effects of free depreciation became too strong. The inflationary pressure that followed the excessive investment ultimately forced the Swedish government to restrict the system in 1951, and completely repeal it in 1955 (Muten and Faxen, 1966).

Muten and Faxen (1966) criticised Sweden’s use of free depreciation for several reasons. First, free depreciation was selective in nature and made self-financing easier for some firms, and for certain types of investments. In particular, free depreciation tended to favour long-term over short-term investment, in addition to investment in machinery and equipment over investment in buildings. Moreover, free depreciation gave more investment stimulus to firms already showing profits than it did to new ones. Second, free depreciation encouraged
overinvestment by misleading firms into undertaking bad investment projects for the sake of acquiring assets on which they could take free depreciation.

The period of recognition of accelerated depreciation: Second World War

Accelerated write-offs were used by a number of governments during the Second World War, when increased investment in defence and defence-related facilities became a matter of overwhelming importance. In Great Britain, for example, the special allowance of depreciation deductions introduced during the First World War was used again during the second global conflict. This time, however, only a 10% interim allowance was given forthwith (Barritt, 1959). In the United States, a scheme of five-year amortisation allowance was introduced in 1940 (Goode, 1955). The scheme allowed the asset to be written off in five years at 20% each year and was applied to defence and defence-related facilities, for which certificates of necessity were issued (Barritt, 1959).\(^5\) In Canada, certificates were issued from 1940 by the Ministry of Defence Production for special initial allowances for projects involving the production of war materials (Sharp, 1952). The specified extra proportion of the asset’s cost that would be allowed to depreciate during the earlier years of the asset’s service life was based on the estimate of the asset’s post-war residual value (Morgan, 1942).

Even though the United States’ five-year amortisation allowance offered significant incentive for private manufacturers to invest more in defence and defence-related facilities, there was still restricted private investment in emergencies during the Second World War. Three causes that contributed to the scheme’s failure were (1) the complications associated with obtaining the necessity certificates from the authorities before accelerated depreciation could commence; (2) the general fear of a post-emergency depression; and (3) the great increase in possibly competitive plants being built with government funds (Brown and Patterson, 1943). The situation was reversed in Canada, where accelerated depreciation successfully encouraged expansion in production of war-related materials, in addition to other products (Morgan 1942; Sharp 1952).\(^6\)

\(^5\) The full cost of these facilities can be written off in five years by a straight-line method, even when the normal useful life exceeded five years.

\(^6\) Up to 1951 in Canada, accelerated depreciation related to $109 million out of $158 million of expenditure being made by the taxpayers for 45 projects, mainly concerning the production of aircraft, steel, aluminium, and sulphur (Sharp, 1952).
The expansionary period of accelerated depreciation: the post-war years

The provision of special depreciation allowances during the wars introduced the idea of accelerated depreciation as a means of stimulating investment (Barritt, 1959). In most cases, however, the application of accelerated depreciation was restricted to war industries. It was not until the post-war period that this measure was expanded to other industries. The rationale behind this was that, after the Second World War, stimulating economic growth was an important agenda of tax policy in many countries (National Bureau of Economic Research, 1966). There was a general belief that accelerated depreciation would facilitate investment financing and thus promote economic growth (Margalioth, 2008).

The general idea that accelerated depreciation could promote more investment led to an increased recourse to accelerated depreciation in the post-war period, with the objective, at least in part, of speeding reconstruction or spurring capital formation so as to promote economic growth (Barritt, 1959). There was, however, no explicitly stated objective to encourage technological investment, although it would appear a concomitant of the overall objectives since raising long-run economic growth is closely related to increasing the rate of technological change (Boskin, 1988). Nonetheless, the rate of investment is argued to have a positive feedback on the rate of technical change since, as part of the process of investment, people learn new production processes and discover new products (Landau and Rosenberg, 1986). This might explain why encouraging investment in general was the first priority.

A wide variety of accelerated depreciation arrangements, including initial allowances and shortened service lives, were evident (Ture, 1967). The declining-balance method of depreciation was widely adopted as an alternative method to the straight-line approach. Moreover, other liberal forms of depreciation arrangements such as investment allowances and price-index adjustments of depreciable basis also featured in many nations’ tax policy for the purpose of increasing investment (Ture, 1967). The post-war development of these measures in selected countries and their efficacy in promoting investment (on a country-by-country basis) are summarised immediately below.

United States

In the first major change of the United States tax law, viz., the Revenue Act of 1954, sum-of-the-years-digits and double declining-balance formulas were introduced as alternatives to the ordinary straight-line approach. In 1962, guidelines for useful lives of assets for tax purposes
were promulgated by Treasury (Margalioth, 2008). These guidelines allowed investors to write assets off over a shorter period than what had been previously allowed (Auerbach, 1982). In 1971, another major change in depreciation practice occurred. Treasury created the Asset Depreciation Range (ADR) system, which allowed firms to write off their assets over a period that was, in most cases, 20% shorter than the 1962 guidelines allowed (Bischoff et al., 1971).

In 1981, Congress adopted the Accelerated Recovery System (ACRS), under which the depreciation system became even more generous than the pre-1981 system. The key aspect of ACRS was the shortening and simplification of depreciation schedules applicable to general industry equipment and structures (Margalioth, 2008). With the enactment of the Tax Reform Act in 1986, ACRS was replaced by the Modified Accelerated Recovery System (MACRS). Significant modifications, generally less favourable to taxpayers, were made to ACRS. The most important alteration was the lengthening of depreciation schedules for certain assets (Givoly and Hayn, 1991). Even though MACRS offered less-generous depreciation rules compared to ACRS, some accelerated depreciation aspects were still apparent. First, MACRS assigned the salvage value to zero (Kranz and Worrel, 2001). Second, the application of the half-year convention allowed taxpayers to take one-half of the total depreciation allowance for the year of purchase, even if the depreciable asset was purchased late in the year (Margalioth, 2008). Third, the 200% declining balance method with switchover to straight-line was applied to assets with short useful lives, while the 150% declining balance methods was applied to assets with longer useful lives (Kranz and Worrel, 2001). MACRS is still in effect.

The stimulus that post-war accelerated depreciation provisions gave was evident in a number of sectors. These provisions fundamentally altered the economics of real estate development in the United States. Since accelerated depreciation mostly affected newly-erected business buildings rather than alternatives such as the renovation of existing structures, there was an explosion in the number and the size of shopping centres and other new commercial constructions, beginning the late 1950s, and gathering momentum throughout the 1960s (Hanchett, 1996). The same conclusion could be drawn with regard to the steel industry. By the mid-1960s, it had replaced many of its open-heart furnaces with the much more efficient basic oxygen furnace, and was able to produce improved steel as a result (Prechel, 1990). According to Prechel (1990), this resulted from the incentive provided by the accelerated
depreciation provision incorporated in the Revenue Act of 1962. Accelerated depreciation allowances also contributed to a significant increase in the steel industry’s rate of reinvestment during the late 1980s.

Changes in tax policy, including the introduction of shortened tax lives and accelerated depreciation, had a positive impact on the investment of equipment and structures in the agricultural sector, during the period 1955–1978 (Halvorsen, 1991). The stimulus that post-war accelerated depreciation measures gave to the rate of technological advance was also notable, especially in the 1981 tax reform with the Research and Development (R&D) tax credit and accelerated depreciation incorporated (Boskin, 1988). Unfortunately, these R&D incentives were severely restricted by the 1986 tax reform (Boskin, 1988).

The situation for rate-regulated firms was different. In more than one case, the regulatory authority insisted that any reduction in current tax payments (from the use of accelerated depreciation deductions) should be treated as an increase in earnings, thereby making it possible to reduce permitted rates, and thus transferring some of the benefits of accelerated depreciation to present customers (Connecticut Public Utilities Commission Docket, 1969). As a consequence, conflict was experienced between regulatory bodies and certain utilities (e.g., AT&T) that would have liked to use accelerated depreciation as a source of working capital (Linhart, 1970).

Furstenberg and Malkiel (1977) argued that the post-war accelerated depreciation provisions were biased in nature, thereby leading to tax inequity. The 1950s and 1960s provisions discriminated against investment in maintenance and repairs relative to investment in new facilities (Boadway, 1978). This discriminatory feature resulted in the reduction in the market value of old capital (Kotlikoff, 1983; Auerbach and Kotlikoff, 1987). The 1981 ACRS discriminated against owner housing and favoured rental housing, which resulted in increasing rental housing relative to owner housing (Berkovec and Fullerton, 1992). The opposite phenomenon occurred when the MACRS was enacted in 1986, since it discouraged rental housing investment relative to owner-occupied housing (Poterba, 1992).

Another criticism was aimed towards the ADR system, which was believed to make tax accounting more complicated for the investor (there were over hundred distinct depreciation classes under ADR) (Auerbach, 1982). Added complexity could explain why many smaller
businesses failed to adopt ADR, even several years after its introduction, and also continued to use straight-line depreciation. Although ACRS fixed the problem pertaining to the ADR, its revenue losses were large by historical standards (Auerbach, 1982). Indeed, Congress passed significant tax increases in both 1982 and 1984, largely in reaction to the revenue losses from the 1981 tax reform (Auerbach and Slemrod, 1997).

Hall and Jorgenson (1967), Sinai and Eckstein (1983), Makin (1984), Sahling and Akhtar (1984), and Boskin (1988) concluded that accelerated depreciation was quite effective in stimulating additional investment in the United States in the post-war years. However, contrasting opinions were expressed by Eisner (1969), Coen (1969), and Auerbach and Hassett (1992). There are several possible explanations for these contrasting findings. First, these empirically-derived results were based on different assumptions made regarding the value of the elasticity of capital stock with respect to the cost of capital (Boskin, 1988; Margalioth, 2008). Second, standard econometric policy evaluation may be misleading since it is based on a number of restricted assumptions (Lucas, 1976). Third, many factors other than taxes influence investment, including the firm’s liquidity, the price of investment goods, interest rates, tax rates, the nature and course of a recovery, and expectations about future economic activity (Boskin, 1988; Margalioth, 2008).

United Kingdom

The British Income Tax Act of 1945 introduced the initial allowance for plant, machinery, shipbuilding, buildings, and mining work (Barritt, 1959). In addition, an investment allowance was introduced in 1954 (Williams, 1966). Rates at which initial and investment allowances were granted and the classes of assets affected were altered several times during the period 1945–1970 (Williams, 1966; Boatwright and Eaton, 1972). Both schemes were rescinded and reinstated several times during the same period (Rozen 1963; Boatwright and Eaton, 1972). The United Kingdom also used a traditional depreciation method called ‘writing down allowance’ (Barritt, 1959), which was granted on a declining-balance basis. In other words, a constant percentage of the consecutive written-down value of the asset could be written off against tax. The absolute value of the allowance would therefore fall year by year. Surprisingly, the ordinary straight-line method of depreciation was permitted after the traditional writing-balance system. In 1970, a new system of accelerated depreciation

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7 The situation was often reversed outside the United Kingdom.
payments was developed (Boatwright and Eaton, 1972). Under this, firms were granted initial allowances of 35%, and annual writing-down allowances of 25%. These rates were larger than those of the previous system.

Williams (1966), after consulting a number of independent surveys, held that investment decisions were materially affected by favourable changes in investment and initial allowances. He noted, however, that the impact of these provisions was much greater on large firms than on small ones, and also much greater on growing firms. The view of Williams was supported by a subsequent empirical study of Fieldstein and Flemming (1971), who used a generalised neoclassical investment function (originally developed by Jorgenson in 1963 and 1965) to assess the effects of tax policy on investment in Britain during the period from 1954 to 1967 and found significantly positive results.  

France

Accelerated depreciation provisions were first used in the early 1950s. A double depreciation allowance was permitted in the first year, together with a 10% special initial allowance, was applied to machinery and certain types of equipment (Barritt, 1959). Beginning in 1953, steelmaking and mining concerns were allowed to add a supplementary depreciation allowance, based on their rate of turnover, to the regular rate of depreciation. During 1957–1959, recognised export firms were allowed to take additional depreciation allowances, which varied with the importance of their export business. In 1959, the use of the declining-balance method of depreciation in lieu of the straight-line approach was introduced. The declining-balance rates varied with assets’ estimated service lives (Tabatoni, 1966). There was also a special 50% initial allowance in the first year for the purchase of buildings, materials, and equipment devoted to research. This was regarded as advantageous to companies setting up research facilities whose equipment had a high rate of obsolescence (Tabatoni, 1966), though this provision was eliminated when the declining-balance method was introduced. A special initial allowance was also given to firms that had research undertaken by a specialised company. These firms were permitted a special depreciation allowance of 50% in the first year for the purchase of shares in an approved research concern.

Fieldstein and Flemming’s model (1971) showed that both the accelerated depreciation allowances and the use of differential taxation to induce the retention of corporate profits had substantial and significant impacts on investment behaviour. Simulations with their investment equation showed that the increases in depreciation allowances accounted for approximately 45% of net capital accumulation in the period after 1954.
This system remained valid for shares purchased since 1960. In addition to accelerated depreciation provisions, an optional system allowed the historic cost and the depreciation allowances to be multiplied by an index factor to bring the cost and allowances into terms of current value (Barritt, 1959). This optional system, instituted in 1955, was applied to capital investment made before 1955.

Although business investment in France rose at a very striking rate during the post-war period, Tabatoni (1966) argued that this was due to the value-added taxation system developed in 1954, not provisions permitting accelerated depreciation. Tabatoni found that a large number of firms did not elect to take advantage of various accelerated depreciation provisions. Many firms were afraid of tax increases during the deceleration phase, or a drop in bank credit, or indeed any other factor likely to create financial difficulties in the future. Some firms chose to postpone depreciation in order to offset against their present inadequate gross income. When their stock is traded on an exchange, firms might have to show a sizeable net income and therefore elect not to claim all their depreciation allowances. Some firms also preferred to have substantial depreciation reserves in advance of large borrowing. A similar conclusion was drawn regarding the effectiveness of the provision that permitted the revaluation of depreciable assets. Among larger firms, the failure to take advantage of this privilege was attributable to the fact that the increase in reserves from revaluation made the firm more vulnerable to the demands of shareholders, associates, and even employees. The limited use of this provision among small businesses was due to ignorance, the complexity of the system and the expense it entailed, and the fact that the tax on revaluation reserves might constitute a financial burden.\footnote{Under the revaluation provision, as a rule, revaluation profits were exempted from profits taxes but a tax of 3% was imposed on the reserve (Tabatoni, 1966).}

The Netherlands

Accelerated depreciation in the Netherlands took the form of the initial allowance (Goedhart, 1966). In 1949, special accelerated depreciation arrangements were given to buildings, motor cars, and office equipment (Barritt, 1959). The precise amount of the initial allowance was changed repeatedly. Taxpayers were originally allowed to write off one-third of the cost in the first 5 years; in 1960, the figure ranged from 0% on passenger cars to 6% on new...
factories, and 8.33% on certain other means of production (Goedhart, 1966). Investment allowance was added in 1953, which permitted firms to write off 4% of the cost of new durable production facilities for 5 successive years (Barritt, 1959). In addition, the Dutch government, in 1950, instituted a revaluation system to certain types of assets purchased before the war and still in use, so as to take account of inflation. Depreciation allowances were then calculated from the inflated cost, rather than the original cost.

In his analysis of the role that tax policy played in promoting post-war economic growth, Goedhart (1966) concluded that the increase in investment activity in the Netherlands since the war was positively influenced by various tax regulations favouring the use of retained profits for investment purposes, one of which was accelerated depreciation. Tempel (1966) supported Goedhart and maintained that these tax incentives solved the previous uncertainty problems regarding future possibilities and a general hesitancy to venture large investments. They resulted in the general increase in the level of investment. Hoorn Jr. (1966), however, was not as optimistic and claimed that the scheme only encouraged investment in existing businesses. He also wondered whether a generally lower level of taxation could accomplish the same task and give private investors freedom to make their own investment choices.

Barritt (1959) has pointed out that excessive investment activity during the 1950s contributed to the nation’s rapid growing inflation during that period. During the mid-1950s, the Dutch government became concerned about growing inflation. This was why several generous accelerated depreciation provisions were subsequently restricted or withdrawn (Barritt, 1959). In 1955, the initial allowance for plant was reduced and, in 1956, investment allowances were withdrawn (Barritt, 1959).

**Sweden**

As previously stated, the free depreciation system was repealed in 1955 owing to inflationary pressure. The system was replaced by a new accelerated depreciation scheme called ‘book depreciation’ (Muten and Faxen, 1966). This was considered less generous in many ways, e.g., there were restrictions placed on the maximum depreciation allowance for machines with a useful life of more than three years. The system was designed to furnish the Swedish

\[10\] Figures provided by the Central Bureau of Statistics indicate that the volume of gross private investment increased every year during the period that these tax regulations were effective (Goedhart, 1966).
government with a better tool against the inflation that followed from the excessive level of investment caused by the free depreciation system (Muten and Faxen, 1966). Book depreciation allowed all business firms to choose between a 20% straight-line depreciation and a 30% declining-balance formula, which enabled them to write off slightly more than half of the cost of a machine during the first two years of its life (Muten and Faxen, 1966). The right was also given to switch from 30% declining-balance rate to a 20% straight-line method, if the former system’s written-down value had been used from the outset.

Even though the taxpayer had to raise more money in the first year of investment under book depreciation than he/she was required under free depreciation, Muten and Faxen (1966) contended that there was no significantly difference between the two systems regarding the degree of investment incentive that they gave. The new system still implied substantial amount of tax deferral because normal useful lives of assets were generally very long (usually 25 years). Sandels (1966), however, noted that tax deferral from accelerated depreciation might impair the free flow in the market of businesses as going concerns. This led Sandels to doubt whether liberalising deferral rules was more advantageous than lowering the corporate tax rate with respect to encouraging investment.

*Italy*

Here, accelerated depreciation took two forms: shortened service life and initial allowance (Forte, 1966). The shortened service life, introduced in 1951, reduced the period of depreciation by not more than two-fifths in the case of new facilities, or where existing facilities were transformed, reconstructed, or improved. This was the first liberalisation of the depreciation provisions in the Italian law that, up to that time, had been quite restrictive and only permitted the straight-line method. The initial allowance, adopted in 1956, granted initial allowances of 10%, which might be spread over 3 years, in addition to the accelerated depreciation allowances under the former system (Forte, 1966). In 1963, the initial allowance was increased to 15% (Forte, 1966). In addition to accelerated depreciation provisions, a revaluation system was adopted before 1953 to revalue assets purchased before 1947 (Barritt, 1959). The re-valued cost of the asset was then used as the depreciable base.

Forte (1966) criticised the initial allowance system (adopted during 1950s) as inequitable; in particular, the rule limiting the allowance to a stated percentage of reported income discriminated against growing enterprises and favoured very large ones. Forte did not attempt
to assess accelerated depreciation’s effectiveness in spurring investment. He suspected, however, that the rule’s limitation diminished the system’s impact. His argument is supported by the fact that increases in the level of investment during the 1950s were greatest in the heavily industrialised sections of northern Italy, but investment in agriculture lagged. This could have been due to the selective nature of the provision. One might argue that Italian accelerated depreciation provisions, even though inequitable, still did their job of spurring investment in targeted industries. However, the high level of investment in these industries might have been caused by other stimulating measures, e.g., tax exemptions and tax reductions were also provided during the same period.

Germany
The then West Germany introduced a wide variety of accelerated write-off measures and specific provisions that permitted the retention of a major portion or of all profits before taxes.\footnote{During 1947–1952, West Germany was subject to the Marshall Plan formulated by the United States (Berger and Ritschl, 1995). As a result, a good deal of the nation’s reconstruction programs, including accelerated depreciation, were influenced by the US practices.} The most important was the Asset Revaluation Law of 1949, which permitted revaluation of all assets to the 1948 cost level and reactivation of written-off items, even though still in use, or assets lost by war action at one-third of their 1948 replacement cost (Wertheimer, 1958; Barritt, 1959). The Income Tax Laws of 1948 and 1949 permitted a fast write-off for replacement of assets lost during the war (Wertheimer, 1958). In 1950, rapid write-off provisions for defence plants were permitted in case of emergency (Wertheimer, 1958) while, in 1951, substantial accelerated depreciation allowances were provided in certain basic goods industries where prices were still controlled, e.g., coal, iron, steel, electricity, gas, etc., and essential food production (Hauser, 1966). This involved permitting one-half of an investment in machinery and one-third of that in a plant to be written off in three years. For other sectors, a shift from the straight-line depreciation to the declining balance method of depreciation at 2.8 times the straight-line rate was permitted in 1952 (Wertheimer, 1958). In 1971, special depreciation allowances were permitted on ships ordered in or after 1971 (Ademuni-Odeke, 1984). The cumulative amount of special depreciation was originally up to 30% of the ship’s acquisition costs.
Hauser (1966) pointed out that accelerated depreciation provisions played an important role in recovering the country’s economic collapse after the Second World War. He noted that accelerated depreciation provisions of the late 1940s and early 1950s were successful in overcoming bottleneck industries and stimulating capital goods industries. Furthermore, he estimated that nearly 3 billion DM were invested as a direct result of the benefits provided. This accomplishment reinforced the boom and spurred growth, but also resulted in overcapacity in some industrial sectors (which contributed to a slowing down of growth by 1958). Hauser’s positive view was shared by Wertheimer (1958), who estimated that tax incentives for investment, including accelerated depreciation, provided 93.5% of all business expenditures on fixed assets and inventory changes from 1950 to 1955. Senf (1966), however, contended that a more rigorous analytical and empirical way was required in order to draw a valid conclusion regarding the impact of special investment-stimulating measures. Neumark (1966) also expressed his agreement with Hauser’s view. Nevertheless, he called particular attention to the inequalities to the complexities in the nation’s growth-promoting tax policies. In particular, they were extremely complicated and therefore only the wealthy, who could afford highly specialised tax consultants, could take full advantage of the system.

**Japan**

Many special provisions for accelerated depreciation were introduced after the enactment of the Shoup Mission of 1949–1950, which proposed a radical reform of Japan’s taxation system (Kaizuka, 1992). In 1950, a revaluation system similar to those permitted in Western European countries was provided in order to curb wartime and post-war inflation (Komiya, 1966). The list of useful lives for each type of fixed asset was reviewed in 1951, and again in 1962. Accelerated depreciation for important industrial equipment was permitted in 1951, with additional initial depreciation for important industries introduced in 1952 (Kaizuka, 1992). Initial allowances for equipment embodying new technology were given in 1958, while accelerated depreciation for equipment for SMEs was provided in 1963 (Kaizuka, 1992).

Accelerated depreciation was also apparent in Japanese export industries. From 1961 to 1972, firms were allowed accelerated write-offs for equipment if they raised the proportion of their businesses from exports above the previous year’s level (Kaizuka, 1992). In 1967, the initial depreciation on machinery and equipment used for the prevention of environmental pollution was increased in 1967 (Ishi, 2001). During the 1970s, the trend towards expanding
accelerated depreciation provisions began to slow down. Accelerated depreciation for export industries was abolished, while the increased initial depreciation for important industries was reduced (Ishi, 2001).

Komiya (1966) questioned the selective nature of the accelerated depreciation system of the 1950s; in particular, that the particular industry or type of machinery and equipment eligible for accelerated depreciation was left to the discretion of the Minister of Finance. He argued that (1) only large firms could cope with such complicated administrative procedures, and (2) that, as a consequence, the stimulus effect was undermined. In addition, even though some of the desired effects were achieved, they were gained at the expense of tax equity (Komiya, 1966). A different view was expressed by Hara (1966) and Yasui (1966), who argued that the largest part of the new investment in Japan was achieved by the application of accelerated depreciation. These observers believed that the selective nature of accelerated depreciation was appropriate because industries eligible for the provisions were to contribute to the modernisation of Japanese industries and the advancement of new technologies and contended that accelerated depreciation is less inequitable than other tax laws in stimulating investment. Komiya’s view was supported by the subsequent studies of Hayashi (1985) and Homma et al. (1989), who used an econometric model called Tobin’s q to provide evidence that, during the period 1956–1970, the contribution of tax incentives (accelerated depreciation included) in promoting investment was limited. Hayashi and Homma et al. argued that a high level of investment was caused by a high expected rate of return, and not necessarily a lower cost of capital as a result of tax incentive schemes.

Australia

The most notable form of accelerated depreciation in Australia during the post-war period was the ‘5/3’ depreciation system (Reinhardt and Steel, 2006). This system permitted eligible assets, which could otherwise be depreciated at a rate in excess of 20% using a straight-line method, to be written off at a rate of 33.33 % (three-year write-off). It also permitted eligible plants, which could otherwise be depreciated at a rate of 20% less, to be written off at a rate of 20% (five-year write-off). It was believed that 5/3 depreciation provided a significant incentive to invest in the modernisation of Australian industry (Network Economics Consulting Group, 2002). The 5/3 depreciation arrangement was gradually wound back in the 1980s (Reinhardt and Steel, 2006).
In the Australian shipping industry, an accelerated depreciation allowance of 20% per annum was introduced in 1984 (Gillies and Cleworth, 2008). This rate was an increase from the previous rate of 6.25%. Ships qualifying for the provision could be written off over 5 years – a period significantly shorter than their actual economic life. The provision even allowed ship owners to begin claiming depreciation in the year before the commissioning of the ship. In practice, the vessels were usually depreciated over four years, 40% in the first year and 20% in each of the following three years. In the late 1980s, this scheme was extended for an additional five years, as a result of recommendations by the Shipping Reform Task Force (BTCE, 1997). As mentioned previously, this scheme was argued to result in the modernisation of the Australian maritime sector (Gillies and Cleworth, 2008).

Accelerated depreciation was also evident in the Australian natural resource sector. Some capital expenditure in the mining and petroleum sector, including natural gas pipelines, was allowed to be written off over ten years, even though actual life might exceed fifty (Department of Minerals and Energy, 1999). The scheme is regarded as positively affecting international competitiveness and investment attraction of these capital-intensive parties, since most other countries provide tax benefits for certain capital expenditures (Queensland Government, 1999). Arguments could be made that there are possible externalities associated with the investment made from these industries, such as technology spin-offs and the importance of high-quality infrastructure in attracting further industry (Review of Business Taxation, 1999).

Following a review, the Commonwealth decided to abolish various accelerated depreciation arrangements in return for a revenue neutral reduction in the company tax rate. Depreciation rates were subsequently aligned to the effective life of the asset (Department of Minerals and Energy, 1999). This change was aimed at removing tax-induced distortions to investment decisions and substantially funding a reduction in the corporate tax rate (Reinhardt and Steel, 2006).

The Queensland Government (1999) submitted that the decision to scale back accelerated depreciation provisions would adversely affect the incentive to invest in mining, manufacturing and some infrastructure provision industries, which were the principal beneficiaries of existing accelerated depreciation provisions. The decision would shift the allocation of investment from major long-term resource projects, particularly in mining, to...
projects with a shorter life (Queensland Government, 1999), thereby posing a serious threat to regional development and employment. More recently, the shipping industry blamed the changes for contributing to the underutilisation of coastal shipping in Australia, and for preventing the industry from re-equipping with more advanced (and cleaner) vessels (Maritime Union of Australia, 2008; Gillies and Cleworth, 2008).\(^{12}\)

Despite the changes, accelerated depreciation provisions remain in force for assets constructed or acquired before September 1999 (Network Economics Consulting Group, 2002). However, the benefit arising from tax deferral has been somewhat reduced by the new approach to taxation in tariffs for rate-regulated firms. These firms are usually the owners of infrastructure assets pertaining to electricity, natural gas, rail, telecommunications, and water networks. In exchange for access to their networks, infrastructure owners are paid transmission tariffs in amounts mandated by independent regulatory agencies, such as the ACCC in Australia (Johnstone, 2003). The new taxation approach (proposed by the ACCC in 2000) involves adjusting the permitted tariff for regulated natural gas pipelines downward, which has the effect of transferring to pipeline customers the full benefits of accelerated taxation depreciation (ACCC, 2000). This system therefore cancels out the investment incentives intended through accelerated depreciation (Network Economics Consulting Group, 2002).

**Recent application of accelerated depreciation: the green taxation era**

Recently, accelerated depreciation provisions were proposed in many parts of the world as part of environmental-based tax programs. These aimed to control greenhouse gas emissions resulting from industrial production and were supposed to encourage businesses to replace carbon-intensive equipment with environmentally friendly equipment so as to reduce emissions. Accelerated depreciation schemes are found in a number of countries.

In the United States, the Emergency Economic Stabilization Act of 2008 contains a number of depreciation incentives for increasing energy efficiency (Cudd and Jewett, 2008). The Act permits accelerated depreciation for smart electric meters and smart electric grid systems. Taxpayers are allowed to recover the cost of this property over 10 years, unless the property

\(^{12}\) The average age of Australian flagged ships is significantly older than the world fleet average (Gillies and Cleworth, 2008).
already qualifies under a shorter recovery schedule. The Act also permits accelerated depreciation for purchase of equipment used to collect, distribute, or recycle a variety of commodities (Cudd and Jewett, 2008). In Canada, an accelerated depreciation provision has been put in place to allow taxpayers an accelerated write-off (at a rate of 30%) for specified energy efficiency and renewable energy equipment. Such equipment can be depreciated at annual rates of between 4% and 20% (Department of Finance Canada, 2004). The program also allow the costs of pre-feasibility and feasibility studies, negotiation costs, site approval costs, etc., to undergo accelerated depreciation (Government of Canada, 1998).

A similar scheme was introduced by the Dutch government in 1991 (Green Tax Commission, 2001). This scheme has provided companies the freedom to choose how to write off the costs of investing in more efficient equipment, although it is only applicable for equipment specified on an environmental list updated by the Ministry of Environment. The list includes equipment pertaining to mitigating water pollution, soil pollution, waste, and noise, etc., that has not yet been widely accepted, has no negative side effects, and has the potential for a substantial market. Costs associated with obtaining advice on the purchased machinery are also subject to accelerated depreciation (McKane et al., 2007). In Singapore, companies investing in energy-efficient equipment are permitted to write-off the capital expenditure in one year (McKane et al., 2007). However, unlike the Netherlands and Canada, expenses related to acquiring information or consultant fees for identifying and analysing the equipment purchase are not subject to accelerated depreciation. An environmental rationale has also been put forward in Japan. Since 1993, an accelerated depreciation allowance equal to 30% of the acquisition cost has been available for investments in specified environmentally friendly equipment (Anderson, 2002). From 2005, Mexican investors were allowed to deduct up to 100% of the investment in the first year for approved renewable energy technology projects (defined under the General Law for Ecological Equilibrium and Environmental Protection). According to the regulation’s guidelines, equipment shall remain in operation at least five years following the tax deduction (Econsense, 2008).

Given the recent nature of these schemes, it is difficult to assess their overall impact on environmentally friendly investment. There are, however, a few theoretical studies indicating their effectiveness in promoting investment in clean technologies. For example, the case study of a Brazilian chemical plant by Soares et al. (2006) illustrates that an accelerated depreciation scheme could increase the expansion of Combined Heat and Power (CHP) plants
in Brazil by 24%. The authors conclude that the scheme is costly to government, yet induces technological advancement and improves the feasibility of ventures that would not otherwise have taken place. A similar result is found in Kranz and Worrell’s study (2001), which investigates and compares several depreciation methods to assess the effectiveness of possible policy measures with respect to the depreciation schedules for investments in CHP plants in the United States.

The table in Appendix A provides a cohesive summary of the utilisation of accelerated depreciation (in some selected countries) since its introduction.

2.3.3 Discussion: moving towards carbon-constrained economies

The general conclusion from the historical review is that accelerated depreciation creates an expansionist atmosphere. In many cases, this has spurred investment in eligible sectors. There is some historical evidence suggesting that the modernisation/replacement efficiency atmosphere associated with accelerated depreciation led to an increase in technological investment, e.g., the steel industry in the United States (Prechel, 1990), and the fast growth in technological advancement in post-war Japan (Hara, 1966; Yasui 1966). Nevertheless, an in-depth analysis of the extent to which accelerated depreciation influences technological investment is still required to prevent ill-conceived decisions relating to taxation.

Although the general conclusion from the theoretical literature is that accelerated depreciation positively influences the investment decisions of firms by lowering a tax obstacle, empirical results have been mixed across different contexts. Studies of the effect of accelerated depreciation provisions in the same place and approximately same time have led to conflicting results, e.g., the debate between Hall and Jorgenson (1967) and Coen (1969). It is thus very difficult to estimate, with confidence, the part played by accelerated depreciation in influencing new investment or replacement decisions. In reality, re-equipment or expansion plans are very complex and may be guided by non-tax factors, e.g., the price of investment goods, interest rates, tax rates, the nature and course of a recovery, expectations about future economic activity, globalisation and foreign direct investment (Boskin, 1988; Margalioth, 2008).
Investment can be stimulated by other measures such as a reduction in taxes or interest rates. Accelerated depreciation, as suggested by historical evidence, has the advantage of being more selective since the benefits are restricted to those acquiring eligible assets. This was the case in Japan, where accelerated depreciation was permitted for certain types of investment necessary for modernising Japanese industries (Komiya, 1966). This discriminatory feature was reasonably effective in bringing about the conspicuous modernising of Japanese industrial equipment (Hara, 1966; Yasui, 1966). In the current situation, where increased attention is being paid to an overall reduction in carbon emissions, the selective aspect of the scheme can be used to encourage carbon-intensive firms to invest in cleaner and less environmentally intrusive technologies. As discussed above, this has already started to take place in various nations.

Despite this, the biased nature of accelerated depreciation has an important drawback. In general, accelerated depreciation tends to favour firms that normally make long-term investment over those that usually undertake short-term investment, since the latter can be written off quickly even without changes in the depreciation rule (Cary Brown, 1962). Accelerated depreciation thus tends to discriminate in favour of well-established firms. New firms, whose income is likely to be negative, will most likely not find tax benefits from accelerated depreciation all that attractive (Williams, 1966). This has historically been the case in Japan and several European countries. The United States’ use of accelerated depreciation, which favoured new capital by lowering the present value of taxes, left old capital at a tax disadvantage, which caused the market value of the old capital to fall (Kotlikoff, 1983; Auerbach and Kotlikoff, 1987). This naturally means little for growing firms; but, for static firms possessing a lot of old capital, accelerated depreciation devalues their equipment. Its selective nature may thus result in political pressure from opponents, especially those who cannot access the scheme’s benefits, and those who will lose from it.

Tax inequity can have serious political repercussions. For example, fairness was part of the reason why the United States’ 1981 ACRS was restricted in 1986 (Auerbach and Slemrod, 1997). It was argued that tax fairness would be improved by the combination of rate reduction, base-broadening and the elimination of special preferences, e.g., those tied to accelerated depreciation (Auerbach and Slemrod, 1997). This would suggest that proponents must find ways to rationalise its enactment so as to reduce the political strain and engender bipartisan support. In the environmental field, if it is assumed that no ETS is operating, firms
relying on older equipment could request justification for why they are at a tax disadvantage if accelerated depreciation laws were passed. The biased aspect of accelerated depreciation thus leads to the necessity of ensuring that the implementation is fair. It also suggests that a comprehensive cost-benefit analysis should be undertaken.

Despite political pressure, it could still be concluded that the adoption of accelerated depreciation to encourage investment in innovative technologies would be difficult to argue against since the broader and more strategic benefits would be distributable to almost everyone. With the increasing enactment of emissions trading schemes, accelerated depreciation would make it easier for firms using cleaner technology to compete in a carbon-constrained business environment, thereby leading to a competitive advantage for nations introducing accelerated depreciation.

Accelerated depreciation, of course, does not always work as intended. There are clearly some lessons to learn so as to guarantee the effectiveness of these provisions. For example, Sweden provides historical evidence that it is possible for firms to abuse the provision, i.e., by undertaking bad investment projects for the sake of acquiring assets so as to make use of accelerated depreciation for tax benefits. There is also the danger that firms will acquire ‘environmentally-acceptable’ equipment for the sake of taking the privilege, rather than equipment (presumably more expensive) with class-leading credentials. This suggests a need for firm guidelines regarding which equipment can be subject to accelerated depreciation.

The historical examples make it clear that the extent to which accelerated depreciation provisions can have a positive effect depends largely on the extent of their use. There are a number of constraints that may militate against firms’ shifting from normal depreciation practice to accelerated methods. Depreciation accounting under accelerated depreciation methods is more complex than under the straight-line approach and involves greater administrative costs. For small companies or those with relatively small amounts of assets eligible for accelerated depreciation, the increase in compliance costs might outweigh the expected benefits. Administrative complexity was part of the reason why the United States’ five-year amortisation allowance and ADR systems were not very successful (Brown and Patterson, 1943). This has also been the case in Japan, France and Germany, where only large firms could cope with the complicated administrative procedure of using the scheme.
(Komiya, 1966; Tabatoni, 1966). This has an important implication: make the scheme simple or not all firms will use it.

The firm’s accounting conventions may make it difficult to report income and costs to shareholders on a different basis from that used for tax purposes. The reported increase in depreciation deductions resulting from using an accelerated instead of straight line depreciation can lead to a reduction in profits before tax. This might reflect adversely, albeit inaccurately, on the firm’s management. Accounting conventions were part of the reason why many French firms did not elect to adopt accelerated depreciation during the post-war years (Tabatoni, 1966). This suggests that the future adaptation of accelerated depreciation aimed at promoting technological investment requires clear government communication regarding the scheme’s financial advantages.

Another factor preventing a firm adopting accelerated depreciation is the expectation of a change in marginal rates of tax. Accelerated depreciation yields less benefit if marginal tax rates are expected to be lowered (Ture, 1967). The inducement to adopt accelerated methods would thus be relatively weak for smaller firms if they expect marginal tax rates to decrease. Adopting accelerated depreciation can also prove problematic if marginal tax rates are expected to rise, as occurred in post-war France (Tabatoni, 1966). The impact is especially significant during the decelerated phase of the scheme, i.e., when depreciation deductions reduce and taxable income from the depreciable facilities rises. Smaller firms expecting an increase in income, and hence in marginal tax rates, might therefore wish to defer adoption of accelerated depreciation. To guarantee its efficacy, industry’s expectations regarding marginal tax rates demands consideration. The historical evidence suggests that it is best for the government to keep marginal tax rates unchanged if accelerated depreciation is to be used.

Uncertainties surrounding the amount that would be allowed to depreciate and uncertainties surrounding when and how long the scheme would be implemented can also potentially deter accelerated depreciation’s intended objective. This was the case in the United States, where uncertainties associated with accelerated depreciation were the most conspicuous factors contributing to the failure of the scheme during the introductory period (Brown and Patterson, 1943). Guidelines regarding the amount of allowance and the length of time of the allowance thus need to be given to potential investors in innovative technologies. It would also be
better, as Barritt (1959) contends, to create a greater atmosphere of confidence by introducing accelerated depreciation provisions with a reasonable guarantee of continuity so as to stimulate forward planning.

Furthermore, accelerated depreciation may not offer significant investment incentive to rate-regulated firms, e.g., owners of electricity, gas, rail, telecommunications, and water networks. Some regulatory authorities (e.g., the ACCC) have advocated that any reduction in current tax payments (from the use of accelerated depreciation deductions) should be treated as an increase in earnings, thereby making it possible to reduce permitted rates, and thus transferring the benefits of accelerated depreciation to present customers. As a result, the investment incentives intended through accelerated depreciation will be entirely negated. This occurred in the United States, where there was conflict between regulatory bodies using this transfer and utilities that would have liked to use the scheme as a source of working capital (Linhart, 1970). This has also been the case in Australia, where the ACCC proposed a new approach to taxation in tariffs for regulated pipelines involving the adjustment of the permitted revenue downward so as to transfer in full taxation benefits to consumers (Network Economics Consulting Group, 2002). If accelerated depreciation provisions were to be introduced to taxation law to encourage investments in innovative environmental technologies, the transfer of the benefit of accelerated depreciation to consumers sends an unfortunate signal to rate-regulated firms, which are also potential investors in these assets. This suggests that there is a need to review current rate-regulation guidelines in order to allow the incentive provided by accelerated depreciation to take full effect.

Considerations also need to be made regarding the costs that accelerated depreciation might produce. The scheme is obviously expensive to implement (e.g., the large revenue losses from the 1981 ACRS in the United States), and perhaps the government might be better off spending its tax revenue in other areas. A number of countries (e.g., Sweden, the Netherlands, and Canada) experienced rapid inflation from excessive investment activity, which was a consequence of permitting depreciation schemes that were too generous. Moreover, when substantial investments made under accelerated depreciation begin to make their full contribution to the output of eligible sectors, overcapacity may occur and slow down the nation’s economic growth. This was the case in Germany during the late 1950s (Hauser, 1966). A review thus needs to take place occasionally to evaluate the scheme’s outcome and guard against unintended consequences.
Finally, taxation is only one of many factors that may restrain investment. This implies that accelerated depreciation alone may not be sufficient to assure a desired level of investment in cleaner technologies. This was always the case in every country surveyed. Indeed, accelerated depreciation is often part of the program to stimulate investment, not the primary mechanism.

With the theoretical foundation and the historical employment of accelerated depreciation having been established, the next section of the literature review will examine how decisions are made in the corporate world regarding capital item replacement investment and, in particular, the influence of sympathetic taxation arrangements, such as accelerated depreciation, on these decisions. The objective of this exercise is to identify appropriate analytical frameworks that can be used to investigate the effects of allowing accelerated depreciation on the investment behaviour of rail freight operators.

### 2.4 Capital Equipment Replacement Decisions

According to Batterham and Fraser (1995), capital items are defined as major and minor equipment items used for producing and distributing goods or services, as well as equipment used for maintenance. Examples of such assets abound in every industry and include aircraft, automobiles, trucks, trains and photocopiers. Capital assets typically have an operational life of many years and depreciate over a set period (computers remain an exception). For economic reasons, they must be replaced at a suitable time. A capital equipment replacement decision generally involves finding the optimal time to replace capital items (Mauer and Ott, 1995). Such a decision is both a complex economic problem and a problem of considerable practical importance to every company, especially when the ongoing cost of running the business and long-term growth are concerned.

#### 2.4.1 Factors driving capital equipment replacement decisions

The information required to solve the capital replacement problem is highly differentiated across the diversity of models developed in the literature. A list of circumstances that alert the organisation to the need for capital equipment replacement also depends on the nature of that organisation and the industry to which it belongs. The following are common factors that have been found to be relevant to many firms faced with decisions involving the replacement of capital equipment. They are drawn from the literature on replacement decision-making.
Trade-off between the replacement cost and the running cost

Ahouissoussi and Wetzstein (1995) define the cost of replacement as the difference between the cost of new equipment (the purchase price, installation cost, delivery, etc.) and the salvage value of the existing asset. The running costs can be divided into three components, viz., overhead cost, operating cost, and unreliability cost (Walker, 1994). Overhead cost includes elements for the provision of the maintenance equipment, supervision and employee-related expenses, in addition to incidentals such as license, insurance, tax, etc. Operating cost includes expenses such as fuel and lubricants, in addition to the cost of parts and labour on routine service maintenance and anticipated major overhauls. Unreliability cost includes estimates of the cost from decline in dependability, the direct costs indicated by parts and labour on breakdown repair, and the indirect costs (or opportunity costs) resulting from idle time as the equipment is repaired.

The trade-off between the replacement cost and the running cost is probably the most important economic force leading to equipment replacement (Ahouissoussi and Wetzstein, 1995). In general, the running cost of a piece of capital equipment increases as its condition deteriorates over time. Replacement is called for at a time when the long-term cost associated with investing in a new piece of equipment becomes less than that of keeping the old equipment. As a result, a basic replacement analysis usually consists of studies of both the trend in operating cost and the net cost of replacement. Trading off the net cost of replacement against the running cost is often considered by typical replacement investment models, such as the influential economic life models of Eilon et al. (1966) and Christer (1984).

Technical obsolescence

In all practical situations for which operating costs of an existing asset are generally near-constant or increasing only slowly, replacement would only be considered if it can bring a significant reduction in operating costs, e.g., a step-change improvement in fuel efficiency, or a significant increase in functionality (Scarf et al., 2007). Examples of assets that age very slowly, and for which there exists more performance-efficient technology, are electric supply network components (Brint et al., 1998), escalators and railway points (Scarf et al., 2007). Capital replacement problems in which replacement is driven by technical obsolescence are considered, for example, by Scarf and Martin (2001), Scarf and Hashem (2002), and Scarf et al. (2007).
Increased performance/capacity
Replacement of an existing asset may be contemplated if the new asset significantly increases performance and/or capacity (Holden, 2003). In the rail sector, these circumstances may occur more frequently than supposed, such as the need to increase locomotive hauling capability or wagon payload. The replacement decision to address performance/capacity issues is largely influenced by the demand analysis (Bae et al., 2005). For example, without investment in new capacity, a potential growth in rail passenger volumes might not be accommodated (Commission for Integrated Transport, 2003). Yet additional capacity and improved services can also lead to an increase in demand, which will guarantee the competitive advantage of the firm vis-à-vis its competitors.

The contribution that the asset will make to the firm’s income-earning capacity
The contribution that the asset will make to the income-earning capacity of the business may have important implications for replacement decisions (Batterman and Fraser, 1995). An asset may make virtually no contribution to the output of some potential products produced by the firms. Yet it may be impossible to produce particular products or provide particular services without that asset. In the latter circumstance, the production loss associated with an unreliable or unavailable asset has a cost associated with it (termed availability costs). It will also affect the replacement decision to a certain degree (Nurock and Porteous, 2008). In this case, the total availability cost (saving) per asset per year post-replacement will be particularly relevant to asset replacement decisions (Scarf et al., 2007). It is also necessary to consider the timing of the replacement and the amount of the assets being replaced if the contribution that the asset will make to the firm’s income-earning capacity is large. The number of unavailable assets at any firm at any time and the duration of the replacement process imply that not all assets can be replaced at a particular time (Scarf et al., 2007). In addition, if replacing the asset causes the production of some particular products to be delayed or to be stopped temporarily, the production loss owing to replacement, which is based on opportunity cost calculation, should also be considered.

Tax considerations
In modelling replacement problems, tax considerations should be incorporated into the financial model depending on the circumstances of the organisation and the nature of the local tax regulations. This is because tax benefits and payments are real cash flows that have the potential to affect financial decisions (Scarf et al., 2007). Tax effects may include
depreciation tax shields, operating cost tax shields, investment tax credit, investment allowances, taxation of the capital gain, or loss on the sale of the asset when it is replaced (Mauer and Ott, 1995).

Tax shields stem from two cost components, viz., capital cost and operating cost. There is a benefit from tax where the capital cost is converted to an expense (through depreciation). In each year, depreciation reduces the company’s net income and hence reduces the tax payable (Nurock and Porteous, 1995). The operating cost of the asset is also tax deductible, in a similar fashion to that of the capital cost. The amount of tax shields is the company tax rate multiplied by the sum of the depreciation value and the annual operating cost. Some types of assets might be eligible for the investment tax credit provision on the new asset’s purchase price. For example, if a 30% investment tax credit is provided, investors will only be $70 out of pocket for every $100 invested in eligible asset. Some types of assets might be eligible for the investment allowance provision. This provision would allow investors to claim a specified extra proportion of the cost of the asset during the earlier years of its life (Goode, 1955). Note, however, that this supplementary allowance will not be taken into account in the calculation of subsequent depreciation allowances. Investment allowances provide taxpayers with a cash grant in a form of a reduction in income tax liability (Samuelson, 1976). It is also necessary to consider the after tax value of any balancing charge associated with difference between the sum of depreciation allowances of the asset and its re-sale value (Chrisholm, 1974).

Alterations made to any of the above tax elements, e.g., changes in the depreciation schedule, investment tax credit, investment allowances, and (most importantly) the marginal tax rate, alter the present value of the associated tax credits, while payments would also change the average returns from new assets and therefore the opportunity cost of holding the current asset. These changes are therefore likely to have an impact on the optimal value of replacement age, and also, by implication, the amount of replacement investment.

**Capital rationing**

Replacement problems will become more difficult to solve in the presence of capital rationing. The amount of cash available at the beginning of the planning period, in addition to the cash generated by the firm during the planning period, constrain the choice of financing methods and hence the optimal replacement period (Weingartner, 1963). Capital rationing is
a limit or cap on the portion of the existing budget used in acquiring a new asset. It is based on a number of current relevant circumstances of the company, the most important of which is the income-earning capacity of the business (Batterham and Fraser, 1995). Taxation implications flow from different methods that may be used to finance the purchase of assets.

**Method of acquiring services from capital assets**
If the asset is to be purchased rather than leased, companies are likely to be committed to securing debt financing from a bank, an undertaking which significantly increases the overall level of risk associated with the decision to acquire new equipment (Mazzarol and Choo, 2003). This set of circumstances places pressure on companies to put a limit on their total budget for capital spending. Acquiring the assets by, for example, contracting, hiring or leasing can therefore reduce the impact of capital rationing. This is particularly relevant to the asset replacement decisions made by firms (Batterham and Fraser, 1995).

**Viability of other asset management strategies**
The asset replacement problem also encompasses decisions regarding the viability of alternative options, such as rebuilding/remanufacturing, rental options, or running old machines into the ground (Scarf et al., 2007). A number of scenarios might cast doubts over the viability of asset replacement. For example, consider a mining company faced with decisions involving the replacement of a machine. If machine life exceeds the life of the mine, machine replacements are not viable. In these circumstances, the above-mentioned options are preferable (Nurock and Porteous, 2008). In another situation where no replacement asset exists at the end of a current asset’s life, a replacement option is clearly not an alternative. The previously mentioned options should be considered instead. In addition, when a market does not exist for existing assets such as a vehicle fleet (i.e., when a buyer cannot be found, or when it is too difficult to find a buyer given current market demand), the overhaul of the existing asset might be a more feasible option than replacement. To ascertain the attractiveness of each alternative, a detailed asset appraisal method, such as net present value or lifecycle costing (which compares each option), should be undertaken (Holden, 2003).

**Manufacturer’s recommended asset life**
The attractiveness of new equipment is also determined by the manufacturer’s recommended life of assets, particularly safety items such as a vehicle’s structure/underframe and electrical
wiring (Holden, 2003). This factor can trigger the consideration of asset replacement, although it does not drive asset replacement per se (Scarf et al., 2007).

**Regulatory requirements for the environmental performance**

Aging equipment in poor condition may no longer satisfy the legal requirements for environmental performance, such as noise and engine emission limits, or may compromise safety regulations. Under these circumstances, the company might need to consider replacing old equipment immediately. Requirements for environmental performance may also be voluntarily set by the firm to maintain a good corporate image, or may be due to other reasons, such as an industry charter or code of practice (UIC International Union of Railways, 2005; Mitchell et al., 2006). In the rail sector, in addition to legal requirements and requirements voluntarily set by the railway operator, additional requirements may be set by infrastructure operators or national authorities that put transport services out to tender (UIC International Union of Railways, 2005). The notion of pre-qualification may therefore be important to some firms. These additional requirements must also be taken into account in the asset replacement decision making process.

**Emerging factors**

Drivers of replacement decisions may change over time. As new factors emerge, the ongoing validity of the replacement decisions may be affected. Replacement that may not have been viable may become viable, or vice versa. These emerging factors imply that there is a strong case to review periodically the original replacement decision, and that the decision itself needs to be risk managed (Scarf et al., 2007). Consideration may also be given to risks associated with, for example, (1) new asset condition/life information, (2) new replacement/refurbishment cost and impact information, (3) changes in functional requirements, (4) value of money, (5) corporate core value changes, or (6) emerging technology (Scarf et al., 2007). It is impossible to avoid such changes in the environment during the decision life given the time scale and cost of replacement decisions.

To prevent suboptimal decision-making, sensitivity analysis should be taken to explore the robustness of the replacement decision and implied values of the decision drivers (Scarf et al., 2007). The analysis should also attempt to quantify customer service and the impact of other factors that are difficult to quantify but would alter a decision to replace or retain an asset. For example, for a passenger transport organisation, quantitative consideration should be
given to delays to passengers from both asset replacement and retention, and also other penalties associated with unplanned events (failure), such as passenger injury.

The exploration of real options theory could also be undertaken to evaluate replacement investment decisions under conditions of uncertainty. As originally developed by McDonald and Siegel (1986), this theory seeks to quantify the cost-benefit of delaying a replacement decision using option pricing theory. Waiting will make a decision to invest in a project less uncertain since more information about project costs may become available. But this has to be weighed against lost opportunity. As a general rule, if the investment outlay is irreversible and the firm can time the investment decision, the investment should be deferred until its value exceeds its indirect cost by an amount equal to the option of waiting to invest (Dixit and Pindyck, 1994).

Mauer and Ott (1995) use a real options model to evaluate replacement strategies under several types of uncertainty. They found that cost uncertainty and uncertainty about the arrival of a technological innovation that would decrease maintenance and operation costs may significantly increase the optimal replacement cycle. The reason is that cost uncertainty increases the value of the option of waiting to replace and thereby discourages replacement investment. As for technological uncertainty, the firm waits longer to replace its deteriorating equipment (despite having to cope with rising costs) in the hope that technological uncertainty is quickly resolved, thus allowing it to replace and operate new equipment at a lower maintenance and operating cost. Mauer and Ott (1995), however, show that uncertainty in tax laws, which might affect the initial purchase price of the asset, the after-tax maintenance and operation cost, the depreciation tax shields and the tax effect on the sale of the asset when it is replaced, can either discourage or encourage replacement investment depending on the type of uncertainty. Uncertainty regarding a tax law change that would discourage future investment increases current replacement investment, while uncertainty in a tax law change that would possibly encourage future investment has the potential to decrease current replacement investment. This result contrasts sharply with standard real options analyses of investment decision under uncertainty, which show that an increase in uncertainty always discourages investment (see, e.g., McDonald and Siegel 1986; Ingersoll and Ross, 1992; Mauer and Triantis, 1994).
Other factors

A number of intangible and non-quantifiable factors exist. These are usually excluded from replacement models owing to their nature. In particular, it is difficult to assign a monetary value to them. Nevertheless, decision-makers might need to focus on these qualitative factors in order to make broad value judgments about funding replacement projects (Scarf et al., 2007). These might include factors such as the value of an asset to the business, business safety, profitability, customer service, work environment, user benefit, corporate image, decrease in utilisation of older machines, maintainability, consumption and operator comfort, etc. (Scarf et al., 2007; Nurock and Porteous, 2008). Consideration might also be given to interactions with other assets and activities of the organisation. For example, similar parts or other assets involved with the delivery of the higher level function or assets requiring the same access arrangements may be candidates for replacement. As a result, there remains the possibility of executing distinct capital projects simultaneously so as to minimise disruption and cost, or to add greater value. Blanchard and Fabrycky (1998) argue that there is a need for the adoption of a system view, something which would allow these interactions to be considered systematically.

To summarise, asset replacement is a complicated problem since there are many factors affecting the decision. Risk is clearly evident in many elements of the decision. It is also likely that many factors that are difficult to quantify in economic terms are highly influential in the decision-making process.

2.4.2 Capital equipment replacement models

This section describes a number of capital equipment replacement models that are used in practice to model replacement decision problems. The problem of interest to the discussion here is whether a firm should replace existing equipment of a certain age and performance with new equipment and, if so, when. There are numerous reasons for replacement of the existing equipment, as described in the previous section. Replacement models considered here focus solely on the economic aspect. In practice, the outcome of an economic replacement model is expected to influence the actual replacement decision, but not necessarily drive it (Scarf and Hashem, 2002). Other technological, social, and political factors would also be brought to the attention of the decision-maker.
Asset replacement models have applications in many areas of economics, in addition to operational research. In the agricultural sector, these models have been applied to problems including determining the optimal replacement of farm machinery assets (e.g., Faris, 1960; Smith, 1995) and culling replacement decisions in livestock management (e.g., Frasier and Pfeiffer, 1994; Larson et al., 2000; Ibendahl and Anderson, 2001). In the transport sector, applications and extensions of these models have been made in bus engine replacement (e.g., Rust 1987), urban railway asset replacement (e.g., Scarf et al., 2007), and aircraft replacement (e.g., Keating et al., 2005). Applications are also evident in other fields, such as in the mining industry (e.g., Nurock and Porteous, 2008), and in the health sector (e.g., Pusatli, 2009).

The purpose of the review presented in this section is to consider whether the models behave sensibly in general, and are therefore useful in practice. An attempt will also be made to compare and contrast alternative model choices. The analysis presented will be used to develop a new capital item replacement model, which will later be employed to ascertain the efficacy of various taxation arrangements in promoting technological investment in the rail freight sector.

**Historical background of replacement theory**

Modern replacement theory of durable equipments originates from two classic papers by Taylor (1923) and Hotelling (1925). Taylor developed a discrete-time formula relating the average unit cost of the output of a machine over the life of the asset to the cost of a new machine, the scrap value of the machine, the operating costs of the machine in each period of service up to the replacement time, the output of the machine in each period, and the interest rate. The optimal life of the machine, according to Taylor, minimises the unit cost of production. Taylor’s framework is challenged by Hotelling (1925), who argues that considerations of profit lead the manufacturer to scrap the machine at some different point in time from that which minimises the unit cost. Hotelling proposes that the owner of the machine would normally wish to maximise the present value of the machine’s output minus its operating costs. Hotelling’s formula is developed by means of a continuous discounting analysis. This is different from that of Taylor, whose formula is based on a discrete period analysis.
Preinreich (1940), however, argues that the optimal service life of a machine should not be determined in isolation from the economic life of each machine in the chain of future replacements extending as far into the future as the firm’s planning horizon. Rather, it should be ascertained by maximising the net present value of all future replacements (the present value of aggregate earnings from all future machine replacements less the present value of the aggregate costs of all future machine replacements). Preinreich’s model thus represents a generalisation of Hotelling’s formula.

Although these early contributions revolutionised the theory of replacement, they do not consider effect of the technological change or obsolescence. The stationary technology wherein machines are replaced by machines of identical type under conditions of certainty is assumed by all the authors mentioned above. In these early capital item replacement models, the only factor that justifies the replacement in economic terms is the effect of age in causing the net earnings of a machine to decline. The first attempt to extend the replacement model to account for equipment obsolescence was made by Terborgh (1949). According to Terborgh, replacement of an existing machine (the Defender) should consider the machine’s performance in relative to that of the latest new comparable machine (the Challenger). On account of Terborgh’s work, technological change has often been included in replacement analysis. Common assumptions regarding technological advancement include improvement at a continuous rate, discontinuous technological improvement, or some combination. A comprehensive review of literature in replacement analysis that considers technological change is provided by Hartman (2005) and Rogers and Hartman (2005).

The broad notion developed by Preinreich (1940) and Terborgh (1949) provides the basis for many now seminal post-Terborghian works on replacement theory. More recently, the work of Dixit and Pindyck (1994) extends the classical framework of replacement theory by suggesting that investment evaluation should also take account of the opportunity cost of foregoing an option value associated with postponing an irreversible investment. According to Batterham and Fraser (1995), Dixit and Pindyck’s work has profoundly influenced the theory of investment and the practical application of the theory to problems such as asset replacement. Indeed, one example of replacement models that applies Dixit and Pindyck’s real options framework is that of Mauer and Ott (1995).
Categorisation of modern economic replacement models

Modern literature on capital asset replacement is quite diverse. The articles published on this topic can be broadly divided into the following three categories (as suggested by Ahouissoussi and Wetzstein, 1995):

- Replacement models based on the profit maximisation principles.
- Replacement models based on the cost minimisation principles.
- Replacement models grounded in the theory of repair limit.

The literature on the above three classes will now be reviewed.

Replacement profit maximising principles

Category 1 of replacement models is based on the fundamental principles of asset replacement decisions as presented by Hirshliefer (1958), Perrin (1972), Burt (1965), Jorgenson (1974), and Samuelson (1976). These principles are grounded in a broad notion that assets should be kept in operation until the net present value of future income streams associated with that asset and future replacement assets is maximised. A decision policy is thus a sequence of replacement decisions. An optimal policy can be defined as a decision policy that maximises net present value of future income streams from a replacement sequence (McClelland et al., 1989).

A condition on asset replacement is developed based on this broad notion. The earlier work by Faris (1960) suggests that the optimal time to replace an existing asset is when its marginal net revenue is equal to the highest amortised present value of expected net revenue of the following asset. Chisholm (1966) and Perrin (1972) can take credit for generalising the theory of asset replacement and accounting for the opportunity cost of investment in all future replacement assets. Perrin, in particular, has developed an alternative and equivalent replacement criterion by equating the present values of marginal revenue and marginal opportunity cost. Perrin’s replacement principle can be characterised as follows: keep the existing asset another period (e.g., year) if the net returns available from it is more than the annuity of the returns available from the series of replacement assets. Subsequent studies of
asset replacement problems based on profit maximisation generally follow the precepts of these early contributions.\textsuperscript{13}

\textit{Replacement cost minimising principles}

Data on the income attributable to individual assets controlled by the firm is required to evaluate the optimal policy using the first class of replacement models. This type of data is difficult to obtain in practice owing to its commercially sensitive nature, a consideration which motivates many researchers to switch attention from maximising the present value of the future earnings of the asset to minimising the net present value of the cost of the sequence of replacement assets. Bertsekas (1976) was the first to provide a generalised theory of machine replacement cost minimising principles. Bertsekas’s theory implies that the optimal replacement policy is the one that minimises the total expected value of the discounted replacement cost over an infinite horizon.

According to Ahouissoussi and Wetzstein (1995, replacement cost minimisation models can be broadly categorised into three groups. The first are age-dependent operating cost models. Terborgh (1949) developed a theory of equipment replacement based explicitly on stated assumptions of a linear operating cost function that is time dependent with known constant parameters. Terborgh’s operating cost function is a combination of two cost components: the first increases with equipment age (operating inferiority), and the second decreases with increasing age (capital cost). The optimal time to replace a machine, according to Terborgh, is when the average increase in costs owing to operating inferiority is equal to the average annual depreciation in capital. Terbogh’s replacement condition is criticised by Malcomson (1954) for being an approximate rule, and one which only applies under certain conditions. Moreover, the rule requires that the optimal replacement age of equipment is constant through time, something which is not necessary the case in practice. To correct these weaknesses, Malcomson developed an iterative procedure, based on specific assumptions about future costs, for determining optimal replacement ages to any desired accuracy, regardless of whether the optimal replacement age is constant through time. The operating

cost function defined by Malcomson is similar to that of Terborgh in that it is also time-
dependent.

The second are models in which an operating cost is a function of cumulative usage model, e.g., that formulated by Rust (1987). Rust studied bus engine replacement problems using a regenerative optimal stopping model that depends on unknown ‘primitive parameters’ which specify (1) the manager’s expectations of the future values of the state variables; (2) the expected costs of regular maintenance; and (3) his perceptions of the customer goodwill costs as a result of unexpected failures. Rust’s model is not very practitioner friendly since an analytical solution (or a closed-form solution) does not exist. Indeed, it requires an estimation technique – called a nested fixed point maximum likelihood algorithm – that allows maximum likelihood estimates of the primitive parameters to be computed, even though there is no analytical formula for the associated likelihood function.

The third are models in which an operating cost is a function of both cumulative usage and mechanical condition, e.g., that of Ahmed (1973). Ahmed contends that the main economic factors affecting the decision to replace a given vehicle are age, mileage, and mechanical condition, which is generally reflected in the trade-in value of a vehicle. Ahmed then formulates the expected operating cost function based on these factors. The optimal policy is the one that will minimise the expected operating cost.\textsuperscript{14}

The most recent replacement cost minimising study is that of Nurock and Porteous (2008), who developed a methodology to determine the optimal asset replacement policy based on the concept of lifecycle costing (LCC). LCC considers costs on a whole lifecycle basis and monitors the incurred cost throughout the life cycle of the product (Taylor 1981; Woodward, 1997). This includes capital costs (depreciation interest) and operation costs (energy, maintenance, etc.). It also considers the timing advantage of equivalent annuity by applying

\textsuperscript{14} There is a large body of literature on replacement cost minimising models, perhaps owing to their practical applicability compared to that of profit maximising models. Apart from those discussed above, Alchian (1958), Chrisholm (1974), Kay and Rister (1976), Bates et al. (1979), Bartholomew (1980), Bates and Rayner (1980), Christer and Goodbody (1980), Reid and Bradford (1983), Christer and Waller (1987), Van Tassell and Nixon (1989), Walker (1994), Scarf and Hashem (2002), Mathew and Kennedy (2003), Rogers and Hartman (2005), and Scarf et al. (2007) also formulate replacement models based on cost minimising principles.
discounting factors to future cash flows. LCC calculates the total value or cost of an alternative (a replacement age) and equates this to an annuity. By using this method, annuities of different alternatives can be compared, on the same basis, with the lowest annuity representing the lowest cost option. The age associated with the minimum represents the optimal replacement age. The LCC model is an example of age-dependent operating cost models.

**Repair-limit-based replacement models**

Another economic replacement model is grounded in the theory of repair limit, which is defined as the upper limit on the cost of repairing a vehicle at any particular job (Drinkwater and Hastings, 1967). Repair limit is a function of the type, age and, in some cases, the location of the asset. The fundamental principle is that a vehicle whose repair costs exceed the repair limit is not repaired, but scrapped (Ahouissoussi and Wetzstein, 1995). The optimal replacement policy is based on this principle.

A method for determining the upper limit for any repair cost on a machine in a fleet of similar equipment was first presented by Drinkwater and Hastings (1967). The limit has a negative relationship with the age of the machine. Drinkwater and Hastings’s model consists of two random variables: (1) the cost of any future repair; and (2) the number of repairs in the future period of use. Drinkwater and Hastings’s decision criterion can be stated as follows. The machine should be repaired if an overall average cost per machine-year is greater than the future cost per machine-year. If not, the machine should be scrapped. Hastings (1969) subsequently applied dynamic programming to the model to improve the method for determining the repair limits.

Lambe (1974) developed a repair limit formula using data on the machine’s past repairs and all available knowledge on the general repair characteristic of the machine class. The replacement criterion given by Lambe’s model is as follows: continue using the machine until the cost for a prospective repair exceeds the expected net benefits from future use of the machine if it was repaired. In this case, the upper limit for the repair cost is equal to the difference between the implicit value of the machine after repair and the value of salvage if it is not repaired.
The impact of taxation on asset replacement models
Researchers have previously examined the influence of taxes on asset replacement using simulation models. Chisholm (1974) made an early contribution. He explored the effects of the time pattern of depreciation and various investment incentives on Australian farm machinery, and extended his analysis to the context of the United States. His simulations showed that the depreciation method and existence of investment allowance or investment credit schemes had little effect. Chisholm’s simulation indicated that the optimal replacement for US farm machinery was around 11 years, which was argued by Kay and Rister (1976) to be longer than actual US firms’ behaviour. A major factor contributing to this inaccuracy is that the pattern of repair costs experienced by farmers is different to that used in the replacement model. Another factor is that the probability of machinery breakdown is not taken into account. In addition, Kay and Rister also found that the after-tax discount rate had the greatest impact on the replacement interval, while the tax rate and the depreciation method, by way of contrast, had little influence.

Bates et al. (1979) used a taxed adjusted replacement model to include the interactions between taxes and inflation. They concluded that inflation effectively increased the magnitude of costs and extended the optimal replacement interval. Bartholomew (1980), however, believed that Bates et al.’s conclusion depends on the assumption that the real discount rate does not alter with the inflation rate, which is unlikely to hold true in practice. Bates and Rayner (1980) later accepted Bartholomew’s arguments. But they defended their original conclusion by arguing that that changes in the real post-tax interest rates as a result of higher inflation is only temporary. It is possible that the after-tax real interest rate will return to their former level, and for equipment replacement to be delayed.

Building on Chisholm’s pioneer work, Reid and Bradford (1983) employed simulations to examine the impacts of using different salvage functions and advantageous tax laws on the optimal replacement period. They observed that more advantageous tax laws reduced the optimal time to replace farming equipment, especially for farmers having both higher income and lower discount rates. Of all the advantageous tax laws examined, investment tax credits provided the strongest incentive to earlier machinery replacement. Van Tassell and Nixon (1989) extended the replacement analysis of Reid and Bradford by also testing the effect of including discounting schemes and self employment taxes on optimal machinery
replacement. It was shown that the optimal replacement interval was reduced by these factors to periods shorter than those determined by Reid and Bradford.

Lynne (1988) used a simulation model to reexamine the results of Chisholm (1974). General tendencies in the simulation are the same as have been found by previous studies. The important difference is the possibility of multiple optima (i.e., multiple optimal asset replacement times) for farmers in the higher income bracket, especially those having low discount rates. The existence of multiple optima indicates that other factors apart from those of the economic type need to be captured in the standard machinery replacement model so as to aid the farmer’s equipment replacement decision. In view of this, Lynne contended that knowledge about the farmer’s objectives that influence their behavior is an important decision-facilitator.

The investment implications of the US Tax Reform Act of 1986 (TRA 1986) were examined by several researchers. Innes and Carman (1988) focused on the TRA 1986 effects on beef cow replacement strategy. It was concluded that the TRA 1986 would increase the optimal replacement age for culling beef cows. Moss et al. (1989) focused on the distortion of farmers investment decisions by TRA 1986. They found that the change in the average tax rate under the provisions of the TRA 1986 reduced the distortionary effects of the tax code on capital investment decisions. Smith (1990) examined the effects of the TRA 1986 on farming equipment replacement using simulations. He observed that there is: (1) a negative relationship between the optimal replacement interval and the size of advantageous tax provisions, e.g., investment tax credits and present value of the depreciation allowances; and (2) a positive relationship between the optimal replacement interval and marginal tax rates. Furthermore, he discovered that the TRA 1986 is likely to reduce the replacement rate for assets with short depreciation lives (e.g., tractors) and increase it for assets with long depreciation lives (e.g., farm structures).

Other exceptional results regarding effect of TRA 1986 on optimal replacement were derived by Prezas (1994). It was found that, as long as the asset has not been fully depreciated upon its disposal, its optimal life: (1) increases if an accelerated depreciation method is used; (2) reduces with higher corporate tax rate if the salvage value is less than asset book value upon termination; and (3) may increase or decrease with higher corporate tax rate if the salvage value is more than asset book value upon termination of the asset. By way of contrast, as long
as the asset has been fully depreciated upon its disposal, its optimal life: (1) is unaffected by
changes in depreciation schedules; and (2) increases with the corporate tax rate. These results
were then combined to predict the changes in optimal asset duration induced by the TRA
1986. The conclusion is that the effect of TRA 1986 on optimal life is ambiguous if the book
value of the asset is positive upon its disposal. Otherwise, the TRA 1986 would shorten the
optimal life.

In the new millennium, a number of researchers attempt to incorporate some unique aspects
of US tax laws into their after-tax replacement models. Hartman and Hartman (2001) focus
on a special law that explicitly defined the difference between an asset retirement and an
asset replacement. Under this law, a gain or loss is only realised when an asset is retired,
while a replacement leads to transfer of any residual book value balance to the acquired asset.
The authors show that this law complicates replacement decisions since capital costs are no
longer stationary over time. This is because the initial book value of each replacement asset is
also dependent on the residual book value of the retired asset, in addition to its purchase price
and the salvage value. Hartman and Hartman (2001) illustrate that their after-tax replacement
models lead to widely different solutions, both in cost and replacement decisions, from those
of traditional models.

Billings and Glazunov (2004) examine the effects of the corporate alternative minimum tax
(AMT) on asset retirement. It is shown that firms that paid the AMT and had debt shares
below a critical level tended to retire higher amounts of machinery and equipment than other
firms. In a recent paper on the effects of taxes on asset replacement, Ibendahl and Norvell
(2007) focus on the US Job Creation and Worker Assistance Act of 2002, under which
conditions for using accelerated depreciation provisions have been changed. It is observed
that, although accelerated depreciation is beneficial to firms as it lowers their yearly cost
(from getting their money earlier rather than later), it does not affect when the asset should be
replaced.
2.5 Establishing Research Questions and Theoretical Framework

As discussed in Chapter 1, the central question addressed in this research is as follows:

Does accelerated depreciation hold a particular promise for addressing the vehicle fleet age problem in the Australian rail freight sector?

To answer this, the research puts forward a number of questions essential to understanding the conceptualisation of using accelerated depreciation for promoting technological investment. These questions are embedded in the literature reviewed in this chapter.

From reviewing the historical employment of accelerated depreciation in several countries, it is clear that accelerated depreciation is always part of a suit of initiatives aiming at promoting investments in selected assets. This suggests that there are many factors that militate against investment. As suggested by a number of empirical studies (e.g., Hayashi, 1985; Homma et al., 1989), accelerated depreciation sometimes plays a very minor role in influencing the target investment. These investment barriers are different across the context of the area in which the investment promotion is needed. For example, different industrial settings (e.g., regulated versus deregulated) clearly have implications for the usefulness of the scheme. Important, too, are current business conditions faced by firms under investigation, such as the recent global financial crisis. Here, therefore, it is important to explore, in thorough fashion, the current characteristics of rail freight sector, especially given that these may have implications for the worthiness (or otherwise) of accelerated depreciation. This leads to the following research question:

What are the specific characteristics of the rail freight sector in Australia that have resulted in the very large long investment period of rolling stock equipment and, in particular, is the contribution of accelerated depreciation likely to be significant in influencing the modernisation of such equipment?

By reviewing the the historical usage of accelerated depreciation in several countries, it is clear that the extent to which accelerated depreciation provisions can have a positive effect depends largely on the extent of their use. This thesis has identified a number of constraints that may militate against firms shifting from normal depreciation practice to accelerated methods, e.g., administrative difficulty, firms’ accounting conventions, uncertainties...
associated with the scheme, and the capital structure of firms. In view of this, the following question emerges:

*Are there any factors that might prevent Australian rail freight firms from adopting accelerated depreciation if it was available?*

It is important, too, to examine the replacement behaviour of the firms for which accelerated depreciation is allowed. Accelerated depreciation, or other tax concessions, would obviously be particularly useful if taxation is the main driver leading to the equipment replacement decision. By reviewing the literature on the asset replacement decisions, however, it is apparent that, in reality, re-equipment or expansion plans are very complex and are guided by many factors, some of which may not be related to taxation. These factors are dependent on the nature of that organisation and the industry to which it belongs. So far, little progress has been made in our understanding of factors driving rolling stock replacement decisions in Australia, particularly in less academic or more practitioner-oriented research. The following research question is raised in order to narrow this gap:

*How are decisions made regarding rolling stock replacement among Australian rail freight firms and, in particular, is taxation implication an important driver of replacement investment?*

The value of sympathetic taxation arrangements, such as accelerated depreciation, depends largely on whether they can influence operators to increase their rolling stock replacement turnover rates. The benefits of increased replacement turnover rates are twofold. First, it can encourage an operator to deploy more rolling stock with better environmental performance. Second, such investment can also enhance general business efficiency, thereby leading to more rail transport and a reduction in the negative externalities associated with road transport of freight. To ascertain the replacement investment implications of accelerated depreciation, previous researchers have examined whether this special deal can significantly reduce the optimal time to replace eligible assets. This thesis shall follow a similar procedure. In particular, whether accelerated depreciation significantly reduces the optimal age of the rail freight rolling stock will be investigated. If this is the case, accelerated depreciation is also likely, by implication, to increase replacement turnover and technological investment in the rail freight sector. This leads to another research question:

*To what extent would accelerated depreciation reduce the optimal replacement cycle of rail freight rolling stock in Australia?*
PROMOTING TECHNOLOGICAL INVESTMENT IN THE AUSTRALIAN RAIL FREIGHT SECTOR: EVALUATING THE FEASIBILITY OF ACCELERATED DEPRECIATION

To answer this, an attempt will be made to develop an after-tax replacement model that represents current situations faced by Australian rail freight firms. Existing models are either based on a number of unrealistic assumptions or are not consistent with the Australian tax environment. The new model proposed by this research hopes to relax some of these restrictive assumptions and represent Australian tax practices in a faithful manner. The development of this model will be explained thoroughly in the following chapter.

The empirical evidence regarding the role of taxes in asset replacement decisions is less clear. As discussed above, a number of researchers have shown that the effect of taxation concessions is shortening the replacement cycle for certain classes of depreciable assets, all the while lengthening the cycle for other classes of assets. There does not appear to be any substantial Australian work on the influence of taxation on optimal replacement of rail freight rolling stock. An examination of ex-post effects of taxation concessions on the replacement of rail freight rolling stock in Australia is intended to bridge this gap.

This research has therefore been developed to assess the likelihood of a policy (accelerated depreciation) being useful to stakeholders, and to assess the possibility of accelerated depreciation being able to encourage the Australian rail freight organisations to invest in modern hardware. Thus, it is clear that the feasibility of accelerated depreciation should be investigated from a stakeholder perspective. By studying the efficacy of accelerated depreciation using such an approach, this research expects to open up a new perspective on the academic debate of the effects of accelerated depreciation on asset replacement. This approach is called the stakeholder approach since the research relies heavily on the perspective of stakeholders, i.e., those affected by the provision of accelerated depreciation to check its efficacy. This point will be apparent when the methods used are discussed in the next chapter. Very little cohesive work has been attempted on this theme from a stakeholder perspective, with most critiques of accelerated depreciation taking a firmly theoretical viewpoint, i.e., relying only on the economic theory or economic models to study the effect of accelerated depreciation. Therefore, the analytical frameworks established for the research will open up a new perspective on the academic debate regarding rolling stock

replacement strategies in the Australian rail freight sector. The analytical framework will also have broader application to other industrial sectors looking to promote technological investment via taxation tools.

### 2.6 Summary

Three main fields were covered: (1) important characteristics of the Australian rail freight industry; (2) the theoretical foundation and historical usage of accelerated depreciation; and (3) factors and economic models pertaining capital equipment replacement decisions.

In (1), aspects such as the economic contribution of the industry to the country, the nature of the freight market, the key players in rail freight, the recent growth in the rail freight task, benefits of rail freight relative to road freight, the environmental performance of the rail freight sector, and existing problems associated with the rail fleet were reviewed.

In (2), it was demonstrated that the tax deferral property of accelerated depreciation would increase the firm’s demand for depreciable facilities and expand its financial capabilities. Different forms of accelerated depreciation and other closely-related taxation mechanisms were described. A great deal of literature that investigated the historical usage of accelerated depreciation was summarised. The review in this section found mixed evidence regarding the success of the accelerated depreciation scheme. It was clear that the selective nature of accelerated depreciation could be used to encourage the investment in cleaner and less environmentally intrusive technologies, as it had modernised the Japanese industrial equipment. However, the scheme did not always work as intended since there were a number of problems that emerged from its use, and there were many factors that restricted its applicability.

In (3), the replacement of capital equipment was shown to be a complicated problem since there were many factors affecting the decision. A list of factors that were found to be relevant to many firms faced with decisions involving capital equipment replacement was discussed. Some of these factors were quantifiable in economic terms. Some factors were difficult to be assigned monetary values. Nevertheless, they were argued to be highly influential in the decision-making process. The research also looked at various capital equipment replacement models. It was shown that most modern replacement theory of durable equipments originated
from papers by Taylor (1923), Hotelling (1925), Preinreich (1940), and Terborgh (1949). Many replacement models were developed from the profit maximisation principles, while others were developed from the cost minimisation principles. It was also contended that quite a few models were developed from the theory of repair limit.

Research questions were then formulated. This thesis was primarily interested in ascertaining whether accelerated depreciation held a particular promise for addressing the infrastructure deficiency in the rail freight sector. To answer these questions thoroughly, a series of related questions followed. The first set of questions related to how specific characteristics of the rail freight industry and its firms might have some implications for the usefulness of accelerated depreciation. The second question investigates the extent to which accelerated depreciation reduces the optimal replacement cycle of rail freight rolling stock.
CHAPTER 3

METHODOLOGY

3.1 Overview

The primary objective of this chapter is to clarify why a mixed methods methodology or, in other words, combining both qualitative and quantitative approaches to research design, is used in this research to develop a more holistic picture of the subject under investigation. The previous chapter has established the research questions and the theoretical framework. By way of contrast, this chapter focuses on the philosophy of research design. Research design is more than simply the methods by which data is collected and analysed (Easterby et al., 1991). In accordance with Easterby et al. (1991), research design deals with what, where, and how evidence is gathered, in addition to how such evidence is interpreted.

This chapter begins with a discussion of the nature of research paradigms. It will contextualise this through an examination of the so-called ‘paradigm wars’, which challenged the dominance of the mono-method paradigm and resulted in the emergence of a mixed-methods era. This section then presents an examination of different approaches to research (quantitative, qualitative and mixed methods) before moving on to explore the rationale for using the mixed methods approach. This is followed by a description of a three-stage mixed methodology designed to investigate the investment implications of accelerated depreciation in the rail freight sector.

In stage one, a series of face-to-face interviews are conducted with respondents from rail freight operators in Australia. These interviewees are selected on account of their significant involvement in making locomotive replacement decisions in the freight rail sector. In stage two, an analytical model of the effects of tax concessions on asset replacement will be developed based on the similar model originally suggested by Perrin (1972), together with findings from the stakeholder interviews. This model is then used to test whether accelerated depreciation can significantly reduce the optimal time to replace rolling stock in the Australian rail freight industry. In the final stage, an expert panel (comprised of six persons) is assembled. This panel consists of experienced managers associated with the rail freight
industry and researchers familiar with the study area. These panel members participate in a focus group designed to examine the findings from the first two stages and provide in-depth expert assessments of the implications stemming from the first two stages of research.

3.2 Justification of using a mixed methods research design

In response to the ‘paradigm wars’ of the 1980s, i.e., the debate between followers of the quantitative research methodology and those favouring a qualitative research methodology, mixed methods became recognised as a new methodological movement (Buchanan and Bryman, 2007). This particular research design has then been very popular, especially in the fields of applied social science (Cameron and Miller, 2007). The use of a mixed methods approach in conducting social research stems from the rationale of making pragmatic decisions in the real world. This is why many subscribers of mixed methods research draw strong associations with the pragmatic paradigm (Armitage, 2007). The objective of this section is to explain the origin of this pragmatic paradigm and establish why it is closely related to the mixed methods research approach.

3.2.1 Pragmatism: the outcome of the paradigm wars

According to Saunders et al. (2003), a paradigm is a basic set of philosophical beliefs about the nature of the world that provides guidelines and principles concerning the way in which research is conducted. Methods and techniques used in any piece of research should therefore be in line with these broader principles. In social and behavioural sciences, research paradigms are often categorised as two major groups, with writers proposing various terminologies to distinguish these camps. For example, Guba and Lincoln (1988) use the terms “scientific” and “naturalistic”, Tashakkori and Teddlie (1998) adopt “positivist” and “postpositivist, James (2005) uses “positivistic” and “phenomenological”, while Johnson and Onwuegbuzie (2004) call these two main paradigms “quantitative” and “qualitative”. These paradigm positions are mutually exclusive, especially with regard to their underlying design approach. In particular, supporters of a positivist paradigm tend to use a quantitative approach, whereas holders of beliefs associated with a constructivist paradigm position tend to rely on a qualitative approach (Burrell and Morgan, 1979). The association between design approach and underlying paradigm position is, however, by no means fixed (Bryman, 2004).
The degree of separateness between the two ends of a spectrum of research paradigms has long been debated. The paradigm debate or ‘paradigm wars’ began as a result of challenges to the dominance of the mono-method era during the 1960s (Tashakkori and Teddlie, 1998). The mono-method era was filled with many ‘purists’ (e.g., Guba, a leading qualitative purist), who asserted that paradigms and methods should not be mixed (Creswell, 2003). At one end, quantitative purists take a realist position and contend that there is a single apprehensible reality whose nature can be known and characterised (Cameron and Miller, 2007). They adopt a dualist epistemological position, which requires separation of the researcher from the researched (Johnson and Onwuegbuzie, 2004). This separation is required for social science inquiry to be objective. In other words, time- and context-free generalisations are possible and desirable, while the real causes of social scientific outcomes can be determined reliably and validly (Nagel, 1986). Quantitative research findings are value-free, i.e., independent of values, opinions, attitudes, or beliefs of individuals, groups, or societies (Neuman, 2006). The major focus of quantitative research is therefore to establish and describe social laws, using a formal writing style, impersonal passive voice, and technical terminology (Tashakkori and Teddlie, 1998). For this reason, mathematical analysis and statistical significance are held in the highest regard by proponents of the quantitative paradigm.

At another end of the spectrum, qualitative purists adopt a position of relativism that allows for multiple constructions of reality. They believe that truth is obtained from a consensus among informed and sophisticated constructors, not from a correspondence with an objective reality (Guba and Lincoln, 1989). Furthermore, they take a monist epistemological position whereby the researcher and the researched interact and are bound together (Caulley, 1994). These purists do not believe that time- and context-free generalisations are desirable or indeed possible (Johnson and Onwuegbuzie, 2004). Instead, they contend that there is a need to put analyses into context and present the interpretations of individuals or groups under investigation in the outcome of instruction (Reeves, 1996). Qualitative research findings are value-bound, i.e., they reflect personal points of views and feelings (Neuman, 2006). Instead of relying on a detached and passive style of writing, qualitative researchers tend to prefer detailed, rich, and thick (emphatic) description (Johnson and Onwuegbuzie, 2004). Their writing style is therefore direct and more informal, at least compared to that of quantitative researchers. Qualitative researchers reject the mathematical modelling of phenomena upon which quantitative purists depend heavily; instead, they emphasise the notion of the human being as the primary research instrument (Reeves, 1996). Many anthropological methods of
inquiry, especially human observation, have therefore been adopted by qualitative researchers. Immersion in the context of a research study is highly preferred over the detachment of the quantitative paradigm.

During the paradigm debate, both quantitative and qualitative purists were exposed to constructive criticisms. For example, on the quantitative side, the fully objective and value-free notion, although it can be a useful one with regard to the generalisability of research outcomes, is regarded as mythical. Many subjective and intersubjective aspects are argued to exist throughout the quantitative research process (Onwuegbuzie, 2002). These subjective features include deciding what to study, developing instruments to measure what the researcher views as being the target construct, selecting specific tests and items for measurement, making score interpretations, selecting significant levels, drawing conclusion and interpretations based on the collected data, deciding which elements of the data to emphasise or publish, and deciding which findings are practically important. Furthermore, quantitative methods of analyses can present the following problems, as outlined by Johnson and Onwuegbuzie (2004):

- The researcher’s categories and theories that are used may not truly reflect local constituencies’ understandings.
- The focus on theory or hypothesis testing rather than on theory or hypothesis generation may lead to confirmation bias.
- Abstract knowledge produced by quantitative research may not have direct application to specific local situations, contexts, and individuals.

On the qualitative side, a strong position of relativism is criticised and, furthermore, associated with a number of problems. For example, the ontological relativist or constructivist places the same value on each individual’s personal points of views and feelings towards the same phenomenon; that is, there are multiple realities. However, these subjective states (i.e., created and experienced realities), which vary from person to person, can confuse the reader if they are called multiple realities (Phillips and Burbules, 2000). For greater clarity and more precision, the word ‘subjective’ should be added in front of the word ‘reality’ so as to direct the reader to the focus of the statement (Johnson and Onwuegbuzie, 2004). Moreover, even though the value-bound aspect of qualitative research can be useful, there remains the potential problem of research simply being one researcher’s highly
idiosyncratic opinions written into a report (Johnson and Onwuegbuzie, 2004). This problem may not be as significant as in the past since many strategies have been developed to mitigate it, e.g., member checking, triangulation, negative case sampling, pattern matching, and external audits (Neuman, 2006). Furthermore, qualitative researchers sometimes may fail to provide an adequate rationale for interpretations of their data (Onwuegbuzie, 2000). Finally, qualitative methods of analyses are often too specific, unlike quantitative methods that are standardised (Constatas, 1992). As a result, there are often doubts as to whether the knowledge produced by qualitative research is trustworthy or defensible.

Since both quantitative and qualitative paradigms are not immune from constructive criticisms, many writers, such as Guba (1990), see the struggle for primacy of one paradigm over others as irrelevant. This is because each paradigm has its own merits and disadvantages. Many compatibility theorists consider the difference between the two paradigms and the exclusivity of their methods to be overplayed (Cherryholmes, 1992). In addition, many pragmatists argue against a false dichotomy between the qualitative and quantitative research paradigms and advocate, by way of contrast, the efficient use of both approaches (Cameron and Miller, 2007). These philosophers share a common objective; that is, to promote epistemological and methodological pluralism so as to resolve the tensions emanating from the paradigm wars (Johnson and Onwuegbuzie, 2004). Since research is becoming increasingly interdisciplinary, complex, and dynamic, there is a need for researchers to be informed about epistemological and methodological possibilities. One can then complement one method with another in order to conduct more effective research (Johnson and Onwuegbuzie, 2004). Howe (1988) argues against the rigid linkage between research paradigm and research methods and contends that qualitative researchers should be free from using quantitative methods, and vice versa. The bottom line is that taking a pluralist or compatibilist or even pragmatist position allows researchers to mix and match design components in ways that offer the best opportunities for addressing research questions (Watson, 1990; Hoshmand, 2003; Maxcy, 2003; Johnson and Onwuegbuzie, 2004).

The concept of epistemological and methodological pluralism leads to the emergence of a third set of beliefs, i.e., ‘pragmatism’, and the birth of mixed methods and mixed models approaches. Pragmatism is pluralistic based on a rejection of the forced choice between quantitative and qualitative paradigms (Creswell, 2003). This paradigm incorporates the
strengths that each opposing paradigm possesses. The following subsection explains in more detail why pragmatism is considered appropriate for this research.

3.2.2 Philosophy of pragmatism: a strong link to this research’s aims

Pragmatism emphasises the application of sensible effects or outcomes-oriented rules through thinking, practical experiences, or experiments (Johnson and Onwuegbuzie, 2004). The fundamental rule of pragmatism is that the current meaning of an expression is determined by the experiences or practical consequences of belief in, or use of, the expression (Murphy, 1990). The implication is that, when judging ideas, the empirical and practical consequences must be traced (James, 1995). The primary objective of pragmatism is therefore to examine practical consequences and empirical findings so as to comprehend the import of philosophical positions and decide which action to take next to understand real-world phenomena (Johnson and Onwuegbuzie, 2004). This objective is consistent with the major focus of this research, which is to explore the practical consequences of introducing accelerated depreciation in the rail freight industry so as to judge the worthiness of using accelerated depreciation to promote technological investment.

Pragmatism links the choice of approach directly to the purpose of and the nature of the research questions posed (Creswell, 2003). The emphasis is on a ‘what works’ tactic; that is, multiple or pluralistic approaches to research are viable if they can provide appropriate answers to research questions (Tashakkori and Teddlie, 1998). Research often has multiple objectives. In view of this, a ‘what works’ tactic will allow the researcher to address questions that do not sit comfortably within a wholly quantitative or qualitative approach (Armitage, 2007). In many situations, researchers can put together insights and procedures from both quantitative and qualitative approaches so as to provide a more workable solution to a research question (Johnson and Onwuegbuzie, 2004). To address some of the questions stated in Chapter 2, one must gain a detailed understanding of the complexity of the influences on the rail operator’s rolling stock replacing behaviour. Thus, a qualitative methodology incorporating a semi-structured interview process is the most effective means to gain a deep understanding of firm behaviour, and the opinions of those currently working for the firms in question (Denzin and Lincoln, 2000). Since the replacement decision-making processes carried out within the firms is closely linked to firm behaviour and the opinions of

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16 The rule underlying pragmatism is called a “maxim” by Murphy (1990).
those working for rail freight firms, only qualitative methods are feasible (Flyvbjerg, 2006). The last research question put forward in Chapter 2 necessitates a quantification of the size of the effects of changes in the tax structure on replacement ages and replacement rates for the rail freight rolling stock. This measurement orientation is thoroughly in line with the quantitative paradigm (Creswell, 2008). The implication is that a mix of quantitative and qualitative approaches is required to address the study’s overall purpose.

3.2.3 Mixed methodology: a methodological partner of pragmatism

The effective use of Johnson and Turner’s fundamental principle (2003) is a major source of justification for using mixed methods in this research. This fundamental principle emphasises the efficacy of collecting multiple data using different strategies, approaches, and methods so that the resulting mixture or combination has complementary strengths and non-overlapping weaknesses. The hope is that, by following this principle, researchers have the best chance to obtain useful answers to research questions (Tashakkori and Teddlie, 2003). The focus on the research question and the inclusive, pluralistic, complementary and eclectic approach to method selection and the thinking about the conduct of research demonstrate a strong connection between mixed methodologies and pragmatism, a paradigm position to which this research is closely related.

In this thesis, development of an economic-oriented model is required to check quantitatively whether accelerated depreciation and other related taxation concessions will provide significant incentives for Australian rail freight operators to increase the rolling stock replacement rate. Yet, in practice, companies’ replacement decisions are more complex and dependent on a number of other factors apart from the outcome of an economic replacement model alone. As Scarf and Hashem (2002) point out, other technological, social, and political factors would also be brought to the attention of the decision maker. As a consequence, qualitative interviews and focus group discussions are used as: (1) a manipulation check; (2) a way to discuss directly the issues under investigation; and (3) an insight into stakeholders’ perspectives and meanings about other important contextual features. If these different approaches yield consistent findings, greater confidence can be placed in the conclusion. Despite this, contradictory findings should allow greater knowledge and better interpretations or conclusions. In this study, the goal of mixing is not to search for consistency, but rather to expand the understanding of the research topic.
Other sources of justification for the use of mixed methodologies in this study relate to the concept of triangulation, which involves looking at the same phenomenon from multiple points of view (Neuman, 2006). Data triangulation involves using a variety of data sources in research; in this case, quantitative and qualitative data (Cameron and Miller, 2007). Likewise, methodological triangulation is the use of mixed methods in a single study (Denzin and Lincoln, 2005). Triangulation of data and methodologies within a single study can also: (1) add insights and understanding that might be missed when only a single method is used; (2) lead toward convergence of results; (3) increase the validity of results; (4) elaborate, enhance, illustrate, and clarify the results from one method with results from the other methods; (5) discover paradoxes and contradictions that lead to a reframing of research questions; (6) use the findings from one method to help inform the other method; (7) expand the breadth and range of research; (9) increase the generalisability of the research outcomes; and (10) produce more complete knowledge necessary to inform theory and practice.

The most important shortcoming associated with mixed research is that it is expensive to conduct since it can be difficult and time consuming for a single researcher to carry out both research approaches. In particular, the researcher has to be proficient and competent in both the approaches and understand how to mix them appropriately (Cameron and Miller, 2007). Furthermore, extensive data collection and resources are required to conduct a mixed method study (Johnson and Onwueguzie, 2004). However, the cost of mixed methods research does not really pose any threat to this study’s rigorousness. It merely means that carrying out the research requires substantial effort.

3.2.4 The mixed design in this study

Designs of mixed methods research can be broadly classified into two major groups: mixed-model designs and mixed-method designs (Tashakkori and Teddlie, 2003; Johnson and Onwueguzie, 2004). In mixed model designs, qualitative and quantitative approaches are mixed within or across several stages of the research process. An example of an across-stage mixed model design is research that collects qualitative data and then converts it into numerical codes that can be analysed statistically, while an example of a within-stage mixed-model design is the use of a questionnaire that includes a summated rating scale and one or more open-ended questions.
In contrast to mixed-model designs, mixed-method designs involve the mixing of quantitative and qualitative approaches only in the methods stage of a study (Cameron and Miller, 2007). This is equivalent to combining both a quantitative and qualitative mini-study in one overall study (Johnson and Onwuegbuzie, 2004). The findings in mixed-method designs must be mixed or integrated at some point. There are two procedures for linking the strands: the sequential style and the concurrent style (Tashakkori and Teddlie, 2003). Sequential mixed-method designs involve collecting data in an iterative process, whereby the data collected from the earlier phase contribute to the data collected in the later phase (Driscoll et al., 2007). In these designs, data is collected so as to provide more data about results from the earlier phase of data collection and analysis, select participants who can best provide the next batch of data, or generalise findings by verifying and augmenting study results from members of a defined population (Creswell and Plano Clark, 2007). In contrast, concurrent mixed-method designs involve collecting data in a parallel process in which one form of data is used to validate the other form; or else one form of data is transformed for comparison with another form, or different types of questions are addressed (Creswell and Plano Clark, 2007).

This study employs the sequential-mixed-method design (Figure 3.1). Qualitative in-depth interviews are conducted first to gain a deep understanding of complexities surrounding how decisions are made regarding rolling stock replacement among rail freight firms. This is intended to assist in (1) the validation of the broader academic literature assembled; and (2) identify key economic issues for the subsequent development of asset replacement model that will be used to analyse in quantitative fashion the economic effects of tax concessions on rolling stock replacement. Findings from in-depth interviews can also assist in explaining and interpreting the findings of the quantitative study (Creswell, 2003). The focus group in the final stage is designed to examine the findings from the first two stages and provide in-depth expert assessments of their implications. A follow-up focus group may be particularly useful when unexpected results arise during the quantitative stage. In this case, the focus group that follows can be used to provide important information on emergent and unexpected themes (Driscoll et al., 2007).

A drawback associated with sequential mixed-method designs is that they are time consuming to conduct since the researcher uses at least two analysis methods over at least two time phases. However, this time consumption is worthwhile since it implies a manner of self-triangulation that will provide greater internal validity (Creswell, 2003; Johnson and
Onwuegbuzie, 2004; Tashakkori and Teddlie, 2003). Although concurrent data collection designs have the advantage of being simpler and less time consuming to conduct, they preclude follow-up on interesting or confusing themes that emerge during the earlier stages of data collection and analysis (Driscoll et al., 2007). Furthermore, this study does not intend to validate one form of data with the other form, or to transform the data for comparison. As an alternative, two types of data are collected in a complementary manner. The objective is to seek elaboration, enhancement, illustration and clarification of the results from one method with results from the other method.

For all the aforementioned reasons, the concurrent design is rejected here in favour of the sequential design. The mixed-model design is not appropriate in this study because there is no intention to mix qualitative and quantitative approaches within or across the stages of the research process: quantitative analysis will be performed on quantitative data, while qualitative analysis will be performed to qualitative data. No attempt will be made to convert qualitative data into numerical codes that can be represented statistically, or to convert quantitative data into narrative data that can be analysed qualitatively. In addition, all questions asked in the interviews and focus group discussions are open-ended (leading to qualitative data). Likewise, the financial data requested for the analysis of the asset replacement model is entirely numerical (leading to quantitative data).

### 3.3 Phase I: Qualitative in-depth interviews

Neuman (2006) defines interviewing as a conversation between two strangers with the purpose of one person obtaining specific information from the other. Interviewing is perhaps the most commonly employed technique for gathering qualitative data. According to Berg (2004), interviews can be summarised into three major groups: standardised, semi-standardised, and unstandardised, with questions ranging from closed to open-ended. In standardised interviews, the interviewer asks all respondents the same set of predetermined questions and records the responses according to a predetermined coding scheme (Simon, 1994). The questions scheduled in standardised interviews are expected to be sufficiently comprehensive so as to elicit from subjects all (or nearly all) the information relevant to the study topic(s) (Berg, 2004). These questions are worded in a manner that allows subjects to understand clearly what they are being asked, so there is no need for additional questions and

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17 Also found as “structured”, “semi-structured”, and “unstructured”.

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clarification. Furthermore, all subjects are assumed to find equal meaning in like-worded questions or, in short, it is assumed that subjects possess the same vocabularies.

Unlike standardised interviews, unstandardised interviews do not employ schedules of questions (Berg, 2004). This is because the interviewers begin with the assumption that they do not know in advance what all the necessary questions are. As a consequence, interviewers must develop, adapt and generate questions and follow-up probes appropriate to each given situation (Schwartz and Jacobs, 1979). Appropriate and relevant questions will arise from interactions during the interview itself. Unstandardised interviews can gain in-depth insight into the subject’s understanding of a situation or process. Questions used are open-ended, so that the subjects’ answers are not constrained by previous categories imposed by the interviewer (Sampson, 1972). Furthermore, different vocabularies may be used for different subjects since not all subjects will necessarily find equal meaning in like-worded questions (Berg, 2004).
According to Flick (1998), semi-standardised interviews are located somewhere between the extremes of the completely standardised and the completely unstandardised interviewing structure. A number of questions and special topics are implemented beforehand. These questions are typically asked in a systematic and consistent order, much like in standardised interviews. The difference is that the interviewers are given the freedom to probe far beyond the answers to their prepared standardised questions in order to seek additional information. Questions in semi-standardised interviews are formulated in vocabularies familiar to the subject’s experience (Berg, 2004). However, interviewers may need to adjust the level of language of given scheduled questions via unscheduled probes that arise from the interview process itself.

The notion of objectivity stressed in the quantitative paradigm does not permit researchers to use questions that have the potential to add subjectivity. Questions asked in quantitative research tend to be specific, rigid, and worded exactly the same way in each interview. Quantitative researchers therefore tend to rely on standardised interviews to collect numerical data. On the contrary, the notion of subjectivity in the qualitative paradigm gives researchers flexibility to probe during the interview so as to dig deep into the subject under investigation. Qualitative researchers thus rely on semi-standardised and unstandardised interviews to achieve a greater richness of textual information. A brief description of each of the three interviewing approaches and the nature of questions used in each of them has been transcribed from Berg’s (2004) Figure 4.1 and are reproduced in Figure 3.2.

Semi-standardised and unstandardised interviews are sometimes referred to as in-depth interviews (Bryman and Bell, 2007). An in-depth interview technique is appropriate when it is necessary to understand the constructs that interviewees use as a basis for their opinions about a particular matter or situation (Easterby et al., 2002). This coheres with the objective of the qualitative phase of this research; that is, to maximise understanding of the constructs that rail freight operators use as a basis for their opinions about the efficacy of tax concessions in promoting technological investment. The in-depth interview technique is also appropriate if one aim of the interview is to develop an understanding of the respondent’s world so that the researcher might influence it either independently or collaboratively (Easterby et al., 2002). Thus, the in-depth interview format suits this research because it aims to understand the complexities of the rolling stock replacement decisions in the rail freight world.
The standardised interview format is rejected as it does not allow flexibility in exploring interviewees’ perceptions (Hussey and Hussey, 1997; Yin, 1994). A failure to inquire into meaningful phenomena might occur (Carson et al., 2001). That said, the unstandardised format is also rejected as the main technique since there is the threat of the researcher missing valuable data (Yin, 1994). The interviews in this research follow a semi-structured format so as to allow the researcher to cover a specific list of topics, all the while still leaving space for probing and allocating the time for each question according to the situation. Furthermore, the semi-standardised technique will ensure consistency amongst respondents, and at the same time explore the unique insights of each respondent (Berg, 2004). Key interview questions are derived directly from the results obtained during the literature review. The semi-standardised format is designed to corroborate the facts that have been established earlier in the literature review (Yin, 1994). All interview questions are open-ended. The open-ended nature of each question not only defines the topic under investigation, but also provides
opportunities for both interviewer and interviewee to discuss topics in more detail if necessary (Neuman, 2006).

All the key features of the in-depth interview imply that they should be conducted face-to-face (Legard et al., 2003). The physical encounter is an essential context for the in-depth interview, which is meant to be flexible, interactive and generative, and in which language and meaning are explored in depth (Legard et al., 2003). Face-to-face interviews allow the interviewee to tell their story, provide instant feedback, enable the use of probe questions, reduce the likelihood of incomplete questionnaires, and allow the use of props and visual aids (Perry, 2001; Zikmund, 2000). All these features are directed toward understanding the informants’ perspectives on their lives, experiences or situations (Taylor and Bogdan, 1984). The important shortcoming of face-to-face interviews is that they are more costly compared to telephone interviews or computer-assisted interviews (Zikmund, 2000). Here, funding is not a serious issue since the research garnered the financial support of the CRC for Rail Innovation.

The emphasis on depth, nuance and the interviewee’s own language as a way of understanding in-depth interviews implies that interview data needs to be captured in its natural form (Legard et al., 2003). To achieve this, interview data collected for this research is audio recorded so that the informant’s words can be captured and used without repackaging or reinterpretation. Note-taking would change the form of the data and also distract both the interviewer and the interviewee. In addition, audio recording permits greater eye contact and leads to better rapport between interviewee and interviewer (Dick, 1998). The interview transcript is subsequently transcribed by a professional, who signs a confidentiality agreement and was supervised by the author.

3.3.1 Schedule development

An interview schedule or a topic guide represents a documentation of the subjects to be investigated and therefore serves as an interview agenda and guide (Burgess, 1984). The interview schedule is carefully prepared for this research to ensure that relevant issues are covered systematically and with some uniformity. At the same time, the schedule is designed in such a way that it allows flexibility to pursue the detail salient to each individual
participant. As described above, standardisation and flexibility are essential ingredients of the semi-standardised interview process.

According to Berg (2004), the first step to schedule construction is to determine the nature of the investigation and the objectives of the research. This determination provides the researcher with a starting point from which to begin developing a schedule of questions. The investigation of this research follows a ‘clarification path’ (Cavana et al., 2001), which, in this case, is to gain a clearer understanding of the conceptualisation of using accelerated depreciation for promoting technological investment. The main purpose of the interview is to seek answers to the following research questions established from the literature review.

General relevant areas to the investigation can be outlined from the questions and objectives of this research, and also a reading of the literature. These include:

A. Vehicle fleet age problem in the Australian rail freight sector
B. General characteristics of rolling stock fleets in the Australian rail freight organisations
C. Rolling stock replacement process in the organisations
D. Currently proposed incentive programs
E. Accelerated depreciation schemes

This preliminary listing allows the general format of the schedule to be visualised (Berg, 2004). Following this, separate lists of questions for each of the five major thematic categories are developed. Under section A, each respondent is asked to provide an opinion on the causes of the vehicle fleet age problem in the rail freight sector. Other questions in section A relate to the mechanisms proposed by the government to solve it. Questions in section B relate to overall characteristics of the organisation’s rolling stock fleets, especially the ownership structure in rail fleets (e.g., leasing, finance arrangements, etc.). Questions in section C determine the procedure for making a replacement decision, including length and steps of the decision process, personnel and organisational departments involved in the process, factors driving the decision, advice sought to aid or direct decision-making, the extent, nature and influence of financial analysis, and other modelling, etc. Questions raised in section D aim to assess the influences of existing programs provided by the government on the organisation’s rolling stock replacement decisions. In section E, the respondent’s opinion in regard to the proposed accelerated depreciation scheme is asked. In particular, questions
listed in section D determine the usefulness of accelerated depreciation in facilitating the uptake of modern rolling stock in the rail freight sector.

Apart from essential questions concerning the study’s central focus, some additional questions are incorporated into the schedule to check on the reliability of responses or consistency in response sets (Berg, 2004). These questions are equivalent to certain essential ones, but are worded slightly differently. For example, in the earlier part of the interview, the interviewee is asked whether certain mechanisms can be used successfully to modernise rail freight rolling stock; later, consistency is checked by asking if these mechanisms would encourage the respondent’s organisation to replace their assets more quickly.

In addition to essential and extra questions, throw-away questions, such as essential demographic questions or general questions, are included. Although throw-away questions are incidental or unnecessary for gathering the important information being examined in the study, they can be used to develop rapport between the interviewer and the interviewee (Berg, 2004). To serve their purpose, throw-away questions are placed at the start of the interview. In this research, the subjects are asked about their background information (e.g., the ownership structure of their organisation, their present position within the company, their current and previous roles in rolling stock replacement, etc.) so as to open the interview.

If the interviewee experiences difficulty answering a question or provides only a brief response, the interviewer should use cues or prompts to encourage the interviewee to consider the question further and elaborate on the original response (Neuman, 2006). This technique is referred to as probing, which allows for more complete stories to be drawn out (Dick, 1998). Probe questions also allow some prior theoretical issues to be addressed in case the interviewee does not raise them in the early parts of the interview (Merriam, 1988). Probing questions are scattered throughout each part of the prepared interview schedule. Questions used to probe in this research, for example, are “Could you tell me more about that?”, “Could you explain how?”, “Is there anything you would like to say that we have not covered?”, and “How come?”.

Dick (1990) argues that the length of the interview is mainly determined by the breadth of the topic under investigation and that the interview should be terminated only when no further information can be gained. In view of this, the length of the schedule and how long the
interview should last was not emphasised during the schedule construction stage. All questions (essential, extra, throw-away, and probing) in the schedule are required to obtain all the necessary information.

3.3.2 Pilot testing the schedule

The questions/topics in the interview schedule are not precisely the same for all respondents in the first pilot interviews leading up to the main stage of the interview process, but they are the same in the main stage; that is, the initial interview schedule is developed from the literature, and then reviewed and revised using a handful of pilot studies.

Zikmund (2000) defines pilot study as a small-scale version of a full-scale study, together with specific pre-testing of a particular research instrument, including a questionnaire or interview schedule. A pilot study is a cognitive process in which researchers examine how respondents answer questions during pilot tests (Neuman, 2006). This information is then used to refine the interviewing process. Pilot testing is valuable because it evaluates the validity and the reliability of the instructions, the questions, and the response system (Bell, 1999). As a result, it should always be conducted before the implementation of the main study (Neuman, 2006).

In this research, once the author developed the interview instrument and was satisfied with the general wording and sequencing of questions, the interview schedule was pre-tested. This process involved two steps. First, the schedule was critically examined by people familiar with the study’s subject matter. These included other researchers from the CRC for Rail Innovation and industry stakeholders fitting the type of stakeholder to be studied. The aim was to identify poorly worded questions, questions with offensive or emotion-laden wording, or questions revealing the author’s own biases, personal values, or blind spots. The schedule was then edited based on these people’s suggestions.

In the second step, several practice interviews were conducted with stakeholders from the Australian rail freight industry other than those selected for the main study. They were requested to assess how effectively the interview worked and whether the type of information being sought could actually be obtained during an interview. The following questions, as suggested by Chadwick et al. (1984), were asked as a means to assess the instrument:
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- Has the researcher included all the questions necessary to test the research issues?
- Do the questions elicit the types of response that were anticipated?
- Is the language of the instrument meaningful to the respondents?
- Are there any problems with the questions, e.g., double meaning or multiple issues embedded in a single question?
- Does the interview guide help motivate respondents to participate in this study?

In general, positive comments were received. Some of the stakeholders participating in the pilot interviews made the comment that some of the questions were redundant. Furthermore, some of the questions needed to be re-cast to make them easier to understand. Guided by the comments received from the practice interviews, the interview schedule was further refined. The final version of the interview schedule consists of seven sections, with 36 questions in total (see Appendix B).

3.3.3 Participants

The main objective of this study is to ascertain whether the accelerated depreciation of newly acquired locomotives, wagons, and handling equipment provides significant incentives for rail freight operators to invest in more efficient and environmentally friendly technology. Thus, the target population of this research would include all rail freight operators in Australia (there are 22 in total according to IE Aust, 2001), in addition to rail hardware manufacturers or suppliers, such as Bombardier Transportation and Downer EDI Rail, and rolling stock leasing companies, such as CFCL Australia, all of which are potentially involved in rolling stock replacement investment.

Sampling method

According to Richie et al. (2003), there are two important criteria that should be used in qualitative sampling, these being “symbolic representation” and “diversity”. The first criterion emphasises the need to include relevant constituencies, events, processes, etc., that can provide informed understanding of the research issues. The second criterion is there to ensure that the sample is as diverse as possible within the boundaries of the target population. Diversity in the sample is required to optimise the chance of identifying the full range of factors or features associated with a phenomenon under investigation. This also allows some investigation of interdependency between variables so that those that are most relevant can be
disengaged from those of lesser importance. The sampling units for the interview process must meet Richie et al.‘s criteria to be chosen. For example, it is important to interview rail freight firms with substantial fleets so as to ascertain whether taxation concessions can significantly facilitate the modernisation of rolling stock fleets in the rail freight sector. Key rail freight players as specified in Table 2.3 would satisfy this condition, especially QR National and Pacific National, whose combined market share is over 70. Important, too, is the diversity in the sampling units. It is therefore crucial to interview different types of rail freight organisations (e.g., both government-owned and privately owned companies, and both rolling stock operators and providers). Participants should also range from relatively small local firms to national concerns. Diversity is also obtained by assuring that informants within these organisations play different roles in rolling stock replacement and come from different hierarchical levels.

Since the objective of the interviews is to obtain a detailed and informed understanding of factors driving rolling stock replacement and mechanisms so as to increase the uptake of new rolling stock, the informants in this case are individuals (within the target population defined above) in an asset managerial role, engineering managerial role, strategic management role, and in a management of capital utilisation role. In addition, interviewees also included individuals with a high-level management role, e.g. the chief financial officers (CFOs), the chief executive officers (CEOs), and the directors or the owners of the organisations responsible for supervising and approving the rolling stock replacement decision. As a result, they comprise purposive or judgemental samples since they possess the knowledge that qualifies them to provide informed responses to the interview questions (Sekaran, 1992).

The interview process involves a certain commitment of the operators involved in terms of employees’ time and information release. This means that it can be difficult to convince all desired operators to participate. In view of this, sample selection was also based on a convenience sampling in terms of choosing those informants accessible to the researcher (Davis, 2005). Convenience sampling technique is strongly related to the concept of pragmatic considerations in real-life research, in which convenience and cost are critical constraints (Patton, 2002). As a consequence, it is to a certain extent unavoidable that the accessibility of the candidate informants is considered. The need to gain access to some of the informants through introductions requires that the sampling technique used in this research must incorporate snowball sampling, where the researcher makes initial contact with
a small group of people who are most relevant to the research topic, and then uses these contacts to establish contact with other potential recruits (Bryman and Bell, 2007).

Since a combination of non-probability samplings is used, it is not possible to draw a representative sample from a huge population to study the sampled units in an intensive manner. The consequence is that statistical generalisability of the findings is potentially restricted. This, however, is not a major issue since generalisation of results in qualitative inquiry is applied to theory, not to population (Yin, 1994; Tellis, 1997). Thus, it is their relevance to the research topic rather than their representativeness that determines the way in which interviewees are selected (Flick, 1998). Moreover, recruiting busy professionals to discuss subject matter relating to their employing organisations is a difficult and time-consuming task. Therefore, the theoretical sampling technique, which aims to select a large sample size in order to achieve a statistically representative group that mirrors the characteristics of the entire population of interest, should be rejected (Sekaran, 2000).

**Sample size**

Patton (1990) argues that the validity, meaningfulness, and insights generated from qualitative inquiry are more closely related to the information-richness of the cases selected and the observational/analytical capabilities of the researcher than sample size. In general, the literature does not offer a clear insight regarding how many interviews should be included in a qualitative study incorporating a semi-standardised interview process. In most cases, it is suggested that the emphasis should be based on the notion of continuing until interpretation of the data is not changing (Dick, 1990; McDowell et al., 1996). Furthermore, the interview process is designed to obtain rich qualitative impressions of attitudes and detailed effects of regulations and taxes on particular business types, rather than to achieve statistical representativeness. In view of these considerations, there is no ideal number of participants. Additional interviews will be determined by the author of this research based on whether “theoretical saturation” (Glaser and Strauss, 1967) or “the point of redundancy” (Lincoln and Guba, 1985) has been reached.

In this thesis, theoretical saturation or the point of redundancy was reached after twelve interviews. Four more interviews were conducted after the saturation point is reached so as to ascertain that a credible picture had really been drawn. Overall, sixteen industry representatives from eight rail freight organisations were interviewed. Three major rail freight

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companies participated. Some relatively small local firms were also involved to ensure a degree of generalisability to the research outcomes. As indicated in the following figure, informants are diverse in terms of the type of services provided by their organisation, the ownership structure of their organisation, their organisation size, and the role played in rolling stock replacement.

Figure 3.3: Diversity in stakeholders interviewed. Of all interview participants, 11 are freight operators, 3 are hardware suppliers, and 2 are rolling stock lessors; 5 are representatives from government entities, while 11 are representatives of private companies; 10 are identified as key rail freight players, whereas 6 are not. Of those middle-level managers, 3 are in an asset managerial role, 1 is in an engineering managerial role, 3 are in a strategic management role, and 2 are in a management of capital utilisation role. Of those high-level managers, 2 are chief financial officers, whereas 5 are directors/chief executive producers.

3.3.4 Ethical considerations

Ethical considerations need to be borne in mind throughout the research process, especially during the qualitative data collection phase, which involves conducting in-depth interviews with key industry personnel, identified by their significant involvement in making rolling stock replacement decisions. In accordance with the guidelines provided by Human Research Ethics Committee, ethical issues that need to be considered are voluntary participation, informed consent, privacy, confidentiality and anonymity, and deception. These ethical issues mutually support each other. For example, the right to privacy can be protected by providing confidentiality and anonymity, while issues pertaining to voluntary participation, confidentiality and anonymity, and deception can be dealt with by providing participants with informed consent statements (Neuman, 2006). In this research, confidentiality and anonymity were established by not disclosing interview participants’ real identity (apart from their role or position within the organisation) in any research publications. All information published
will be represented as overall data. The structure of the informed consents statements used in this research follows that of Neuman (2006) (see Figure 3.4). The statements, which can be seen in Appendix B, were split into an information sheet and a consent form.

Participants in research must be able to make a voluntary, informed decision to participate (Bouma, 2000). To satisfy this principle, the informed consent statements were given to industry personnel identified as being appropriate for interview. These statements were briefly discussed with the participants before the interview commenced. Participants completed and signed the consent form before the interview began, and could withdraw at any time without penalty. Participants could also take a break during the interview whenever they needed to do so.

**Figure 3.4: Informed consent statements.**

<table>
<thead>
<tr>
<th>Informed consent statements contain the following:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A brief description of the purpose and procedure of the research, including the expected duration of the study.</td>
</tr>
<tr>
<td>2. A statement of any risks or discomfort associated with participation.</td>
</tr>
<tr>
<td>3. A guarantee of anonymity and the confidentiality of records.</td>
</tr>
<tr>
<td>4. The identification of the researcher and of where to receive information about subjects’ rights or questions about the study.</td>
</tr>
<tr>
<td>5. A statement that participation is completely voluntary and can be terminated at any time without penalty.</td>
</tr>
<tr>
<td>6. A statement of alternative procedures that may be used.</td>
</tr>
<tr>
<td>7. A statement of any benefits or compensation provided to subjects and the number of subjects involved.</td>
</tr>
</tbody>
</table>


### 3.3.5 Data analysis strategies

The objective of this research phase is to undertake careful analysis of the qualitative data collected for the research. The main type of analysis employed is analytic induction. In particular, a search for themes and categories flowing out of the detailed description of interview transcripts was conducted. This technique is called ‘thematic analysis’, which
represents a process for encoding qualitative information (Boyatzis, 1998). The patterned themes and regularities obtained from thematic analysis are then be used to interpret the data. The analysis also involves some deduction or confirmation/disconfirmation of prior theories regarding the rolling stock replacement strategies. Merriam (1988) advises that a blend of induction and deduction is usually preferred by researchers. The reason is that pure induction without prior theory might prevent the researcher from benefiting from existing theory, while a pure deduction might prevent the researcher from developing new and useful theory.

## Coding, searching, and modelling

The interview transcripts were entered into N*Vivo, a computer program which facilitates the analysis of qualitative data (Sinkovics, Penz and Ghauri, 2005). Responses to each question were collated into a node for that question. Core statements constituting the essence of respondents’ answers to the questions were then extracted. The nodes were then identified based on concepts in the literature review, terms used by interview participants, or new thoughts stimulated by immersion in the data (Neuman, 2006). After the open coding process, axial coding was applied to inter-relate the categories and sub-categories (Mertens, 2005). Nodes expressing the same concepts were merged as a result of the axial coding process, and selective coding was subsequently applied to develop a theoretical understanding of factors influencing rolling stock replacement decisions. At this stage, all the data and previous nodes were examined in order to identify and select data that would support the conceptual coding categories developed earlier (Strauss and Corbin, 1990). The selective coding was used to link nodes with other nodes or nodes with memos that emerge during coding. After coding, the searching process took place. In particular, after the right container for ideas was identified, the container would be inspected and its content would be theorised (Sinkovics, Penz and Ghauri, 2005).

During the search process, N*Vivo helps to provide a deeper analysis of textual data. This software enables researchers to pose whatever question they might want to ask, with the program providing a text-based answer immediately. This research looked for data illustrating factors affecting the rolling stock replacement decisions and their relative importance. As a result, nodes such as “increased capacity”, “technological obsolescence”, “environmental performance”, etc. were searched, and a matrix intersection between nodes was produced. This research is also interested in mechanisms to increase the uptake of new rolling stock in the Australian rail freight sector. As a consequence, nodes such as “ETS”, 
“investment allowances”, “accelerated depreciation”, etc., were searched for. Following the searching process, a modelling process took place. This involved crafting theoretical models of graphical illustrations of the underlying textual data (Sinkovics, Penz and Ghauri, 2005). This process assisted in developing a new categorisation scheme that could be used in the subsequent coding process. Modelling is also instrumental for the conceptualisation of ideas arising during the ongoing coding and search process. Similar to all qualitative approaches, models established for this research evolve and change continuously, and are also refined and updated during the research process. Figure 3.5 illustrates the process of data analysis undertaken for this research.

**Establishing trustworthiness of qualitative findings**

Like other forms of qualitative research, this research accentuated the concept of triangulation. Triangulation (i.e., the use of multiple sources of evidence) improves the accuracy of qualitative research (Neuman, 2006). Several types of triangulation were achieved. First, triangulation of data sources was undertaken by comparing responses from multiple informants in two or more organisations. This triangulation improves the overall dependability of the data (Hoepfl, 1997). Second, triangulation of theory was achieved by using multiple theoretical perspectives when reviewing the literature and interpreting the data. In particular, the literature review reported both supporting and contradicting theories, while the analysis also looked at the data coming from each theoretical perspective. Finally, triangulation of methods was carried out by mixing inductive and deductive styles of research. As mentioned above, this project mainly used an inductive analysis of data. The data was sifted through for patterned themes and regularities that could subsequently be used to interpret the data. This project also employed elements of theory so as to test the deductive approach. It also identified existing theoretical concepts and tried to confirm these concepts using observable empirical evidence. In short, theoretical and methodological triangulations allowed the research to develop a more holistic picture of the subject under investigation (Neuman, 2006).

Qualitative researchers address the issue of integrity by emphasising trustworthiness as opposed to objectivity in quantitative research design. Lincoln and Guba (1985) argue that the trustworthiness of qualitative research can be established by making sure that research findings are credible, transferable, dependable, and confirmable. Credibility depends on the richness of the information gathered and on the analytical abilities of the researcher.
Transferability of the research findings to other situations depends on how similar the original situation and the situation to which it is transferred. Dependability is the degree of validity of the research findings, while confirmability refers to how much the researcher can demonstrate the neutrality of the research interpretations (Patton, 1990; Hoepfl, 1997).

Triangulation to check the dependability of the data was achieved by comparing responses from multiple informants in two or more organisations. Reflexivity was achieved since the theoretical framework outlined in the literature review made it clear that prior expectations have the potential to shape research. Note that rail freight firms’ replacement policies are dynamic, but the envisaged studies of rail industry replacement decisions are cross-sectional rather than longitudinal and therefore do not allow for change over time. As a result, this research acknowledges that future revisitation might be desirable as a means to test the dependability of its ultimate outcomes. Note also that the research is primarily concerned with investment behaviour of rail organisations, even though individuals provide much of the data. This weakness can be dealt with using the concept of triangulation as described above.

The approach is confirmable to the extent that evidence instances that both supporting and contradicting theory will be reported, while typical or representative statements will be presented in reports so as to allow the reader to judge whether the interpretation offered is adequately supported by the data. Confirmability of the research outcomes can also be improved through triangulation. Transferability is established through analytic generalisation, or comparing the research results with theoretical propositions, and by comparing the results with those of other studies (Yin, 1989). A detailed description of the context to which this study belongs has already been provided in the literature review chapter. This thorough description can be used by the reader to determine whether the findings can be transferred to the new situation. Credibility is then boosted through triangulation and member checks. The former can be achieved by several ways, as explained above. The latter can be obtained by gathering and analysing stakeholder feedback of the research findings (Lincoln and Guba, 1985). In this research, member checks were carried out via the focus group discussions explained in Section 3.5.
3.4 Phase II: An Extended Asset Replacement Model

3.4.1 Originality of the model

A classical asset replacement model was developed by Perrin (1972). Perrin’s model has been used by others (with some variations) to examine the effects of taxation on asset replacement (e.g., Chrisholm, 1974; Kay and Rister, 1976; Bates et al., 1979; Reid and Bradford, 1983; Lynne, 1988; Moss et al., 1989; Smith, 1990; Chen, 1991; Billings and Glazunov, 2004; Ibendahl and Norvell, 2007). In this model, the firm is assumed to choose the replacement time that maximises the PV of the net income stream associated with a particular type of asset over an infinite time horizon. It is also assumed that there is no uncertainty about the size of all revenue and cost streams associated with that asset. The firm is assumed to replace the existing equipment with an identical asset at any moment in time. At the moment of replacement, a new sequence of cost and revenue streams is initiated and the sequence is replicated at each subsequent moment of replacement.
Perrin’s model was modified for the purpose of this research so as to include the effects of accelerated depreciation and other tax special concessions. The variables will also be made to account for inflation and technological advancement. The novelty of the model presented is its comprehensiveness. The effects of technological advancement, taxes, and inflation have been analysed by previous replacement studies. The literature, however, indicates that these three factors have not been incorporated into the replacement model simultaneously.

Perrin (1972) derives the form of the asset replacement equilibrium when the technological advancement is included. Different forms of asset replacement conditions that take account of the technological advancement are derived by, e.g., Elton and Gruber (1976), Kuzaka and Suzuki (1990), Scarf and Hashem (2002), Rogers and Hartman (2005), and Scarf et al. (2007). By way of contrast, Chisholm (1974), Kay and Rister (1976), Van Tassell and Nixon (1989), and Smith (1990) adjust Perrin’s (1972) model to reflect the tax environment. Their models, however, still do not take account of inflation and technological advancement. Christer and Waller (1987), Prezaz (1994), and Ibendahl and Norvell (2007) also came up with tax-adjusted replacement models, but with a different format from those mentioned previously. Some economists incorporate two factors into their proposed replacement models at the same time. Bates et al. (1979), Bartholomew (1980), Bates and Rayner (1980), Reid and Bradford (1983), Howe and Lapan (1987), and Chen (1991) examine the effects of taxation and inflation on the optimal asset replacement, but still do not take care of the unrealistic stationary technology assumption. Yet Hartman and Hartman (2001) use a dynamic programming approach to show how the replacement decision is made under the tax environment and technological change. Inflation is omitted by Hartman and Hartman.

This research derives a deterministic asset replacement model under taxation, inflation, and technological progress environment. Overall, the model developed here most resembles that of Smith (1990). The main difference is that the present model relaxes stationary technology and uniform effect of inflation assumptions made by Smith. The model presented here is therefore a generalised version of Smith’s model.

As in the work of Perrin (1972), the term ‘Defender’ is used to indicate an existing asset, while the term ‘Challenger’ is employed to represent an asset than can be purchased to replace a Defender. The developed model is a continuous-time model of capital equipment replacement that maximises the PV of the stream of residual earnings of the asset in order to
determine the optimum replacement time for a perpetual chain of asset cycles. Note that, in most real-world replacement problems, all variables are observed as discrete annual levels rather than continuous functions of time. All variables represented here are in continuous-time. This allows simpler algebraic and economic interpretations.

3.4.2 Model assumptions

The following are characteristics of the replacement problem under consideration.

1) The company under investigation is profitable so that depreciation charges and losses from the sale of an asset may be treated as tax credits (revenues) since they reduce tax liabilities elsewhere in the entity.

2) Cash flows from depreciation tax shields, operating cost tax shields, investment tax credit, investment allowances, and taxation of the balance adjustment on the sale of the asset when it is replaced do not affect the tax bracket of the company so that the marginal income tax rate may be used for analysis.

3) All cash flows (operating cash flows, future salvage value, depreciation tax savings, investment tax credit, investment allowances, and tax on the divergence between salvage and book values) are discounted at the same rate.

4) The Defender will be replaced by a perpetual series of identical Challengers.

5) The Challenger is to be purchased new, rather than leased. Through discussions with industry stakeholders during the in-depth interview process, it was found that rail operators currently purchase most of their rolling stock rather than lease it. This assumption is made in order to be consistent with that finding, and also to simplify the analysis since the taxation treatment of lease finance as compared to forms of borrowing to purchase an asset is particularly complicated.

6) The Challenger is subject to once-and-for-all technological and capacity improvement. This improvement is represented by a step-up enhancement in revenues generated by the Challenger, an increase in salvage values, and a higher purchase price (Hartman, 2005).

7) The Challenger is subject to tax advantages, namely accelerated depreciation, an investment allowance, and an investment tax credit, while the Defender is not. For the investment allowance, it can be assumed that the firm can claim additional depreciation in the first year after the purchase of the asset. Likewise, the investment credit is also assumed to be taken in the first year after the asset’s purchase.
8) It is assumed that the company will switch to accelerated depreciation if it is provided. In real life, a number of constraints may militate against firms’ shifting from normal depreciation practice to accelerated methods. These barriers include, e.g., administrative costs, firms’ accounting convention, expectation of a change in marginal rates of tax, and uncertainties associated with the accelerated depreciation scheme (see Chapter 2 for more detail on these potential barriers).

9) The replacement process does not cause (or does cause but only slightly) the production of some particular products to delay or to stop temporally. In other words, there is no production loss owing to replacement. This assumption coheres with results from the in-depth interviews.

10) There is no capital rationing. In real life, replacement decisions are subject to fund constraints. If this is the case, firms should consider replacement decisions and other investment decisions simultaneously (Bradford and Reid, 1982). The optimal decision for firms might be to delay replacement in order to accept other investment projects that will achieve a higher PV. This constraint is too complex to be modelled and is therefore left out.

11) When the asset is acquired, the firm pre-commits to holding it for the period of time that maximises its NPV. As a consequence, it is assumed that there is no uncertainty about the size of all revenue and cost streams associated with rolling stock equipment. The firm decides irrevocably about asset duration at time zero, i.e., the value of the deferral option is zero. In addition, tax rates and discount rates are assumed to be known with certainty.

12) Changes in the expected rate of inflation will alter the optimal replacement ages since they will effectively change the PV associated with investment tax credits, depreciation allowances, and balance charge adjustments (Bates et al., 1979). For simplicity, it is first assumed that the inflation rate is constant and that the acquisition of a new asset results in the replication of real income streams. This assumption will be relaxed later.

13) All qualitative or intangible factors that might be drivers of replacement decisions in real life are excluded on account of their nature. In particular, these qualitative factors are excluded from the model because no monetary values can be assigned to them.
3.4.3 The model for optimal scrapping decisions (with zero inflation)

In line with Perrin’s notation, the PV of the net revenue stream associated with a specific unit of the Defender may be written as:

\[
Q(a,c,l) = (1 - T) \int_a^c \pi(t)e^{-\rho(t-a)} dt + M(c)e^{-\rho(c-a)} - M(a) \\
+ T \int_a^c D(t)e^{-\rho(t-a)} dt - T \left[ \int_a^c D(t)dt + M(c) - M(a) \right] e^{-\rho(c-a)}
\]  

(3.1)

where \( Q(a,c,l) \) is the PV of the stream of residual earnings of one unit of the Defender of age \( a \) to be disposed of at age \( c \); \( T \) is the marginal tax rate; \( t \) is time; \( \rho = \ln(1+r) \) is the interest rate that, when compounded continuously, results in an annual growth rate of \( r \), i.e. \( e^{\rho t} = (1+r)^t \); \( \pi(a) \) is the flow of residual earnings (current revenues less current costs) associated with the asset at age \( a \); \( D(a) \) is the tax depreciation permitted for the asset at age \( a \); and \( M(a) \) is the market (or salvage) value of the asset at age \( a \).

(3.1) has a straightforward economic interpretation. The income stream associated with the Defender consists of the PV of the firm’s after-tax residual earnings, \( (1 - T) \int_a^c \pi(t)e^{-\rho(t-a)} \), plus the sum of the discounted resale value of the Defender, \( M(c)e^{-\rho(c-a)} \), and the discounted sum of the depreciation tax shields that accrue over the life of the Defender, \( T \int_a^c D(t)e^{-\rho(t-a)} dt \), less the sum of the initial cost of the Defender, \( M(a) \), and the discounted after tax value of any balance charge associated with the sum of the depreciation allowed on the Defender and its re-sale value less its original cost, \( T \left[ \int_a^c D(t)dt + M(c) - M(a) \right] e^{-\rho(c-a)} \).

Note that the balance charge adjustment occurs when a difference exists between resale value and depreciated book value at the time of asset disposal. The depreciated book value at the time of asset disposal generally equals the original price of the asset less the accumulated depreciation allowances. If the resale value exceeds the depreciated book value, the excess depreciation is added to taxable income. On the contrary, if the resale value is less than the depreciated book value, the loss may be deducted from the year’s taxable income. In Australia, realising a gain or loss on the sale of an asset is a requirement under the uniform capital allowance, unless that asset has been totally used for a non-tax purpose (e.g. for personal use) (ATO, 2009b). The term ‘gain or loss’ on the sale of an asset is different from the term ‘capital gain or loss’. Under the current tax code, a capital gain is defined as the difference between the purchase price of an asset adjusted for inflation and its eventual resale value (ATO, 2009b). As a result, if an asset appreciates in value, the capital gain is realised and a capital gain tax must therefore be paid. This is different from a gain on the sale of an asset, which represents the difference between the depreciated book value of an asset and its selling price. However, under the current law, capital gain or capital loss can arise at the time of the balancing adjustment event, but only to the extent that the
On some occasions, the firm might consider scrapping the asset, rather than replacing it. In these circumstances, we find \( c \), which maximises the one-cycle PV of holding the Defender, \( Q(a,c,l) \). This can be done by setting the derivative of \( Q(a,c,l) \) to zero and obtaining:

\[
(1-T)(\pi(c) + M'(c)) = \rho \left[ M(c) - T \left( \int_a^c D(t) dt + M(c) - M(a) \right) \right]
\]

(3.2a)

where the prime indicates derivative. The term on the LHS of (3.2a) represents the after-tax marginal revenue (residual earnings at \( c \), \( \pi(c) \), plus changes in asset value, \( M'(c) \), adjusted for tax liabilities). The terms on the RHS of (3.2a) are the interest that could be earned by selling the Defender, \( \rho M(c) \), less the interest yield on the balance adjustment tax liabilities avoided at \( c \) by delaying disposal of the Defender, \( -\rho T \left( \int_a^c D(t) dt + M(c) - M(a) \right) \). (3.2a) says that the Defender should be scrapped when the marginal revenue from the Defender (LHS of (3.2a)) equals marginal opportunity costs of holding it (RHS of (3.2a)). This point occurs at age \( c \). More implications can be obtained by dividing (3.2a) throughout by \( (1-T) \) to give

\[
\pi(c) + M'(c) = \rho M(c) - \frac{\rho T}{1-T} \left( \int_a^c D(t) dt - M(a) \right).
\]

(3.2b)

(3.2b) can be used more conveniently to examine how changes in the tax structure affect the selection of the optimal scrapping age. The LHS of (3.2b) is unaffected by changes in any element of the tax structure. It is a negative function of changes in \( c \). To be more specific, as equipment age increases, the marginal cost of operating the asset rises or its marginal product declines, or both phenomena occur,\(^{19}\) thereby leading to a decrease in the value of the LHS of (3.2b). Tax elements only appear on the RHS of (3.2b). Thus, any change in the marginal tax rate, \( T \), that increase the value of the RHS of (3.2b) will reduce the optimal value for \( c \) and vice versa.

---

\(^{19}\) These phenomena are assumed to occur at a rate sufficient to offset any reductions in the rate at which the remaining value of the equipment declines. As stated by Smith (1990), this assumption is feasible for most physical assets.
3.4.4 The model for optimal replacement decisions (with zero inflation)

More often than not, rather than ceasing the activities associated with the asset after just one cycle (i.e., scrapping the asset and not replacing it), firms will replace the existing asset with others on a continuous basis. By implication, the solution to the replacement problem given by (3.2) is no longer valid. This is consistent with Preinreich’s replacement theory (1940), which was explained in Section 2.4.2 of the literature review chapter. As a consequence, it is necessary to incorporate the PV of the net revenue streams associated with the Challenger into our replacement problem. The PV of an individual Challenger may be written as:

\[
C(0,s,1) = (1-T) \int_0^s \pi(t)e^{-\rho t} dt + M(s)e^{-\rho s} - M(0) \\
+ T \int_0^s D(t)e^{-\rho t} dt + Ie^{-\rho} + TAE^{-\rho} - T \left[ \int_0^s D(t) dt + M(s) - M(0) \right] e^{-\rho s}
\]

(3.3)

where \(C(0,s,1)\) is the PV of the stream of residual earnings of one unit of the Challenger to be purchased at age 0 and replaced at age \(s\); \(Ie^{-\rho}\) is the PV of the investment tax credit obtained after a year after the purchase of the Challenger; \(TAE^{-\rho}\) is the PV of the tax savings from an investment allowance; \(\pi(a), M(a), D(a)\) have the same meaning as their counterparts \(\pi(a), M(a), D(a)\) from (1). The economic interpretation of (3.3) is the same as that of (3.2), except that, in this case, the income stream associated with the Challenger includes two additional components, \(Ie^{-\rho}\) and \(TAE^{-\rho}\). The Challenger is also an improved asset compared to the Defender as a result of technological and capacity improvement. This improvement can be represented by an increase in the flow of residual earnings, i.e., \(\pi(a) \geq \pi(a), \forall a\), and an increase in equipment market value, \(M(a) \geq M(a), \forall a\).

The PV of the perpetual series of identical Challengers may be written as:

\[
C(0,s,\infty) = C(0,s,1) + e^{-\rho s}C(0,s,1) + e^{-2\rho s}C(0,s,1) + \cdots \\
= (1 + e^{-\rho s} + e^{-2\rho s} + \cdots)C(0,s,1) \\
= (1 - e^{-\rho s})^{-1}C(0,s,1) \\
= (1 - e^{-\rho})^{-1}(1 - e^{-(s+1)\rho})C(0,s,1)
\]

(3.4)

An assumption was made that the Defender will be replaced by a perpetual series of identical Challengers. As stated by Perrin (1972), the replacement problem is to maximise the PV of the Defender and the entire series of Challengers:

\[
Q(a,c,\infty) = Q(a,c,1) + C(0,s,\infty)e^{-\rho(c-a)}
\]

(3.5)
with respect to \( c \). The solution to the above problem is obtained by differentiating (3.5) with respect to \( c \) and setting it to equal zero. This first order condition may be represented by the following equation:

\[
(1-T)(\pi(c) + M'(c)) = \rho M(c) - T \left( \int_a^c D(t)dt + M(c) - M(a) \right) + C(0,s,\infty)
\]  

(3.6a)

or dividing throughout (6a) by \((1-T)\) to get an alternative representation:

\[
\pi(c) + M'(c) = \rho M(c) - \frac{\rho T}{1-T} \left( \int_a^c D(t)dt - M(a) \right) + \frac{\rho}{1-T} C(0,s,\infty).
\]  

(3.6b)

(3.6) and (3.2) have the same economic interpretation. The additional term on the RHS of (3.6), \( \rho C(0,s,\infty) \), indicates the opportunity cost of delaying the receipt of net income streams that will be realised from the next and subsequent held assets. This opportunity cost is the interest charge, \( \rho \), on the PV of those income streams, \( C(0,s,\infty) \). The existence of the opportunity cost implies that, in general, the firm will be more impatient with respect to replacing the Defender than scrapping it.

### 3.4.5 The tax impact of inflation

Suppose all parameters that affect marginal conditions (3.2) and (3.6) are defined in real terms and consider what the inflation could have impacted these parameters. One possibility is that inflation has a uniform impact on these parameters (Watts and Helmers, 1979). If constant relative prices and a constant expected rate of inflation are assumed, all incomes and outlays (including tax credits and allowances) will increase at the expected rate of inflation. At the same time, the discount rate will also include an inflationary premium. Proportional changes in costs and revenues therefore will not change the PV amount and alter the investment decision.

Let the rate of inflation be \( f \) and define all the previous parameters in real terms. If it is assumed that both \( \pi(a) \) and \( M(a) \) maintain their real value, then the inflation-adjusted PV of the stream of residual earnings may be written as:

\[
Q(a,c,l) = (1-T) \int_a^c \pi(t) e^{-\rho(t-a)} dt + M(c) e^{-\rho(c-a)} - M(a)
+ T \int_a^c D(t) e^{-(\rho+f\times c-a)} dt - T \left[ \int_a^c D(t)dt + M(c) - M(a) \right] e^{-(\rho+f\times c-a)}
\]  

(3.7)
(3.7) and (3.8) are different from their counterparts (3.1) and (3.3) in that investment tax credits, depreciation allowances, and balance charge adjustments are based on historical costs and are now measured in depreciated money (it is assumed that \( f \) is positive). As a result, their PV to the firm will change.

If it is assumed that costs and benefits rise at the same rate \( f \), \( C(0,s,k) = C(0,s,1)e^{(a-1)fs} \) at the \( n \)th cycle. The discount factor at the \( n \)th cycle would also increase to \( e^{-(a-1)(\rho + f)s} \) owing to higher inflation. Both changes completely offset each other in the PV calculation. This means that inflation does not change the formula for \( C(0,s,\infty) \). In mathematical terms,

\[
C(0,s,\infty) = C(0,s,1) + e^{-(\rho + f)s}C(0,s,1)e^{fs} + e^{-2(\rho + f)s}C(0,s,1)e^{2fs} + \cdots \\
= C(0,s,1) + e^{-\rho s}C(0,s,1)e^{-fs} + e^{-2\rho s}C(0,s,1)e^{-2fs} + \cdots \\
= C(0,s,1) + e^{-\rho s}C(0,s,1) + e^{-2\rho s}C(0,s,1) + \cdots \\
= (1 - e^{-\rho s})^{-1}C(0,s,1).
\]

For similar reasons, the inflation does not change the formula for \( Q(a,c,\infty) \). Thus, in mathematical terms,

\[
Q(a,c,\infty) = Q(a,c,1) + C(0,s,\infty)e^{(c-a)}e^{-(\rho + f)s(c-a)} = Q(a,c,1) + C(0,s,\infty)e^{-\rho(c-a)}.
\]

Despite this, marginal conditions (3.2) and (3.6) will change to

\[
(1 - T)e^{-f(c-a)M'(c)} = \rho M(c) - (\rho + f)T\left[\int_a^M D(t)dt + M(c) - M(a)\right]e^{-f(c-a)} \quad (3.9)
\]

and

\[
(1 - T)e^{-f(c-a)M'(c)} = \rho (M(c) + C(0,s,\infty)) - (\rho + f)T\left[\int_a^M D(t)dt + M(c) - M(a)\right]e^{-f(c-a)} \quad (3.10)
\]

respectively as a result of inflation. (3.9) and (3.10) are derived in the same fashion as their inflation-less counterparts (3.2) and (3.6).

### 3.4.6 A special case: cost minimisation replacement models

If the Defender earns revenue according to some function \( R(a) \) and, in doing so, incurs age-dependent running expenses according to some function \( E(a) \), the value of residual earnings
to the firm may be given by $\pi(a) = R(a) - E(a)$. Likewise, the value of residual earnings associated with the Challenger is $\pi(a) = R(a) - E(a)$.

Smith (1961) argued that, in the absence of technological change, a replacement decision cannot affect price or output. When a firm’s price-output decisions are independent of its replacement decisions, cost minimisation and profit maximisation are completely separable (Chrisholm, 1974). The implication is that revenues generated by the asset are not needed for the replacement decision. The firm can therefore choose to focus entirely on minimising the asset’s cost components. When a stationary technology assumption is relaxed, Elton and Gruber (1976), in their examination of equipment replacement, generally made the following assumptions:

- The revenues generated by an existing asset decrease linearly with time, or alternatively, revenues are constant and costs increase linearly with time.
- Technological innovation increases the efficiency of new assets over time.

Both assumptions draw support from almost all practical situations. The first assumption is feasible since many machines share a common characteristic; that is, their efficiency declines with age. This reduction in efficiency can be represented by, e.g., decreasing revenues, increasing maintenance and repair costs, increasing downtime costs, and decreasing resale value (Walker, 1994). The linear characteristic of the revenue and cost functions receive support from the seminal research of Terborgh (1949 and 1958). Terborgh studied eight classes of productive equipment and observed a negative linear relationship between revenues generated by this equipment and their age (or equivalently, there is a positive linear relationship between costs and the equipment age). Furthermore, Terborgh found that technology tends to improve the revenues generated by new equipment over time, an observation which is consistent with the second assumption. For example, in the rail sector, the replacement of the existing passenger rolling stock with new modern train fleets with increased acceleration and deceleration rates to reduce journey times could lead to better service quality and, as a result, higher demand (Holden, 2003). The second assumption may have an alternative representation; that is, revenues can be assumed to be constant. Technological innovation can therefore be represented by a step-reduction in age-dependent running costs.
Suppose that:

- revenues generated by both existing and new rolling stock are constant, i.e., \( R(a) = R(a) = R \);
- costs increase with their life according to some linear function, \( E(a) \) for existing rolling stock, and \( E(a) \) for new rolling stock;
- and technological innovation is represented by a reduction in costs generated by new rolling stock, i.e., \( E(a) \leq E(a), \forall a \);

It can then be proved that revenues generated by rolling stock are irrelevant to the replacement decision.

First, the marginal condition (3.6b) can be expanded and rearranged to give

\[
R - E(c) + M'(c) \\
= \frac{\rho}{(1-T)(1-e^{-\rho s})} \left[ -M(0) + T \int_0^T D(t)e^{-\rho t} dt + Ie^{-\rho} + TAE^{-\rho} - T \left( \int_0^T D(t) dt - M(0) \right) e^{-\rho s} \right] + \frac{\rho}{(1-e^{-\rho s})} \left[ \int_0^s (R - E(t)) e^{-\rho t} dt + M(s)e^{-\rho s} \right] + \rho M(c) - \frac{\rho T}{1-T} \left( \int_a^s D(t) dt - M(a) \right). 
\]

(3.11)

Noting the following rules of integration

- \( \int_a^b f(x)dx = f(b) - f(a) \)
- \( \int_a^b (f - g)(x)dx = \int_a^b f(x)dx - \int_a^b g(x)dx \)
- \( \int_a^b cf(x)dx = c \int_a^b f(x)dx \)
- \( \int_a^b e^{cx} dx = \frac{e^{cb}}{c} - \frac{e^{ca}}{c} \)

where \( f \) and \( g \) are functions of \( x \), and \( a, b, \) and \( c \) are scalars, (3.11) can then be simplified to

\[
- E(c) + M'(c) \\
= \frac{\rho}{(1-T)(1-e^{-\rho s})} \left[ -M(0) + T \int_0^T D(t)e^{-\rho t} dt + Ie^{-\rho} + TAE^{-\rho} - T \left( \int_0^T D(t) dt - M(0) \right) e^{-\rho s} \right] + \frac{\rho}{(1-e^{-\rho s})} \left[ \int_0^s (R - E(t)) e^{-\rho t} dt + M(s)e^{-\rho s} \right] + \rho M(c) - \frac{\rho T}{1-T} \left( \int_a^s D(t) dt - M(a) \right) 
\]

(3.12a)

or, alternatively,
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\[ E(c) - M'(c) \]
\[ = \frac{\rho}{(1 - T)(1 - e^{-\rho})} \left[ M(0) - T \int_0^T D(t)e^{-\rho} dt - Ie^{-\rho} - T Ae^{-\rho} + T \left( \int_0^T D(t)dt - M(0) \right) e^{-\rho} \right] \] (3.12b)
\[ + \frac{\rho}{(1 - e^{-\rho})} \left[ \int_0^T E(t)e^{-\rho} dt - M(s)e^{-\rho} \right] - \rho M(c) + \frac{\rho T}{1 - T} \left( \int_0^T D(t)dt - M(a) \right). \]

by rearranging and collecting terms.

(3.12) demonstrates that revenues generated by rolling stock are irrelevant to the replacement decision since they are by definition constant. As a result, maximising the PV of residual earnings is equivalent to minimising the PV of the machine’s costs. (3.12a) is the condition for the maximum, while (3.12b) is the condition for the minimum. The economic interpretation of the cost minimisation criterion can be given more conveniently by multiplying both sides of (3.12b) by \( 1 - T \) and rearranging in order to achieve

\[ (1 - T)(E(c) - M'(c)) = \rho \left[ \frac{1}{(1 - e^{-\rho})} \left( \int_0^T E(t)e^{-\rho} dt - M(s)e^{-\rho} + M(0) \right) \right. \]
\[ - T \int_0^T D(t)e^{-\rho} dt - Ie^{-\rho} - T Ae^{-\rho} \]
\[ + T \left( \int_0^T D(t)dt + M(s) - M(0) \right) e^{-\rho} \]
\[ - M(c) + T \left( \int_0^T D(t)dt + M(c) - M(a) \right) \] (3.12c)

(3.12c) says that the asset should be replaced in that period when its after-tax expenses, \( (1 - T)E(c) \), plus decline in its resale value adjusted for tax liabilities, \( -(1 - T)M'(c) \), just equal the interest on the capitalised value of all future costs. These future costs equal the net cost streams from subsequently held assets (reflected in the first term of the RHS of (3.12c) involving the big square bracket) less the salvage value of the existing asset at \( c \), \( -M(c) \), plus the balance adjustment tax liabilities associated with the current asset at \( c \), \( T \left[ \int_0^T D(t)dt + M(c) - M(a) \right] \).

In similar fashion, with the constant revenue assumption, the inflation adjusted replacement condition can be simplified to:
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\[
(1 - T)E(c) - (1 - Te^{-f(c-a)})M'(c)
\]

\[= \frac{\rho}{(1 - e^{-\rho s})} \left[ (1 - T)\int_0^t E(t)e^{-\rho s} dt - M(s)e^{-\rho s} + M(0) \right] - T\int_0^t D(t)e^{-(\rho + f)s} dt - Ie^{-(\rho + f)} - Tae^{-(\rho + f)} + T\left( \int_0^t D(t)dt + M(s) - M(0) \right)e^{-(\rho + f)s} \]

\[- \rho M(c) + (\rho + f)T\left( \int_0^t D(t)dt + M(c) - M(a) \right)e^{-f(c-a)}.
\]

3.4.7 Data inputs and assumptions required for the analysis

The efficacy of accelerated depreciation or other tax concessions may be analysed in the following manner. By using the extended asset replacement model developed above, a researcher can calculate the optimal life of rolling stock equipment under the status quo. The optimal life is then recomputed under special tax arrangements, such as accelerated depreciation, investment allowances, investment tax credits, reductions in tax rates, and their various combinations. If these tax indulgences significantly reduce the optimal age of the rail freight rolling stock, they are also likely, by implication, to increase replacement and technological investment in the sector.

To calculate the optimal time of the scrapping decision or the replacement decision, the model requires all the elements of costs associated with the purchase, operation, and disposal of a rolling stock fleet. In addition to cost elements, the data used for input into the replacement model also contain the revenues generated by a piece of equipment, the amount of depreciation allowances, the amount of investment allowances, the amount of investment tax credits, the marginal tax rate, the inflation rate, and the firm’s required rate of return or the discount rate. Several of these modelling inputs are readily available. Some, however, necessitate the researcher to confront several empirical problems. The major difficulties are:

1. reasonably estimating the revenue generated by the equipment over time;
2. realistically estimating the age-dependent running cost of equipment over time; and
3. accurately estimating remaining market values of the equipment over time.

With regard to (1), there are several difficulties involved with obtaining the revenue data.

- Companies are often reluctant to provide the revenue data owing to commercial confidentiality concerns.
• Revenue figures are usually aggregated on a maintenance facility or operational basis and are not readily available on an individual piece of equipment.

• Revenues occurring at different past points in time need to be updated by past inflation rates to present values.

• Revenues generated by new rolling stock are not available. Future revenues are both difficult to forecast accurately and are likely to be stochastic given uncertain economic conditions.

One can take care of the above empirical problems by simply making the constant revenue assumption. As illustrated in Section 3.4.6, this assumption implies that the level of the revenue flow is irrelevant to the replacement decision and that the marginal criterion will be based on cost minimisation principles. Note, however, that the assumption that the revenue generated by rolling stock equipment is constant in the presence of technological innovation might not be empirically realistic since technological advancement can have some feedback effects on price and output. In other words, the increase in efficiency of new equipment as a result of technological advancement will increase revenues generated by new equipment over time.

With regard to (2), the collection and analysis of the running costs are difficult and tedious. The difficulties are similar to those itemised for the revenue data:

a) Companies are often reluctant to provide the cost data owing to commercial confidentiality concerns.

b) There is usually a complexity of allocating the fixed and semi-variable expenses to an individual piece of equipment and determining which are age-dependent.

c) Cost figures are usually aggregated on a maintenance facility or operational basis and not be readily available on an individual piece of equipment.

d) There is little regular collection of the indirect unreliability costs owing to repair time among Australian rail freight firms.

e) These costs are held over the whole life of equipment. Thus there is a problem of costs being incurred at different points in time that need to be updated by past inflation rates to present values.

The last four problems necessitate some considerable work. (b) and (c) can be solved using the routine graphical analysis and the discipline in setting up and updating the database.
With regard to (d), it may be assumed that the indirect unreliability costs are a constant proportion of the maintenance and repair costs, which are relatively easy to obtain. The proportion may be set to match the provision of relief equipment, e.g., 10% if that represents the proportion of equipment in the fleet allocated as relief equipment. The proportion of relief equipment can be approximated through discussions with the interview participants. (e) can be easily taken care of using the data on the past inflation rates, which are publically available.

The real difficulty faced is that no Australian rail freight companies are willing to release their maintenance and repair cost data. Moreover, even if the data is available, formulas to determine the general behaviour of the running costs of a particular piece of equipment over time would need to be specified. These formulas are major influences on the model’s results. The appropriate resale value function should be specific to the type of rolling stock equipment for which the replacement decisions are to be made. Like the running cost function, the resale value function should be able to account for factors specific to the situation for which the estimates will be used. In particular, the function should logically account for the size and make of the equipment, as well as the type of activity in which the equipment is engaged. Furthermore, the function should allow for significant ups and downs in yearly expenditures so as to capture the appropriate timing of major expenditure.

In many replacement studies, the simple linear regression function is used to specify the relationship between the equipment costs and age or mileage (see, e.g., Clapman, 1957; Fetter and Goodman, 1957; Eilon et al., 1966; Kent, 1977; Christer and Goodbody, 1980; Russell, 1982; Walker, 1994). For most of vehicle fleets, the regression model therefore often shows a poor fit (see Russell, 1982; and Walker, 1994 for example). As a result, in many similar studies, the researcher will often be concerned about deriving a replacement criterion based upon such a poor model of repair costs. Other possible (and presumably more sophisticated) cost curves (e.g., a third-degree polynomial or some transcendental function according to Bradford and Reid, 1982) can be used to represent the relationship between the equipment costs and age or mileage. However, they have often either proved impractical owing to lack of data or estimation errors, or have given no better results (Russell, 1982; Walker, 1994).

With regard to (3), the initial market value of the equipment is easy to obtain since it represents the purchase and installation cost of rolling stock, which is available from various
business reports provided by the ARA (see e.g., ARA, 2007b; and ARA and Booz Allen & Hamilton, 2007). The problem is the collection of the remaining market values over time. The resale value is generally the most profitable disposal value of the equipment (Walker, 1994). For this research topic, the major difficulty in determining the resale values is that there is no active market for rolling stock equipment, especially in the case of narrow gauge rolling stock. Resale values may be more readily available for standard gauge rolling stock, but the data will be too meagre for fitting into the model. This is because the operators in Australia have experience of selling equipment only after their tenth year (some of them are never sold). A number of rail freight companies normally calculate a depreciated replacement cost of equipment and use it to indicate resale value. Thus, the time series data of annual depreciated replacement costs of rolling stock may be requested from a number of rail freight operators and use it as a proxy for the resale value data. This, however, is where problems occur, for Australian rail freight companies are reluctant to provide this type of data owing to commercial confidentiality concerns.

Even when the data is available, a number of empirical difficulties still need to be confronted. First, the effects of past inflation need to be unscrambled before further analysis is carried out. The other problem is the specification of formulas that determine the general behaviour of the remaining resale value of a particular piece of equipment over time. Like the running cost function, the appropriate resale value function is difficult to specify. A simple linear regression form (after suitable log transformation of data) of resale value against age (see an example in Russel 1982; and Walker, 1994) usually gives a poor fit, whereas other more sophisticated models have either yielded an estimation problem, or have not given better results.

There is another way that the efficacy of accelerated depreciation or other tax concessions may be analysed without having to confront all of the above difficulties. To see how it can be done, it must first be assumed that the inflation rate is constant and that the acquisition of a new asset results in the replication of real income streams (or alternatively, that the inflation rate is zero). If this assumption is made, it can be mathematically proved that firms’ residual earnings and resale values of assets are irrelevant to the replacement decision. As a result, all the empirical problems pointed out above can be avoided. Note that the constant-inflation assumption is not infeasible to make since it is not important to the interest of this research. Even though changes in the expected rate of inflation may alter optimal replacement ages (as
will be shown later in the next chapter), in this research, the effects of changes in tax laws are of primary concern.

If the inflation rate is constant, the replacement condition will be given by (3.6). The RHS of (3.6b) can be expanded and rearranged to give:

$$\frac{\rho}{(1-T)(1-e^{-\rho})}\left[-M(0) + T \int_0^T D(t)e^{-\rho} dt + Ie^{-\rho} + TAe^{-\rho} - T \left( \int_0^T D(t)e^{-\rho} dt - M(0) \right) e^{-\rho} \right]$$

$$+ \frac{\rho}{(1-e^{-\rho})} \left[ \int_0^T \pi(t)e^{-\rho} dt + M(s) e^{-\rho} \right] + \rho M(c) - \frac{\rho T}{1-T} \left( \int_0^T D(t) dt - M(0) \right)$$

(3.14)

Directly observed from the above expression is that changes in the tax structure directly affect all terms in (3.14) other than residual earnings, the \( \pi(t) \)'s, and asset’s resale prices, \( M(s) \) and \( M(c) \). This, however, might not be true in reality as changes in the tax code can have some feedback effects on price and output. Despite this, such feedback effects cannot be accounted for in the replacement model proposed here, so they are omitted for the sake of simplicity. The after-tax discount rate, \( \rho \), is assumed to be neutral to changes in the tax structure. This assumption is also not unreasonable if the effect that \( T \) has on the before-tax discount rate and the effect that \( T \) has on the after-tax discount rate completely offset each other.\(^{20}\) Moreover, as in the case of the inflation rate, the results will not be sensitive to changes in this assumption since there is an ambiguity associated with the effects of the changes in the discount rate on optimal replacement ages (shown later in the next chapter). Given all these conditions, tax adjustments affect only the following components of (3.14).

$$\frac{\rho}{(1-T)(1-e^{-\rho})} \left[ -M(0) + T \int_0^T D(t)e^{-\rho} dt + Ie^{-\rho} + TAe^{-\rho} - T \left( \int_0^T D(t)e^{-\rho} dt - M(0) \right) e^{-\rho} \right] - \frac{\rho T}{1-T} \left( \int_0^T D(t) dt - M(0) \right)$$

(3.15)

\(^{20}\) In general, the marginal tax rate and the after-tax discount rate are inversely related. However, things become more problematic if the change in the marginal tax rate also alters the before-tax discount rate. According to Smith (1990), the change in the marginal tax rate, \( T \), is likely to alter the before-tax discount rate, \( \rho \), in the same direction. In particular, reductions in marginal tax rates increase the after-tax cost of loanable funds, thereby raising the demand for those funds. At the same time, reductions in marginal tax rates increase the after-tax returns to lenders, thereby raising the supply for loanable funds. Both phenomena tend to reduce the before-tax discount rate. Hence, reductions in marginal tax rates could either increase or decline the after-tax discount rate. This will depend on the degree to which the before-tax discount rate changes, which, in turn, is determined by the elasticity of demand and supply for loanable funds.
(3.15) represents the components of the opportunity cost for the firm of holding the current piece of rolling stock equipment at the present time that are affected by changes in the tax structure. (3.15) can be used to analyse the efficacy of in the following manner. The value of (3.15) is computed under the initial scenario and then recomputed under accelerated depreciation or other tax concessions environment. If the value of (3.15) under the new scenario is larger than that under the original scenario, the optimal replacement age for the asset would fall, and by implication, the replacement investment would rise. The opposite is also true. Thus, the effectiveness of a particular change in the tax structure can be measured from the extent to which the value of (3.15) increases as a consequence of it. A similar style of analysis was also used in the seminal work of Smith (1990).

Since market data is observed at discrete annual levels rather than continuous functions of time, the analysis will use the discrete version of the above expression. The direct discrete-time analogy of (3.15) is

\[
\frac{r}{(1-T)(1-(1+r)^{-S})} \left[ -\frac{M(0)}{T} \sum_{t=1}^{S} D(t)(1+r)^{-t} + I(1+r)^{-1} \right] + TA(1+r)^{-1} - T \left( \sum_{t=1}^{S} D(t) - M(0) \right)(1+r)^{-1} - \frac{rT}{1-T} \left( \sum_{t=1}^{S} D(t) - M(0) \right).
\]

(3.16) depends on the marginal tax rate, \( T \); the after-tax nominal discount rate, \( r \); the original market value of the existing asset, \( M(0) \); the original market value of the new asset, \( M(0) \); the optimal replacement age of the existing asset, \( c \); the optimal replacement age of the new asset, \( s \); the depreciation functions, \( D(t) \) and \( D(t) \); the amount of the investment allowances, \( A \); and the amount of the investment tax credits, \( I \).

Values of the optimal replacement ages will not affect the analytical results and may therefore be selected arbitrarily. Nevertheless, to be realistic, the selected values will be close to the average figures reported by Philip (2008) and Booz Allen & Hamilton (2007). Likewise, the purchase prices of rolling stock equipment may also be selected arbitrarily. In this research, the selected values will be consistent with those reported by ARA and Booz Allen & Hamilton (2007). The following subsections describe how to obtain the values for other parameters.
Discounting and marginal tax rates

In the original version of the replacement model presented in this research, the default assumption that all parameters affecting the replacement decision are inflated at the same rate is initially used. As described in Section 3.4.5, all parameters affecting the replacement decision can be treated in either real or nominal terms. The optimal solution will not be affected by this choice. In this research, we choose to isolate the effect of inflation from the replacement model by undertaking all calculations in constant real terms, i.e., cash flows in each replacement cycle are treated in real terms and are subject to the after-tax real discount rate in calculating their NPV. Given a real after-tax discount rate $r$, there must exist a nominal pre-tax discount rate, $i$. The relationship between $r$ and $i$ is given by Bartholomew (1980) and is as follows:

$$ r = \frac{1 + R(1-T)}{1 + \theta} - 1 = \frac{i(1-T) - \theta}{1 + \theta} $$

(3.17)

where $r$ is real after-tax discount rate; $T$ is the marginal company tax rate; $\theta$ is inflation rate; $i$ is nominal pre-tax discount rate.\(^{21}\)

To proxy for the before-tax nominal discount rate, $i$, the fixed interest rate for large business loans in Australia is used. The time series of average fixed interest rates for large business loans over each financial year since 1990 can be sourced from the Reserve Bank of Australia’s (RBA) website. The path of company marginal tax rates since 1990 can be sourced from Reinhardt and Steel (2006), while estimates of CPI ‘all groups’ inflation rate can be collected from the RBA’s website. They are measured as year-ended percentage change of CPI for all groups. The data is updated every quarter. Figures shown in the following time series data are the average over each financial year since 1990. (3.17) is used to compute the after-tax real discount rate for each year since 1990. The average after-tax real interest rate over the last five financial years, which is approximately 6%, will be used as a proxy for $r$.

\(^{21}\) The pre-tax real interest rate can be computed using the Fisher equation: real rate = (1+nominal rate)/(1+inflation rate) – 1.
Table 3.1: Interest rates, tax rates, and rates of inflation since 1990. All rates are reported in percentage.

<table>
<thead>
<tr>
<th>Year</th>
<th>Nominal or Market Rate</th>
<th>Inflation Rate</th>
<th>Pre-tax Real Rate of Interest</th>
<th>Company Marginal Tax Rate</th>
<th>Post-tax Nominal Rate of Interest</th>
<th>Post-tax Real Rate of Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>20.43</td>
<td>7.3</td>
<td>12.24</td>
<td>39</td>
<td>12.46</td>
<td>4.81</td>
</tr>
<tr>
<td>1991</td>
<td>18.71</td>
<td>3.2</td>
<td>14.98</td>
<td>39</td>
<td>11.41</td>
<td>7.91</td>
</tr>
<tr>
<td>1992</td>
<td>16.17</td>
<td>1.0</td>
<td>15.03</td>
<td>39</td>
<td>9.86</td>
<td>8.79</td>
</tr>
<tr>
<td>1993</td>
<td>14.51</td>
<td>1.8</td>
<td>12.47</td>
<td>33</td>
<td>9.72</td>
<td>7.77</td>
</tr>
<tr>
<td>1994</td>
<td>13.23</td>
<td>1.9</td>
<td>11.12</td>
<td>33</td>
<td>8.86</td>
<td>6.84</td>
</tr>
<tr>
<td>1995</td>
<td>13.98</td>
<td>4.6</td>
<td>8.93</td>
<td>36</td>
<td>8.95</td>
<td>4.12</td>
</tr>
<tr>
<td>1996</td>
<td>13.54</td>
<td>2.6</td>
<td>10.64</td>
<td>36</td>
<td>8.67</td>
<td>5.89</td>
</tr>
<tr>
<td>1997</td>
<td>12.72</td>
<td>0.3</td>
<td>12.43</td>
<td>36</td>
<td>8.14</td>
<td>7.87</td>
</tr>
<tr>
<td>1998</td>
<td>11.45</td>
<td>0.9</td>
<td>10.50</td>
<td>36</td>
<td>7.33</td>
<td>6.42</td>
</tr>
<tr>
<td>1999</td>
<td>11.02</td>
<td>1.5</td>
<td>9.41</td>
<td>36</td>
<td>7.05</td>
<td>5.51</td>
</tr>
<tr>
<td>2000</td>
<td>11.80</td>
<td>4.5</td>
<td>7.03</td>
<td>34</td>
<td>7.79</td>
<td>3.18</td>
</tr>
<tr>
<td>2001</td>
<td>11.40</td>
<td>4.4</td>
<td>6.69</td>
<td>30</td>
<td>7.98</td>
<td>3.42</td>
</tr>
<tr>
<td>2002</td>
<td>11.75</td>
<td>3.0</td>
<td>8.49</td>
<td>30</td>
<td>8.23</td>
<td>5.07</td>
</tr>
<tr>
<td>2003</td>
<td>11.73</td>
<td>2.8</td>
<td>8.71</td>
<td>30</td>
<td>8.21</td>
<td>5.29</td>
</tr>
<tr>
<td>2004</td>
<td>11.88</td>
<td>2.3</td>
<td>9.31</td>
<td>30</td>
<td>8.32</td>
<td>5.84</td>
</tr>
<tr>
<td>2005</td>
<td>11.95</td>
<td>2.7</td>
<td>9.05</td>
<td>30</td>
<td>8.37</td>
<td>5.55</td>
</tr>
<tr>
<td>2006</td>
<td>12.29</td>
<td>3.5</td>
<td>8.45</td>
<td>30</td>
<td>8.60</td>
<td>4.89</td>
</tr>
<tr>
<td>2007</td>
<td>12.73</td>
<td>2.3</td>
<td>10.16</td>
<td>30</td>
<td>8.91</td>
<td>6.43</td>
</tr>
<tr>
<td>2008</td>
<td>14.11</td>
<td>4.4</td>
<td>9.35</td>
<td>30</td>
<td>9.88</td>
<td>5.29</td>
</tr>
<tr>
<td>2009</td>
<td>13.68</td>
<td>2.5</td>
<td>10.90</td>
<td>30</td>
<td>9.57</td>
<td>6.90</td>
</tr>
</tbody>
</table>

Figure 3.6: Time series of interest rate and inflation since 1990.
Depreciation allowances and investment tax credits

In Australia, companies generally have the choice of two methods to work out the decline in value of a depreciable asset: the straight-line method and the diminishing-balance method (ATO, 2009b). Under the straight-line depreciation method, the value of a depreciable asset decreases uniformly over its effective life. For rolling stock equipment, the annual rate of 4\% is used for the locomotive and 3.33\% is applied for the wagon (ARA and Booz Allen & Hamilton, 2007). In mathematical terms, the annual depreciation under the straight-line method may be calculated as

\[
D(t) = \frac{1}{N} M(a)
\]  

(3.18)

and

\[
D(t) = \frac{1}{N} M(0).
\]  

(3.19)

where \(N\) is the asset’s tax life, which is 25 years for locomotives, and 30 years for wagons (ARA and Booz Allen & Hamilton, 2007).

The diminishing-value method assumes that the amount of depreciation deduction each year is a constant proportion of the remaining value and produces a progressive smaller deduction over time. Through interviews with several CFOs of rail freight companies, the 150\% declining-balance method appears to be a common depreciation method in the rail freight industry. Under this method, a fixed depreciation rate, \(1.5/N\), is applied to the remaining undepreciated balance in the asset account. If it is assumed that the asset is acquired at the beginning of the year and a depreciation rate of \(1.5/N\) is used, the annual depreciation per dollar of the asset cost under the declining-balance method is \(1.5/N\) in the first year. Each year thereafter, the taxable value of the asset is computed by subtracting from the initial value the amount already deducted. In particular, the annual declining-balance depreciation per dollar of the asset cost is

\[
1.5/N(1-1.5/N)
\]

in the second year,

\[
1.5/N(1-1.5/N-1.5/N(1-1.5/N))=1.5/N(1-1.5/N)^2
\]

in the third year, and so on. This is actually a geometric sequence with initial value \(1.5/N\) and common ratio \((1-1.5/N)\). Thus, the annual declining-balance depreciation allowance for any year can be represented by a geometric sequence formula:
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\[
D(t) = \frac{1.5}{N} \left( 1 - \frac{1.5}{N} \right)^{-1} M(a) \tag{3.20}
\]

and

\[
D(t) = \frac{1.5}{N} \left( 1 - \frac{1.5}{N} \right)^{-1} M(0). \tag{3.21}
\]

where \( t = 1, 2, \ldots, N - 1 \) is the number of years (including the present year) for which depreciation has been deducted. The declining-balance depreciation does not always depreciate an asset fully by its end of life. Thus, (3.20) and (3.21) only apply up to the year \( N - 1 \). In the last year of depreciation, the original cost of the asset is subtracted from the accumulated depreciation deductions. The remaining is used to indicate the depreciation in year \( N \). Both the straight-line and the 150\% declining-balance methods will be tested for the purpose of sensitivity analysis. Both methods can be accelerated by reducing the asset’s effective life, \( N \).

Also included in the replacement model are investment allowances and investment tax credits. The investment allowance provision permits a firm to claim a specified extra proportion of the cost of the asset during the earlier years of the asset life as additional depreciation. However, this supplementary allowance is not taken into account in the calculation of subsequent depreciation allowances. In this research, it is assumed that the firm can claim additional depreciation in the first year after the purchase of the asset. In Australia, newly-acquired and tangible depreciating assets are subject to different rates of investment allowances, as summarised in Table 2.6 of Chapter 2.

Another tax mechanism included in the replacement model is an investment tax credit. As mentioned in Chapter 2, this provision permits a portion of the purchase price of specified assets to be used as a credit against income taxes. Unlike the US tax system, the investment tax credit scheme does not exist under the current Australian tax code. It is included in this research for academic interest only. Like the investment allowance, the credit is assumed to be taken in the first year after the asset’s purchase.

3.5 Phase III: Focus Group Discussions

In the final stage of the research, an expert panel comprising six persons was assembled. They participated in a focus group designed to examine the findings from the first two stages.
and provide in-depth expert assessments of their implications. All the participants were knowledgeable personnel from the policy-making side of the rail industry and experienced researchers familiar with the study area. Two persons were representatives from a peaked advocacy body of the rail freight industry with expertise pertaining to transport and energy policy pertaining to rail operations. Three academics with strong expertise in the area of transport and energy policies were also involved. Their involvement will ensure that policy implications of the research results can be identified. The last person was an asset management representative from a major rail freight operator. This person’s participation in the focus group discussions ensured the applicability of the research to industry.

3.5.1 Justification for using a focus group

Neuman (2006) defines a focus group as a special qualitative research technique in which people are informally interviewed in a group-discussion-like environment. In comparison to individual interviews, focus group interviews more easily provide opportunities for participant involvement and interaction. In particular, focus group participants respond to the research questions and to each other’s responses. As a result, focus groups can provide information in ways that would be less easily accessible without group interactions (Morgan, 1988). This method is especially useful for exploring people’s knowledge and experiences and can be used to examine what, how, and why people think about particular issues (Kitzinger, 1995).

The primary reason to conduct a focus group for this research is that follow-up interviews with key industry personnel to investigate how things change over time are not conducted. Moreover, early findings are not presented to the respondents, so no additional comments are forthcoming. Here, the longitudinal interview approach is instead carried out using the focus group technique. So, the focus group conducted for this research is used in particular to achieve member validation, which requires that the research findings are presented back to the communities that have been studied so as to gain their appraisal of the results (Crilly et al., 2006). As mentioned earlier, member validation is necessary to enhance the credibility of the research findings (Lincoln and Guba, 1985).

As shown in Section 3.4, in order to derive an extended asset replacement model for the quantitative analysis part of the research, many simplifying assumptions needed to be made.
Clearly, there was a possible gap between the analysis and the practices of rail freight organisations in general. The focus group could be used to explore this matter. As stated in the previous paragraph, doing so would increase the applicability of the research outcomes to the rail freight industry as a whole. In fact, there was a reality gap in the quantitative results that required additional assumptions to validate the analysis. This issue will be dealt with in an in-depth manner in the next chapter. Here, it is sufficient to note that this important finding would not have been obtained had a focus group not been conducted.

In addition, it was decided to conduct the focus group in the final phase of the research so as to explore emergent issues and unexpected themes arising in the early research phases. This is consistent with Denzin and Lincoln (1998) and Hines (1998) who contend that the focus group is particularly useful in pursuing emergent themes that occur during the previous stages of the research. Several interesting (and possibly confusing) themes that emerged during the first two stages of the research can be seen from the focus group discussion guide in Appendix B. Although it is not yet important to discuss them in great detail here, suffice to say that the focus group was incorporated into the methods used to validate these themes and to make sure that nothing critical was missed.

Moreover, the opinion of many rail executives participating in the interview process could be biased towards the tax subsidies, e.g., accelerated depreciation, or any other policy suites that will only benefit their company or a small group of rail freight players, but not the rail freight industry as a whole. The focus group in this phase of the research intends to interview stakeholders who are more likely to have a reasonably neutral perspective. This is needed to identify an appropriate set of policies that will facilitate the uptake of modern rolling stock technology in the Australian rail freight sector, and will be viable enough to propose to the government. It is difficult to obtain the required policy set from individuals who have the tendency to protect only the benefits of their organisation. In other words, the expert panel is formed to eliminate this potentially biased nature of part of the research findings.

According to Hines (2000), focus groups are exploratory, clinical, and phenomenological in nature. Exploratory focus groups are a means of eliciting consumer preference and can be used for exploration of an issue before or after conducting a field survey (Hines, 2000). Clinical focus groups can be used to gain a clear and sufficiently nuanced understanding of human behaviour, while phenomenological focus groups can be used to share perceptions and
experiences of group of people and to participate in that shared understanding (Hines, 2000). While predominantly exploratory in nature, the focus group used in this study also served a phenomenological purpose. In discussing transport and energy policy pertaining to rail operations, for example, the group aims to understand the issues and experiences of the people involved in the policy-making processes. In view of this, the interaction between the participants was necessary for the identification of the true feelings of the group.

There are obviously some disadvantages associated with the focus group interview technique. Particularly important ones are (1) articulation of group norms may silence individual voices of dissent; (2) the dominance of strong individuals can deteriorate into an unfocused group; and (3) the presence of other research participants makes it difficult to explore sensitive issues in a group (Kitzinger, 1995; Hines, 2000; Zikmund, 2000; and Neuman, 2006). In this research, some of these disadvantages are less important. Some particular members of the focus group may possess more knowledge about particular topics than other group members and thus have more to say. In that case, the possible existence of dominant personalities, which is often listed as a disadvantage of conducting focus groups, may not be considered as a shortcoming for the group discussion (Hines, 2000). The weakness of conducting research into sensitive issues is not that relevant in this research, which deals with non-personal issues. Moreover, this weakness is of minimal importance because the group participants signed confidentiality agreements. The downside of fewer ideas being produced in the group discussions can be dealt with by using probing techniques so as to ensure that the relevant issues are covered in depth and from all angles.

3.5.2 Sampling and group composition

A number of researchers, e.g., Hussey and Hussey (1997) and Carson et al. (2001), set the ability and suitability to contribute rich information as the main criterion for the selection of participants in the focus group. This research follows the same rule. Recruiting a suitable group of people with sufficient experiences in common on the topic being studied is part of good focus group practice (Hussey and Hussey, 1997).

A combination of purposive and convenience samplings was used to select people to participate in the focus group discussions. The focus group in this research was mainly designed to examine the findings of the first two stages of the study and to provide in-depth
expert assessments of their implications. Thus, purposive sampling was used to recruit members of a specialised population to discuss the research findings (Neuman, 2006). These people include experienced asset managers specialising in rolling stock replacement, representatives of a peak advocacy body of the rail freight industry with expertise in environmental policy planning, and transport policy researchers. Since the focus group needed to be administered according to the tight time constraints of the participating members, convenience sampling was also used as the sample selection method.

The literature does not suggest a fixed number of participants in each focus group, but recommends a range from 6 to 12 (e.g., Veal, 2005; Neuman, 2006). There has recently been a trend towards a lower number of participants. For example, Kitzinger (1995) recommends that the ideal group size should be between 4 to 8 people. Likewise, Carson et al. (2001) argues that 5 to 8 respondents are enough to conduct a useful focus group discussion. A problem with small groups is that one or two specialised members may intimidate others to share opinions, whereas groups that are too large may not permit adequate participation by each group member (Zikmund, 2000). In this research, an expert panel comprising of 6 persons was assembled. Many researchers (e.g., Neuman, 2006) recommend aiming for homogeneity within group members in order to capitalise on people’ shared experiences. However, this research intended to bring together diverse group members to maximise exploration of different perspectives within a group setting (Kitzinger, 1995). Focus group participants in this research therefore comprised people with various background and expertise as stated previously.

Hines (2000) argues that the usefulness of the group research largely depends on the opinion of the group under investigation. Here, the central topic for the focus group discussion is the most appropriate policies for promoting technological investment in freight rail. As a consequence, it is important to establish the view of the knowledgeable personnel from the policy-making side of the rail industry and the management team determining the strategy of the rail organisation. In this respect, the thesis aims to select a specialised sample, rather than a large representative sample. Moreover, the group does not need to be representative of the general population since the aim is simply to explore a range of views so as to allow deeper interpretation. Accordingly, the group in this research is drawn from diverse backgrounds. As an exploratory tool, the focus group discussion is a highly useful step in the research process.
that leads to the refinement of the analysis of the quantitative results and the exploration of the emergent themes from the preceding findings.

3.5.3 Planning and running the focus group

Similar to the interview process, we follow Bouma’s ethical criteria (2000) discussed in Section 3.3.4 to make sure that the focus group is conducted in an ethical fashion. Once ethics approval was received from the Human Research Ethics Committee of Southern Cross University, the industry partners of this research contacted the prospective focus group participants more formally. An information sheet was then distributed in order to seek potential participants’ interest and arrange a time to participate. An informed consent form was signed by each participant before the start of the group interview to cover the consent requirement. The structure of both the information sheet and the consent form for the focus group was the same as their corresponding items prepared for the interview participants (see Figure 3.4). In addition, a structured discussion guide was used, while the important findings of the first two stages of the study were presented at the commencement of the focus group.

The discussion guide was formulated as follows. The opening question aims to warm up the group to the topic being studied and encourage discussion (Hussey and Hussey, 1997; Dick, 2002). In view of this, the participants were asked to introduce themselves and state their opinion on current infrastructure deficiencies in the rail freight sector. The main discussion followed. The participants were asked to provide feedback on the findings from the first two stages. Particular attention was paid to their applicability to the practices of rail freight firms. This question thus provided an opportunity for reflection and member validation, which is a means of ensuring the credibility of data collection and interpretation (Janesick, 2000). The panel members were also asked to provide their interpretation of interesting or confusing themes emerging from the earlier stages of data collection and analysis. Next, based on the results found so far, the group was encouraged to provide in-depth expert assessments of the policy implications of the research to date. The discussion guide used for the group interview can be found in Appendix B.

A focus group requires a moderator who is not one of the group participants and is familiar with the purpose of the study and the questions to be asked (Dick, 2002). The author of this research thus qualifies. The process of running the session was not unduly intrusive or
A number of researchers, e.g., Hussey and Hussey (1997) and Kitzinger (1995), recommend that group discussions should be tape recorded and transcribed. This recommendation was followed. In addition, general notes were taken throughout the process as a reminder of the important themes that emerged. As with the interviews, a professional was hired to transcribe the recording. The transcript is strictly confidential. The participants’ real identity (apart from their role or position within the organisation) will not be identified in any research outputs.

3.5.4 Analysing focus group discussions

Analysing focus group discussions is more or less similar to analysing interview transcripts. This research will draw together and compare discussion of similar themes and examine how these relate to the findings of the literature review and the study’s first two stages. An attempt will also be made to distinguish between individual opinions expressed and the actual group consensus. As Dick (2002) suggests, idiosyncratic information may not be ignored if it belongs to the key stakeholders. Attention is particularly given to minority opinions and examples that do not fit in with the research’s overall theory. Looking for contradictions in the data and for rival explanations of phenomena (negative evidence) is a crucial ingredient of a negative case method for analysing qualitative data (Miles and Huberman, 1994; Dick, 2002; Neuman, 2006). Searching and describing negative instances that contradict prior observation will also contribute to the confirmability of research findings. In this case, credibility or internal validity was achieved through identification and confirmation of the findings of the literature review and first two stages of the study (Hines, 2000).
3.6 Summary

This chapter outlines the justification for using the mixed methods methodology in this particular research. It is clear that the research questions established in Chapter 2 require both quantitative and qualitative approach in order to answer them thoroughly. Both research designs have complementary strengths, and using mixed designs can therefore aid in the development of a more holistic picture of the subject under investigation. The concept of triangulation also supports this argument. The shortcoming of this mixed methods approach is its expensiveness, which implies that more effort is required to carry out the research. This shortcoming, however, does not put the study’s rigorousness at risk.

A three-stage mixed methodology was designed for this research. In Phase I, qualitative in-depth interviews were conducted with 16 individuals within the rail freight organisations directly involved in the process of making rolling stock replacement decisions. The interviews were semi-structured in nature. The main type of analysis strategies employed for the interview data was analytic induction. The analysis aims to arrive at a more informed understanding of (1) the context of the rail freight sector in Australia that might have implications for the worthiness of using accelerated depreciation to address the vehicle fleet age problem; (2) factors that might prevent Australian rail freight firms from adopting accelerated depreciation; and (3) how decisions are made regarding rolling stock replacement among Australian rail freight firms and whether taxation is an important driver of replacement investment.

In Phase II, a new asset replacement model was proposed. This model was developed by modifying Perrin’s (1972) model to include the effects of tax concessions, inflation, and technological advancement. It was then demonstrated that the efficacy of accelerated depreciation and other tax special provisions can be tested by measuring the extent to which they increase the components of the opportunity cost for the firm of holding the current piece of rolling stock equipment that are affected by changes in the tax structure. The analysis in this phase aims to arrive at a more informed understanding of the extent to which accelerated depreciation and other tax concessions would reduce the optimal replacement cycle of rail freight rolling stock in Australia.
In Phase III, an expert panel comprising six persons was assembled. They participated in a focus group designed to examine the findings from the first two stages, and provide in-depth expert assessments of their implications. The participants included knowledgeable personnel from the policy-making side of the rail industry and experienced researchers familiar with studies pertaining to the transport policy. A thematic analytical strategy similar to that used to analyse the interview data is employed to interpret the focus group data. The analysis in this phase aims to arrive at a more informed understanding of the appropriate policies for facilitating the uptake of new technology in the Australian rail freight sector.
PROMOTING TECHNOLOGICAL INVESTMENT IN THE AUSTRALIAN RAIL FREIGHT SECTOR:
EVALUATING THE FEASIBILITY OF ACCELERATED DEPRECIATION
CHAPTER 4

FINDINGS

4.1 Overview

This study seeks to ascertain the viability of accelerated depreciation as a means to provide incentives for rail freight operators to invest in more efficient and environmentally friendly technology. A three-stage sequential mixed methods approach was designed to investigate the investment implications of accelerated depreciation in the rail freight sector. This chapter presents the findings that emerged from the data collected in each stage of the research. These are presented in chronological order. Findings from an in-depth interview technique will be reported first. This part of the chapter concentrates on discussing complexities surrounding how decisions are made regarding rolling stock replacement among rail freight firms, and whether those complexities have important implications for the efficacy of using accelerated depreciation and other alternative schemes to provide incentives for rail freight operators to invest in more efficient and environmentally friendly technology. The second part considers whether accelerated depreciation and other tax concessions can significantly reduce the optimal time to replace rolling stock in the Australian rail freight industry using an extended asset replacement model developed exclusively for this research. The implications of the properties of the proposed model are considered first, before scenario analysis and sensitivity analysis techniques are employed to ascertain the relative efficacy of changes in tax policies. Finally, the qualitative findings from the focus group discussions will be presented. The final part of this chapter focuses on examining the validity of the findings from the first two stages and their policy implications.

4.2 Phase I: In-depth Interviews

In this section, the data collected from in-depth interviews is examined using an analytic induction technique explained in section 3.3.5 so as to arrive at a better standing of the context of rolling stock replacement. Recall that semi-structured interviews are conducted with various groups of rail freight stakeholders. This enables a triangulation of data sources since respondents are asked similar questions. These questions concern the following areas of investigation:
PROMOTING TECHNOLOGICAL INVESTMENT IN THE AUSTRALIAN RAIL FREIGHT SECTOR: EVALUATING THE FEASIBILITY OF ACCELERATED DEPRECIATION

- Vehicle fleet age problem in the Australian rail freight sector
- General characteristics of rolling stock fleets in the Australian rail freight organisation
- Rolling stock replacement processes in Australian rail freight organisations
- Currently proposed incentive programs
- Efficacy of accelerated depreciation schemes

Seventeen representatives of the Australian rail freight industry (see Table 4.1) were asked to provide views on the above five issues. Three main parties are involved in the rolling stock replacement process: the rolling stock operator, the rolling stock lessor, and the rolling stock supplier. Key individuals involved in decisions to replace rolling stock equipment in these organisations take part. ‘Asset managers’, ‘engineering managers’, ‘strategic managers’ and ‘capital utilisation managers’ are broadly representative of all the important middle management staff involved in rolling stock replacement in rail freight organisations. The primary role of asset managers in rolling stock management is the development and implementation of maintenance strategies from frontline maintenance to overhauls so as to best manage the lifecycle of rolling stock. With respect to engineering managers, their general responsibility in rolling stock management includes procuring rolling stock on behalf of a business group and also providing an internal consultancy for that activity, and for design modification. Strategic managers are mainly responsible for allocating the assets within the business to achieve the best business outcome. In relation to rolling stock replacement, strategic managers provide capacity planning and modelling, i.e., they look at tonnages and configure trains to meet those tonnages, bearing in mind rolling stock demands. Capital utilisation managers are generally responsible for evaluating the viability of capital expenditure on new rolling stock. Here, CFOs, CEOs, and board members or directors represent the top level management team. CFOs are primarily responsible for evaluating the financial risks of the purchase of any new rolling stock, while board members or directors are ultimately responsible for endorsing purchases of rolling stock.
Table 4.1: Rolling stock decision-makers interviewed. The table reports both the interviewee’s position within his/her company and the type of rail organisations that the interviewee works for.

<table>
<thead>
<tr>
<th>Perspective</th>
<th>Primary representative player</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asset manager #1 (AM #1)</td>
<td>Rolling stock operator</td>
</tr>
<tr>
<td>Asset manager #2 (AM #2)</td>
<td>Rolling stock operator</td>
</tr>
<tr>
<td>Asset manager #3 (AM #3)</td>
<td>Rolling stock operator</td>
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<tr>
<td>Engineering manager #1 (EM #1)</td>
<td>Rolling stock operator</td>
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<tr>
<td>Strategic manager #1 (SM #1)</td>
<td>Rolling stock operator</td>
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<tr>
<td>Strategic manager #2 (SM #2)</td>
<td>Rolling stock operator</td>
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<tr>
<td>Capital utilisation manager #1 (CM #1)</td>
<td>Rolling stock operator</td>
</tr>
<tr>
<td>Capital utilisation manager #2 (CM #2)</td>
<td>Rolling stock operator</td>
</tr>
<tr>
<td>Chief Financial Officer #1 (CFO #1)</td>
<td>Rolling stock operator</td>
</tr>
<tr>
<td>CEO/Director #2 (CEO #1)</td>
<td>Rolling stock operator</td>
</tr>
<tr>
<td>CEO/Director #3 (CEO #2)</td>
<td>Rolling stock operator</td>
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<tr>
<td>CEO/Director #4 (CEO #3)</td>
<td>Rolling stock supplier</td>
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<tr>
<td>CEO/Director #5 (CEO #4)</td>
<td>Rolling stock supplier</td>
</tr>
<tr>
<td>Strategic manager #3 (SM #3)</td>
<td>Rolling stock supplier</td>
</tr>
<tr>
<td>Chief Financial Officer #2 (CFO #2)</td>
<td>Rolling stock lessor</td>
</tr>
<tr>
<td>CEO/Director #7 (CEO #5)</td>
<td>Rolling stock lessor</td>
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4.2.1 Vehicle fleet age problem in the Australian rail freight sector

The interview data pointed out that the vehicle fleet age in the Australian rail freight sector is older than that in other developed countries. This is consistent with the point made earlier in Chapter 2. A number of factors contributing to the vehicle fleet age problem in the Australian rail freight sector were raised by the interview participants. They also recognised that there is a need to modernise the rail freight sector with regard to its rolling stock fleet since there are many benefits that the industry can obtain from using more modern equipment. All these aforementioned issues will be discussed in this section.

The problem

All the interview participants recognised that the average rolling stock age is significantly older than that of other developed countries’ railways. For example, SM #1 stated that “in terms of particularly locomotive age, we are probably worse … [than] in North America and probably Europe”. According to EM #1, “Australia is a very small market compared to America or Europe rail freight, so … the average age of locomotives and wagons in Australia
… would be much higher than it is in America. Thirty to forty year old rolling stock in Australia is not uncommon” (EM #1). The point regarding the vehicle age made by the above interview participants is consistent with what is reported by Phillip (2008) and Booz Allen & Hamilton (2007).

When asking the interviewees about factors contributing to the vehicle age problem, a variety of answers were provided. These factors can be broadly grouped into four categories: economic, technical, political, and psychological factors. Some of these are related to each other. Figure 4.1 illustrates these factors.

On the economic side, a number of interviewees blamed the lack of rail freight business as a reason for the aging rolling stock fleet. Since it is difficult to obtain capital, operators are generally unable to build a business case that justifies the purchase of new equipment. SM #2 saw this problem particularly in the intermodal section of the industry, but not in the coal department. His view was supported by CM #1, who contended that, “in terms of the demand, coal generally has more certainty … [whereas] freight markets are in general less certain”. A similar analysis was provided by CEO #4: “Containers and bulk make money; they are a good profitable business that can afford to pay $8 million for a new loco”. In intermodal and grain segments, this CEO argued that these businesses undergo boom and bust periods. Here, operators cannot expect constant income and, therefore, find it difficult to build a business case to justify the expenditure of buying new equipment. This was corroborated by a CEO partly operating in this market (CEO #2). He claimed that his organisation cannot afford to purchase new rolling stock equipment. The reason is that, “in the grain industry, … there aren’t very high margins and there isn’t a very strong ability to pay by the users of rail freight” (CEO #2). This is not the case in other markets, where there is a higher level of ability to pay. Indeed, that is where the same company has introduced new rolling stock. The CEO of another operator (CEO #1) indicated that his organisation also faces the problem of not having the size of business or sufficient capital resources to new equipment for grain carriage. As a result, the company is locked into using old rolling stock and is not looking to replace them during the next seven or eight years.
Figure 4.1: Factors contributing to the vehicle fleet age problem.

- **Economic**
  - Lack of business
  - Acquisition cost
  - Limited suppliers
  - Non-standard infrastructure framework

- **Technical**
  - Different accreditation standards
  - Limited capacity of network

- **Political**
  - Unequal government treatment
  - Current tax regimes
  - Weak environmental regulations

- **Psychological**
  - Resistance of older rail staff
  - Tradition of railway engineering
There is a political factor that is strongly correlated with the low demand issue experienced by the industry. A number of interviewees claimed that the sector does not receive equal treatment from the government in comparison with other transport sectors, especially road. EM #1 and AM #2 explained that, compared to road, a similar amount of investment has not been made in rail infrastructure, which could have allowed higher axle loads and longer passing loops. Rail freight operators have therefore been constrained by the amount that they can pull, and the length of the train allowed. According to CEO #1, there is an opportunity for rail to be more competitive against road, but there has to be policy support for rail. This CEO expressed a particular concern regarding the broad gauge network in Victoria, which he regarded as having been marooned by the government. The consequence is that intrastate traffic in Victoria is struggling to grow and in fact has declined over the last 15–20 years. The notion that the lack of investment in rail infrastructure has undermined the market service quality competitiveness of the industry, thereby leading to limitations in the growth of rail freight task, is consistent with an ARA report on this issue (2008a).

In contrast, CM #2 regarded the road freight sector as much more competitive than the rail freight sector, simply because of the inequality in access regimes. AM #2 explained that, unlike rail freight operators, road freight operators pay for their vehicles, but are not required to pay for using the network. To encourage more competition in the rail freight industry and increase rail’s freight task, there should be competitive neutrality on access charges through road and rail (CEO #2 and SM #1). Another injustice pointed out by several interviewees is that the regulations pertaining to rail do not allow the same flexibility as experienced by other transport modes. AM #1 stated that “the standards required for rolling stock is severe; no road operator would go through what we [rail operators] have to go through just to turn around and move freight”. The same manager gave the following example: “You can go and buy a road vehicle tomorrow and put it on the road, [but] you can’t do that with rolling stock or locos in Australia”. In addition, CFO #1 advocated that rail freight operators “should be running wagons that are capable of carrying a lot more payload tonnes on the track” than what they are currently allowed to do. Stiff regulations add more costs to the operators for moving freight, which ultimately have to be passed on to their customers. Recall that the industry reports provided by BTRE (2006b) and the ARA (2008a) indicates a similar argument, i.e., that there is a need to improve the fundamental difference between road and rail with regard to their regulatory and pricing regimes so as to facilitate a modal shift.
CEO #2 recommended that the government should concentrate on driving the modal shift for long-haul movements, particularly in the intermodal sector. What the government can do, for example, is to “provide motivations to the wool works, to the steel companies, to the major importers and shippers of product around Australia to utilise rail rather than road, because of the social benefits around safety, emissions, etc.” (CEO #2). This was also communicated by SM #1, who stressed the need for the government to alert the community that rail freight is more efficient in terms of carbon emissions, safer, and kinder to the environment than road freight. He also suggested that any reduction in fuel price or any rebates, either directly to operators or to shippers, would reduce the rail cost base and, as a consequence, would motivate the shift. CEO #1 is confident that rail has an opportunity to be more competitive against road if the government installs an emission trading system so that “there are penalties or costs brought to bear on road transporters that have high levels of emission”.

The next issue was the acquisition cost of replacing rolling stock. SM #3 regarded the price of new equipment, in general, as too expensive. The consequence is that it is cost prohibitive for operators to replace the existing equipment given the current level of demand, more so given that the old equipment generally suffices. In the main, there are two technical issues and one economic dilemma that make new equipment too expensive. The most important technical problem, as stated by several interviewees (AM #3, EM #1, SM #2, CEO #2, and CEO #3), is that the kinematic envelope or the infrastructure framework that operators have to use within Australia does not cohere with the size of standard equipment from overseas. This means that the equipment imported from overseas must be tailored to suit Australian infrastructural conditions. The need to customise locomotives for running in Australia makes them a lot more expensive than they otherwise would be. Since it is very expensive to replace locomotives, operators need to get as much life out of them as possible. This explains why most of the rail freight operators are still locked in to using existing old-age locomotives and rolling stock. According to CFO #2, the infrastructure constraint “is a significant impediment to taking advantage of developments occurring overseas”.

The second technical problem is that there are different accreditation standards across Australia. This is partly because of gauge and track quality variations across the national network, but is also the legacy of federalism. One of the CEOs, who is also conducting some work associated with outlining locomotive profiles, stated that “There are thirty four … [locomotive models] in Australia. We have three gauges (four if you count sugar cane), thirty
four or thirty five different loading gauges. There is no standardisation, it is a mess” (CEO #4). Introducing new equipment requires approval in multiple jurisdictions. This makes it harder, more complex, and more expensive to get new equipment accredited nationally (CEO #2). CEO #1 and EM #1 were passionate about the need to achieve standardisation in terms of infrastructure, administration systems and regulations. EM#1 stated that the harmonisation of standards could have “a significant effect on reducing the variety and reducing the cost of rolling stock in Australia”.

Different gauges and track quality present another technical problem apart from adding to the cost of accrediting new rolling stock. As contended by CEO #3, large locomotives developed for bulk haulage (e.g., coal and iron ore) can only be shuffled down into certain other areas when they get older. The track on the grain lines does not support these big locomotives. Thus, operators cannot normally buy second-hand locomotives from the bulk hauling section that are more efficient because they do not fit the track, while they also cannot afford to buy new locomotives because of the pricing problem. This means that some of the antiquated locomotives operating on these grain routes are unlikely to disappear in the near future. Moreover, the different gauges and the track quality mean that a fleet is captive in many areas, so operators cannot utilise their fleet optimally because of the track constraints, gauge and track quality variations across the network (CM #2). For example, instead of being able to use the most optimal (modern) locomotives to haul coal throughout a particular route, operators need to sub-optimise their locomotive operation because some of the tracks along the route do not fit these quality locomotives.

The economic factor contributing to the high price of the new rolling stock equipment is that there are limited suppliers in Australia. As stated by AM #1, “there is only, from a point of view for locos, two major suppliers within Australia, so they have got a duopoly [power to set a high price]”. CFO #2 supported this asset manager’s view: “if we had more people manufacturing [the equipment], obviously the cost would come down”. The effort has been put into seeking alternative suppliers in addition to two of the main US-based suppliers. According to AM #2, his organisation has been looking at other companies in China that are able to manufacture new rolling stock to meet minimum standards at a price lower than what the American suppliers can offer. However, “from a rolling stock maintenance point of view, it is the ongoing maintenance costs and the availability and conformity of component supply chains that is probably a greater cost over the lifecycle of the asset than the upfront capital
cost” (AM #2). Thus, Chinese companies still lag behind their American competitors with respect to the component support and technical support. CFO #2 also indicated that manufacturers have lost a significant amount of money on their locos by having to pay liquidated charges, i.e., financial compensation required upon a specific breach of contracts (e.g., late delivery). This incidence encourages the suppliers to try to recoup on the later orders by keeping the price high. Another reason that manufacturers cannot lower the price is that “they do not have a continuity of orders” (CFO #2). Their production line starts and stops, so there are additional costs to factor into the sale price.

The interview data indicates the need for the government to encourage more competitiveness on the supply side. CM #1 suggested that competition among rolling stock suppliers could be enhanced by either “supporting some of the local manufacturers to achieve different levels of scale, or encouraging some level of imports”. As discussed above, more competition among the suppliers can reduce the costs of rolling stock. Furthermore, CEO #3 advocated that the government should provide some form of financial assistance for suppliers to undertake research and development in emission efficient equipment. After all, rolling stock that is modern and meets environmental target must be available for operators to encourage them to replace their aging fleets.

Political factors also contribute directly to the aging fleet problem. Two of the CFOs regarded the current tax regime as militating against a substantial investment in the rail freight industry. CFO #1, CFO #2, and SM #2 were certain that various rail operators are locked in to using old rolling stock because there is no tax incentive for operators to go out and invest in new equipment. In particular, they argued that the depreciation write-off period of these assets are currently too long. The other political factor mentioned by SM #2 and SM #3 is that there are no regulations pertaining to pollution or environmental performance that can effectively drive behavioural change. Moreover, “the government does not give incentives to [transport] modes that are more environmentally friendly and more socially friendly” (AM #1). The carbon price system currently being considered, according to this asset manager, does not recognise the environmental advantage that rail has over road: “You will pay a tax per tonne [of carbon] that you produce... there is no incentive associated with being the one who is down the lower end of the scale”.
For CEO #3 and CEO #4, the aging fleet problem is also caused by some rail staff being comfortable with old equipment and, as a consequence, resisting change. CEO #4 stated that “Most of the guys that run railroad are ex-government railroad. They started work in the 70s and 80s with a class of locomotive. They are comfortable with it. They have lived with this class of locomotive all their working life. They swap parts between themselves”. To protect their jobs, “it is in their best interest to keep the older equipment running and not make it too efficient. It is also in their best interest to make everything look hard” (CEO #3). Another psychological factor is simply railway engineering tradition: “[rail] companies re-engineer things, rather than replace” (SM #2). This is possible since suppliers of rail hardware have technical and part support for locomotives and rolling stock that are thirty years old, “whereas in other industries, they do not have that kind of support” (AM #2).

The need to modernise rail freight rolling stock

All the interviewees agreed that there is a need to modernise rolling stock fleets in Australia. One of the direct benefits from modernisation is that the sector will be more competitive against road transport. This was communicated clearly by SM #1 and CFO #1. In particular, “[to] really move freight and take a greater share of the national freight market of the road, … [the sector needs] to really capitalise on the bigger, longer, [and] heavier haul” (SM #2). Several industry reports (ARA, 2008a; Jolley and Symons, 2009; Jolley et al., 2009) also state that the sector desperately requires further investment in rolling stock and intermodal facilities in order to realise increased market share for rail freight.

Another direct benefit to the rail freight sector from using more modern rolling stock equipment is cost savings. Several CEOs (CEO #1, CEO #3, and CEO #4) contended that the sector needs to invest in new rolling stock equipment to take advantage of their increased fuel efficiency. CEO #3, who represents one of rolling stock suppliers companies, indicated that the upgraded equipment, with the new technology installed, can “save [operators] around 170,000 million litres of fuel per year”. The repair and maintenance bill of rolling stock equipment becomes higher as they become more unreliable over time. CEO #3 commented that “only 80% of the freight that moves in Sydney every night actually gets to its final destination because [the loco] breaks down”. Using modern equipment with more performance-efficient technology would improve the operator’s reliability, and therefore reduce repair and maintenance bills and indirect unreliability costs (see Section 3.4.5 for the definition of indirect unreliability costs). An ARA report (2009a) puts forward the view that
rebuilt locomotives cannot be a sustainable solution in the long term, and at some point in time, further rebuilding and adaption becomes uneconomic. This notion was confirmed by one of the CEOs: “The old equipment is wearing out, so it is going to come to a critical point … [where] there will be a physical requirement to upgrade” (CEO #1).

The interviewees also acknowledged that modern rolling stock equipment would provide a number of environmental benefits. CEO #4 pointed out that the noise issue, which is more pronounced in Sydney and Melbourne, can be solved by installing the latest noise technology into locomotives. The consequence, as stated by this CEO, is that “[the locomotives] would be 80% quieter, so the government doesn’t get anyone ringing up and saying you’ve got all these noisy things waking up in the middle of the night [and] you don’t need more sound barrier”. As mentioned by CEO #3, there can be improvement in emissions if operators use modern rolling stock equipped with low emissions technology. CEO #4 estimated that 583 million tonnes of CO$_2$ could be saved each year if modern low-emission technologies are used. Likewise, SM #2 emphasised the need to improve the flow or movement of the train by achieving a “more aerodynamic design of the wagons, not necessarily for the energy or the air flow, but more for containment of loss of loads”. As stated by this strategic manager, if operators use a wagon with a more modern design, “they will get a better airflow across the top and they won’t get lifting of particles”. Apart from carbon emissions and air pollutants, safety is another issue that the sector can improve by using more modern rolling stock. CEO #4 noted that, in May 2009, “there were 12 locomotives burnt to the ground by fires”. He further explained that “it is normal that, on these locomotive engines, the oil lines fatigue and crack and spray oil on the exhaust”. This causes a fire that completely destroys the locomotive.

All the interviewees felt that the government has not been doing enough to encourage modernisation. The interviewees urged the government to fix the issues that contribute to the aging fleet problem as soon as possible (see the previous subsection for an in-depth discussion of this agenda). In addition to that, several other top-level managers (CFO #2, CEO #3, and CEO #4) argued that the government should provide an upfront subsidy or grant toward the costs of rolling stock. A tax incentive scheme such as accelerated depreciation is NOT considered enough to drive the operators to commit to a substantial investment in rolling stock. These executives advocate a dollar for dollar grant scheme, i.e., the employment of “some financial mechanisms that allow the companies to come up with half
the money and the government to come up with the other half” (CEO #3). The up-front subsidy is viewed by CEO #4 as the only way that can make modernisation possible. This CEO doubted that compliance mechanisms such as tougher standards on pollution or performance to enforce operators to use environmentally friendly equipment will be successful: “If some law comes in that says you’ve got to do it, there will be just wholesale scrap in cancelling of services and closing of rail lines and we will get massive increases in trucks” (CEO #4).

More discussion about potential means to encourage modernisation in Australia can be found in Sections 4.2.4 and 4.2.5, where the usefulness of a number of proposed incentive schemes is investigated.

4.2.2 Rolling stock fleets in the Australian rail freight organisation

In this subsection, we discuss how the rolling stock fleet in rail freight organisations are managed and financed. This subsection is not directly related to rolling stock suppliers, which build and sell rolling stock, but do not operate them. Some of the interview participants representing these companies therefore chose not to answer the interview questions relating to this section. The discussion in this subsection is divided into three parts and proceeds in roughly chronological order, starting with a discussion of the general characteristics of the rolling stock fleets, then consider the financial management of the fleets, before contextualising the operational management of the fleets.

General characteristics

The interview data indicates that most medium and large operators have a mixed rolling stock fleet. This means that the age of locomotives and wagons ranges from brand new to very old. Let us take the example of one operator, whose rail freight rolling stock can be divided into two areas: one is coal and another is freight, which includes everything else apart from coal. With respect to the coal fleet, the strategic manager of this organisation explained that they have 370 locomotives “and they range in age from brand new to the oldest ones, which are 70s and early 80s technology” (SM #1). With respect to coal wagons, this organisation has “about 8,600 coal wagons, once again ranging in age from brand new to early 80s” (SM #1). In the freight area, an asset manager of the same organisation (AM #2) mentioned that it has about 220 locomotives. The newest ones (about 50 locomotives) were built in 1995. The rest
were built between 1979–1981. The oldest ones were built in the late 60s and early 70s. On the traffic wagon side, its newest wagons are “mid to late 90s, going back to 50s [and] 40s” (AM #2).

A substantially mixed fleet is also the case for another major operator (as indicated by CM #2) and a major leasing company (as indicated by CFO#2). Small operators, however, either possess a very young fleet or a very old fleet, depending on their economic situation. To build up their rail business and be competitive, some small operators need to have good quality rolling stock, and by implication, operate very young fleets. As AM #1, who works for a small operator, observed that “our rolling stock is about 8.5 years on average, while our locos are two years old”. Yet some small operators are undercapitalised and are locked into operating old equipment so as to be cost effective. The CEO of the another small operator stated that “We own very little equipment. We own about 5 locos and about 30 wagons …. We’re just severely undercapitalised. The equipment is about thirty years old” (CEO #1).

The average age of the coal locomotive fleet of medium and large operators is more respectable. As SM #1 stated, “the average age of the loco fleet … in coal is probably reasonable. Probably the majority of the fleet is … either under ten years old or had a major upgrade in the last ten years”. But medium and large operators run a fairly old locomotive fleet for general freight traffic that includes everything else other than coal (e.g., containers, general goods, cattle, sugar, and minerals). The main reason why the average age of the coal fleet is not as old as that of the general freight fleet is that business operations in general freight have lower performance requirements than the heavy haul of coal. As explained by AM #3, new locomotives can be run in coal for about 25 years. After this, “the performance cannot match the coal requirement; however, it may be able to match other requirements in intermodal or regional freight … where the loads it has to pull are nowhere near as high and the utilisation is nowhere near as high”. As a result, a lot of rolling stock once used for coal is now used for general freight traffic. SM #2 added that a large part of his organisation’s coal locomotive fleet has recently been upgraded and overhauled. The investment is justified because the business demand in coal has been reasonable. But in the freight sector, operators generally find it difficult to make a business case that supports capital to for upgrading or reengineering.
In terms of wagons, the situation is similar. The age of the coal wagon fleet is generally younger on average than that of the general freight fleet. SM #1 argued that the oldest coal wagon possessed by his organisation is approximately 25 years old. In contrast, the oldest freight wagon possessed by the same organisation was made in the 40s (AM #2).

**Rolling stock financial management**

All the operators indicate that the majority of their rail freight rolling stock is acquired (generally in excess of 90%). Only a small fraction of the fleet is leased. The purchased equipment is generally financed either through finance lease, hire purchase, or a tracking mortgage (CFO #1). Most of the financial arrangements are generally medium to long term, and they are with major financial institutions located in Australia.

The main reason why only a small portion of rolling stock equipment is hired is that “there has not been a strong leasing market in Australia” (EM #1) and “there is only one major provider” (CM #2). SM #1 further explained that “there is a leasing market in standard gauge, but nothing in narrow gauge”. Note that limited opportunity for leasing domestically has forced some operators to go into offshore leasing (AM #2). According to EM #1, “A lot of the rolling stock we own is subject to border cross leasing, with overseas firms”.

There are a number of other reasons why operators still hire some of their rolling stock equipment. Several interviewees regarded the problem of long lead times to actually acquire rolling stock as the key factor. Operators are forced to lease so that they can get operational quickly (SM #2). Moreover, for some market segments, their future demand is volatile. Leasing therefore allows the opportunity to cover spikes in demand or dips in demand (CM #1). This situation often occurs in the grain industry since it is very seasonal. In particular, if it is very busy, operators might want to increase their fleet for a relatively short period of time to take advantage of the opportunity being offered (CEO #2). Apart from flexibility, some operators lease for reasons related to the availability of cash flow and the return on asset. As explained by SM #2, “If you are building a new business, unless you have a guaranteed ten-year contract like coal and guaranteed volume, intermodal for example, you would hesitate to immediately invest in all new rolling stock. Because of the shorter term contractual basis, there is no guarantee of return”. Some operators lease because of equipment availability. This point was raised by AM #2: “In 2003 ... the demand for coal was going up. All the suppliers had their books full as far as production went, so we leased”. For some small operators, the
main motive to lease some equipment is a lack of capital (CEO #1). Likewise, for some medium and large operators, the lack of capital in market segments where there is not very high demand has also led them to lease equipment (AM #2).

In general, operators procure more than one piece of equipment at the same time. This is the case regardless of the organisation’s size. AM #1, who works for a small operator, stated that his organisation generally purchases a large number, ranging between 30–100 pieces of rolling stock. One of the major operators typically orders in “batches of twenty, or a minimum would be twelve or thirteen” (SM #1). Operators acquire a large number of rolling stock equipment in one order for both physical and economic reasons. If a new mine is being opened or is expanding capacity, more than one locomotive is usually required.

There are a number of economic factors that motivate operators to purchase a lot of rolling stock equipment at the same time. Apart from an increase in the purchasing power when more than one piece of equipment is ordered, another reason is the economy of scale. As one of the strategic managers put it: “There’s quite a big cost in locomotive design, so to justify that cost in locomotive design, you need to buy a number” (SM #1). This point was also raised by one of the asset managers: “It is not economic for a supplier to build one loco at a time; it costs too much” (AM #3). CFO #1 regarded the problem of having limited suppliers in Australia to be the reason why it is not cost effective to buy one piece of rolling stock at a time: “Because it is a duopoly, you can’t just go and order one, it just costs you too much money”. In the US, as this CFO explained, it would not cost operators extra to just buy a single piece of equipment. This is because the production lines are always open. SM #3 felt that local suppliers “can offer shorter lead times for delivery, probably better price, and better quality locomotives and wagons if the industry was less project based”. In other words, if there is a continuity of orders, the cost and lead time problems would be less severe.

The need to acquire/lease more than one piece of equipment at the same time is also driven by future demand. As explained by SM #2 and CFO #2, rail operators need to plan ahead and acquire/lease a number of locomotives and wagons to meet future tonnage contracts. On some rare occasions, a large number of rolling stock equipment can be purchased in one go. This will particularly occur if operators undergo a major replacement of their fleets. As explained by AM #3, “We’ve ordered up to 166 electric locomotives … when we were going from diesel to electric. So we were taking a whole diesel fleet out and putting a whole electric
Rolling stock operational management

All the operators agreed that they usually do not operate the equipment until it physically fails in use. In general, each organisation has some sort of maintenance standard that the equipment must satisfy in order to be maintained in operation. AM #3 explained the maintenance standards that his organisation adheres to for its coal locomotive fleet: “To manage the coal business, the rolling stock needs to be 95% available, ... have emissions reliability of 98%, and ... have a loco reliability of two delays per 100,000”. SM #2 contended that his company’s rolling stock needs to be within certain operational and safety parameters, otherwise it will be retired. Safety was also emphasised by one of the small operators. The CEO admitted that his organisation “maintains and operates the rolling stock equipment in safe manner in accordance with the standards under the Rail Safety Act” (CEO #1).

At a certain point in time, rolling stock is too old to meet maintenance requirements. Moreover, “there is a trade off as equipment gets older; maintenance becomes more expensive and parts are more difficult to source” (SM #2). This is the time when the company has to consider whether this should be the end of the asset’s useful life. This decision is also guided by a range of other criteria, e.g., “the condition of the equipment at the time” (SM #1) and “the total cost of operation versus potential use of the equipment” (SM #2). The company will ideally try to keep the rolling stock equipment in the commercial environment as long as it is giving a return, fitting the business purpose, and meeting all the environmental issues (CM #2). This point is also illustrated by the following: “We take measures to ensure we get the upmost out of it on rail life…. We maintain fairly heavily to ensure we get the length out of our rolling stock” (AM #1). As a result of this mindset, CEO #2 admitted that some of his organisation’s locomotives are fifty years old, but a lot of them have been replaced through component changed outs. As explained by this CEO, “The actually base platform might be the original base platform, but it has had ten sets of wheels, three different engines, two different bits and bobs. The actual shell looks the same, but a lot of the workings inside are replaced as required”. Likewise, SM #3 commented that “increasingly, and particularly in Western Australia, often operators of wagons are looking to refurbish”. For example, on certain types of wagons, his company (one of the suppliers) will take hoppers off and replace
them, and then supply these refurbished equipments back to operators. These second-tier operators therefore usually operate equipment that is older than twenty years.

Eventually, the time will come when it is no longer worthwhile to continue using rebuilt or reengineered equipment. CFO #2 outlined two cases that lead his company to dispose of its locomotives:

(1) “When they get to the end of their life, when you look at the cost you would need to spend on an overhaul and you look at the future return from it, you think, well, it’s not worth overhauling it”.

(2) “The other reason we would have for disposing of locomotives is where … it’s hard to get the parts”.

Operators have a number of options with equipment that is no longer commercially utilised. Some retired rolling stock equipments are scrapped. This is particularly the case for equipment that is very old (AM #2 and EM #1), or has experienced catastrophic failure (SM #2). What usually occurs is that some of these are stripped down for their useful parts (SM #2). The rest can be sold for scrap metal. Some retired rolling stock equipment is mothballed for potential re-use, while some operators may find “a bit of track that isn’t used anymore and park them for spares” (SM #3). Other operators might strip the equipment down and put the potentially useful components into warehouses (SM #2). Since most rolling stock equipment can be reengineered or rebuilt, some retired equipment might get overhauled and reused in other business sections. As indicated by SM #2, his organisation “is looking at a program of bringing back some semi-retired rolling stock … with some major overhaul to deal with some operational markets where they didn’t have rolling stock; a short-haul … for agriculture for example”. AM #2 pointed out that his organisation has converted some wagons from narrow gauge and is now using them on standard gauge. A similar description was given by AM#3 and SM #1, who contended that their organisations initially put unused coal locomotives and wagons into storage. If they are not reactivated for coal activity, the management would consider if the equipment could be shifted to other sections of the company, e.g., other bulk business or general freight. Another operator is carrying excess equipment because it is growing its business (AM #1). EM #1 added that his company handles some of the peaks by pulling retired equipment out of storage, servicing it, and then using it. This is especially the case when the company does not have a leasing option.
When rolling stock breaks down unexpectedly, the extent to which it affects the revenue flow of the company is a circumstantial issue. AM #1, EM #1, SM #1 and SM #2 argued that the revenue loss depends on the extent of the breakdown, the goods involved, and the class of equipment. To a small operator, however, the breakdown is always very bad news regardless of its extent: “In the rail industry, there is not much margin for profit, … so you really do need your equipment working day by day to make your returns. So 2% might not sound much, but it is pretty critical” (CEO #1).

The data indicated that operators will take certain precautions to minimise the cancellation of services from the breakdown of equipment. SM #1 and AM #1 mentioned that the company would plan for such an event and prepare relief equipment to deal with the emergency, thereby minimising the revenue loss from the breakdown. CEO #2 also observed that the loss from a breakdown is insignificant. His reasoning is that “We have a benefit of a very large fleet, so we have flexibility and ability to bring in replacement locomotives quite quickly if one fails” (CEO #2). The notion of operators having backup equipment to deal with a breakdown was confirmed by CFO #2, who commented that his company usually provides a backup or rotation locomotive to its lessees (CFO #2).

A number of interviewees mentioned that their organisation carries out scheduled maintenance to limit the number of breakdowns. Rolling stock is no different from a truck, which has to be brought in “for scheduled services at various intervals [and] major overhauls for every number of kilometres” (CFO #1). CM #2 contended that his organisation has a strong preventative maintenance regime, while SM #2 pointed out that his company has an oil monitoring program incorporated into its scheduled maintenance process for rolling stock. This program pre-warns the organisation, for example, that “it is the bottom end bearing or ring … [that] is on its way out”, which intelligence results in another locomotive taking its place in service until it is repaired (SM #2).

Figure 4.2 on the next page illustrates how rolling stock is operationally managed among the Australian rail freight firms.
4.2.3 Rolling stock replacement process in the organisation

The decision to replace rolling stock is a continuing activity. As one asset manager put it, “We do a planning session every six months where we predict the future requirements for the next eight years” (AM #3). This is reinforced by a capital utilisation manager who pointed out that “each business unit [within the organisation] has their operating plan and a maintenance plan and they will work to a scheduled maintenance profile for their fleet” (CM #1). CEO #5 and AM #1 mentioned that their organisations works on a kilometre base (AM #1). So, at certain kilometre interval, rolling stock needs to be serviced and appraised. If the rolling stock does not meet company standards, it will be overhauled or replaced.
The duration of the replacement decision itself is often significant since it also includes a buying process and an asset-selection process. The latter can be quite time consuming since the company needs “to look at the timing, cost, quality, warranty, [and so on]” (CFO #2). Another factor is that, in Australia, there are limited rolling stock suppliers. Particularly for locomotives, there is a long lead time to build a new loco or undertake design work for customised locomotives (as discussed previously). For planning, this implies that rail freight firms need to work at least three years ahead to get their capacity right. By way of contrast, the decision to dispose the asset is much quicker, since the organisation does not need to consider all the aforementioned factors. As mentioned by CFO #2, this can be done “in a month … after analysing relevant data”.

The long duration of the replacement decision does not usually slow down or temporally stop the business of the rail freight organisation. Operators generally will attempt to “minimise any disruption of a replacement program and certainly to plan out in advance” (EM #1). In particular, it is the replacement acquisition lead times that require operators to plan intelligently. In the trucking industry, if operators face an increase in demand, they can deal with multiple suppliers, order a truck, and have it in operation almost instantly. With rail freight rolling stock, as CM #1 explains, the minimum time for getting a new locomotive after ordering it is somewhere between 13 and 16 months, and a little shorter for a wagon.

Upon receiving the equipment, defects can arise. According to SM #1, “New locomotives … always have some design issues … and there are reliability problems that need to be fixed”. SM #2 added that compatibility with the Australian infrastructure is important for new wagons: “The track is that wide, so obviously the wheels have got to be that wide and not six inches shorter or wider. So when they get that equipment they test it particularly for safety and operational integrity” (SM #2). To deal with these issues, operators will always purchase a warranty or defects liability from suppliers (AM #2). Alternatively, the supplier may be required to be on site for a certain period to make sure that the equipment works (AM #2).

Just as the life of an asset can be theoretically divided into phases, e.g., design, testing, production, use, and scrapping (Blanchard and Fabrycky, 1998), the life of a decision also comprises a number of phases (Scarf et al., 2007). With regard to the decision to replace rolling stock, rail freight companies often conduct the following steps: alert, investigation,
decision, implementation, and review (see Figure 4.3). Each phase of the decision is reviewed below.

**Figure 4.3: Rolling stock replacement process.**

- **Stage 1: Alert**
  - Identification of circumstances leading to the alert
  - Exhaustive enough?
    - No
    - Yes

- **Stage 2: Investigation**
  - Replace
  - Grow
  - Cascade
  - Proposal put forward to a committee
  - External advice
  - Assist

- **Stage 3: Making and implementing**
  - Approved?
    - No
    - Invest
  - Proposal
  - Investment appraisal methods
  - Assist

- **Stage 4: Reviewing and risk managing**
  - Emerging factors
  - Audits and reviews
  - Revise
Alert

The first phase of an asset replacement decision is when the potential requirement for capital expenditure on an asset is made known within the organisation. This phase can be called “alert”. An alert should then lead to a study of the asset and its function in the second phase of an asset replacement decision. There are a number of circumstances that can give rise to the alert. Many interview participants, particularly middle-level managers, mention that replacement of existing rolling stock within their organisations is usually contemplated if the new equipment significantly increases performance/capacity of the business. For example, SM #1 stated that, “it starts with tonnage forecasts … and then an analysis of future demand against what our capacity is”. SM #2 confirmed this point and added that “the market had to be there [for the replacement process to start]” (SM #2). A similar view is also provided by EM #1, CM #1, and AM #3.

AM #1 observed that additional capacity and improved services will guarantee the competitive advantage of the firm. The view that added capacity can lead to more demand and more competitive advantage in the rail sector is consistent with Holden (2003) (see Section 2.4.1). One of the top-level managers was aware of the significance of increased performance/capacity as a factor driving rolling stock replacement decisions. CFO #1 claimed that his organisation runs fairly modern rolling stock, so their best option for that rolling stock is obviously to repair it. He argues that the replacement decision “will be more driven by business case, [i.e.,] increased customers”.

Another situation believed by many interview participants to give rise to the alert is when asset age-dependent running costs are higher than attainable with an alternative asset. This driving factor was acknowledged by both middle-level and top-level managers. As one engineering manager put it, “You look at how the cost over time actually increases and generally if you are looking at that, there gets a point where the cost of new rolling stock and reduced maintenance – the two lines – cross” (EM #1). One of the strategic managers (SM #1) also noted something similar: “We do monitor [the] maintenance cost as a percentage of [the] replacement cost …. So if there is a problem, we would tend to shorten up the lifecycle and replace it earlier”. The trade-off between annual repair and maintenance costs and replacement costs is watched closely by CEO #2 and his team. This CEO mentioned that “at some point, the repair and maintenance bill each year is too high and it makes sense to get a new one”. CFO #2 noted that his organisation will replace existing equipment if they find that
the maintenance costs or the overhaul costs become too high as a proportion of the value, or as a proportion of the return.

In addition to the two key drivers explained above, there are also other alerting circumstances. These factors were not mentioned by the majority of participants. They reflect, instead, the personal view of some interviewees. Nevertheless, they are important for the context investigated here. These drivers include:

- **Increased reliability and/or availability.** This is believed by several top-level managers to drive the replacement decision. A CEO of a rolling stock operator mentioned that it is very important that his organisation delivers the job on time. To do that, the organisation needs efficient rolling stock equipment and therefore “reliability is a critical factor” (CEO #1). CFO #2 also commented that utilisation and reliability are the key drivers. There will always be some sort of mechanical problems, even for new locos. One way to “solve the reliability issues is with the backup locos” (CFO #2).

- **Safety.** SM #2 advocates safety as another key driver. Without safety, there is no market for the company and, consequently, no locos or wagons are needed. Thus, “if something was to become unsafe, it would be exchanged or fixed” (SM #2). This manager added that safety is beyond a compliance issue. Rail freight organisations not only have to meet a standard for safety, but also must perform due diligence to ensure that the equipment works safely.

- **Performance evaluation.** AM #1 nominated performance evaluation as a key driver. He stated that “at certain kilometre intervals, the [rolling stock] components go through a series of tests. If they do not meet those tests, we replace the components”. He added that the structure is examined to ensure its integrity. His department will then assess the quote provided by its engineers in the event of work being necessary and “establish whether or not they will continue with that piece of rolling stock or whether it is more commercially viable to replace it”.

- **Technological obsolescence.** EM #1 regarded an improvement in technology to be another key replacement consideration. In his view, there is actually a good business case “when you can get 40% more productivity [out of new equipment]” (EM #1). This was reinforced by SM #1, who argued that his organisation is replacing its 80-tonne wagons because they have become obsolete. The situation is similar with
locomotives. As the same strategic manager put it, “Locomotives that we are buying now, we do a three for five replacement. So three locomotives do the work of five of the older locos”.

Many participants offered the same opinion about tax considerations; that they are not the main driver of a replacement decision. According to CEO #3, “Whether you buy more wagons depends on whether you need more wagons”. AM #1 agreed that, if the rail freight company does not have the business, it would not go out and order more locomotives just because it will receive tax benefits. Nevertheless, several interview participants commented that tax considerations become more important in the third phase of the decision, i.e., the implementation phase where NPV and life cycle costing analysis of competing replacement options are taken to inform the decision. CFO #1 argued that tax “forms part of the business case; whether to invest”. CM #1 contended that tax would help the replacement case, “but it would not make the case”. Although tax is clearly not the main driver for replacement, “it will bring financial incentives to … [the replacement]. It would [also] bring forward some of … [the rolling stock] acquisition” (AM #3). More discussion on the relationship between the tax and the replacement decision can be found in Sections 4.2.4 and 4.2.5.

Investigating a decision

After rail freight firms are certain that alerting circumstances are exhaustive enough, they carry out an investigation of the feasibility of the replacement decision. This investigation will identify other asset management strategies apart from the replacement. For example, the company has to decide “whether to replace an existing fleet or to grow the fleet” (CEO #2). If the freight business is in the boom period, the company would not want to reduce its fleet size. Alternatively, the company may opt for a cascading option. This point was communicated by CM #1: “If they purchase some new rolling stock here, potentially some of the older can be cascaded into this group so they don’t really need to buy new rolling stock” (CM #1).

If the organisation does decide to replace the equipment, there is an assessment made of how many locomotives or wagons need to be purchased. Engineering considerations would typically determine a number of feasible options. This would result in a number of challengers for replacement of the defending assets being identified. Broad costs and consequences of each option would need to be quantified. As mentioned by CEO #5, the
organisation needs “to look at the timing, cost, quality, warranty, etc., [of different options]”. 
CEO #2 points to the importance of legal implications of the replacement and the importance of matching the delivery window and the commercial contracts.

Compatibility with the infrastructure must also be investigated. CEO #1 stated that there are different requirements in different states in Australia and that the new equipment must be compatible with the infrastructure of the state where it is operated. The same CEO also commented that considerations should be given to: (1) the revenue that the organisation needs to earn to cover the total lifetime costs of new equipment and (2) the chances of that happening. As he put it, “We have to have a strong revenue stream coming in. Because to buy new locos, … you would need a strong revenue for the next seven or eight years to pay for it”.

The data also suggested that rail freight firms usually seek external advice to assist their asset replacement study, especially regarding the procurement or the engineering side dimensions, although the commercial decision is made wholly internally. One organisation “would seek advice from consulting companies on the legal, … warranties …, things like technical, but not about the decision itself” (CFO #2). This point was also illustrated by CFO #1: “Once we conceptually design something, then we get external engineers … to review our concept.” For CFO #1, the need for external engineering advice is particularly important if “it is purpose-built equipment for the movement of a product … [that they have not] moved before, with different loading or unloading or size or scale or track”. CEO #5 mentioned that his organisation has always hired railway consultants to prepare the market review reports. Likewise, several middle-level managers (SM #2, EM #1, and CM #2) are aware of the external consultants assisting the organisation on the rolling stock asset strategy.

The end product of the investigation is the proposal to be put forward to the capital committee (CEO #2). A decision is then made as to whether the capital will be made available. This process occurs in the next phase of the decision. The interview data indicates that the asset replacement study must be planned far enough in advance to avoid loss of function since there is a long lead-time to build new rolling stock in Australia (see more discussion in Section 4.2.1), or to take advantage of emerging technology in a timely manner.
Making and implementing the decision

In this phase, the business case is submitted to the capital committee. This committee consists of different company members depending on the amount of capital requested. According to CM #1, there are delegation levels: “if it is below a certain amount, the CEO might approve or even the GM of the business unit may be able to approve”. However, for rolling stock, normally the dollar amount requested is very high, so it is normally presented to the board for approval (CFO #1). For government-owned organisations, the business case may also need ministerial endorsement if the dollar amount reaches a certain threshold (CM #1).

A majority of interviewees supported the use of various financial models to inform the asset replacement decision. Standard NPV and internal rate of return (IRR) analyses are raised very frequently by middle-level managers. As CM #1 explained, “We look at IRR or NPV of the proposal …. There are [also] hurdle rates for the business units. They need to achieve certain hurdle rates … based on the weighted average cost of capital for their particular business unit”. CM #2 agreed, but added that the company also considers the payback period analysis. Likewise, NPV and IRR analyses are believed by several top-level managers to aid the organisation’s decision making. CFO #1 advocated NPV as the standard capital budgeting analysis of the company, while CFO #2 pointed to IRR, an equity model, and a debt model. The latter is important since “the market at the moment is a bit challenged on the debt side and a lot of banks don’t understand … the railway industry”. Most of the interviewees explained that all these financial models are helpful for making broad value judgements about funding of replacement projects. Through a standard investment appraisal system, the relative importance to business outcomes can be judged.

During the implementation phase, the engineering management for a project will be considered in more detail. As stated by a strategic manager, “Once it get past [the capital approval process], … you get into writing performance specifications and calling tenders” (SM #1). AM #3 added that the company would go out with a specification for a design and a certain life of rolling stock. After that, it gets into the acquisition process, which could take a good deal of time since it takes over a year to build new rolling stock.

Reviewing and risk managing the decision

A formal decision follow-up process from budget approval up to execution was mentioned by a number of interviewees. According to AM #3, who represented a supplier, there are audits

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and review done on how well the does, and whether it delivers the desired outcome. The revision process focuses particularly on the condition of the newly acquired rolling stock. As mentioned by the same asset manager, “They will review to make sure that we delivered them on time, on cost, on budget, and that it can do the job that they were supposed to do”. This point was reinforced by EM #1, while CM #2 and SM #1 also pointed out that their organisations usually do a post-order review of the equipment function.

Emerging factors may affect the ongoing validity of the replacement decision. In a case where the business environment has changed, a replacement that may not have been viable may become so. As mentioned by CFO #2, because of the lack of equipment in Australia, the market value of equipment tends to rise over time. This would lead to an improvement in the NPV of the replacement decision. Under these circumstances, therefore, there is a strong case for reviewing the original decision. A process that identifies changed circumstances and triggers a review of current projects that might be vulnerable to such a change would be very beneficial to rail freight firms.

The existence of emerging factors provides an incentive for firms to review the original replacement decision overtime and also to risk manage the decision against changes in the business environment (Scarf et al. 2007). This is true among rail freight firms regarding the decision review (as discussed above). With regard to the decision risk management, a number of interviewees admit that risk evaluation is normally submitted as part of business cases. SM #1 explained this point as follows: “We also do sensitivity analysis as part of that business case .... We do the sensitivity analysis based on changes in the market”. According to CEO #1, there are many different risks that the company would have to identify and manage. Considerations are particularly given to commercial, operational, maintenance, and financial risks. These critical risks would need to be identified, while the organisation also needs to be “satisfied that those risks can be minimised or eliminated” (CEO #1). Other interviewees mentioned risks associated with, e.g., new asset condition/life information (AM #1), new asset cost (CFO #2), changes in functional requirements or in emerging technology (CM #1), safety (SM #2), political circumstances (SM #2), and meeting market demand (SM #2).

Such changes in the business environment during the decision life are to be expected because of the time scale and cost of decisions. Scarf et al. (2007) argue that these changes necessitate
some particular actions during the decision life, e.g., identification and sensitivity analysis of decision drivers, identification of risks, staged implementation to allow revision of the decision, specification of information to be collected during implementation, and the establishment of timing for decision reviews. During the interviewing process, several interviewees were adamant that sensitivity analysis should be part of the asset replacement process. They contended that such analysis could be used to examine the robustness of the replacement decision.

### 4.2.4 Currently proposed incentive programs

This subsection explores the interview data on the following theme: Can currently proposed incentive programs facilitate the modernisation of rail freight rolling stock? This research is particularly interested in their influences on rail freight organisations’ replacement decisions and which barriers in the rail freight sector that militate against their worthiness. The interviewees were also asked to provide ideas or suggestions that might improve the usefulness of these schemes. The thrust of asking these questions is not that these incentive schemes are necessary and that all barriers to their implementation removed. Conversely, the real objective is to identify meaningful policy advice about what needs to be done to make these schemes more useful if they were to be implemented in the rail freight sector in the future. The discussion here begins with the ETS, then moves on to the investment allowance scheme, before concluding with the R&D tax concession. In general, the interview participants contended that every proposed program is associated with several drawbacks and therefore, none of these programs would solve the vehicle fleet age problem on its own.

**ETS**

A number of companies are all trying to become more energy efficient. EM #1 argued that his organisation has been very proactive in trying to save energy since it is good for the environment, and good for businesses. For example, the company has developed and invested in technology to help drivers drive in such a way to save fuel. Another example is the electrification of track in some of the coal network, which is much more environmentally efficient than the diesel system (CM #1). The same capital utilisation manager also contended that there is already the Energy Efficiency Opportunities program that encourages large
energy-using businesses to improve their energy efficiency. According to CM #1, his organisation and other companies have joined the program since “it is actually good business sense to reduce energy usage”. So, there are already a number of mechanisms in place (both legislatively and voluntarily) that encourage operators to purchase new rolling stock. ETS will probably bring in an extra impetus to drive operators to invest in cleaner technologies. Whether or not the ETS would be ultimately successful, however, depends on a number of factors.

As a pricing initiative, the idea of introducing an ETS is that, if it costs more to use carbon-based energy, operators might look for a cheaper alternative to keep their businesses viable. The interview data suggested that there will be impacts, but no direct obligations on railways. SM #2 argued that rail operators can almost ignore the scheme if they can (1) pass the cost on to their customers and (2) get their customers to accept this. CEO #1 and CEO #2 agreed and confirmed that there will be no incentive for the operators to reduce the fuel emission if that is the case. Furthermore, this could result in rail freight having a reduced competitive advantage with road freight if the road lobby group manages to negotiate an exclusion from an ETS (SM #3, CEO #2, and CFO #2). If the clients do not like wearing the cost, they might shift to an operator that is “a bit more innovative, has done a bit more investment, and has got more reliable, modern, longer, better, more efficient, and in fact … is passing on less carbon cost too” (SM #2). SM #2 expected that leading rail companies will change in anticipation of that, and change earlier so as to put themselves on the front foot. Thus, an ETS ultimately depends on what customers want. Its success in the context of rail freight rolling stock investment will depend on the demand and level of acceptance of clients.

The interview participants expected that an ETS will not entail any law such as that associated with the GST, where it is mandatory to pass on the tax to the product price. Thus, operators might not pass the cost on, and instead will try to look for alternative technologies that are less carbon intensive in order to avoid paying for the emission permits and reduce (hopefully) their operating cost in the long term. However, “to get less carbon intensive, there is a lot of investment needed … and someone has got to pay for that investment” (SM #2).

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23 This incidence happened before in the past with the Carbon Production Reduction Scheme, which was a type of ETS proposed by the Labour government.
The lack of demand for rail transport is an important barrier here. Furthermore, even if the cost is not passed on to customers, it is difficult to say whether all operators will buy their own permits, which would ultimately motivate them to change to new low-emissions technologies at some stage. Operators might come back to the rolling stock suppliers and tell them to buy the permits instead (SM #2). Likewise, CFO #2, from one of the leasing companies, contended that the customer might go back to his organisation and try to negotiate a discount. If this is the case, an ETS would not be very influential with respect to driving new low-emissions technologies. The following tree diagram summarises the incentive level of the ETS with regard to different customer issues.

**Figure 4.4: Incentive level of the ETS with regard to different customer circumstances.**

The interview data confirmed that the core problem militating against an ETS is still the price of the new rolling stock equipment, which is very high for reasons raised in Section 4.2.1. Rail freight operators would generally choose to continue using old equipment and pay high penalties over buying new emission friendly equipment because they cannot afford it with the level of demand that they currently have. This notion was recognised by CEO #2, who contended that the mechanism would add to the company’s fuel cost only slightly. This small increase in the operating cost is “not enough, compared to the costs associated with new equipment, which is $30 million plus for a train set, to motivate … [the organisation] to
suddenly re-invest and replace the entire fleet”. One of the supplier representatives (SM #3) claimed that his organisation has done a reasonably detailed study on what the carbon price would need to be before an ETS would be a compelling case with regard to encouraging fleet modernisation. He argued that the savings that the new technologies would generate will not compel operators to pursue them in the context of the carbon price mechanism.

Another implementation issue is how the penalty system will be designed. AM #1 doubted that an ETS would meet its objectives if (1) the penalty was associated with the tonnes of carbon produced and (2) there was no incentive associated with being the transport mode that is more environmentally friendly. He explained that, “If [his organisation] moves 3,000 tonnes and only produce 2 tonnes of carbon, but roads move 3,000 but produce 5,000 [tonnes of] carbon, they should also recognise the differential, and the advantage we get should be greater than road”. This is to prevent more freight going on trucks, which would imply more business for rail and improved justification for the investment of new rolling stock (CEO #3 and CEO #4).

Another argument against an ETS is that it would disadvantage the Australian coal companies vis-à-vis their international competitors. According to CM #2, this might have a flow-on effect with regard to rail freight companies’ coal hauling businesses. CEO #2 further describes the situation: “If the Koreans and the Japanese start buying coal from Indonesia and not Australia because the Australian coal prices increased … [owing to] the impact of the ETS, there will be less coal exported from Australia, [and as a result] less haulage, less margin, [and] less ability and motivation to invest in new technology”.

To improve the usefulness of an ETS, the government could strengthen enforcement by requiring all the existing fleet to meet the emissions standard immediately or there will be heavy financial penalties (AM #3). This would not only push the operators into replacing their existing fleet, but also encourage the leasing companies to acquire more modern equipment and retire their older rolling stock (CFO #2). CEO #3 proposed that a more aggressive enforcement system, which is used in the US, should be applied to Australia. This system, called the tier system (tier zero through to tier four) has been created since there are various groups of transport devices in the US. In essence, all American operators need to achieve tier three by 2012, or there will be a progressive penalty system for using tier one or tier two equipment (CEO #3).
Subject to how an ETS is structured between the three different modes of transport (road, rail, sea, and air), the scheme’s efficacy would “also depend on whether rail loses market share to other modes of transport” (AM #1). There are several things that could be done to prevent rail losing a significant market share. As mentioned above, there is an important issue regarding the penalty being associated with the tonnes of carbon produced from a piece of equipment. The interview participants argued that the government needs to recognise the differential and that the advantage that rail achieves should be greater than road (AM #1, SM #3, and CEO #4). An ETS would probably have an adverse effect on the intended modal shift, particularly if the government decides to exclude the trucking industry (CEO #2). While an ETS would increase rail’s price per carry, thereby making rail less attractive, road’s situation would stay the same because of the exclusions incorporated in the proposed ETS model.

Several interviewees recognised that an ETS alone will not be enough to achieve an optimal outcome for the transport sector with respect to reducing emissions and encouraging investment in cleaner technologies. CFO #1 was confident that an ETS would bring additional investment into the rail sector, although he stressed that the government must also build track that can carry more weight. If operators could put more tonnes on every train, fewer trains would be required to carry the same amount of freight. The consequence is that the emissions coming from the rail sector would be further reduced (CFO #1). AM #2 argued that his organisation would not “buy a new engine just because it saves … [the organisation] on particular emissions and maybe 5% fuel efficiency”. A more attractive force would be better track to go along with new engines, since this would allow operators to put more wagons on a train. But to make best use of these improvements, network providers also have to come to the party and allow a train to pull a greater amount (AM #2). To achieve the greatest benefit from an ETS, the interview data indicates that all stakeholders need to work as a total rail system, not as individual parts.

**Investment allowance**

While being useful, the investment allowance scheme alone is unlikely to modernise the rolling stock fleet in the rail freight sector, at least according to the interview data. One of the main reasons is that tax benefits provided by the investment allowance scheme are not large enough to drive the vast investment in rolling stock required. Many interviewees (e.g., CEO
#1, CEO #2, CEO #3, CEO #5, AM #1, SM #1, SM #2, and CM #2) revisited their earlier point about the decision to invest being primarily driven by market dynamics.24

Even though the benefits provided by the scheme do not solely drive the replacement decision, they help to facilitate it. As discussed in Section 4.2.3, in the third phase of the replacement process, viz., making and implementing the decision, several investment appraisal methods, such as NPV and IRR, will be used as guidance. The investment allowance increases the amount of cash flows received in the earlier years (from the replacement), which are subject to relatively slight discounting, to cash flows received in the later years. Thus, the scheme increases the NPV of the replacement decision or, equivalently, reduces the average effective discount for the replacement decision. Another way to look at it is from the suppliers’ point of view. SM #3 contended that the investment allowance scheme affects his organisation in the context of the total cost of ownership calculations. As a consequence, “it is easy to sell more locos in an investment allowance environment. It is also easier to encourage people to replace in that sort of environment”. CEO #3, from another rolling stock supply company, mentioned that the benefits given by the allowance “will be factored in the contract price” set by the operators. This means that the price that they charge customers for moving coal, for example, would be reduced. So, the scheme “is stimulating the economy” (CEO #4). It can be argued that, if the business of rail freight improves, it will be easier for operators to justify spending a large sum of money on new rolling stock.

One very important issue of the investment allowance scheme is its timeline. As mentioned by AM #2, the scheme might influence a single purchasing decision, but not the ongoing replacement decision. This is because the timeline and the lifecycle of the decision have always been longer than the timeframe allowed for by the scheme. Even though it would not influence the rolling stock replacement decision in the long term, the scheme would encourage operators to bring some of their pending capital purchases forward in order to earn a significant discount. However, this is not a positive sign that the scheme would significantly influence the uptake of new technology in the rail freight sector. It is clear from the interview data that organisations would purchase rolling stock for business needs regardless of the scheme’s existence (AM #1, AM #3, EM #1, and CFO #1).

24 An in-depth analysis of crucial factors driving the replacement decision is found in Section 4.2.3.
Several interview participants indicated that another important issue with the investment allowance scheme is that it does the same thing for every type of businesses. CFO #1 argued that the scheme would not drive a modal change because the ratios are still the same for both road and rail sectors. According to this CFO, “the government needs to have a differential between the modes because otherwise nothing will change”. AM #1 agreed and stated that “The incentive should be based on what does it do to the country as a whole, i.e., social impacts and all that”. He recommended that rail should receive a 40% investment allowance, while road should only get 25%.

There is also an educational issue associated with the government incentives and advantages. In particular, what is available at present is not widely known among the smaller operators. As mentioned by CEO #3, “The big companies have got the flash financial people who know exactly what happens and will take it down to the last bit and get every penny that they can. The smaller companies ... don’t know much about it”. CEO #4 was of the same opinion and described the situation as follows: “Small operators of rail … are just mechanics [and] truck drivers. They know their locomotives. They know their wagons. They have a little niche that is good business, but they are not business men as such and a lot of this sort of stuff is way beyond them”.

A number of ways to improve the worthiness of the investment allowance scheme for promoting fleet modernisation in the rail freight sector could be identified from the interview data. Several participants believed that the scheme should be provided on a full-time basis and that the amount given to rail should be greater than road (CFO #1, CEO #2, CM #1, CM #2, and EM #1). This suggestion arises from the short timeframe of the scheme, which would not encourage the ongoing replacement decision; and its indiscriminating aspect, which would not encourage a modal shift from road to rail. In addition, CFO #1 urged the government to address the depreciation life of rail equipment. The current regime does not encourage the investment: “If you can only write off equipment over twenty five years, you’ve got to make sure it is going to last twenty five years, even though in ten year time, there is much more innovative equipment on the market”. SM #3 maintained a similar view: “there needs to be a fundamental change in depreciation and rules that allow for higher value assets – [in particular] accelerated depreciation”.

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Any investment allowance incentive requires a positive tax position. Since a number of Australian rail freight companies are not in a tax-paying position, CFO #2 is therefore more optimistic about an upfront subsidy or grant for every environmentally friendly locomotive bought. According to this CFO, the benefits provided by the subsidy or grant program would be more tangible and targeted than those of the investment allowance scheme.

**R & D tax concession**

This government enabler was mentioned by several interviewees as another program set up to encourage the uptake of new technology. AM #3 briefly described the scope of the scheme: “There is R&D advantage; so any research and development of new technology, you get a substantial benefit out of the government for that” (AM #3).25

CEO #3 and CEO #4 contended that, like an investment allowance scheme, there is an educational issue associated with the R&D tax concession. CEO #3 argued that the scheme is “too complex and [there are] too many accountants involved”, while CEO #4 felt that the information about the scheme “doesn’t actually reach the people who make the decisions”. This CEO has not witnessed a lot of R&D being carried out by Australian rail freight operators: “They don’t have spare bodies to say go and run an R&D project …. It is not the way they are structured …. Even with the big boys like [a major rail freight operator], it just doesn’t really fit their culture” (CEO #4). The view that not a lot of R&D is being conducted in the rail freight industry in Australia is consistent with the fact that not many of the industry representatives interviewed were even aware of the scheme’s existence.

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25 The following bullet points summarise important features of this tax concession scheme. The information can be extracted from the website of the Australian Tax Office.

- This program has been designed to increase the level of R&D being conducted by Australian companies.
- It is broad-based, not industry specific, and market driven with the applicant entity deciding upon the scope and timing of the R&D.
- Companies with low or no sales in the first year (or those in tax loss from the current or previous years) and have a group of turnover of less than loss $5 million can access the tax rebate, which is 30% of their total R&D spending plus the 25% concession component. This is equivalent to an after tax grant of 37.5% of the company’s eligible R&D expenditure.
- Companies in a positive tax position can get an extra 25% deduction for a tax year, even if they have already lodged their tax return.
It is clear from the interview data that the R&D tax concession is more utilised by suppliers and lessors than operators. SM #3 from a rolling stock supplying company contended that the program provides a significant funding for one of the company’s research programs, which is seeking a way to reduce the heat resulting from the operation of a locomotive’s engine. One of the major rolling stock leasing companies in Australia, who also supplies rail equipment, is taking advantage of the scheme since it is now working on new multi-purpose wagons (CFO #2). This organisation will “use the R&D [tax concession] in the future to come up with an appropriate priced loco” (CFO #2). Moreover, the organisation is in a negative tax position. Thus, it could be argued that the R&D tax concession provides a stronger incentive than the investment allowance scheme, since those not in a positive tax position can still claim the benefits. Nonetheless, SM #3 and CFO #2 suggested that the scheme should focus more on environmental issues and improving efficiency, and be more industry specific. The current program is broad-based, not industry specific, and market driven with the applicant entity deciding upon the scope and timing of the R&D. CEO #3 and CEO #4 feel that the government should also address an education issue of the scheme in a similar way to that mentioned for the investment allowance scheme.

4.2.5 Efficacy of accelerated depreciation schemes

In similar fashion to the last subsection, we investigate, here, whether accelerated depreciation schemes could be used to encourage the modernisation of rail freight rolling stock in Australia. Like other proposed programs, the interview participants were unsure if accelerated depreciation alone could do much with regard to solving the vehicle fleet age problem in the sector. A number of the scheme’s potential weaknesses have been raised as discussed below.

Like investment allowances, accelerated depreciation would facilitate the replacement case, but it would not directly lead to it (CM#1). This point was also expressed by several other interviewees. According to SM #2, accelerated depreciation is part of the replacement decision process that “would help in the decisions, but there are a whole heap of criteria for market need”. Likewise, CEO #5 commented that “the replacement of rolling stock is only necessary if the market grows; … accelerated tax depreciation is [however] not a driver”. In
essence, these interviewees repeat the point made earlier in Section 4.2.3, viz., that there are other economic factors driving the replacement decision rather than tax benefits.

Although the benefits derived from an accelerated depreciation scheme alone are unlikely to drive firms to replace their existing rolling stock, they could make the case more compelling. Accelerated depreciation, to recap, effectively transfers cash flows generated from the rolling stock equipment from later years to earlier years. Cash flows received in the earlier years are subject to relatively slight discounting to cash flows received in the later years. It follows that accelerated depreciation increases the NPV of the replacement decision, or alternatively, reduces the average effective discount for risk and justifies earlier replacement of existing equipment. Besides the theoretical viewpoint, the interview data also acknowledges the helpfulness of accelerated depreciation. As indicated by AM #3, accelerated depreciation would deliver some financial savings to the organisation and, as a result, make the acquisition of new rolling stock more worthwhile. SM #2 stated that leading-edge technology equipment would come at an additional cost because it is not mainstream. As a consequence, “to be able to recoup some of that investment earlier [with accelerated depreciation] instead of spreading it out will perhaps encourage freight operators to buy the new improved version rather than the stock standard version because they are able to get a quicker return” (SM #2). SM #3, from a rolling stock supplier, felt that accelerated depreciation would make the investment decisions of the customers a lot easier, although it would not necessarily drive out the old equipment since the poor infrastructure is prevalent in some parts of the nation. This means that some of the antiquated equipment operating on grain and livestock routes, for example, would never disappear because they are the only ones suitable to operate on these tracks.

As a tax-based mechanism, accelerated depreciation only applies when companies are in a tax-paying position. This explains why, in general, interview participants who are positive about the implementation of accelerated depreciation work for companies in a positive tax position. AM #1 and CFO #2 had no doubt that their organisations and other operators would be encouraged to replace their existing rolling stock more often if accelerated depreciation were available. According to AM #2, operators are motivated to look for new efficient equipment after old equipment is written off. If the write-off period is reduced, this phenomenon would occur more frequently. CEO #1 was positive that permitting accelerated depreciation to the rail sector would ensure the modernisation of rail freight rolling stock and, as a result, would allow rail operators to avoid the extra cost of the ETS and become more
competitive vis-à-vis road transport. The shorter write-off period could also reduce broader overall costs to the rail industry because operators would not need to sweat the equipment for a long time, a regime which involves more maintenance and upgrades (SM #2).

A number of the interviewees, especially those whose organisations are not in a tax-paying position were more sceptical about accelerated depreciation. CM #2 commented that the scheme “is nice to have definitely … but you also have to assume that the entity is a tax-paying entity”. His organisation, however, will carry forward losses for another couple of years at least and thus “the benefit of accelerated depreciation isn’t there [at present]”. CFO #2 added that companies with a high asset base will be in negative tax position. Operators that do not own all their equipment, in general, will not be, “but then they are not the ones that are making ownership decisions” (CFO #2). Thus, it could be argued that accelerated depreciation is unlikely to facilitate the modernisation of rail freight rolling stock fleets in Australia to a substantial extent since it is not possible for the major operators that own the majority of the equipment in the country to claim the benefits, at least in the next few years. There will come a point when these rail operators can take the advantage of the benefits provided by accelerated depreciation schemes. However, it is potentially not the most useful scheme to implement if results are required within a short period of time (CEO #2).

Another group of rail players who appeared to be enthusiastic about accelerated depreciation was the suppliers and lessors. Suppliers of rail hardware are likely to face higher rates of demand for their products if favourable changes are made to the tax rules. The positive outcome might be enhanced by the impact of changes in tax rules on the price of these assets. In particular, changes to the tax code would reduce the price of rail hardware because of higher depreciation allowances and/or the raise in investment tax credits and investment allowances. This theoretical viewpoint was recognised by SM #3, from a company supplying rolling stock.

If accelerated depreciation is allowed, many leasing organisations would be able to match the write down of the locomotive to the write down of the length of the lease. The problem with the lengthy depreciation schedule currently faced by the rolling stock lessors was elucidated by SM #3: “Suppose that I had managed to secure a lease on ten locos for five years, but the company is tied to a 25-year depreciation schedule. When those locos come back to me, they will still be at 75% straight line depreciation of their value. Depending on the market, you
may not be able to lease it into the market, or sell them, so you need to do some repricing”.
This situation would be less severe if the lessor could match the depreciation length with the
leasing duration. It follows that this would be easier with the implementation of accelerated
depreciation.

Apart from the tax status of the major rail freight organisations, there are many other aspects
of the rail freight sector that might work against the efficacy of accelerated depreciation.
These complicating industrial factors can be extracted from the interview data as shown in
the following paragraphs.

_**High upfront capital required to purchase new equipment.**_ CEO #1 contended that
accelerated depreciation would reduce the profit figure in the first year, which would be a big
help to his organisation in terms of reducing its tax. However, upfront capital is required to
purchase new equipment. If the company is undercapitalised, it would not be able to afford
the expensive equipment (CEO #1). SM #3 commented that the high price of new equipment
is a significant barrier. Since investment in the rail hardware is substantial, rail freight
organisations would not risk their business and borrow a large sum of money from the bank
to modernise their rolling stock fleets, even in an accelerated depreciation environment.
Many other driving factors play a more important role.

_**New equipment acquired might not be technologically better.**_ Accelerated depreciation might
encourage operators to purchase more new equipment, but whether the new equipment will
be technologically efficient is another issue (CEO #2). SM #2 argued that, if there are no
criteria for improvement with respect to the purchasing of rolling stock purchasing, firms
might simply acquire more of the lower-end technology, rather than rolling stock using
improved technology. As noted in the literature review, there is historical evidence that firms
can abuse the provision of accelerated depreciation, i.e., by undertaking bad investment
projects for the sake of acquiring assets on which they could make use of accelerated
depreciation for tax benefits (Muten and Faxen, 1966).

_**The firm’s accounting conventions.**_ The literature review indicates that the firm’s accounting
conventions are one of many factors that might prevent organisations from adopting
accelerated depreciation. In particular, the use of accelerated depreciation can lead to a
reduction in before-tax profits. This might adversely reflect on the firm’s management, which
would not impress the organisation’s shareholders. The problem was confirmed by several interview participants (CM #1, AM #2, and EM #1). CEO #1 argued that the problem will be more pronounced among publicly listed organisations since the reduced profit figures would have an adverse impact on share prices. In addition, reduced profit figures might negatively affect the credit rating of the company (CEO #1).

The same privilege allowed to other competitors of rail. One problem associated with the investment allowance is that the scheme is applicable to all types of business, including rail’s competitors. As a result, that scheme is unlikely to drive any modal change. The same problem could occur if accelerated depreciation schemes are allowed for the road sector in addition to rail. As stated by EM #1, if any of rail’s competitors use accelerated depreciation, the benefits provided from accelerated depreciation schemes on the rail sector would be reduced. CEO #1 felt that the government will always have a hard task relaxing the taxation system for one industry without doing the same for another. He contended that the road sector has a strong lobby group that is likely to pressure the government to provide the same taxation system.

Re-powering not eligible for the benefits of accelerated depreciation. As discussed previously, the rail freight industry has a long tradition of re-engineering rather than replacing equipment. The problem noticed by CEO #3 is that the proposed accelerated depreciation scheme would only help a replacement case, but not a re-powering case. He also pointed out that it would be too difficult and too costly to make the operators replace all their existing fleet. As stated by CEO #5, “no railway industry can afford that”. A more viable solution would be to encourage them to overhaul their existing equipment with environmentally friendly engines. As stated by CFO #2, “if we use the old underframe and bring in environmentally friendly engines, it improves the carbon footprint and everything else without having to buy a new loco”.

Education. CEO #3 and CEO #4 again pointed that there is an educational issue associated with government incentives. These CEOs suggested that the adaptation of accelerated depreciation for the rail industry would require clear government communication regarding the scheme’s financial advantages. The government also needs to realise that, for some firms, especially the small ones, the scheme might be administratively too complex, while there might also be too many accountants involved in the process.
Implementation costs. To be fully effective, the majority of the interviewees indicated that accelerated depreciation would need to be provided on an ongoing basis. Yet it might be a difficult task to convince government since the scheme would obviously be expensive to implement. Moreover, it might be held that government would be better off spending its tax revenue elsewhere. By permitting accelerated depreciation, the government will delay collecting tax revenue, and there is a cost in terms of the interest forgone. In some situations, this interest forgone could be large, such as the large revenue losses stemming from the 1981 ACRS in the United States (Auerbach, 1982; Auerbach and Slemrod, 1997). The expensiveness of the scheme might result in it being abandoned. This has happened before in Australia, when the decision to abolish various accelerated depreciation arrangements during the late 1990s to fund a reduction in the corporate tax rate prevented the shipping industry from re-equipping with modern vessels. This point was also reflected in the interview data. As stated by AM #1, implementing the scheme “means less revenue from the government’s point of view”, which effectively means that the government needs to find a way to finance it. At the same time, this asset manager argued that the government needs to weigh the loss in tax revenue from the implementation against the benefit from higher economic growth generated by more investment in the rail sector, which obviously has the potential to yield greater tax revenue in due course.

Several suggestions were offered by the interviewees for increasing the value of an accelerated depreciation scheme if it were to be implemented in the rail freight industry. SM #2 explained that there are two types of accelerated depreciation: (1) the shortened-service-life method; and (2) the initial-allowance method. SM #2 holds that both methods would increase the turnover rate of rolling stock equipment. An increase in the equipment turnover rate would also allow firms to invest in the more costly option, with the implication that firms are more likely to spend higher dollars on better quality equipment (SM #2). However, the rate of depreciation allowed by the accelerated scheme needs to be significant so as to encourage the desired type of investment behaviour. With respect to the initial-allowance method, this strategic manager contended that rail freight firms should be allowed to claim at least 60% of the overall depreciation within the first 5 years. He added that the depreciation life of rolling stock should be reduced to 5 years if the shortened service life method is implemented.
The majority of interviewees also felt that the current depreciation schedule used in Australia is far too excessive and that a shorter depreciation time would be better. For example, CFO #1 proposed 15 years for locomotives, and 10 years for other rolling stock; AM #1 proposed 10 years for locomotives, and 8 years for other rolling stock; while CEO #4 proposed that the depreciation life for all types of rolling stock equipment should be reduced to four to five years. On the other hand, CEO #5 and CFO #2 believed that the same piece of equipment should be written off several times by different owners (CFO #2). This system should result in the rolling stock market having more liquidity. In particular, it is more convenient for operators to sell the equipment after they are completely written off and get a new one (CEO #5). As a result, the turnover rate of the rolling stock equipment in the rail freight sector should improve immensely (CEO #5 and CFO #2).

As indicated in the literature review, and as was reflected in the interview data, taxation is only one of many factors that may restrain investment. Accelerated depreciation alone may therefore not be sufficient to assure a desired level of investment in new rolling stock. Thus, there is a need to adopt other measures to support the use of accelerated depreciation schemes. Most of these suggestions have already been mentioned previously. First, the government needs to create more demand within the industry by simply driving a modal shift from road to rail. Second, the government needs to reduce the rolling stock replacement cost. Third, to prevent rail firms abusing the provision of accelerated depreciation as discussed above, the privilege should only be given to those that purchase efficient environmentally efficient equipment. Everyone else has to use the existing and less advantageous depreciation schedule. Fourth, the government should provide an incentive for suppliers to do research, so that they can make more environmentally efficient rolling stock equipment that operators can buy. Fifth, it is necessary for the government to address the education issue associated with the scheme.

CM #2 and CFO #2 believed that the investment allowance scheme in relation to fuel technology – if it is provided permanently and with higher rate – would be a more advantageous program than accelerated depreciation. The reason, according to CFO #2, is that the benefits from the investment allowance would yield a higher present value to the firm than those under accelerated depreciation. This CFO’s view should not surprise since, for many firms, the investment allowance scheme is equivalent to a cash bonus. By way of contrast, under accelerated depreciation, the firms are only allowed to claim a higher amount
of depreciation during the earlier years of an asset’s life – the total amount of depreciation allowed over an asset’s life is the same. If accelerated depreciation acts like a loan provided by the government to the firms, investment allowances would represent subsidies for investment. This explains why several industry members would prefer an investment allowance to accelerated depreciation.

Some interviewees advocated the use of non-tax incentive programs instead of liberal depreciation schemes since the benefits from these schemes can be enjoyed by all rail freight companies regardless of their tax position. On the contrary, several interviewees indicated that a focus on operating expenditure would be preferable. While initiatives have been introduced to reduce fuel use, actual fuel use and consumption per unit (of freight or per locomotive) are not accurately captured. Attractive incentives therefore would be targeted (e.g., re-engineering existing locomotives during upgrades) to decrease fuel use and emissions, thereby benefitting government and industry objectives (CM #2 and CEO #2).

New technologies in relation to reduce fuel burn rates and consumption (e.g., FreightMiser), are attractive possibilities (CM #2). Possible financial policies including grants, loans, subsidies, etc., are also preferable because they have broad application, i.e., are not restricted to tax-positive companies (CM #2 and CEO #2). CFO #2 agreed with this point and held that the government should switch from permitting accelerated depreciation to providing a rebate that allows the rail freight companies to cash in the benefits. CEO #3 and CEO #4 were both keen to see a direct cash scheme that helps operators to convert to low-emissions equipment, while CEO #4 argued that the cash grant should be given in an up-front manner. When the new equipment is bought, the government, according to this view, should give 70% of the cost directly to the supplier, whereas the operator provides 30%. By way of contrast, CEO #3 felt that the amount of cash granted need not be that high. A dollar for dollar scheme would, over a five-year period, should “completely convert every locomotive in the country” (CEO #3). Furthermore, any financial policies must be part of a larger comprehensive suite and not introduced in isolation. For example, mass-distance-location charging for trucks, continuing track investment, etc., would also need to occur (CEO #2).
4.3 Phase II: An Extended Asset Replacement Model

4.3.1 Model analysis

In this subsection, the implications of properties of the proposed model are considered. The research will proceed by looking at the model without inflation first, before analysing what happens when inflation is incorporated into the model. When inflation is omitted, the tax effects on scrapping and replacement decisions depend on the equipment tax life and the country depreciation law. When inflation is considered, the tax effects on scrapping and replacement decisions also depend on whether the asset is “short” or “long”, in addition to the aforementioned factors. When the tax-advantage schemes are considered, the general observation is that they are likely to have positive impacts on replacement decisions.

Tax effects on scrapping decisions

The effects of a change in the marginal tax rate, \( T \), on the optimal time to scrap the asset depend on whether the tax change alters the after-tax discount rate faced by the company. In general, the marginal tax rate and the after-tax discount rate are inversely related. However, things get trickier if the change in the marginal tax rate also alters the before-tax discount rate. According to Smith (1990), the change in the marginal tax rate, \( T \), is likely to alter the before-tax discount rate, \( \rho \), in the same direction. In particular, reductions in marginal tax rates raise the after-tax cost of loanable funds, thereby dropping the demand for those funds. At the same time, reductions in marginal tax rates increase the after-tax returns to lenders, thereby raising the supply for loanable funds. Both phenomena tend to reduce the before-tax discount rate. Hence, reductions in marginal tax rates could either increase or decline the after-tax discount rate. This will depend on the degree to which the before-tax discount rate changes, which, in turn, is determined by the elasticity of demand and supply for loanable funds.

To investigate the total effects of the change in \( T \) on the asset’s optimal replacement age, we must allow for the effects of a change in \( T \) on \( \rho \). This can be done by finding the total derivative of the RHS of (3.2b) with respect to \( T \):

\[
\frac{dx}{dT} = \frac{\partial x}{\partial T} + \frac{\partial x}{\partial \rho} \frac{d\rho}{dT}
\]
where \( x \) is the RHS of (3.2b); \( d \) indicates the total derivative; \( \partial \) indicates the partial derivative. If the before-tax discount rate is defined as \( \rho/(1-T) \) and if it is assumef that it remains constant for simplicity, \( dx/dT \) may be written in the following form:

\[
-\frac{\rho}{(1-T)^2}\left( \int_a^c D(t)dt-M(a) \right) - \frac{\rho}{1-T}\left( M(c)-\frac{T}{1-T}\left( \int_a^c D(t)dt-M(a) \right) \right)
\]  

(4.1)

(4.1) indicates that a change in the tax rate has two effects on the optimal scrapping time. The first part of the equation

\[
-\frac{\rho}{(1-T)^2}\left( \int_a^c D(t)dt-M(a) \right)
\]  

(4.2)
corresponds to the direct effects of \( T \) on the components of the revenue stream in (3.2b). The remaining

\[
-\frac{\rho}{1-T}\left( M(c)-\frac{T}{1-T}\left( \int_a^c D(t)dt-M(a) \right) \right)
\]  

(4.3)

represents the effect of \( T \) on the RHS of (3.2b) via the after-tax discount rate. The part of (4.3) in the large square bracket is the derivative of the RHS of (3.2b) with respect to \( \rho \).

If the after-tax discount rate does not change as a result of changes in marginal tax rates, the effects of changes in marginal tax rates on optimal scrapping strategies can be determined by examining (4.2) alone. (4.2) contains two expressions: \(-\rho/(1-T)^2\) and \( \int_a^c D(t)dt-M(a) \).

The former is ambiguously negative for \( \rho > 0 \) and \( T < 1 \). The sign of (4.2) therefore depends on the relative sizes of the accumulated depreciation allowances and the original market value of the asset, which, in turn, are determined by types of depreciation methods and whether or not the asset is fully depreciated before its termination. Four scenarios need to be considered:

(a) depreciation schemes are based on the original cost concept and the asset is held longer than its tax life (or equivalently, the asset’s tax life is less than or equal to its economic life);

(b) depreciation schemes are based on the original cost concept and the asset is not fully depreciated before its termination (or equivalently, the asset’s tax life is more than its economic life);
(c) depreciation schemes are based on the replacement cost concept or price-index adjustment of the original cost, and the asset is held longer than its tax life (or equivalently, the asset’s tax life is less than or equal to its economic life); and

(d) depreciation schemes are based on the replacement cost concept or price-index adjustment of the original cost and the asset is not fully depreciated before its termination (or equivalently, the asset’s tax life is more than its economic life).

It is obvious from (4.2) that the components of the tax and depreciation allowance adjustments would have no effect on the timing of the scrapping decision if the balance adjustment term, \( \int_a^t D(t) dt - M(a) \), is zero. This is true under scenario (a). This scenario represents the situation faced by rail freight operators in Australia, where depreciation deductions for rail freight rolling stock equipment are calculated based on the original cost. Furthermore, the ARA indicates that the average age of rolling stock is 32 years (ARA and Booz Allen & Hamilton, 2007), which implies that rolling stock equipment are generally held longer than their tax life (25 years for locomotives and 30 years for wagons). Overall, tax considerations are likely to have either no effect or else an insignificant effect on the rolling stock scrapping decision in the Australian rail sector; if only the direct effect that \( T \) has on \( c \) regardless of the indirect effect of \( T \) via \( \rho \) is counted.

Under scenario (b), the term \( \int_a^t D(t) dt - M(a) \) is negative and so the sign of (4.2) becomes positive. As a consequence, an increase in the marginal tax rate generally shortens the optimal time to scrap the asset. The reason is that, when the term \( \int_a^t D(t) dt - M(a) \) is negative, the sign of the term \(- \rho T / (1 - T) \left( \int_a^t D(t) dt - M(a) \right)\) from (3.2b) becomes positive. In other words, the balance adjustment will provide the firm with some tax shields instead of tax liabilities. The higher \( T \) increases the return the firm realises at the asset disposal by investing the tax shields associated with the asset’s book value by an amount equal to \( \rho T / (1 - T) \left( \int_a^t D(t) dt - M(a) \right)\). Hence, delaying asset liquidation provides the firm with a loss. Furthermore, continuing the asset provides the firm with a pre-tax cash flow of \( \pi(c) + M'(c) \) from operation and from the change in the asset’s market value. (3.2b) indicates that this cash flow exceeds the pre-tax return \( \rho M(c) \) that the firm could realise by terminating the asset and investing the salvage value at a rate \( \rho \). As a result, the higher \( T \) increases the firm’s tax
liability if asset termination is postponed. The combination of these two effects implies that the firm has an incentive to terminate the asset earlier as the marginal tax rate increases.

Replacement cost-based depreciation schemes substitute replacement cost for original cost as the basis for the depreciation deduction. Likewise, the price-index adjustment of the original cost method calculates the basis for the depreciation deduction based on the inflation-adjusted cost of the asset. With advancement of technology and inflation taken into account, replacing an asset that originally costs $1,000 may now cost substantially more. Under the replacement-cost method and price-index adjustment of depreciable basis, it is thus possible to claim depreciation deductions a sum greater than the original cost of the asset (Goode, 1955; Barritt, 1959). Under scenario (c), the term \( \int_0^a D(t)dt - M(a) \) is likely to be positive, and so the sign of (4.2) becomes negative. This means that an increase in the marginal tax rate generally lengthens the optimal time to scrap the asset. The reason is that, when the term \( \int_0^a D(t)dt - M(a) \) is positive, the sign of the term \(-\rho T/(1-T)\left(\int_0^c D(t)dt - M(a)\right)\) from (3.2b) is negative. In other words, tax shields in the previous case now become tax liabilities. The higher \( T \) increases the interest yield on the balance adjustment tax liabilities avoided at \( c \) by delaying disposal of the asset, \(-\rho T/(1-T)\left(\int_0^c D(t)dt - M(a)\right)\). It follows that delaying asset liquidation provides the firm with a profit. In the presence of a tax rise, continuing the asset also increases the firm’s tax liabilities since the divergence between the pre-tax cash flow \( \pi(c) + M'(c) \) from continuation and the pre-tax return \( \rho M(c) \) from asset termination is positive. Yet this effect is likely to be weaker than the first effect. Overall, the firm has an incentive to delay asset liquidation as the marginal tax rate increases under scenario (c).

The relative sizes of the accumulated depreciation and the asset’s original cost if scenario (d) is true cannot be precisely forecasted. That is, under scenario (d), the sign of the term \( \int_0^a D(t)dt - M(a) \) is ambiguous. The sign of (4.2) and the direct effects of a change in the marginal tax rate on the optimal scrapping age therefore are ambiguous.

(4.3) indicates the indirect effect of \( T \) on the optimal scrapping age. The indirect effect exists because a higher \( T \) is likely to increase the after-tax discount rate \( \rho \) (Smith, 1990). This equation contains three expressions. The first one outside the large square bracket \(-\rho/(1-T)M(c)\) is ambiguously negative for \( \rho > 0, \ T < 1 \). The second one, which is inside
the large square bracket $M(c)$, represents the salvage value of the asset at the time of its disposal. This term is generally positive, i.e., $M(c) \geq 0$. The sign of the remaining term $T/(1-T)(\int_a^D(t)dt - M(a))$ depends on the relative sizes of the accumulated depreciation allowances and the cost of the asset at the beginning period.

Under scenario (a), the term $\int_a^D(t)dt - M(a)$ is zero, and so the sign of (4.3) is negative. The indirect effect of $T$ on the optimal scrapping time is therefore positive. That is, a higher $T$ reduces $\rho$, hence reducing the interest charge associated with holding the asset itself at $c$. This phenomenon optimally lengthens the scrapping time of the asset. When the direct and indirect effects are combined, the optimal asset life increases as the marginal tax rate increases.

Under scenario (b), the term $\int_a^D(t)dt - M(a)$ is negative, and so is the sign of (4.3). The indirect effect of $T$ on the optimal scrapping time is still positive, but is now stronger than that under the previous scenario. As mentioned previously, higher $T$ reduces $\rho$, hence reducing the loss that the firm suffers by delaying asset termination, i.e., by postponing the investment of the after-tax cash flows resulting from the termination of the asset at rate $\rho$. At the same time, the lower $\rho$ also reduces the interest yield obtained at the time of asset’s disposal by investing the tax shields associated with the asset’s book value by an amount equal to $\rho T/(1-T)(\int_a^D(t)dt - M(a))$. Both phenomena optimally lengthen the scrapping time of the asset. When combining the direct and indirect effects, optimal asset life could either increase or decline as the marginal tax rate increases if the depreciation basis is calculated based on the original cost of the asset, and if the asset is not completely written off before its termination. The overall effect of the change in the marginal tax rate on the optimal time of scrapping depends on the relative sizes of the indirect and indirect effects.

Under scenario (c), the term $\int_a^D(t)dt - M(a)$ is positive. The sign of (4.3) and the indirect effect of $T$ on the optimal scrapping time are ambiguous. This is also true under scenario (d), where the sign of the term $\int_a^D(t)dt - M(a)$ is unclear. When the direct and indirect effects are combined, therefore, the optimal asset life could either increase or decline as the marginal tax rate increases if the depreciation basis is calculated based on the replacement cost or the
inflation-adjusted cost of the asset. This conclusion is independent of the asset’s duration. Table 4.2 summarises all the results obtained in this section.

Table 4.2: The effect of changes in the marginal tax rate on the optimal timing of the scrapping decision under different scenarios. 0 indicates that changes in $T$ has either no effect or very little effect on scrapping decisions. $+$ indicates that the effect $T$ on the optimal scrapping time is positive. $-$ indicates that the effect $T$ on the optimal scrapping time is negative. $-,+)$ indicates that the effect $T$ on the optimal scrapping time is ambiguous.

<table>
<thead>
<tr>
<th>Asset duration</th>
<th>Original Cost Depreciation</th>
<th>Replacement Cost Depreciation (or Price Index Adjustment)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Direct Effect</td>
<td>Indirect Effect</td>
</tr>
<tr>
<td>Tax Life ≤ Economic Life</td>
<td>0</td>
<td>+</td>
</tr>
<tr>
<td>Tax Life &gt; Economic Life</td>
<td>-</td>
<td>+</td>
</tr>
</tbody>
</table>

The marginal condition (3.2) also indicates that allowing accelerated depreciation to the asset has no effect on the timing of the scrapping decision if the asset is fully depreciated upon its termination, which is true with many types of assets (Howe, 1987). In these circumstances, changes in depreciation schedules will not alter the total amount of depreciation that can be taken for tax purposes. In particular, the term $\int_a^\infty D(t)dt$ and therefore the asset life remain unchanged. Changes in the depreciation schedule do alter the present value of tax rebates, $\int_a^\infty D(t)e^{-\rho(t-a)}dt$. This term, however, does not appear in the marginal condition (3.2).

If the asset is partially depreciated upon its termination, allowing accelerated depreciation induces the firm to operate the asset longer. The rationale behind this conclusion is as follows. If tax life is longer than economic life, there is a tax shield associated with the asset’s book value. This means that the term $\int_a^\infty D(t)dt - M(a)$ is negative. The use of an accelerated depreciation method is likely to increase the term $\int_a^\infty D(t)dt$, thereby reducing the value of the tax shield that the firm could realise by liquidating the asset. This has the effect of increasing the optimal time of the scrapping decision. The results regarding the effect of accelerated depreciation are consistent with those obtained by Prezas (1992, 1994), although with a different model employed.
Tax effects on replacement decisions

As with (3.2b), (3.6b) is analytically more convenient than (3.6a) in the examination of how changes in the tax structure affect the selection of the optimal replacement age. The tax code adjustments that have the potential to alter the asset’s optimal replacement age include changes in marginal tax rate, depreciation schedules, investment allowances, and the investment tax credit.

Changes in the marginal tax rate

As mentioned above, a change in the marginal tax rate, $T$, is likely to alter the after-tax discount rate, $\rho$, in the opposite direction, given that the before-tax discount rate remains the same. To investigate the total effects of the change in $T$ on the asset’s optimal replacement age, one must therefore allow for the effects of a change in $T$ on $\rho$. This can be done by finding the total derivative of the RHS of (3.6b) with respect to $T$:

$$\frac{dy}{dT} = \frac{\partial y}{\partial T} + \frac{\partial y}{\partial \rho} \frac{d\rho}{dT}$$

where $y$ is the RHS of (3.6b); $d$ indicates the total derivative; $\partial$ indicates the partial derivative. Similar to what was carried out in the case of scrapping decisions, the before-tax discount rate is defined as $\rho/(1-T)$ and assumed to remain constant. As a consequence, $dy/dT$ may be written in the following form:

$$\frac{\rho}{(1-T)^2(1-e^{-\rho s})} \left( \int_0^t D(t)e^{-\rho s} dt + Ie^{-\rho s} + Ae^{-\rho s} - M(0) \right) + \frac{\rho}{(1-T)^2(1-e^{-\rho s})} \left( M(0) - \int_0^t D(t)dt \right) e^{-\rho s}$$

$$+ \frac{\rho}{(1-T)^2} \left( M(a) - \int_a^T D(t)dt \right) - \frac{\rho}{(1-T)} \left[ \frac{1-e^{-\rho s}(1+\rho s)}{(1-T)(1-e^{-\rho s})^2} C(0,s,1) \right]$$

$$+ \frac{\rho}{(1-T)(1-e^{-\rho s})} \frac{\partial C(0,s,1)}{\partial \rho} + M(c)$$

$$- \frac{T}{(1-T)} \left( \int_a^t D(t)dt - M(a) \right)$$

(4.6)

The first three terms of (4.6)

$$\frac{\rho}{(1-T)^2(1-e^{-\rho s})} \left( \int_0^t D(t)e^{-\rho s} dt + Ie^{-\rho s} + Ae^{-\rho s} - M(0) \right)$$

$$+ \frac{\rho}{(1-T)^2(1-e^{-\rho s})} \left( M(0) - \int_0^t D(t)dt \right) e^{-\rho s}$$

$$+ \frac{\rho}{(1-T)^2} \left( M(a) - \int_a^T D(t)dt \right)$$

(4.7)
represent the direct effects of $T$ on the components of the revenue stream in (3.6b), while the remaining terms

$$
- \frac{\rho}{(1-T)} \left[ \frac{1-e^{-\rho s}}{(1-T)(1-e^{-\rho s})^2} C(0,s,1) + \frac{\partial C(0,s,1)}{\partial \rho} + M(c) \right]
$$

represent the effects of $T$ on the RHS of (3.6b) via $\rho$.

Consider first the direct effects of $T$ on the optimal replacement age. The first term of (4.7) contains two expressions: $\rho / ((1-T)^2(1-e^{-\rho s}))$ and $\int_0^T D(t)e^{-\rho s}dt + e^{-\rho s} + Ae^{-\rho s} - M(0)$. The former is unambiguously positive for $\rho > 0$. The latter represents the present value of the difference between the sum of the depreciation allowances, the investment tax credits, and the investment allowances associated with Challenger and its purchase price. The sign of this expression may be either positive or negative, depending on the type of assets under consideration and the country’s tax system. In Australia, depreciation schemes are based on the original cost concept (a choice of either straight line or diminishing value methods), while newly acquired tangible depreciating assets are subject to different rates of investment allowances, as summarised in Table 2.6.

**Table 4.3: Discount rates (in percentage) that make the expression $\int_0^T D(t)e^{-\rho s}dt + Ae^{-\rho s} - M(0)$ and the first term of (4.7) positive for different investment allowance rates and asset lives. The calculation is based on the Australian tax code, under which depreciation schemes are based on the original cost concept and there is no investment tax credit. The straight-line method is assumed. An additional assumption is that the asset is totally written off before its replacement.**

<table>
<thead>
<tr>
<th>Asset’s Tax Life (years)</th>
<th>Investment Allowance Rate (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>&lt; 3.49</td>
</tr>
<tr>
<td>10</td>
<td>&lt; 1.93</td>
</tr>
<tr>
<td>25</td>
<td>&lt; 0.83</td>
</tr>
<tr>
<td>30</td>
<td>&lt; 0.69</td>
</tr>
</tbody>
</table>
Unlike the US tax system, the investment tax credit scheme does not exist under the current Australian tax code, and therefore the term $I e^{-\rho}$ vanishes. If, for example, a new locomotive subject to a 30% investment allowance is allowed to be fully depreciated over a 25-year period under the current Australian tax code, the nominal discount rate would have to be less than 2.85% for the expression $\int_0^T D(t)e^{-\rho}dt + A e^{-\rho} - M(0)$ to be positive (it is assumed that the straight-line formula is used and that the asset is fully depreciated before its replacement).

For assets with a 10-year depreciation life, the nominal discount rate would have to be less than 6.52% for this expression to be positive. If the depreciation allowances associated with new assets were to be spread over 5 years, the nominal discount rate would have to be less than 11.46% for this expression to be positive. Thus, the longer the asset’s tax life, the lower the nominal discount rate has to be to make the expression $\int_0^T D(t)e^{-\rho}dt + A e^{-\rho} - M(0)$ positive. With lower rate of investment allowances, the nominal discount rate would have to be significantly lower than the aforementioned rates for this expression to be positive. Yet, with a higher investment allowance rate, the nominal discount rate would have to be significantly higher for the expression $\int_0^T D(t)e^{-\rho}dt + A e^{-\rho} - M(0)$ and the first term of (4.7) to be positive. Different discount rates that make the expression $\int_0^T D(t)e^{-\rho}dt + A e^{-\rho} - M(0)$ and the first term of (4.7) positive under various settings are summarised in Table 4.3.

The results obtained in Table 4.3 rely on the implicit assumption that depreciation schemes are based on the original cost concept and that the asset is held longer than its tax life; that is, the results are based on scenario (a) outlined above. Under the original cost-based depreciation schemes, if the asset’s tax life is longer than its economic life (scenario b), the value of the sum of depreciation allowances, $\int_0^T D(t)e^{-\rho}dt$, would reduce. Ceteris paribus, nominal discount rates would have to be lower than those specified in Table 4.3 in order for the expression $\int_0^T D(t)e^{-\rho}dt + A e^{-\rho} - M(0)$ and the first term of (4.7) to be positive. If the depreciation basis is calculated based on the replacement cost or the inflation adjusted cost and the asset is completely written off before its replacement (scenario c), $\int_0^T D(t)e^{-\rho}dt$ would increase. Ceteris paribus, nominal discount rates would have to be higher than those specified in Table 4.3 in order for the expression $\int_0^T D(t)e^{-\rho}dt + A e^{-\rho} - M(0)$ and the first term of (4.7) to be positive. Under scenario (d), where the depreciation basis is calculated based on the replacement cost or the inflation adjusted cost and the asset is not fully
depreciated before its replacement, it is impossible to predict what will happen to the value of
\[ \int_0^t D(t)e^{-\rho} dt. \]
As a consequence, the conclusion regarding the sign of
\[ \int_0^t D(t)e^{-\rho} dt + Ae^{-\rho} - M(0) \]
is ambiguous. Overall, the sign of the expression
\[ \int_0^t D(t)e^{-\rho} dt + Ae^{-\rho} - M(0) \]
and the sign of the first term of (4.7) is also affected by types of depreciation methods and the asset’s economic life, in addition to the depreciation lives for tax accounting and the size of the investment allowances.

The second term of (4.7) contains two expressions:
\[ \frac{\rho}{(1-T)^2(1-e^{-\rho})} \]
and
\[ M(0) - \int_0^c D(t) dt. \]
The former is ambiguously positive for \( \rho > 0 \). The latter represents the difference between the original price of the Challenger and the total amount of depreciation claimed for tax purposes over the life of the Challenger. The expression \( M(0) - \int_0^c D(t) dt \) is generally zero if the depreciation schemes are based on the historical cost and the asset is held longer than its tax life, i.e., under scenario (a), as outlined in the previous section. The sign of this expression and therefore the sign of the second term of (4.7) is positive, negative, and ambiguous under scenarios (b), (c), and (d) respectively. The conclusion regarding the sign of the last term of (4.7) involving \( M(0) - \int_0^c D(t) dt \) is the same.

Table 2.3 in Chapter 2 shows revenue figures of major rail freight players for the year 2006–2007. This table indicates that Australian rail freight companies are likely to have an annual turnover of $2 million or more. Thus, the 50% investment allowance rate is unlikely to be relevant to them. Coupled with the fact that the depreciation life is currently 25 years for locomotives and 30 years for wagons, only the bold figures in Table 4.3 are likely to be relevant to rolling stock replacement decisions made by Australian rail freight firms. These figures imply that the first term of (4.7) is generally negative since it is very unusual for both actual and expected nominal after-tax market discount rates to be less than 3%. As shown in Figure 4.5, annual average nominal before-tax interest rates charged on new business loans by the commercial banks in Australia never fell below 10%. This implies that nominal after-tax discount rates for the vast majority of rail operators have recently been considerably greater than 3% given that the marginal corporate tax rate for both general and private companies has been 30% since 2001 (Reinhardt and Steel, 2006).
Since rail freight operators in Australia: (1) face a depreciation rule based on historical cost (ATO, 2009b); and (2) tend to hold on to rolling stock even after they are completely depreciated (ARA and Booz Allen & Hamilton, 2007), the second and third terms of (4.7) will generally be negligible. As a result, the direct effects of $T$ on the components of the revenue stream in (3.6b), which consist of the first three terms in (4.6), is likely to be negative for rolling stock replacement problems in Australia; that is, if the after-tax discount rate remains constant, or its effects are negligible, a reduction in the marginal tax rate will generally reduce the optimal age of rail freight rolling stock and, by implication, is likely to increase rail freight rolling stock replacement investment in Australia. The reason is that the tax cut has two opposing effects: it increases the present value of the after-tax earnings from future assets (net of depreciation allowances) and, at the same time, reduces the present value of the depreciation allowances associated with the asset. In the Australian rail freight industry, the first effect is likely to be the dominant one, thereby making new rolling stock more attractive to the operator. At the lower marginal tax rate, the operator would want to acquire the larger net revenue streams associated with new rolling stock sooner and so replace existing rolling stock more quickly.

If the effects of the change in the marginal tax rate on the after-tax discount rate are included, the sign of (4.8) needs to be considered. The part of (4.8) outside the large square bracket $-\rho/(1-T)$ is ambiguously negative for $\rho > 0$ and $T < 1$, while the part of (4.8) inside the large square bracket is the partial derivative of the RHS of (3.6b) with respect to $\rho$. This means that the sign of this expression may be either positive or negative. The first term of this
partial derivative is a product between the capital recovery factor and $C(0,s,1)$. $C(0,s,1)$ is unambiguously positive, while the capital recovery factor is generally positive for $\rho > 0$ and $T < 1$. This is shown in Figure 4.6, which graphs the relationship between the capital recovery factor and the discount rate for different values of $s$. The figure shows that a higher $\rho$ increases the capital recovery factor and therefore has the effect of optimally shortening the time of replacement. Yet, the second term involving $\partial C(0,s,1)/\partial \rho$ is generally negative since the higher $\rho$ commonly decreases the present value of the net revenue streams associated with future assets. To the extent that the annuity associated with the ownership of future units of assets decreases, the opportunity cost of holding the current asset one period longer reduces, and the replacement interval tends to increases. Overall, the net effects of a change in the after-tax discount rate on the optimal replacement age are ambiguous. This conclusion is true regardless of asset types and the country’s tax system. It follows that, if the after-tax discount rate changes as a result of changes in marginal tax rates, the effects of a change in marginal tax rates on optimal age of most assets (including rolling stock in the Australian freight industry) cannot be determined with certainty.

Figure 4.6: The relationship between the capital recovery factor
\[
(1 - e^{-\rho s} (1 + \rho s))/((1 - T)(1 - e^{-\rho s})^2)
\]
and the discount rate with $s = 5$ in the broken curve, with $s = 10$ in the solid curve, and with $s = 25$ in the dotted curve. The marginal tax rate is assumed to be 33%.

The effects of tax-advantage schemes on replacement decisions

A similar procedure employed in Section 2.4.1 can be used to assess the effects of changes in tax-advantage schemes on replacement strategies. The effect of changes in the investment tax
credit can be determined by finding the partial derivative of the RHS of (3.6b) with respect to \( I \) to obtain:

\[
\frac{\rho e^{-\rho}}{(1-T)(1-e^{-\rho})}. \tag{4.9}
\]

(4.9) is ambiguously positive for \( \rho > 0 \) and \( T < 1 \). Thus, changes in the investment tax credit is likely to change the value of the RHS of (3.6b), which represents the marginal opportunity costs of holding the current asset in the same way. This implies that an increase in the investment tax credit generally reduces the optimal replacement age of the asset and, by implication, is likely to increase replacement investment.

The effect of changes in the investment allowance can be determined by partially differentiating the RHS of (3.6b) with respect to \( A \) to obtain:

\[
\frac{T\rho e^{-\rho}}{(1-T)(1-e^{-\rho})} \tag{4.10}
\]

which, similar to (4.9), is also ambiguously positive for \( \rho > 0 \) and \( T < 1 \). The same conclusion applies; that is, an increase in the additional first-year depreciation generally increases the marginal opportunity costs of holding the current asset, thereby inducing the firm to replace their existing assets more quickly.

Now, consider what happens if accelerated depreciation were to be applied to the new asset. Since accelerated depreciation is only applicable to the new asset, it has nothing to do with the term \( \int_a^T D(t)dt \) of the RHS of (3.6b). Changes in depreciation schedules also do not alter the total amount of depreciation that can be taken for tax purposes. The term \( \int_0^T D(t)e^{-\rho}dt \) of the RHS of (3.6b) will therefore remain the same. Changes in depreciation schedules, however, will alter the present value of the tax credits associated with the new asset, \( \int_0^T D(t)e^{-\rho}dt \). To determine the effect of accelerated depreciation on optimal replacement rates, the partial derivative of the RHS of (3.6b) with respect to \( \int_0^T D(t)e^{-\rho}dt \) must therefore be found. This partial derivative may be written as:

\[
\frac{T\rho}{(1-T)(1-e^{-\rho})}. \tag{4.11}
\]
The sign of (4.11) is also positive if \( \rho > 0 \) and \( T < 1 \). Accelerated depreciation, which increases the present value of the tax rebates, will increase the opportunity cost of holding the current asset. Accelerated depreciation will therefore generally reduce the optimal age of the asset, which leads to greater replacement investment. Since the sign of (4.9), (4.10), and (4.11) only depends on the value of \( \rho \) and \( T \), the analysis presented above is generally true for all assets, including rail freight rolling stock.

Some fascinating results can be found when accelerated depreciation is allowed for the existing asset, in addition to the new asset. The marginal condition (3.6b) implies that allowing accelerated depreciation for the existing asset will not alter the optimal replacement interval if the asset is held longer than its tax life. In particular, the term \( \int_{t}^{T} D(t)dt \), which indicates the accumulated tax depreciation of the existing asset, will remain the same. This is because accelerated depreciation will only change the PV of the deductions, not the total deductions allowed.

If the asset is not fully depreciated before its replacement, the term \( \int_{t}^{T} D(t)dt \) may increase and will lead to a longer optimal replacement age and, by implication, less replacement investment. The reason is the same as that raised in the scrapping case. An increase in depreciation reduces the asset’s book value at the replacement time. The loss from delaying investment of the book value tax shields associated with the existing asset, \( \int_{t}^{T} D(t)dt - M(a) \), at the rate \( \rho \) is also reduced as a consequence of that. This has the effect of optimally lengthening the time of the replacement decision. This result, however, does not depict the situation faced by Australian rail freight firms, which are likely to hold on to their rolling stock even after they are completely depreciated (ARA and Booz Allen & Hamilton, 2007).

**Expected effects of other incentive programs on replacement decisions**

In addition to the tax code adjustments examined above, the asset replacement model proposed can equally be used to analyse the effects of many other factors that may exert a significant influence on the optimal replacement decision. We begin with the effects of an ETS that penalises assets heavily reliant on carbon-based fuel sources such as coal, natural gas or petroleum, with the rate of penalty increasing with time so as to encourage an overall reduction in carbon emissions (Garnaut, 2008). Under an ETS, firms relying on fossil fuels,
especially those in the transport and stationary energy sectors, have to purchase increasingly expense carbon credits (HM Treasury, 2006). This increase in expense will particularly reduce the residual earning associated with the existing asset at the time of disposal, i.e., the term \( \pi(c) \) on the LHS of (3.6). The additional expense incurred by the firm as a result of the existence of an ETS will also reduce the flow of residual earnings associated with the new asset, i.e., the term \( \int_0^T \pi(s)e^{-\rho t}dt \) on the RHS of (3.6). This effect will be counteracted if it is assumed that the new asset is more fuel efficient and produces substantially lower emissions impacts, which will lead to lower operating expenses. If this is the case, the effect on the value of the RHS of (3.6) is likely to be insignificant. Ceteris paribus, the equipment age has to decrease for the condition (3.6) to remain true.

Similar analysis can be performed on other policies that could influence the asset replacement decision. Policies that focus on reducing operating expenditure, as suggested by several interview participants, are expected to yield unfavourable outcomes as long as they are aimed at the old asset. Re-engineering old locomotives with new clean engines to minimise fuel use and therefore emissions would increase the flow of residual earnings associated with the old locomotive, i.e., the term \( \pi(c) \) on the LHS of (3.6). This would increase the marginal revenue of holding the current equipment, thereby motivating firms to delay replacement. Other possible financial policies such as cash grants and subsidies can be incorporated into the replacement model in a similar fashion to the investment tax credit. This indicates that the effect of the investment tax credit on the replacement decision as analysed above still holds true for these other policies.

**The tax impact of inflation**

When inflation is considered, the scrapping condition is depicted by (3.9). Both the LHS and the RHS of (3.9) are affected by changes in inflation. To examine how changes in the expected inflation affect the optimal time of the scrapping decision, the partial derivative of both sides of the equation with respect to \( f \) were computed. Differentiating the LHS of (3.9) with respect to \( f \) gives \( (c-a)Te^{-f(c-a)}M'(c) \). Since the salvage value of the asset generally reduces as the asset ages, \( M'(c) \) is generally negative. The partial derivative of the LHS of (3.9) with respect to \( f \) is therefore generally negative for \( f > 0 \) and \( T < 1 \). The higher rate of inflation would increase the after-tax reduction in the asset’s salvage value, i.e., the term
(1 – Te^{-(c-a)})M'(c). This phenomenon reduces the after-tax net marginal benefit of holding the asset, which encourages the firm to scrap that asset more quickly. Differentiating the RHS of (3.9) with respect to \( f \) gives

\[
T[(c-a)(\rho + f) - 1] \left( \int_a^\infty D(t)dt + M(c) - M(a) \right) e^{-f(c-a)}.
\]

(4.12)

If it is assumed that \( \rho > 0 \), \( f > 0 \) and \( T > 1 \), the sign of (4.12) clearly depends on the sign of the expression \((c-a)(\rho + f) - 1\), and the sign of the expression \( \int_a^\infty D(t)dt + M(c) - M(a) \). The former is positive for “long” assets, i.e., if \((c-a) \geq 1/(\rho + f)\), and negative for assets with “short” duration, i.e. if \((c-a) < 1/(\rho + f)\). The sign of \( \int_a^\infty D(t)dt + M(c) - M(a) \) is positive, ambiguous, positive and ambiguous under scenarios (a), (b), (c), and (d) respectively.

Overall, the effect of \( f \) on the time of the scrapping decision clearly is not monotonic since increased \( f \) can either decrease or increase the marginal opportunity cost of holding the asset depending on the economic life, relevant tax features and replacement situation of the particular asset. If the balance adjustment provides the firm with a tax liability, i.e., \( \int_a^\infty D(t)dt + M(c) - M(a) \geq 0 \), increased inflation results in two opposing effects on the present value of the interest yield obtained by avoiding tax liabilities associated with the balance adjustment term. First, higher inflation increases the yield since a higher nominal rate \((\rho + f)\) would have been earned on delaying balance adjustment tax liabilities. The effect is to encourage longer retirement. Second, an incentive to retire the asset more quickly occurs since the nominal discount rate is increased with inflation, which reduces the discount factor applied to interest yield. For ‘long’ assets, the discounting effect is stronger, thereby resulting in an earlier retirement, while, for ‘short’ assets, the first effect is stronger, thereby resulting in an incentive to postpone abandonment. The opposite rationale holds if the balance adjustment provides the firm with a tax liability, i.e., \( \int_a^\infty D(t)dt + M(c) - M(a) < 0 \). The effect of \( f \) on the LHS of (3.9), the RHS of (3.9), and the optimal scrapping age is summarised in Table 4.4.
Table 4.4: The effect of changes in the inflation rate on the after-tax net marginal revenue of holding the asset, the after-tax net marginal opportunity cost of holding the asset, and the optimal scrapping age. + indicates the positive effect. - indicates the negative effect. \( \gamma \) indicates the ambiguous effect.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Short Assets ( (c - a) &lt; 1/(\rho + f) )</th>
<th>Long Assets ( (c - a) \geq 1/(\rho + f) )</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Effect on MR</td>
<td>Effect on MC</td>
</tr>
<tr>
<td>(a)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(b)</td>
<td>-</td>
<td>+,( \gamma )</td>
</tr>
<tr>
<td>(c)</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>(d)</td>
<td>-</td>
<td>+,( \gamma )</td>
</tr>
</tbody>
</table>

Next, it is necessary to consider the replacement problem under inflation. The replacement condition under inflation is represented by (3.10). The effect of \( f \) on the LHS of (3.10) is monotonically negative. We can use the same economic rationale stated for the LHS of (3.9) to explain this result. On the other hand, the effect of \( f \) on the RHS of (3.10) can be represented by the following expression:

\[
\frac{\rho}{1 - e^{-\infty}} \frac{\partial C(0,s,1)}{\partial f} + T((c - a)(\rho + f) - 1) \left( \int_{a}^{c} D(t) dt + M(c) - M(a) \right) e^{-f(c-a)}.
\]

As Bates et al. (1979) state, inflation lowers the real value of the tax shield associated with the depreciation, the investment tax credit, and the investment allowance. Thus, the first term of (4.13) involving \( \partial C(0,s,1)/\partial f \) is likely to be negative. The effect of this is that the replacement will be postponed. As with the retirement case, the sign of the remaining expressions in (4.13) is ambiguous and depends on the economic life, relevant tax features and replacement situation of the particular asset. Overall, higher inflation can either increase or decrease the RHS of (4.13). It follows that the net effect of \( f \) on the time of the replacement decision is indeterminate. Unlike the scrapping case, however, the inflationary effect on the optimal replacement time is always ambiguous. Table 4.5 summarises the results.
Table 4.5: The effect of changes in the inflation rate on the after-tax net marginal revenue of holding the asset, the after-tax net marginal opportunity cost of holding the asset, and optimal replacement age. + indicates the positive effect, - indicates the negative effect, and -,+ indicates the ambiguous effect.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Short Assets ((c - a) &lt; 1/(\rho + f))</th>
<th>Long Assets ((c - a) \geq 1/(\rho + f))</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Effect on MR</td>
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</tr>
<tr>
<td>(a)</td>
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<tr>
<td>(b)</td>
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<td>-,+</td>
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<tr>
<td>(c)</td>
<td>-</td>
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<tr>
<td>(d)</td>
<td>-</td>
<td>-,+</td>
</tr>
</tbody>
</table>

4.3.2 The relative efficacy of different tax concessions

The analytical results from previous sections indicate that various combinations of tax codes, e.g., accelerated depreciation, investment tax credits, and investment allowances, could be used to reduce the optimal life of rolling stock and increase replacement investment. There has been, however, no suggestion regarding which combination is likely to be the most effective at encouraging the required levels of replacement investment. The analysis in this section attempts to ascertain the relative efficacy of any change in tax policy.

As discussed in Section 4.3.1, when the depreciation basis is calculated based on the original cost and the asset is held longer than its tax life, changes in tax codes have either no effect or very little effect on most scrapping decisions (if it is assumed that the after-tax discount rate remains the same). This is likely to be true in the Australian rail freight sector, which is governed by original cost-based depreciation schemes and long investment periods for rolling stock. In light of this, only replacement decisions are examined in the analysis presented in this section. The analysis in this section finds that accelerated depreciation and other tax advantage schemes are worse off than the investment tax credit program with respect to the influence for quicker replacement. The section first outlines the procedure of the experiment before provides an in-depth discussion of why we obtain such the result.
Procedure

The relative efficacy of changes in the tax structure can be measured in the following manner. First, initial values for all parameters that affect (3.16) are selected. The marginal tax rate is assumed to be 30%, which is the rate that Australian rail freight firms are currently facing (Reinhardt and Steel, 2006). The discount rate is estimated to be 6% as shown in 3.4.7. Initial optimal asset lives of 20, 25, 30 years are considered for the locomotive. For the wagon, initial optimal lives of 25, 30, and 35 years are examined. The original market value is assumed to be $5.5 million for the existing locomotive, and $0.4 million for the existing wagon. These values are consistent with those reported by ARA and Booz Allen & Hamilton (2007). Given that technological advancements result in improved fuel use (for locomotives in particular), lower repairs or other improvements in equipment performance, one can expect certain percentage – \( \alpha \) – increases in equipment market values, i.e.,

\[
M(0) = (1 + \alpha/100)M(0)
\]

\( \alpha \) is initially assumed to be 10%. The rail freight company is initially assumed to be operating under the straight line depreciation method, with the annual rate of 4% for the locomotive and 3.33% for the wagon. (3.17) and (3.18) can be used to calculate annual depreciation deductions of rolling stock under the straight-line method.

The value of (3.16) is computed under the initial scenario (without any tax concessions) and then recomputed using these hypothetical tax regulations:

- **Tax Code 1:** Current depreciation rate is used. The 30% investment allowance rate is permitted to newly acquired equipment. No investment tax credit is allowed.

- **Tax Code 2:** New locomotives are written down over 12 years. New wagons are written down over 15 years. Investment allowances and investment tax credits are not permitted.

- **Tax Code 3:** New locomotives are written down over 12 years. New wagons are written down over 15 years. The 30% investment allowance rate is also permitted to newly acquired equipment. No investment tax credit is allowed.

- **Tax Code 4:** New locomotives are written down over 3 years. New wagons are written down over 5 years. Investment allowances and investment tax credits are not permitted.

- **Tax Code 5:** New locomotives are written down over 3 years. New wagons are written down over 5 years. 30% investment allowance rate is also permitted to newly acquired equipment. No investment tax credit is allowed.
• **Tax Code 6:** Current depreciation rate is used. The 30% investment tax credit is permitted to newly acquired equipment. No investment allowance is permitted.

• **Tax Code 7:** Current depreciation rate is used. Investment allowances and investment tax credits are not permitted. The tax rate is 50% reduced.

The efficacy of these hypothetical tax codes is measured by the extent to which they increase the value of (3.16) from the initial scenario.

With the quality of data on which replacement decisions are made, there is a clear motivation for sensitivity analysis. Further motivation is provided by management practices that often only use financial models to form the basis for further discussion to a final decision, which should be made with due regard to intangible or qualitative factors (Christer and Waller, 1987). It is suggested that the context in which replacement decisions are made tends to make a parsimonious method of providing support worthwhile. In this research, sensitivity analysis is performed on the following parameters:

• **Discount rate.** The firm’s required rate of return has always fluctuated as indicated by its time series. A change of ±5 percentage points from the original assumed value will be used as a sensitivity run in order to investigate the extent to which variation in the discount rate affects the effectiveness of those hypothetical tax concessions.

• **Marginal tax rate.** Given the current economic outlook, there has been no indication from the Australian Government that the marginal company tax rate will be altered in the short term. In the long term, as shown by the historical path of corporate income tax rates, there is a chance that the rate will change as a response to base contraction measures, such as the introduction of accelerated depreciation, or massive debt. The effectiveness of those hypothetical tax concessions is therefore evaluated for various rates of corporate tax: in this case, 15% and 50%.

• **The purchase cost.** There are various models of rolling stock equipment with different purchase costs. Of interest is what happens to the efficacy of those hypothetical tax concessions as the purchase cost changes. The evaluation is therefore carried out for both the locomotive and the wagon for this price sensitivity purpose.

• **Rates of technological advancement.** Improvement in technology can be represented by a uniform percentage reduction in the Challenger’s running cost function and a uniform percentage increase in the Challenger’s resale value function. Since the
running cost functions are irrelevant to the analytical results, it is necessary to test how large percentage changes in market values of rolling stock are needed to cause a significant change in the efficacy of the hypothetical tax codes outlined above.

- **Optimal lives.** Values for the optimal lives are arbitrarily selected since it is expected that they would not significantly affect the replacement decision. The purpose of the sensitivity analysis is to prove that this is actually the case. In particular, it will be shown that the analytical results are insensitive across all combinations of assumed optimal lives of rolling stock.

- **Depreciation method.** Of interest is whether the choice of depreciation methods available to the rail freight firms in Australia affects the analytical results. Therefore, the evaluation is redone using the 150% declining-balance method of depreciation. Under this method, (3.19) and (3.20) are used to compute the annual declining-balance depreciation allowance for \( t = 1, 2, \ldots, N - 1 \). The last year’s depreciation is set to equal the difference between the original cost of the asset and the total amount of depreciation deductions from the first year up to year \( N - 1 \). As mentioned in Chapter 3, \( N \) in (3.17)-(3.20) is defined to be 25 years for locomotives, and 30 years for wagons.

### Results

The effects of using Tax Codes 1–6 for the locomotive are presented in Tables C.1–C.6, while the results for the wagon are presented in Tables C.7–C.12 (see Appendix C). Some apparent features can be observed from looking at these tables.

First, all hypothetical tax codes are likely to increase the marginal opportunity cost of holding current locomotive and wagon, thereby leading to more rapid replacement. These results hold true for all assumed parameters, all of which confirms that accelerated depreciation, investment tax credits, and investment allowances have the potential to modernise rail freight rolling stock fleets in Australia.

Second, doubling the depreciation rate (Tax Code 2) increases the marginal opportunity cost of holding current locomotives and wagons and therefore encourages more replacement investment, but not as much as the 30% investment allowance scheme (Tax Code 1). This is not surprising given that the benefits derived from depreciation tax shields are still spread...
over many years into the future (12 years for locomotives, and 15 years for wagons). Tax Code 4, which proposes that newly acquired locomotives be written down over 3 years and that new wagons be written down over 5 years, is likely to be more effective than the other two schemes when the discount rates are 5% and 10%. When the discount rate is 1%, however, the 30% investment allowance scheme prevails again. As expected, a combination of both accelerated depreciation and investment allowances (Tax Codes 3 and 5) provide better results than those of a standalone policy.

Third, the investment tax credit (Tax Code 6) is likely to influence the optimal replacement interval and the replacement investment to the largest extent possible. The evaluations show that an increase in the marginal opportunity cost of holding current rolling stock is maximised when the investment tax credit is allowed, while the growth is even larger than that resulting from combinations of accelerated depreciation and investment allowances. The rationale behind these results is as follows: the benefit from the investment allowance must be taxed before it is given to the firm, while the benefit from the investment tax credit is not. In particular, if the marginal tax rate is 30%, the 30% investment allowance provides equal amount of benefits to that under the 9% investment tax credit. Thus, if both were to be allowed at the same rate, the investment tax credit is likely to boost more asset replacement investment than the investment allowance. If the investment tax credit and the depreciation tax rebates are compared, the benefit to the taxpayer from the former could be realised in the first year after the asset’s acquisition, while the benefit from the latter is often spread over many years into the future. The benefit from the depreciation tax rebates would therefore be subject to relatively heavy discounting to the benefit from the investment tax credit when the applicable discount is relatively slight. As a result, changes in the investment tax credit are

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26 Here, the evaluations are carried out by assuming that no adjustment is made to the depreciable basis. For tax-neutrality reasons, some governments provide the investment tax credit with a condition that the company must reduce the depreciable tax basis of the eligible asset with the amount equal to the credit allowed (Bradford, 1980). In other words, the investment tax credit reduces the amount that can later be claimed as depreciation on the eligible asset. If this is the case, the incentive provided by the investment tax credit is somewhat reduced. When the simulations are carried out in a tax neutral fashion, the increase in the marginal opportunity cost of holding existing rolling stock is, as expected, reduced, but still higher than that resulting from permitting Tax Codes 1–5. All the conclusions obtained in this section therefore hold true even when the capital cost of the asset is adjusted by the amount equal to the investment tax credit.
likely to have a more significant influence on asset replacement decisions than changes in the
depreciation schedules.

Fourth, benefits provided by investment allowances and investment tax credits are slightly
reduced when the discount rate is increased as the discount factor applied to these benefit is
somewhat declined. However, the degree of discount rate sensitivity is low in comparison to
that of accelerated depreciation. These robust results are not surprising given the ambiguity
associated with the effects of the changes in the discount rate on optimal replacement ages.27
Moreover, the benefits of investment allowances and investment tax credits are paid to the
firm at the end of the first year after the acquisition of new assets. It can therefore be
concluded that the applicable discounting effect on these schemes is slight.

Fifth, accelerated depreciation does not seem to work well when the discount rate (or the
firm’s required rate of return) is low. A possible explanation is that changes in the discount
rate have two opposing effects on the marginal opportunity cost of holding the current asset:
(1) a negative effect based on changes in the discount factor applied to depreciation tax
shields associated with new assets, and (2) a positive effect based on the rate charged on
delaying receipt of depreciation tax shields associated with new assets. When the discount
rate is low, an increase in the PV of tax shields from accelerated depreciation is significantly
offset by low interest charged on delaying receipt of depreciation tax shields, which results in
an insignificant increase in the marginal cost of holding the current asset. When the discount
rate is high, the discounting effect becomes as strong as the second effect since the benefits of
depreciation tax shields are spread over a number of years into the future. In short, the results
regarding accelerated depreciation are insensitive to high discount rates.

Sixth, a combination of both accelerated depreciation and investment allowances not only
provides more incentive for the firm to replace their assets more quickly, but also can allow
these firms to hedge against a variation in the future discount rates (or the firm’s required rate
of returns). This conclusion is based on an observation that the results associated with Tax

27 The derivative of the RHS of the marginal condition (6b) with respect to the discount rate is

\[
\frac{1 - e^{-\gamma}}{(1 - T)(1 - e^{-\gamma})^2} C(0, s, l) + \frac{\rho}{(1 - T)(1 - e^{-\gamma})} \frac{\partial C(0, s, l)}{\partial \rho} + M(c) - \frac{T}{(1 - T)} \left( \int_{s}^{T} D(t) dt - M(a) \right).
\]

The sign of this expression is ambiguous, thereby indicating the ambiguous effect of changes in the discount
rate on the optimal replacement age.
codes 3 and 5 are insensitive to changes in the discount rate. Since the investment tax credit is equivalent to the investment allowance with higher rate, a combination of accelerated depreciation and investment tax credits would also be insensitive to changes in the discount rate.

Seventh, the results regarding investment allowances, accelerated depreciation, and their combinations are sensitive to the value of the marginal tax rate. In particular, liberal depreciation policies do not work well under low rates of marginal tax. This is not surprising given that benefits from depreciation deductions must be taxed before they are given to the firm. Accelerated depreciation and an investment allowance therefore yield less benefit if marginal tax rates are expected to be lowered. The opposite holds true if marginal tax rates are expected to be higher. Unlike accelerated depreciation and investment allowances, investment tax credits are not as sensitive to changes in the marginal tax rate. This conclusion follows from the fact that the benefit from the investment tax credit is not taxed when given to the firm.

Eighth, the results for the locomotive and the wagon are very similar. When performing the analysis against various rates of technological advancements in Tables 4.7a and 4.10a, it is also found that the results are extremely robust. Thus, it is clear from the evaluations is that the investment incentive provided by accelerated depreciation, investment allowances, investment tax credits, and their combinations is insensitive to equipment prices.

Ninth, all results described above are similar across all combinations of assumed optimal lives of rolling stock. This indicates that all the conclusions obtained above still hold, even when actual optimal replacement lives are different to those assumed here.

When parallel evaluations are performed with the 150% diminishing-balance depreciation method chosen instead of the straight line method, the same patterns discussed above can still be observed. This suggests that all the conclusions obtained above still hold for firms that choose to use the diminishing-balance method to work out the decline in value of their depreciable assets.

The analysis carried out above highlights how changes in depreciation tax rules and investment tax credits would impact the optimal replacement age. As an alternative to these
policies, the Australian Government could influence asset replacement strategies by changing marginal tax rates. In view of this, the test is also performed with the assumption that the tax rate is reduced by 50% (Tax Code 7). Results are presented in Table C.13 for the locomotive and C.15 for the wagon.

From looking at Tables C.13 and C.15, it is clear that a 50% tax cut is likely to increase the marginal opportunity cost of holding current rolling stock, which would have the effect of shortening the optimal replacement age and increasing replacement investment. This result is not surprising. If it is assumed that the after-tax discount rate is neutral to marginal tax rate adjustments, the direct effect of tax on the marginal opportunity cost of holding the current asset is always negative if: (1) no investment allowance and investment tax credit are permitted; (2) the depreciation basis is calculated based on the original cost; and (3) the asset is held longer than its tax life.\(^\text{28}\) (1) and (2) hold true for all the calculations performed here. In some cases, the asset is partially depreciated on its replacement. This provides a positive tax effect on the marginal opportunity cost of holding the current asset. The effect is to encourage the firm to postpone replacement. In all the simulations conducted here, however, this positive effect is not strong enough to offset the negative effect from (1) and (2). This means that the replacement age tends to fall from the tax cut. On average, however, an increase in the marginal opportunity cost as a result of the 50% tax cut is not as high as that resulting from permitting all the previous tax codes. This implies that the tax cut may not be

\[ \frac{\rho}{(1-T)^2(1-e^{-\rho T})} \left( \int_0^T D(t)e^{-\rho t}dt + 1e^{-\rho} + Ae^{-\rho} - M(0) \right) \]

\[ + \frac{\rho}{(1-T)^2(1-e^{-\rho T})} \left( M(0) - \int_0^T D(t)dt \right) e^{-\rho T} \]

\[ + \frac{\rho}{(1-T)^2} \left( M(0) - \int_0^T D(t)dt \right) \]

The second term and the third term of the above expression are zero under all the depreciation schemes permitted in the Australian rail freight sector if the asset is held longer than its tax life. The sign of the above expression therefore depends on the first term of the above expression. If investment tax credits and investment allowances are not permitted, the first term of the above expression and therefore the effects of a change in the marginal tax rate on the marginal opportunity cost of holding the asset are always negative under original cost-based depreciation schemes.

\(^{28}\) The partial derivative of the RHS of (6b) with respect to \( T \) is given by.
as effective in encouraging the rail equipment modernisation as liberalised depreciation and tax credit schemes.

It is also clear is that the efficacy of the tax cut varies directly with the discount rate (or the firm’s required rate of return). The reason is that the difference between the PV of the depreciation tax credits and the original cost of the asset is small in the presence of a low discount rate. This phenomenon weakens the negative tax effect on the marginal opportunity cost of holding the current asset.\(^{29}\) Moreover, if investment allowances and investment tax credits are permitted, the tax cut has the potential to reduce the marginal opportunity cost of holding the current asset and optimally increase the replacement interval when the discount rate is low.\(^{30}\) The tax cut provides slightly more incentive to the replacement of locomotives than to that of wagons. Since the results are insensitive to rates of technological advancement, it can be concluded that the efficacy of the tax cut is fairly robust with respect to the equipment price.

Tables C.14 and C.16 show parallel evaluations of Tables C.13 and C.15, with the 150% declining-balance method used instead of the straight-line depreciation method. The same patterns observed from Tables C.13 and C.15 are present in Tables C.14 and C.16. The discussion above is therefore still valid for firms using the declining-balance method. Note, however, that the efficacy of the tax cut, on average, is slightly reduced when firms are using the declining balance depreciation method instead of the straight-line depreciation method. This phenomenon is apposite given that the 150% declining balance method is a type of depreciation paradigms with accelerated cycle. Firms using this method have already enjoyed some benefits, and additional benefits provided by the government will be less pleasing to these organisations compared to those using the nominal depreciation method. This result is closely related to the concept of a diminishing marginal utility, under which most risk-averse individuals would behave in this way (Rejda, 1998). It is assumed, here, that rail freight firms are risk averse, an assumption which is standard for most businesses (Rejda, 1998). In sum, it is surprising that this diminishing marginal utility behaviour is not clearly observed with other tax codes.

\(^{29}\) Without investment tax credits and investment allowances, the first term of the expression shown in n. 28 above becomes less negative when the discount rate is lower.

\(^{30}\) With investment tax credits and investment allowances provided, there is a chance that the first term of the expression shown in note 9 becomes positive. The chance is higher as the discount rate is lower.
4.4 Phase III: Focus Group Discussions

In this final stage of the study, the data collected from an expert panel comprising six persons, who participated in a focus group designed to examine the findings from the first two stages and provided in-depth expert assessments of their implications, are examined. As stated in Section 3.5, the panel was comprised of a group whose expertise is in policies pertaining to rail operation. A structural discussion guide was used and important findings of first two stages of the study were presented to the panel at the commencement of the focus group. The discussions focused on the following themes:

- Examining the validity of findings from the first two stages.
- Providing in-depth expert assessments of their policy implications, i.e., identifying appropriate mechanisms to increase the uptake of new rolling stock in the Australian rail freight industry.

To put it briefly, the expert panel was generally satisfied with most of previous points established during the interview process. Further clarification regarding why the vehicle fleet age problem existed in the Australian rail freight section was contributed by the expert panel. This significantly illuminated our understanding of the core factors contributing to the problem of interest. The results from the quantitative analysis were found by the expert panel to entail a reality gap. Additional assumptions therefore needed to be made in order to validate our previous quantitative analyses. From the early findings, the expert panel then went on to draw out an appropriate set of policies (namely, a two-pronged approach to energy efficiency) that was expected to facilitate the uptake of new technology in the rail freight industry. The following subsections discuss these general results and their rationale in more detail.

4.4.1 Validity of early findings

The panel discussions reinforce the previously established underlying reason for the vehicle fleet age problem, which is the inadequate below-rail infrastructure existing in many parts of Australia. This deficient infrastructure prevents operators from buying the latest rolling stock technology off the shelf and putting it on Australian tracks, except for those lines where the infrastructure is able to support this new equipment. The additional cost of modifying
imported locomotives is too huge. This means that not many Australian rail freight operators can afford them, while those which can need a long life from their customised locomotives.

Several participants argued that the state of the track in Australia does not facilitate effective use of locomotives. An example given by the representative of a major operator is the cross between the heavy-haul coal environment and the light-weighty passenger system. Since only lighter locomotives can go through the passenger system, operators need to put more loco capacity onto hauling coal, i.e. three lighter locos instead of two bigger locos. This means that rail freight operators in Australia are exploiting more capital and more energy to haul the same amount of coal that they could do more efficiently if the infrastructure is set up differently. Thus, even if the rail freight industry in Australia were to have exactly the same technologically improved locomotives as those in other developed countries, running them on Australian track would still result in sub-optimum energy efficient. This means that the environmental and social impacts contributed by rail would still present even with the success of rail fleet modernisation. The implication drawn from the discussions here is that Australian infrastructure is the most important contributor to all the vehicle fleet issues, even more significant than other factors identified in Section 4.2.1.

According to the panel, the rail freight industry needs to address the problem with its domestic supply side, which is not performing in terms of ability to provide a product on time and at a reasonable cost. This confirms the same point found established by the interview data. One participant, who represents an advocacy body, indicated that the rail freight sector does not have the critical mass in terms of locomotive demand to have a supplier that builds locomotives from scratch. Instead, the industry relies heavily on the modification of locomotives built overseas, an undertaking which is hugely expensive. This has an important implication: creating more local demand for rolling stock equipment has a significant potential to fix the limited domestic supply of rail hardware problem. Doing so would also reduce the replacement cost of rolling stock equipment, which is one of important barriers militating against the technological investment in the rail freight sector.

The panel contended that many rail freight operators face market cycles and commodity cycles, especially the grain operators or those hauling other seasonal agricultural products. Customers will demand high-performance hauling services when commodity prices are high, and low-cost hauling services when commodity prices are low. Given this cyclical nature,
most major operators must have a mixed rolling stock fleet, i.e., the fleet comprises of equipment that ranges from brand new to very old. It is only when customers require high performance hauling that operators are able to afford the expense of purchasing new assets to provide high performance. When customers want low cost, however, the operators will utilise their old assets because that is the cheapest way to provide a service. This implies that, even when all the incentives to purchase modern rolling stock are provided by the government, old equipment may never disappear. The cyclical nature of the industry also makes it difficult to plan ahead with capital investment with any degree of certainty.

According to the panel, the additional cost resulting from the installation of any carbon price mechanism would certainly be passed on to customers, or be absorbed by the operator. Nevertheless, the mechanism would affect the strategic thinking of rail freight organisations and would make them more responsible. This mechanism would urge operators to measure their carbon footprint, gain control of it, and then start to look for ways to reduce it. One of those means is improved driver training so as to reduce inefficient practices, while another is investment in more new technology. Operators generally want to be good corporate citizens that minimise their carbon footprint, although there remains the possibility of them simply passing on the burden to their customers. The panel suggested that the installation of a carbon price mechanism is necessary to create a reasonable level playing field and that such a scheme should not bias other modes of transport for political reasons. This is to prevent the distortion of the market, i.e., more customers shifting to road, which would militate against the modernisation of rolling stock equipment as explained earlier during the stakeholder interview process.

With regard to the efficacy of using an investment allowance to provide incentives for rail freight operators to invest in more efficient and environmentally friendly technology, the panel discussions supported the main point emerging from the stakeholder interviews; that is, an investment allowance would only help the business of rail freight organisations in one particular year and would not change the landscape of rolling stock equipment across the sector. Furthermore, the scheme would only bring forward capital investment that has been already planned.

The panel contended that existing rail freight organisations have a rigid mindset that their rolling stock equipment should be kept in operation according to the current depreciation
schedule, i.e., 25 years for locomotives and 30 years for wagons. This mindset exists mainly within the CFOs, who, on the whole, are resistant to making the switch to new assets before the expiration of the old assets’ tax life. The only way to retire old equipment before the end of their tax life is to take most of the depreciation deductions upfront. Accelerated depreciation thus has the potential to change that mindset and could encourage operators to dispense with their equipment more quickly. This behavioural change is expected to be even more significant for wagons than locomotives. As stated by the representative of a major operator, wagons are currently thirty year assets according to the current depreciation schedule, but from a cost and technology perspective, it is too redundant. This representative is positive that his organisation’s replacement turnover would have been more quickly if wagons are ten-year assets.

Accelerated depreciation is likely to be supported by the incumbent major operators since the scheme would indirectly assist them in competing effectively against new entrants. As new competitors come into the market, they are likely to acquire new fleet in order to take market share off the existing operators, who will be stuck with their old fleet given the rigid mindset explained above. Thus, having a new depreciation paradigm with an accelerated cycle, which could turn that mindset over and could facilitate the move to a more updated fleet, is potentially attractive to operators. In addition to this, accelerated depreciation would help the rail freight sector to compete more effectively against the road transport sector, which already has a rapid turnover with respect to its equipment.

Another important point reiterated by the panel is that a reduction in profits as a result of using accelerated depreciation could potentially become a significant issue for listed companies since they need to deliver strong profits in order to impress their shareholders. This confirms the similar point made earlier during the report of the interview data. The panel also confirmed that, as a stand-alone policy, accelerated depreciation would not help much since it is not the only driving factor for rolling stock replacement. Nevertheless, it could be part of a whole suite of initiatives to assist rail fleet modernisation.

The panel agreed with the results from the scenario analysis, which indicated that the incentive provided by the tax credit is, on average, stronger than that of accelerated depreciation and investment allowances. The panel felt that this is largely owing to the fact that the benefit of the investment tax credit is not taxed before being given to the firm and is
therefore subject to slight discounting effect. It is expected that cash grants and subsidies would provide a stronger incentive than the investment tax credit. This is because cash grants and subsidies can be incorporated into the replacement model in a similar fashion to an investment tax credit. Moreover, the benefits paid to the firms via cash grants or direct subsidies are up-front, which means that they are not subject to discounting.

Although the panel held that the analytical results from the extended replacement model developed in the second phase of the research to be economically feasible, it was unsure if the model takes into account all the contextual features of the rail freight industry. If the objective is to incentivise organisations to put new assets on the ground, the analytical results found from the model make perfect sense. However, if the intention is to retire old locomotives and wagons and replace them with new technology, the panel argued that there is a gap in the analysis. In particular, even though accelerated depreciation and other tax incentives would definitely motivate them to buy new stuffs as the marginal opportunity cost of holding the current asset rises to a level that becomes uneconomic, the panel disagreed that these schemes would necessarily make existing operators completely retire their old assets. What would occur is more modern equipment being purchased instead of more replacement being undertaken. Part of this conclusion stems from the fact that Australian rail freight operators generally keep some of the ‘clunkers’ for areas of business that are cyclical in nature, for the reasons explained above.

One very important assumption that needs to be made in order to validate the analytical results from the modelling phase is that the below-rail infrastructure is optimal for both old assets and new assets. For example, the net after-tax marginal benefit of holding the asset may be reduced from utilising the new locomotive instead of the old locomotive; part of which results from a decrease in the repair and maintenance costs. However, it is useless to replace the old locomotive with the new locomotive if the new one cannot be operated in the current rail track. This suggests that, even with all the tax incentives being installed by the government, no replacement might occur at all. In this case, the operators have no choice but to keep on utilising their old assets since it they fit the infrastructure. One may also argue that operators can modify modern equipment to go on the Australian track, but there is a cost in doing so. This additional modification cost might sub-optimise the replacement decision. Therefore, it should have been included in the replacement model developed here.
4.4.2 Policy implications
The panel identified that many of the problems facing the Australian rail freight sector would disappear if the country had better below-rail infrastructure. For example, operators would be purchasing more modern locomotives from overseas if they did not have to pay high costs to modify them to suit Australian track conditions; fuel consumption of the sector would improve if the track has been set up differently so as to facilitate the optimal use of the operators’ rolling stock; the efficacy of accelerated depreciation and other tax concessions would not be suppressed by the substandard below-rail infrastructure that does not allow modern and efficient equipment to run on it. If the objective is to incentivise the modernisation of above-rail assets, the panel strongly contended that the below-rail assets need to be more closely attuned to that objective, even if this is often beyond the control of the operator. If there are no incentives to set up the below-rail infrastructure in a way that achieves efficiency goals for the above-rail part of the sector, these goals will never be achieved.

According to the panel, rail has the potential to have zero emissions if it is electrified. This, however, is difficult to achieve for two reasons. A representative of a rail advocacy body explained that there is regulatory impediment with regard to the access arrangements controlled by the ACCC. This is completely a political issue. The representative of a major operator pointed out that there is a huge cost involved in electrifying the network and, as a result, customers are not yet ready to pay for an electrified system. The recent Goonyalla to Abbot Point expansion of the coal chain in Queensland was raised as an example to illustrate a case where electrification could not be economically justified. On account of the two problems specified above, the project has been constructed for diesel-electric operations.

The above example indicates that upgrading the infrastructure (track, bridges, tunnels, etc.) is not an easy task that can be achieved rapidly. This led the panel to submit that it would be useful for the Australian rail freight industry to have other initiatives to assist in achieving greater technological investment in rolling stock in the short term. Direct financial incentives in terms of a subsidy or cash grant could achieve this. There are also indirect fiscal incentives, such as accelerated depreciation, investment allowance, and other tax concessions, that could, according to the panel, be implemented. Any incentive tied to the purchase of technologically efficient equipment was viewed by the panel as politically palatable, even
though this, alone, would not make any sweeping changes to the rail freight industry. In other words, any program that would allow government to be seen as doing something in the environmental box would almost certainly be politically attractive.

One panel member with expertise in policies pertaining to transport argued that the government would be reluctant to give direct financial incentives. Fiscal incentives appear to serve as a natural policy tool for a market-oriented government wanting to increase rail investment expenditures. Here, rail operators decide where and how to spend their investment rather than have it determined through a bureaucratic central authority, as in the case of a direct subsidy or cash grant. This means that there would reduced less administration costs for the government.

Panel members representing transport policy researchers were very vocal about the injustice of helping only the rail freight sector and completely ignoring the trucking industry because rail is alleged to be much better for environmental reasons. The trucking industry also needed to improve its environmental credentials since this sector results in many other externalities that rail does not contribute, e.g., degradation of road infrastructure, road fatalities, traffic congestion, etc. It is argued by the majority of the panel members that a level playing field needs to be established between the two sectors. The concern raised is that, once road starts using Liquefied Natural Gas (LNG), rail would lose its advantage in terms of its emissions performance. Rail could retaliate by having its system electrified or using LNG. The former is unlikely to happen in the short term for the reasons explained above, whereas the latter requires a considerable amount of funding for R&D. The panel was therefore very supportive of a subsidy program that encourages suppliers to undertake R&D on equipping locomotives with an LNG capability. It was contended, however, that suppliers will not do this independently and that there needs to be a prospective order from their customers. The policy implication is that R&D sponsorship needs to be set up in a way that promotes a partnership between buyers and their suppliers.

Since it makes no sense for operators to retire their old assets completely, it was argued that any incentives given should be tied to getting rid of some of the older equipment. Even if new equipment is being purchased, operators should only be qualified to enjoy the benefits if they retire some of older rolling stock, and locomotives in particular. Policies focusing on incentivising operators to upgrade their old locomotives and make them more energy efficient
are also necessary. This is because they are the only locomotives that are capable of running on the sub-standard track found in many regions of Australia.

A two-pronged approach to energy efficiency in the rail freight sector was proposed. In particular, it was argued that some incentives to buy new equipment combined with a ‘cash for clunkers’ scheme with a refurbishment option to make existing assets more energy efficient are needed to deliver appropriate outcomes in the short term. Incentives aimed at buying new equipment were regarded as particularly crucial for regions where the rail networks have already been upgraded to suit modern energy-efficient equipment, whereas programs targeting the refurbishing of older assets are necessary for track that is not suitable for modern equipment, which is generally heavier than the older equipment. In the long term, however, improving the below-rail infrastructure was identified as the only way to ensure the ongoing sustainability of the rail freight sector in terms of its overall efficiency.

4.5 Summary

The interview data confirmed that the rail freight sector in Australia performs poorly in terms of the average age of the equipment compared to that of other developed countries. It was also found that most medium and large operators have a mixed rolling stock fleet. By way of contrast, small operators either possess a very young fleet or a very old fleet, depending on their economic situation. In general, the average age of the coal fleet (both locos and wagons) is not as old as that of the general freight fleet, which transports everything else other than coal (e.g., containers, general goods, cattle, sugar, and minerals).

With respect to the decision to replace rolling stock, rail freight companies often conduct the following steps: alert, investigation, decision, implementation, and review. The replacement decision is a continuing activity. The duration of the decision is often significant since it also includes a buying process and an asset selection process. The latter can be quite time-consuming since the organisation needs to look at the timing, cost, quality, warranty, and so on. There is also long lead-time to build a new locomotive or undertake design work for customised locomotives.

With respect to the efficacy of using accelerated depreciation and other alternative schemes to provide incentives for rail freight operators to invest in more efficient and environmentally
friendly technology, it was found that none of the proposed schemes would make a sweeping change to the rail freight industry on its own. This is owing to both the scheme’s shortcomings and industrial factors that militate against the scheme’s purposes. An ETS is unlikely to meet its objectives since operators can almost ignore a carbon price if they: (1) passed the cost on to their customers; and (2) got their customers to accept this; or (3) could tell the rolling stock supplying companies to buy the permits instead; or (4) go back to the leasing organisations and try to negotiate a discount.

While being useful, the investment allowance scheme alone is unlikely to modernise the rolling stock fleet in the rail freight sector. Tax benefits provided by the investment allowance scheme are not large enough to drive the vast investment of rolling stock equipment. The decision to invest is primarily driven by market dynamics. The scheme would only bring forward capital investment that was already planned. Participants argued that an R&D tax concession provides a stronger incentive than the investment allowance scheme, since those not in a positive tax position can still claim the benefits. However, there is an educational issue associated with the R&D tax concession that needs to be addressed.

Accelerated depreciation on its own is unlikely to be successful because (1) tax is not the main replacement driver, rather, the business need is; (2) it would only apply to companies in a positive tax position; (3) it reduces the profit figure; (4) there are no criteria for improvement with respect to the purchasing of rolling stock equipment; (5) upfront capital is still required for equipment purchase; (6) it is too costly to make operators replace all their existing fleet; and (7) there are education issues.

The extended asset replacement model developed in Chapter 3 was applied to study rolling stock replacement in the rail freight sector. It was shown that, if the after-tax discount rate remains constant, or its effects are negligible, a reduction in the marginal tax rate would generally reduce the optimal age of rail freight rolling stock and, by implication, is likely to increase rail freight rolling stock replacement investment in Australia. But if the after-tax discount rate changes as a result of changes in marginal tax rates, the effects of a change in marginal tax rates on optimal age of rolling stock in the Australian freight industry are ambiguous.
The model also implies that all the tax-advantage schemes, e.g., accelerated depreciation, investment tax credits, and investment allowances, are likely to increase the marginal opportunity cost of holding the current rolling stock equipment. Ceteris paribus, this will lead to earlier replacement. Policies that focus on reducing operating expenditure are expected to yield unfavourable outcome as long as they are aimed toward the old asset. Re-engineering locomotives during replacements (e.g., installing new locomotives with new clean engines) to minimise fuel use and therefore emissions is likely to increase the marginal revenue of holding the current locomotive. This will lead to later replacement. Other possible financial policies such as cash grants and subsidies have the same effect on the replacement decision as that of the investment tax credit. Finally, it was demonstrated that the inflationary effect on the optimal replacement time is always ambiguous.

Scenario analysis and sensitivity analysis techniques were then employed to ascertain the relative efficacy of changes in tax policies. The results cohere with preliminary results gained from the in-depth interviews. Benefits from depreciation tax shields are spread over many years into the future. Thus, the financial incentive provided by accelerated depreciation is not as strong as that given by the investment allowance, which, in turn, provides less encouragement than the investment tax credit scheme. Accelerated depreciation does not seem to work well when the discount rate or the firm’s required rate of return is low. The efficacy of accelerated depreciation was found to be insensitive to high discount rates. A combination of both accelerated depreciation and investment allowances not only provides more incentive to the firm to replace their assets more quickly, but also can be used to hedge against a variation in the future discount rates or the firm’s required rate of return. The results regarding investment allowance, accelerated depreciation, and their combinations are sensitive to the value of the marginal tax rate. Investment tax credit is insensitive to changes in all parameters that affect the replacement decision, including the marginal tax rate. The investment incentive provided by accelerated depreciation, investment allowances, investment tax credits, and their combinations, is insensitive to equipment prices and the method of depreciation chosen. Finally, a tax cut is likely to cost the government more than the level of new investment that it is likely to create. The efficacy of the tax cut varies directly with the discount rate but is robust with respect to the equipment price. The effectiveness of the tax cut reduces slightly for firms using declining balance depreciation method.
Finally, the focus group data was presented. It was identified during the discussions that most major operators keep some old rolling stock in order to provide a low-cost service when this is required by customers. This is mainly due to the cyclical nature of the rail freight business, especially where agricultural products are being transported. It was revealed that the replacement process identified during the stakeholder interview is not followed by rail freight companies, with replacement decisions being driven primarily by ‘gut feel’, tonnage growth, and the need to match changes in the below-rail infrastructure. In general, the panel was optimistic about an accelerated depreciation scheme and felt that it would be able to encourage, to some degree, a more rapid turnover of rolling stock. An important barrier against the effectiveness of the scheme would be a reduction in profits as a result of using the scheme. This problem was regarded as being particularly significant for listed firms. With regard to the analytical results from the extended replacement model developed in the second phase of the research, the panel agreed that they are economically feasible. It was noted, however, that the currently suboptimal below-rail infrastructure and the cyclical nature of the rail freight business are not taken into account by the model. It was argued that, in the short term, the government would need to provide some other instantaneous initiatives. The first set of programs should aim to promote investment in new environmentally friendly rolling stock. The second set of incentives should aim at improving existing locomotives so that they can operate in an efficient way on sub-optimal infrastructure.
CHAPTER 5

CONCLUSIONS

5.1 Overview
This thesis aimed to ascertain the viability of using accelerated depreciation to increase the uptake of new rolling stock in the Australian rail freight industry. It began with a review of the literature so as to identify an appropriate set of research questions. It then dealt with methodological choices and rationale with respect to the methods used in each stage of the research. Having reported the findings that emerged from the data collected in each stage of the research, I now conclude with what this thesis has found. First, each research question established previously will be answered. Second, contributions to theory and practice will be discussed. I finish off with an indication of future research directions.

5.2 Research Answers
By reviewing the literature review closely related the research main focus, this thesis specified a number of questions essential to understanding whether accelerated depreciation could be used to address the aging rolling stock problem in the rail freight sector. The first set of questions related to how the effectiveness of accelerated depreciation might be reduced by specific characteristics of the rail freight industry and its firms. These questions were:

- What are the specific characteristics of the rail freight sector in Australia that have resulted in the very large long investment period of rolling stock equipment and, in particular, is the contribution of accelerated depreciation likely to be significant in influencing the modernisation of such equipment?
- Are there any industry-specific factors that might prevent Australian rail freight firms from adopting accelerated depreciation even though it is available?
- How are decisions made regarding rolling stock replacement among Australian rail freight firms and, in particular, is taxation implication an important driver of replacement investment?

The second set of questions related to the extent to which accelerated depreciation could be used to reduce the optimal replacement cycle of rail freight rolling stock.
This section presents the answers to each question listed above by summarising the findings from the literature review and the results from the three-stage mixed methodology. It finishes off by providing answers to the core research problem: does accelerated depreciation hold any for addressing the vehicle fleet age problem in the Australian rail freight sector?

What are the specific characteristics of the rail freight sector in Australia that have resulted in the very large long investment period of rolling stock equipment and, in particular, is the contribution of accelerated depreciation likely to be significant in influencing the modernisation of such equipment?

The proposed accelerated depreciation regime is intended to provide incentives for operators to invest in more efficient and environmentally friendly technology. It appears that the Australian rail freight industry possesses a number of unique characteristics that could militate against the modernisation of its rolling stock equipment, even in the presence of an accelerated depreciation environment.

Accelerated depreciation reduces the profit figure in the first year, which would be a big help to his organisation in terms of reducing its tax. However, upfront capital is still required to purchase new equipment. If the company is undercapitalised, it would not be able to afford this expensive equipment. It is clear that many of rail freight companies would face this problem as a result of rail’s low market share of freight compared with its direct competitor: the trucking industry. The low demand issue within the rail freight sector is strongly correlated with the limited capability of the network in Australia. Rail freight operators have long been constrained by the amount that they can pull, and the length of the train allowed. The inequality in access regimes between road and rail sectors also plays its part in leading rail to have a low market share of freight. Unlike rail freight operators, road freight operators pay for their vehicles, but are not required to pay for using the network. This implies that the road sector is much more competitive than the rail sector in the freight market. Furthermore, the regulations pertaining to rolling stock operation are not as flexible as those pertaining to truck operation. Stringent regulations add more costs to the rail operators for moving freight, which ultimately have to be passed on to customers.

The next issue is obviously the acquisition cost of replacing rolling stock. The price of new equipment is generally expensive. The consequence is that it becomes cost prohibitive for operators to consistently replace the existing equipment given the current level of demand,
and given that the old equipment still generally suffices. Accelerated depreciation might reduce the severity of this problem by offering some financial benefits for the new equipment purchase, i.e., firms would be able to recoup some their investment in new rolling stock earlier. However, it is clear, from the modelling, that the benefits are not that large compared to other tax concessions. Many of the participants during the interview process also believed that only a few operators would be moved by the limited benefits of accelerated depreciation and risk their business by borrowing a large sum of money for the rolling stock replacement.

Australian rolling stock equipment costs a lot more than an equivalent US example. First, the kinetic envelope or the infrastructure framework that operators have to operate within cannot fit standardised equipment from overseas, and imported locomotives must be tailored to suit the local infrastructure. Second, there are different accreditation standards across different Australia. Different state-based accrediting authorities require a different set of features. Introducing new equipment requires approval in multiple jurisdictions, thus making it harder, more complex, and more expensive to get new equipment accredited nationally. Finally, there are limited suppliers in Australia. There is only, from a point of view for locos, two major suppliers, so they have a duopoly power to set a high price. Moreover, manufacturers generally cannot get the price down because there is no continuity of orders. Production lines start and stop, so there are additional costs to factor into the sale price.

Apart from making the cost of replacement expensive, the limited capability of the below-rail networks in Australia presents the most important issue identified. Even though accelerated depreciation could successfully motivate operators to acquire emission-efficient equipment, the below-rail infrastructure would still not allow operators to put them immediately on certain areas of track. Another interesting theme identified is that, even after the modification, the substandard state of the rail track in the country would still mean that operators need to sub-optimise the use of their equipment. In other words, even if the rail freight industry were to have exactly the same technologically-sound locomotives as those in developed countries, running them on the Australian track that does not facilitate their effective use would still not be efficient. In this case, fleet modernisation that might result from implementing accelerated depreciation will not greatly improve the environmental and social outcomes of the rail freight sector. The implication is that accelerated depreciation would have limited value to the Australian community if the infrastructure problem prevails.
Grain and cattle lines are representative of segments of rail freight business that are extremely cyclical in nature owing to seasonal variability. Customers along these commodity rail networks will demand high performance supplier of hauling services when commodity prices are high, and low cost hauling services when commodity prices are low. This means that rail freight operators would need to keep their older assets for the low-cost tasks required by customers. Accelerated depreciation might lead to greater acquisition of efficient rolling stock, but it would not necessarily reduce the number of inefficient assets because of the business’ cyclical nature.

Another factor working against accelerated depreciation is that current regulations pertaining to the environmental performance of the rolling stock equipment in Australia are not particularly stringent. Accelerated depreciation might encourage operators to purchase more new equipment, but whether the new equipment will be environmentally efficient is another issue. At present, there are no criteria for improvement with respect to new rolling stock purchasing. Rail freight firms might simply purchase more of the lower-end technology, rather than rolling stock using improved technology. This is consistent with the situation in Sweden during the post-war period, where a lot of bad investment projects were undertaken by Swedish firms for the sake of acquiring assets on which they could make use of accelerated depreciation for tax benefits (Muten and Faxen, 1966).

Are there any industry-specific factors that might prevent Australian rail freight firms from adopting accelerated depreciation even though it is available?

The historical examples make it clear that the extent to which accelerated depreciation provisions can have a positive effect depends largely on the extent of their use. A number of constraints that may militate against rail freight firms’ shifting from normal depreciation practice to accelerated methods have been identified.

As a tax-based mechanism, accelerated depreciation only applies when companies are in a tax-paying position. Yet major rail freight operators with a high asset base will usually be in a negative tax position. Thus, accelerated depreciation is unlikely to facilitate the modernisation case in the rail freight sector to a substantial extent. This problem has historically been the case in Japan and several European countries (see Section 2.3.2 for more details).
A firm’s accounting conventions might also prevent rail freight organisations from adopting accelerated depreciation. In particular, its use can lead to a reduction in the profits before tax. Publicly listed rail freight organisations would surely have to face this dilemma since the reduced profit figures would have an adverse impact on share prices. General rail freight firms also might not elect to adopt accelerated depreciation since reduced profit figures might negatively affect their credit rating when they are seeking loans.

The rail freight industry is used to re-engineering and cascading rather than replacing. Many operators store unused equipment for future use. Some of the older locomotives and wagons from the coal fleet usually get cascaded into the intermodal or regional freight area, in which the performance requirements are lower than those of the heavy haul of coal. This re-engineering-oriented characteristic is largely correlated with the sector’s inability to grow market share and the difficulty of acquiring new equipment, which involves huge costs and long lead time. It is also correlated with the fact that suppliers of rail hardware have technical and parts support for locomotives and other rolling stock that are very old, whereas in other industries, they do not have that kind of support. Accelerated depreciation only help a replacement case, but not a re-powering case. The problem is that it is too difficult and too costly to make the operators replace all their existing fleet.

Administrative complexity could suppress the scheme’s applicability. This problem might be prominent among small rail freight operators. Here, the scheme might administratively be too complex and there might be too many accountants involved in the process of claiming the benefits, thereby causing additional costs.

**How are decisions made regarding rolling stock replacement among Australian rail freight firms and, in particular, is taxation implication an important driver of replacement investment?**

The use of tax mechanisms to encourage more replacement of rolling stock would be effective if tax considerations were the main driver of a replacement decision. In the rail freight sector, however, tax benefits would facilitate rolling stock replacement decisions, but would not directly lead to the decision. There are other more important alerting factors. In particular, the decision to replace is primarily driven by market dynamics.
The replacement of existing rolling stock within the rail freight sector is usually contemplated if the new equipment significantly increases performance/capacity of the business. The market needs to be there for the replacement process to start. Another key alert situation is when asset age-dependent running costs are higher than attainable with an alternative asset. Other replacement drivers include (1) increased reliability and/or availability; (2) a standard for safety; (3) performance evaluation (at a certain kilometre interval); (4) an improvement in productivity; and (5) the need to match changes in the below-rail infrastructure.

According to the literature pertaining to capital equipment replacement, all the driving factors explained above are common circumstances that alert the organisation to the need for equipment replacement. Replacement for increased performance/capacity of the rail freight business therefore accommodates tonnage growth. The trade-off between the replacement cost and the age-dependent running cost is regarded by almost every replacement investment study to be a very important economic force leading to equipment replacement (e.g., Eilon et al., 1966; Christer, 1984; Ahouissoussi and Wetstein, 1995). The only exception is where operating (revenue) costs are generally near-constant or increasing only slowly over time. In these business sectors, an improvement in productivity is considered to be a more significant replacement driver (Scarf et al., 2007). The total reliability and/or availability cost (saving) affects the replacement decision to a certain degree, and so increased reliability and/or availability can be a vital replacement force. A standard for safety and performance evaluation (at a certain kilometre interval) are voluntary requirements set by firms for reasons relating to service standards and/or good corporate image, whereas the need to match changes in the below-rail infrastructure is the additional requirement set by the infrastructure owner. This notion of prequalification for environmental performance is important to the rail freight industry’s code of practice, and therefore is often taken into account in the asset replacement decision making process.

Even though the benefits provided by accelerated depreciation do not solely drive the replacement decision, they help to facilitate the decision. This is because tax benefits would increase the NPV of the replacement decision, or equivalently, reduces the average effective discount for the replacement decision. Tax benefits will also reduce the contract price for hauling freight. This should improve the business of the rail freight, and make it easier for operators to buy more new rolling stock. Furthermore, benefits given by accelerated depreciation will be factored into suppliers’ cost of equipment ownership calculations. This
means that the price of rail hardware is likely to decrease, thereby encouraging operators to replace in this environment. The above analysis is consistent with the literature, which tends to say that favourable changes made to the depreciation schedule tend to have a positive impact on the replacement decision to a certain degree.

**To what extent would accelerated depreciation reduce the optimal replacement cycle of rail freight rolling stock in Australia?**

The components of the opportunity cost for holding a piece of rolling stock equipment that are affected by changes in the tax structure are derived in equation (3.16). The extent to which each tax concession would reduce the optimal replacement cycle of rail freight rolling stock is then measured by the degree to which it increases the value of (3.16) from the status quo scenario. The efficacy of accelerated depreciation was compared with alternative mechanisms, including an investment allowance scheme, combinations of investment allowance and accelerated depreciation, an investment tax credit scheme, and a reduction in the company tax rate.

Ceteris paribus, the investment allowance scheme currently permitted in Australia is likely to reduce optimal replacement age and increase replacement investment rates. The efficacy of the scheme is insensitive to changes in discount rates (or the firm’s required rate of return), technological advancement rates, equipment prices, and the method of depreciation chosen by firms. The effectiveness of the investment allowance scheme, however, varies directly with the marginal corporate tax rate. Since there has been no indication that changes in the marginal corporate tax rate are likely to be made in the near future, the investment allowance scheme will continue to be effective. The expiration of the scheme at the end of 2010 will negatively affect the replacement investment ages and rates for rail freight rolling stock. The limited timeline of the scheme is also unfavourable to the rail freight sector, in which most firms are classified as medium and large enterprises.

Doubling the depreciation rate encourages rail freight firms to increase replacement investment rates. Yet, the incentive is not very strong, compared to the investment allowance scheme. This is due to the very long lifespan of rail freight rolling stock. Benefits from 50% reduction in the tax life of rolling stock are still spread over too many years in to the future, and thus are subject to heavy discounting. The analysis shows that the incentive provided by another tax code, which proposes that newly acquired locomotives be written down over 3
Like the investment allowance scheme, accelerated depreciation is insensitive to equipment prices and choices of depreciation methods, but sensitive to variations in rates of the marginal tax. The results also indicate that accelerated depreciation does not work well if the discount rate (or the company’s required rate of return) is low and that the results are robust to high discount rates. However, it has been estimated that the discount rate is currently greater than 5% (on the after-tax basis) and that the figure is likely to continue rising in the near future (see Table 3.1). Since the marginal tax rate is expected to remain constant, while the discount rate is expected to rise, the efficacy of accelerated depreciation is unlikely to be compromised if it is introduced now. To hedge against variations in discount rates (firms’ required rate of returns), one can combine accelerated depreciation policies with investment allowances, although the combinations are still sensitive to levels of marginal tax rates. Furthermore, the incentive provided by the combinations is also significantly stronger than that given by an individual policy.

The investment tax credit is likely to reduce the optimal replacement interval and the replacement investment to the largest extent possible. An increase in the marginal opportunity cost of holding current rolling stock is maximised when the investment tax credit is allowed – the growth is even larger than that resulting from combinations of accelerated depreciation and investment allowance. The efficacy of the tax credit scheme is insensitive to changes in all parameters that affect the replacement decision, including variations in the marginal tax rate that cannot be neutralised by allowing the previous incentive schemes. Cash grants and subsidies are expected to provide a stronger incentive than the investment tax credit. This is because the benefits paid to the firms via cash grants or direct subsidies are up-front, which are not subject to discounting.

The rise in the marginal opportunity cost of holding current equipment as a result of the 50% tax cut is not very significant. This implies that any tax cut is likely to cost the government more than the level of new investment that it is likely to create. Moreover, the consequences of tax cuts are not always favourable. If tax credits and investment allowances are permitted, the analytical results provided here show that the tax reduction has the potential to adversely affect the replacement investment rates. The efficacy of the tax cut, on average, is slightly
reduced when firms are using the declining balance depreciation method instead of the straight line depreciation method. This result is closely related to the concept of a diminishing marginal utility. Apart from this, the efficacy of the tax cut varies directly with levels of discount rates. It is insensitive to equipment prices.

**Does accelerated depreciation hold a particular promise for addressing the large long investment periods for rolling stock in the Australian rail freight sector?**

It was found that the efficacy of using accelerated depreciation to encourage rolling stock fleet modernisation in the rail freight sector is limited. The most fundamental problem is that poor infrastructure is prevalent in many parts of the nation, which means that some of the antiquated locomotives operating grain and livestock routes, for example, would never disappear because they are the only ones suitable to operate there. This infrastructure problem weakens the opinion of many rail executives participating in this research who rather unsurprisingly support a tax subsidy that will improve their bottom line at no costs to their budgets. This is proof of nothing given that when offered a subsidy, most parties will assent. Although such subsidies presumably would cause some increase in the purchase of new equipment, it is not at all clear that the modernisation would fully take place, especially if deficient infrastructure is the prime culprit. Apart from poor infrastructure, there are many other contextual factors militating against the usefulness of accelerated depreciation. Taxation is one of many factors that may restrain investment in environmentally efficient technologies. Even with a financial assistance provided by accelerated depreciation, rail operators might not to re-invest in new rolling stock unless they can (1) achieve both a certainty of investment and profitable returns, and (2) afford the significant replacement cost.

It is likely that accelerated depreciation, on its own, will not be widely applicable in the rail freight sector. For example, (1) companies not in a tax-paying position will not be able to enjoy the benefits; (2) publically listed companies will be reluctant to shift from normal depreciation practice to accelerated methods because of the reduction in profits as a result of using accelerated depreciation; and (3) small operators might find the use of accelerated depreciation methods too administratively complex. Most rail freight companies possess a re-engineering-oriented characteristic, and therefore will choose not to use any incentive scheme associated with the replacement option. The financial incentive given by accelerated depreciation is not as strong as that given by other competing schemes, e.g., investment allowances, investment tax credits, and cash grants or subsidies. Moreover, accelerated
depreciation does not seem to work well for firms that require a low rate of return on capital investment. Allowing accelerated depreciation to existing equipment is also unlikely to affect the replacement strategies of the Australian rail freight firms, which tend to hold on to their rolling stock even after they are totally depreciated.

Despite this, accelerated depreciation is certainly not without some uses for the rail freight industry. Even though accelerating the depreciation schedule would not be a significant driver for equipment replacement, it would relax the operators’ rigid mindset that their rolling stock equipment should be kept in operation according to the current depreciation schedule, apart from improving the NPV of the replacement decision. While accelerated depreciation alone is unlikely to bring about desired level of investment in more efficient rolling stock (unless all of the obstacles described above are addressed), the scheme could form part of a suite of initiatives. An important point is that accelerated depreciation should never be treated as a primary mechanism. To change the landscape substantially, there is a need to adopt other measures to support the use of accelerated depreciation. This has always been the case in every country where accelerated depreciation is used as an instrument to encourage investment in selective business areas.

Furthermore, there are some specific conditions that need to be implemented along with the scheme to improve its usefulness or to prevent it from being misused. In particular, there should be criteria for improvement with respect to the purchasing of rolling stock equipment so as to prevent firms from acquiring greater numbers of environmentally-acceptable rather than class-leading rolling stock. Alternatively, the privilege should be given to firms that purchase new equipment in order to retire some of their older equipment. Another recommendation is that the amount of allowance and the length of time of the allowance need to be made clear to potential investors. It would also be better for the government to provide the scheme on an indefinite or indeed continuing basis, rather than on a short-term basis so as to create an atmosphere of confidence and enable forward planning.

Finally, the political climate is right to pursue any incentive tied to the purchase of emission efficient equipment. Introducing accelerated depreciation would allow the government to be seen as doing something in the environmental box given its failure to introduce a carbon price. Even though this, alone, would not make any sweeping changes to the rail freight industry, it would almost certainly be politically attractive.
5.3 Contributions to Theory and Practice

Given the original motivation of this thesis, which is to ascertain the viability of accelerated depreciation as a means to provide incentives for rail freight operators to invest in more efficient and environmentally friendly technology, this thesis has accomplished more than it sets out to. This section focuses on the contributions that this study makes to managerial practices and policy making, in addition to its theoretical contributions.

5.3.1 Practical contributions

Stakeholders concerned with rail freight operations in Australia are able to benefit from the research findings, with implications for rail freight organisations themselves, in addition to transport policy makers. It should be noted that all the practical implications from this research discussed below only apply to the rail freight industry. The asset replacement procedure and other managerial systems of each industry would be unique. Therefore, it cannot be said with certainty that the managerial practices found in this thesis can be generalised to other sectors beyond the rail freight industry. Likewise, the effectiveness of the policies considered in this study largely depends on the context of the area in which they would be used. To determine whether their efficacy would be the same in other sectors would require another in-depth study on the specific surroundings of the sector under investigation that might jeopardise the viability of the proposed policies.

Contributions to managerial practices

The procedural issues of rolling stock replacement and the rolling stock replacement system methodology discussed in this thesis are based on the current practise at several rail freight operators participating during the interview process. Obviously, managers of rail freight organisations who are significant involved in making rolling stock replacement decisions can utilise the management systems that have been established here in order to ensure appropriate and effective consideration of possible rolling stock replacement requirements. Key elements in the replacement process include: identifying a list of circumstances that give rise to a replacement alert; information gathering (undertaking of asset replacement studies); the engineering evaluation of feasible replacement or other strategies (e.g., refurbishment and cascading); decision-making based on investment appraisal criteria widely understood with the organisation; the ability to update decisions as emerging factors arise; and follow-through systems (monitoring of replacement implementation, risk management, and review).
In addition to rolling stock replacement recommendations, this research explains management systems with respect to finance and operation of rail freight rolling stock fleets. The underlying principles for leasing the equipment and for purchasing a large amount of rolling stock equipment have been put forward. The procedural issues of rolling stock maintenance have also been suggested. These are (1) main cases that lead operators to dispose their rolling stock equipment; (2) a number of options to deal with equipment that is no longer commercially utilised; and (3) certain precautions to minimise the cancellation of services from the unexpected break down of equipment (see Figure 4.2 for the summary of rolling stock operational management process). All these recommendations can be exploited by asset managers for efficient management of rolling stock fleets within their organisations.

**Contributions to policies pertaining to rail freight operation**

Policy makers looking for a suite of incentives to increase rail freight’s social, environmental and economic advantages can certainly utilise the results. This study has assessed the efficacy of accelerated depreciation against other incentive schemes. It indicates that accelerated depreciation alone cannot be the ultimate answer with respect to improving the efficiency of Australian rail freight fleets. This is mainly because of the often poor below-rail infrastructure, which cannot be fixed in a short period of time. This study advocates a mixture of initiatives may be more appropriate in the short term:

- **Investment in new environmentally friendly rolling stock.** Tax incentives (e.g. depreciation schemes, investment allowances, R&D tax credit and changes in marginal tax rate) should be introduced for purchasing new, environmentally friendly locomotives, wagons and other equipment, designed to encourage re-equipping of the fleet and provision for growth;

- **Refurbishment options to make existing rolling stock more energy efficient.** Since it makes no sense for operators to retire their old assets completely, policies focusing on technological investment in rail freight rolling stock should be combined with direct funding support (e.g. cash grant) to incentivise operators to upgrade their old equipment (e.g., installing existing locomotives with a freight-miser system or installing new, energy-efficient engines) to minimise fuel use and emissions;
In the long term, however, improving the below-rail infrastructure is the only way to ensure the ongoing sustainability of the rail freight sector in terms of energy efficiency.

Also highlighted is that all the incentive schemes being considered, e.g., an ETS, investment allowances, R&D tax, and accelerated depreciation, have their own issues that need to be addressed. A number of ways to increase the efficacy of each scheme have been addressed. All the policy advices presented have implications for the potential implementation of these policies as means to promote technological investment within the rail freight sector. They will also have broader application to other transport sectors looking to promote technological investment via similar incentives.

5.3.2 Theoretical contributions
A major theoretical contribution is the extended asset replacement model developed in Chapter 3. The novelty of this model is its comprehensiveness. The effects of technological advancement, taxes, and inflation have been analysed by previous replacement studies. The literature, however, indicates that these three factors have not been incorporated into the replacement model simultaneously. The model developed here is therefore a more generalised version of many previous replacement models. Since the model was derived from the replacement procedure of general assets (not just rolling stock equipment), the model certainly could be used by other studies that seek to investigate asset replacement beyond the rail freight sector. As a consequence, the implications of properties of the proposed model drawn in this thesis could be applied to any depreciated asset.

Contributions to asset replacement study
By analysing the properties of the extended asset replacement model exclusively developed for this research, several implications for the study of asset replacement have been discovered.

When the corporate tax rate is changed exogenously, optimal asset duration must be recalculated. Higher $T$ has two effects on the asset’s optimal scrapping time. The first or direct effect is independent of the discount rate. The second or indirect effect of $T$ on the optimal time to scrap the asset exists because the higher tax rate is likely to reduce the after-tax required rate of return or the after-tax discount rate. Both effects depend on asset duration
and types of depreciation methods used to calculate depreciation deductions. In specific terms, the firm must determine a) whether the asset is completely written off upon the termination time, and b) which type of depreciations governs their deduction calculations.

The overall effect that the tax rate has on the optimal scrapping time depends on the relative sizes of the direct and indirect effects. If the depreciation basis is calculated based on the original cost of the asset and the asset is fully depreciated before its termination (the circumstance that mostly reflects the Australian rail freight sector), this research shows that the optimal asset life is likely to increase as the marginal tax rate increases. Other results obtained for this matter have been summarised in Table 4.2. Note that the tax-adjusted asset replacement model developed by Smith (1990), which the model derived here mostly resembles, indicates completely different observations. Smith (1990) finds that tax rate adjustments play a very minor role on most scrapping decisions.

Likewise, there are both direct and indirect effects of exogenous changes in the marginal tax rate on the optimal timing of the replacement decision. By ignoring the investment tax credit not permitted in Australia, this study finds that the direct effect of changes in the marginal tax rate on the optimal replacement timing is dependent on types of depreciation methods and the asset’s economic life, in addition to the depreciation life for tax accounting and the size of the investment allowances. By considering the tax environment under which the Australian rail freight sector is governed, it can be concluded that the direct effect of tax adjustments on the optimal time to replace rolling stock is generally positive. However, if the indirect effects are included, the net effect of tax rate adjustments on the optimal replacement interval is always ambiguous, regardless of asset types and the country’s tax system. This conclusion contradicts that of Smith (1990), who contends that the overall effects of changes in the marginal tax rate on the optimal replacement age of the asset is generally positive. The model demonstrates that the effects of tax-advantage schemes (e.g., accelerated depreciation, investment allowances, and investment tax credits that are permitted to the purchase of new assets) on the optimal replacement time is generally negative. This conclusion is generally true for all assets, including rail freight rolling stock. Smith (1990) also observes the same phenomenon.

Provision of accelerated depreciation to existing equipment, in addition to new equipment, might sound like a double-incentive tool on the surface. However, the model developed here
indicates that this provision is unlikely to affect the scrapping strategies of the Australian rail freight firms, which tend to hold on to their rolling stock even after they are fully depreciated. Even worse, if the asset is partially depreciated upon its termination or replacement, allowing accelerated depreciation to apply to existing equipment has the potential to encourage the firm to postpone replacement decisions. These conclusions are consistent with those obtained by Prezas (1992, 1994), though with a different model employed.

When inflation is included in the scrapping condition, the model derived here implies that it affects both the marginal benefit and the marginal opportunity cost of holding the current asset. The analysis indicates that the after-tax marginal benefit of holding the existing asset always reduces if the inflation rate is higher. The effect of changes in the inflation rate on the marginal opportunity cost, however, can be either positive or negative, depending on (1) whether the asset is short or long; (2) asset duration; and (3) type of deprecations governs the deduction calculations. The overall effect is therefore not monotonic.

The replacement problem under inflation yields slightly different results. As with the scrapping case, the inflationary effect on the marginal benefit is monotonically negative, while it is ambiguous on the marginal opportunity cost depending on the economic life, relevant tax features and replacement situation of a particular asset. Overall, higher inflation can either increase or decrease the optimal time of the replacement decision. The difference is that the net effect for the replacement case is always ambiguous, while the same effect can be negative in some circumstances for the retirement case.

The conclusions drawn here with regard to the inflationary effects on asset abandonment or replacement are similar to those found by Howe and Lapan (1987); that is, the effect of inflation is indefinite depending upon the economic life, relevant tax features, and the replacement situations of the particular asset. Other similar studies often find that the effects are generally unambiguous. For example, Nelson (1976), Bates et al. (1979), and Bates and Rayner (1980) find that the effects are generally to lengthen the optimal replacement age, whereas Bartholomew (1980) discovers the opposite results. Brenner and Venezia (1983) observe that increased inflation tends to decrease the duration of ‘short’ assets and tends to increase the duration of ‘long’ assets. On the other hand, Howe (1987) contends that for many business assets, the impact of a change in inflation on asset life is effectively neutralised.
Contributions to research methodology

Research findings in finance often require time- and context-free generalisations. Thus, they must be value-free, i.e., independent of values, opinions, attitudes, or beliefs of individuals, groups, or societies. Mathematical analysis and statistical significance are repeatedly used as tools for answering the questions of interest in this type of research. In many respects, research in finance is closely related to a philosophical foothold in the quantitative methodology camps.

Combining a qualitative method and a quantitative approach, or in other words, using mixed methods in finance has not been proved to be very popular. The use of a mixed methodology in the field of applied social sciences, which includes finance, has been growing, as reported by, e.g., Alise and Teddlie (2010), and Molina-Azorin (2009) and (2011). However, the dominant research approach in business research studies is still quantitative (more than 50%), whereas only a small fraction (less than 20%) employs the mixed methods approach as its prevailing research methodology. This thesis provides another source of justification for using mixed methodology in finance research. It demonstrates that this approach is justifiable in instances where it is necessary to assess the likelihood of a policy being useful to stakeholders, and where the context of the policy and the context of the area in which it is applied are important. The evidence is that the mixed-method analytical framework established for this study has allowed the research findings to be fuller and more comprehensive. Had the quantitative part been conducted alone, what was found would have been meaningless without a better appreciation of the context, which was derived from the qualitative aspect of the research. In particular, it would have given mathematical results that would have constituted a perverted view of what the mechanisms could achieve in practice. In addition, the qualitative elements considered early in this study allow the subsequent development of the quantitative model to be more truly representative of the subject under investigation. Nevertheless, quantitative studies can only provide some answers in some limited circumstances and do not always explain the full complexity of what happens in the world where there are many variables. It has been shown in this study that the qualitative elements are able to fill in this reality gap.

The typology of the mixed methods design used can be defined as a partially mixed sequential design, whereby the qualitative and quantitative elements are conducted
sequentially in their entirely before being mixed at the data interpretation stage (Leech and Onwuegbuzie, 2007). It is therefore not significantly different from the partially mixed sequential design used in other studies (e.g., Bos et al., 1999; Hayter, 1999; Weisner, 2000). The major innovation of the design used is that, whereas other partially mixed sequential designs often involve only two stages where the quantitative and qualitative data sets are analysed separately and mixing takes place during the data interpretation stage, a third stage employing a focus group technique to gather and analyse stakeholder feedback of the findings from the previous two stages has been included. This member-checking component leads to the enhancement of the credibility of the research findings. In addition, it allowed the analysis of the quantitative results to be refined, and the emergent themes found in the previous two stages to be explored rigorously.

With some modifications, the research instrument developed will have application to other industrial sectors looking to promote technological investment via taxation tools. Interview schedule and focus group discussion guide could be slightly fine-tuned to suit similar studies in other industrial sectors. It is important that the questions asked during the interview process and focus group do not lead the participants to think that the proposed policy is entirely good for the industry and should be implemented in any case, and that the research exists only to support its effectiveness. To make the research outcomes rigorous and meaningful, it is important that we take a neutral stance when conducting the feasibility study. Since the viability of the proposed policies is largely dependent on the contextual features of the industry in which such policies would be applied, it is also necessary that the interview schedule and focus group discussion guide ask the participants to draw out these issues.

The extended asset replacement model exclusively developed for this research could be applied to study the replacement problem of other assets. Its all-inclusive aspect should allow future asset replacement study to be much more realistic. We have also derived a cost minimisation version of the model (see Section 3.4.6), which implies that revenues generated by an asset under investigation are irrelevant to the replacement decision. The novelty of using this version of the model in future asset replacement studies is that the amount of data collection should be significantly reduced without having to radically compromise the applicability of the replacement model developed.
In addition, the research has demonstrated an innovative way to analyse the effects of changes in the tax structure without having to rely on information about the inter-temporal cost and revenue stream associated with a specific asset. For commercial confidentiality-related reasons, corporate firms are often reluctant to release this piece of information. Thus, this approach should make future asset replacement study still plausible, even when this specific data is unavailable. This innovative approach should also allow future researchers to avoid confronting many empirical problems emerged from collecting that specific data. Having said that, the study would be more holistic if accurate data on residual earning streams and asset acquisition, and resale prices are available. That is, significant policy implications over the long run for the industry in which the proposed tax concessions would be applied could be provided if such financial data were made available in the first place. Researchers should obviously try to obtain all the relevant financial data first, and should only decide to employ the approach proposed in this thesis when there is no other alternative.

### 5.4 Limitations of the Study and Implications for Future Research

The models and analytical frameworks derived in Section 3.4 employ many simplifying assumptions. In specific terms, cash flows and future salvage values of rolling stock are assumed to be uncertain. The implication is that the value of the implicit abandonment option, which is a product of uncertainty itself, is zero. Ignored, too, is the value of waiting to invest as more information about the replacement costs become valuable, which has to be traded off against the lost opportunity. An extended analysis should therefore employ a real option pricing theory to study the effects of tax concessions on optimal asset life when the abandonment option and the delaying option are explicitly valued. A more extensive analysis should also account for the effects of uncertainty about future government tax programs.

All the scrapping and replacement conditions developed here implicitly assume that the salvage value is positive upon termination and that there are no retirement costs. In real life, such costs frequently surface when the assets are retired. As an example, operators might need to rent a place to park their retired equipment. In addition, there might be some costs incurred for getting rid of the unusable components from the retired equipment that cannot be sold for scrap. However, relaxing this assumption is costly, i.e., it requires another
assumption regarding the size and duration of the retirement costs and their effects on the firm’s cost of capital. These issues are left for future research.

Another unrealistic assumption made is that the company under investigation is always profitable. This rarely occurs in real life, where variability in income exists. Thus, the value of tax deductions to rail freight firms in any particular year is uncertain. A decrease in income may go against an operator’s ability to utilise all tax deductions, while an increase in taxable income may make early replacement more profitable. Future research should explicitly incorporate such income variability in the analysis. One very useful extension of the analysis would be to quantify the size of the effects of changes in the tax structure on replacement ages and rates for rail freight rolling stock. This analysis, however, would require considerable amounts of accurate data on residual earning streams, asset acquisition, and resale prices that are often difficult to obtain. It would also require some assumptions about the process describing changes in these variables.

One important weakness of the replacement models employed in this research results from the lack of simultaneous considerations. Several aspects of replacement decisions depend on simultaneous situations. For example, the choice of replacement should be made from among a set of several potentially feasible challengers instead of a particular technologically improved asset. This is because a technologically improved challenger is not necessarily the most economically efficient replacement choice for each given situation. Another important example is to consider replacement decisions subject to a fund constraint, i.e., capital rationing. This implies that the discount rate should be determined at the same time as the capital budget. When capital rationing exists, an optimal decision might be to delay the replacement in order to accept other investment projects that will result in a higher firm value.

Another important weakness is that the analysis does not address the role of capital structure in affecting the impact of accelerated depreciation. Using debt to finance an investment is common and the interest tax shield has a direct impact on taxable income and tax benefit. The discount rate in the model therefore needs to be adjusted accordingly. However, this is beyond the scope of this study and should therefore be left for future research.
The asset replacement model derived in this study addresses the impact of inflation. An interesting research extension in the future would be to consider the impact from the state of the economy (i.e., expansion versus recession) on accelerated depreciation. In particular, the popular Markov chains and Markov processes could be incorporated into the existing model.

Finally, as a result of constraints in terms of resources, time and funding, this study could not include all the stakeholders in the target population. Nevertheless, a careful sampling procedure has been formulated to ensure that the samples included are representative of the target population as much as possible.

5.5 Summary

Accelerated depreciation should not be used as a primary mechanism to drive rolling stock modernisation since there are many other factors that restrain the replacement investment in the rail freight sector. The most important one is the poor infrastructure that still prevails in many parts of the nation. Furthermore, there are issues associated with the scheme that need to be addressed so as to increase its potential efficacy and/or to prevent the scheme from being misused. Another important point is that, to assure a desired level of investment in cleaner technologies in the long term, there is a need to improve the below-rail infrastructure so as to support effective use of modern equipment. Since this cannot be addressed overnight, some incentives to purchase new equipment together with programs targeting at refurbishing old assets are needed to deliver desirable outcomes in the short run.

A major theoretical contribution made by this thesis is the derivation of the extended asset replacement model, which simultaneously takes taxes, inflation, and technological advancement into account. The work also contributes to the research methodology used in finance by proposing a unique three-stage sequential mixed methodology, which can be used to increase the credibility of the preceding findings, and to explore the emergent themes found in the earlier stages of research. The models employed in this study make many simplifying assumptions that should be relaxed in future research. These assumptions include: (1) there is no uncertainty in cash flows and future salvage values; (2) there are no retirement costs; and (3) the variability in income does not exist. One very useful extension of the analysis presented in this research would be to quantify the size of the effects of changes in the tax structure on replacement ages and rates for rail freight rolling stock. Other future
research directions would be to consider simultaneous aspects of replacement decisions, or to incorporate capital structure and Markov chain in the asset replacement model.
PROMOTING TECHNOLOGICAL INVESTMENT IN THE AUSTRALIAN RAIL FREIGHT SECTOR:
EVALUATING THE FEASIBILITY OF ACCELERATED DEPRECIATION

NATTAWOOT KOOWATTANATIANCHAI
REFERENCES


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# APPENDIX A

## HISTORICAL EMPLOYMENT OF ACCELERATED DEPRECIATION

The following table summarises the utilisation of accelerated depreciation (in some selected countries) since its early introduction.

<table>
<thead>
<tr>
<th>Era</th>
<th>Country</th>
<th>Forms</th>
<th>Eligible Assets</th>
<th>Notes</th>
</tr>
</thead>
</table>
| Pre-WW II    | US      | ● Immediate reduction.     | ● War-related assets. | • Loss in value of facilities used to produce articles contributing to the prosecution of the war was recognised in excess of ordinary wear and tear.  
                  |         | ● Reasonable deduction.   |                 | • Intended to give incentives to US manufacturers of war goods to expand their plants.  
                  |         |                            |                 | • Late introduction, uncertainties surrounding the length of time that the emergency demand was expected to last, and uncertainties surrounding the amount that would be allowed to depreciate result in restricted expansion.  |
| (1915–1940)  |         |                            |                 |                                                                      |
| Britain      |         | ● Immediate deduction.     | ● War-related assets. | • A certain amount of depreciation could be claimed immediately.  
                  |         |                            |                 | • To subsidise war-related firms.  |
| Sweden       |         | ● Free depreciation.       | ● General assets. | • Allow corporate taxpayers to write off the full cost of assets in first year after the acquisition.  
                  |         |                            |                 | • To eliminate conflicts between taxpayers and tax administrators over correct depreciation rates.  
                  |         |                            |                 | • Strong expansionary effect of the scheme led to inflationary pressure.  |
| WW II        | US      | ● Five-year amortisation  | ● War-related assets. | • To encourage more investment in defence- |

### Promoting Technological Investment in the Australian Rail Freight Sector: Evaluating the Feasibility of Accelerated Depreciation

<table>
<thead>
<tr>
<th>Period</th>
<th>Allowance Types</th>
<th>Related Facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1940-1945)</td>
<td>allowance.</td>
<td>Restricted expansion owing to (1) complications of obtaining the necessity certificate before accelerated depreciation can commence; (2) general fear of a post-emergency depression; and (3) great increase in possibly competitive plants being built with government funds.</td>
</tr>
<tr>
<td>Canada</td>
<td>Initial allowances.</td>
<td>Related to $109 million out of $158 million of expenditure being made by the taxpayers for 45 projects, mainly concerning the production of aircraft, steel, aluminium, and sulphur.</td>
</tr>
<tr>
<td>UK</td>
<td>Immediate deduction.</td>
<td>Only 10% interim allowance is given forthwith.</td>
</tr>
</tbody>
</table>
| Post-WW II (1945-1990) | Sum of the year digits.  
|                  | Double declining balance.  
|                  | Shortening depreciation lives.  
|                  | Initial allowances.  
<p>|                  | Investment allowances.              | To subsidize war-related firms.                                                    |
| US              | General assets.                                     | To stimulate investment in depreciable assets.                                       |
|                 | War-related assets.                                 | Stimulus is evident in a number of sectors, e.g., real estate, steel industry, agricultural sector. |
|                 | Industrial assets.                                  | Not successful for rate-regulated firms.                                            |
|                 | War-related assets.                                 | Empirical studies produce contrasting results regarding the efficacy of ADSs provided in US. |
| Canada          | Initial allowances.                                 | Expected sharp rise in the level of capital expenditures leads to strong inflationary pressure. |
|                 | Investment allowances.                             | Investment decisions materially affected by favourable changes in investment and initial allowances. |
|                 | Declining balance.                                  | Effects much greater on large firms than on small firms.                             |</p>
<table>
<thead>
<tr>
<th>Country</th>
<th>Allowances/Depreciation Schemes</th>
<th>Export-Related Assets</th>
<th>Other General Assets</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>• Initial allowances.</td>
<td>• Export-related assets</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Bonus depreciation.</td>
<td>• Research facilities.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Declining balance.</td>
<td>• Steel production.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Mining assets.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Not used by large number of firms owing to i) fear of future tax increases; ii) accounting convention; iii) ignorance; iv) complications associated with utilisation of the scheme; and v) administrative expenses.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Netherlands</td>
<td>• Initial allowance.</td>
<td>Buildings.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Investment allowances.</td>
<td>• Motor cars.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Inflation cost-based depreciation schemes.</td>
<td>• Office equipment.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Investment activities significantly influenced by these schemes, thus leading to inflation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Criticised for giving less freedom to investors in making their own investment choices.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweden</td>
<td>• Free depreciation.</td>
<td>General assets.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 20% straight-line depreciation.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• 30% declining-balance with an option to switch to a 20% straight-line.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Significant investment incentive given.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Criticised for impairing the free flow in the market.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>• Shortened service life.</td>
<td>New facilities.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Initial allowances.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Investment allowances.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Criticised for being inequitable against growing firms.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Investment spurred in the industrialised sector but lagged in the agricultural sector.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>• Inflation adjusted depreciation system.</td>
<td>Assets lost during wartime.</td>
<td>Successful in the recovery of the country’s economy after WWII.</td>
</tr>
<tr>
<td></td>
<td>• 50% initial allowances.</td>
<td>Basic goods (e.g., coal, iron, steel, electricity, gas, and essential foods).</td>
<td>Resulted in overcapacity in some industrial sectors.</td>
</tr>
<tr>
<td></td>
<td>• 33% initial allowances.</td>
<td>Ships.</td>
<td>Criticised for inequalities and complexities involved.</td>
</tr>
<tr>
<td></td>
<td>• Declining balance.</td>
<td>Other general assets.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Promoting Technological Investment in the Australian Rail Freight Sector: Evaluating the Feasibility of Accelerated Depreciation

<table>
<thead>
<tr>
<th>Country</th>
<th>Description</th>
<th>Benefits</th>
<th>Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>5/3 depreciation system.</td>
<td>Assets in the shipping industry. Assets in rate regulated sectors, e.g., electricity, natural gas, rail, telecommunication s, and water networks. Assets normally depreciated at the rate 20% pa or more be written off over 3 years.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Assets normally depreciated at less than 20% pa be written off over 5 years. Provided significant incentive to invest in the modernisation of Australian industry. I ncentive not very strong in rate-regulated sectors.</td>
<td></td>
</tr>
<tr>
<td>Green era (1990-present)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>US</td>
<td>Shortened tax life.</td>
<td>Assets with increased energy efficiency. Equipment used to collect, distribute, or recycle a variety of commodities.</td>
<td>Encouraged businesses to replace carbon-intensive equipment with environmentally friendly equipment that would reduce emissions.</td>
</tr>
<tr>
<td>Canada</td>
<td>Shortened tax life.</td>
<td>Specified energy efficiency and renewable energy equipment.</td>
<td>The program also allowed the costs of pre-feasibility and feasibility studies, negotiation costs, site approval costs, etc., to be subject to accelerated depreciation,</td>
</tr>
<tr>
<td>Mexico</td>
<td>Immediate deduction.</td>
<td>Approved renewable energy technology projects.</td>
<td>Equipment shall remain in operation at least five years following the tax deduction.</td>
</tr>
<tr>
<td>The Netherlands</td>
<td>Freedom of choosing depreciation rate.</td>
<td>Equipment pertaining to mitigating water pollution, soil pollution, waste, and noise, etc.</td>
<td>Costs associated with obtaining advice on the purchased machinery are also subject to accelerated depreciation.</td>
</tr>
<tr>
<td>Singapore</td>
<td>Immediate deduction.</td>
<td>Energy-efficient equipment.</td>
<td>Expenses related to acquiring information or consultant fees for identifying and analysing the equipment purchase are not subject to accelerated depreciation.</td>
</tr>
<tr>
<td>Japan</td>
<td>Initial allowances.</td>
<td>Specified environmentally friendly equipment.</td>
<td>Heat pumps, floor heaters, combined heat and power production (CHP) systems, district heating and cooling systems, high efficiency electric trains, low-emission vehicles, energy-efficient textile manufacturing equipment, solar power systems, small- and medium-size hydro generators, and equipment for producing recycled paper and plastics are eligible.</td>
</tr>
</tbody>
</table>
PROMOTING TECHNOLOGICAL INVESTMENT IN THE AUSTRALIAN RAIL FREIGHT SECTOR:
EVALUATING THE FEASIBILITY OF ACCELERATED DEPRECIATION
APPENDIX B

DATA COLLECTION DOCUMENTS

B.1 Interview Schedule

CRC for Rail Innovation Project

Promoting Technological Investment in Rail: Investigating the Feasibility of Accelerated Depreciation

INTERVIEW SCHEDULE

Date ______________   Interviewee __________________________

Organisation _________________________

Introduction
The project aims to assess factors driving the rolling stock replacement decisions in order to identify mechanisms to increase the uptake of new rolling stock in the Australian rail freight industry.

For the term “rolling stock”, the project elects to concentrate primarily on locomotives and wagons.

The project is funded by the Cooperative Research Centre for Rail Innovation, with QR and the ARA as industry partners. The researchers are from Southern Cross University.

We are interviewing people from the rail freight industry, noted for their significant involvement in making rolling stock replacement decisions, in order to obtain their views.
Based on what you and others say, the project will develop an analytical model that can be used to economically and empirically analyse the efficacy of certain mechanisms used to promote technological investment in the rail freight sector.

Each interview is confidential. Only members of the research team will have access to your interview transcript, the transcript will be kept secure, and you will not be personally identified in any project publications.

We are not looking for particular responses, so please answer in any way that you want to. We are asking everybody the same questions, but we realise that you may not be in a position to answer every question.

Also, please bear with me if I ask a question that you’ve already answered in a previous response. It’s important that I don’t omit any of the set questions.

Do you have any questions before we get started?

You have our contact details in the Participant Information Sheet so you can get in touch later if you want to.

**Background information**

*First, we need some background information.*

(1). What is the ownership structure of your organisation? (e.g., privately owned, publically owned, or a government or local authority organisation)

(2). What is your present position in your organisation?

(3). What is your role in rolling stock replacement?

(4). How long have you been in this role?

(5). Have you been involved with rolling stock replacement in other roles before?
Rail freight rolling stock in Australia

Now I’d like to hear your opinion regarding the current environmental performance of rail freight rolling stock in Australia.

(6) According to the ARA, there are currently more than 1550 locomotives in Australia, of which more than 50% are over 20 years old, while 30% are more than 30 years old. In your opinion, what are reasons the operators are still using such old rolling stock fleets?

(7) Do you believe that there is a need to modernise existing rail freight rolling stock fleets in Australia?
   - If so, could you please explain why?
   - If not, could you please explain why?

(8) Are there any barriers to modernising rail freight rolling stock?
   - If so, what are they?

(9) The Commonwealth is currently seeking the introduction of a Emission Trading Scheme (ETS) that would penalise assets with high carbon emissions. Do you feel that the ETS will be successful at modernising rail freight rolling stock fleets?
   - Why?
   - Why not?
   - Do you have any ideas or suggestions that you think might improve the usefulness of the scheme for rail if it were to be implemented in the future?

(10) The Commonwealth has recently proposed to increase the investment allowance rate from 10% to 30% (for businesses with turnover of $2 million or more); that is, 30% of the cost of a newly acquired asset can be claimed as extra depreciation expenses in the first year after the acquisition of the new asset. Do you think that this scheme will help to ensure the modernisation of rail freight rolling stock?
   - Why?
   - Why not?
   - Do you have any ideas or suggestions that you think might improve the usefulness of the scheme if it were to be implemented in the future?
(11). Are you aware of any other enablers provided by the Commonwealth (or other levels of government) to encourage the modernisation of rail freight rolling stock?
   - If so, what are they?
   - Will they ensure the modernisation of rail freight rolling stock? If so, how?

(12). Overall, do you feel that the Commonwealth is doing enough to encouraging the modernisation of rail freight rolling stock?
   - If not, what additional mechanisms (or policies or programs) could be used to encourage fleet modernisation?

**Rolling stock fleets in your organization**

*Thanks for that. Now I’ll ask you about how the rolling stock fleets in your organisation are managed and financed.*

(13). First, could you please tell me a little bit about your organisation’s rolling stock fleets? You needn’t provide complete detail now. We’re looking for overall impressions here. A complete detail can be supplied separately.
   (E.g., the age of the equipment in the fleets in general, the amount of locomotives and wagons in the fleets, types of locomotives and wagons, or any other important characteristics that you think of)

(14). [Operators only]

Does your organisation acquire or lease its rolling stock, or both?
   - What are the reasons for this?
   - If leasing, what are the benefits of leasing versus acquiring rolling stock?

(15). [Operators only]

Does your organisation acquire or lease more than one piece of equipment at the same time?
   - If so, how many?
   - Are there any particular reasons for doing so?

(16). [Operators only]

In a general, does your organisation lease/acquire new or used rolling stock or both?
• Why?

(17). [Operators only]
Does your organisation operate rolling stock fleets until they physically fail in use?
• If not, are there any particular guidelines about the length of time that rolling stock fleets should be kept in operation?
• Could you please tell me a bit more about these guidelines?

(18). What does your organisation do with equipment that are no longer commercially utilised? (E.g., sell them, or store, or a bit of both?)

(19). When rolling stock equipment breaks down, to what degree does the breakdown affect the revenue flow of your business? (E.g. idle time for repair causes the service to be delayed or cancelled.)
• If so, could you please give me an estimate of the opportunity costs by idle time for repair as a percentage of the overall costs of maintaining and operating rolling stock equipment?

Rolling stock replacement process
Thanks for that. Now I’d like to find out about the procedure for making a replacement decision within your organisation.

(20). Could you please explain to me how decisions are made regarding rolling stock replacement in your company?
• How long is the decision life?
• Does the life of a decision comprise a number of phases? What are they?
• How many areas of the organisation are involved in the procedure? Who is ultimately responsible for approving purchases of rolling stock?
• Does your organisation seek any kind of advice to aid or direct decision-making? Could you please tell me more?
• Could you please explain the extent, nature, and influence of financial analysis and other modelling on the decision making process? What kind of financial analyses or models is usually taken?
Does your organisation risk-manage the replacement decision, e.g., review the decision over time? Could you please explain the process for risk management of the replacement decision?

Is there a guided length of the rolling stock replacement cycle? If so, how long? Does it influence the approach to rolling stock procurement? How?

Are there any other important aspects of rolling stock replacement policies within your organisation that haven’t been covered?

(21). What are the important forces that drive your organisation to consider replacing its rolling stock fleets?

• Could you please explain why they are important?
• Could you please explain the relative importance of these factors?

(22). Is rolling stock replacement a viable option for your company now?

• If so, why?
• If not, what barriers are there?

(23). Does the replacement process usually slow down or temporally stop the business of your organisation?
(E.g., The physical difference on the network, such as different types of electrification, signalling systems or gauging constraints, might require adjustments to new rolling stock and/or infrastructure if transferring new rolling stock from one part of the network to another. The business might slow down or temporally stop as a result.)

• How does your organisation deal with this problem?

Proposed incentive programs

Next, I’ll ask you about the influences of existing incentive programs provided by the Commonwealth on your organisation’s rolling stock replacement decisions.

(24). If the ETS were implemented, would the scheme push your organisation to consider replacing its aging rolling stock fleets with the modern ones?

• If so, could you explain how?
• If not, what are the reasons?
(25). Has your organisation ever taken advantage of the benefit provided by the current Investment Allowance scheme?
   - If so, does it influence your organisation’s rolling stock replacement decisions? Could you explain how?

(26). Are you aware of any other programs or policies provided by the Commonwealth (or other tier of government) that have influenced your rolling stock replacement decisions?
   - If so, could you please give more information about them?
   - What has been the impact of these schemes on your organisation’s rolling stock replacement decisions?

**Accelerated Depreciation**

*Before we wrap up the interview, I would like to ask for your opinion regarding an accelerated depreciation scheme.*

(27). What depreciation method(s) does your organisation use for locomotives and wagons at present? What rate?

(28). [**Lesser only**]

If accelerated depreciation were to be allowed for newly acquired rolling stock, would it affect lease terms negotiated with your lessee?
   - If so, how is the effect of accelerated depreciation incorporated in lease models?
   - Will accelerated depreciation to increase your organisation’s ability to negotiate a faster replacement cycle of rolling stock?

(29). If accelerated depreciation were to be allowed for newly acquired rolling stock, would it prompt your organisation to consider replacing its existing rolling stock?
   - Why?
   - Why not?

(30). Do you think accelerated depreciation has the potential to ensure the modernisation of rail freight rolling stock fleets in Australia?
PROMOTING TECHNOLOGICAL INVESTMENT IN THE AUSTRALIAN RAIL FREIGHT SECTOR: EVALUATING THE FEASIBILITY OF ACCELERATED DEPRECIATION

- Why?
- Why not?

(31). What barriers are there that could reduce the usefulness of the scheme?
- What can be done to remove these barriers?

(32). Are there any other factors that might prevent your organisation from adopting accelerated depreciation even though it is available?

(33). Given that a number of incentive schemes have already been proposed, do you feel that accelerated depreciation is a necessary addition?
- Why?
- Why not?

(34). Could you please give any ideas or suggestions that you think might improve the usefulness of an accelerated depreciation scheme if it were to be implemented in the future?

Wrap up

(35). Could you please give any other ideas and suggestions that you think would be helpful to facilitate the introduction of more modern rolling stock in the rail freight sector?

(36). Is there anything you would like to say about rolling stock replacement in the rail freight sector that we haven’t covered?

Thank you very much for giving us your time and your thoughts on accelerated depreciation and rolling stock replacement in the rail freight sector.

B.2 Information Sheet for Interview Participants

Project Title
Promoting Technological Investment in Rail: Investigating the Feasibility of Accelerated Depreciation
What is this research?
This project is looking at rolling stock replacement decisions. It aims to identify factors that trigger the consideration of rolling stock replacement and mechanisms to increase the uptake of new rolling stock in the Australian rail freight industry. Based on what you and others say, it will develop an analytical model that can be used to economically and empirically analyse the efficacy of certain mechanisms used to promote technological investment in the rail freight sector.

The project is funded by the Cooperative Research Centre for Rail Innovation, with QR and the ARA as industry partners. The researchers are from Southern Cross University. We are interviewing people from the rail freight industry with significant involvement in making rolling stock replacement decisions in order to obtain their views.

What does this research involve?
You will be interviewed by one of our researchers. The interview should take approximately an hour. Since we will not be able to recall everything you say, we will need to record the interview if that’s okay with you.

Each interview is strictly confidential. Only members of the research team will have access to your interview transcript. The transcript will be kept secure, and you will not be personally identified in any project publications.

As a participant, what do I need to do in this research? How do I do it?
Please spare us some of your time so that we can interview you. We are not looking for particular responses, so please answer in any way that you want to.

Are there any discomforts or risks?
Your participation is entirely voluntary, and you may withdraw from the interview at any stage without consequence. You may take a break during the interview whenever you need to.
Publication of this research
As a participant, you will receive an executive summary of the findings. For those interested in greater detail, the full report may be accessed. Details of how to do this will be readily available from the researchers.

How can I make further enquiries?
You can contact any of the following research team members:

- Michael Charles (SCU), Project Leader
  Ph: (07) 5506 9383
  Email: michael.charles@scu.edu.au
- Ian Eddie (SCU), Research Supervisor
  Ph: (07) 3203 7030
  Email: ian.eddie@scu.edu.au
- Nattawoot Koowattanatianchai (SCU), Researcher
  (Mob): 0412 717 511
  Email: n.koowattanatianchai.10@scu.edu.au

This research has been approved by the Southern Cross University Human Research Ethics Committee. The approval number is: ECN-09-091

If you have any concerns about the ethical conduct of the research, please contact:

- The Ethics Complaints Officer
  Southern Cross University
  P.O. Box 157
  Lismore, NSW, 2480
  sue.kelly@scu.edu.au

All information is confidential and will be handled as soon as possible.

B.3 Consent Form for Interview Participants
(This consent form is based on the National Statement on Ethical Conduct in Human Research (National Statement/NS)
Appendix B: Data Collection Documents

Promoting Technological Investment in Rail: Investigating the Feasibility of Accelerated Depreciation

Researchers: Dr Michael Charles
Senior Lecturer
Graduate College of Management, Faculty of Business and Law,
Southern Cross University, Brett St, Tweed Heads, NSW 2485
Telephone: (61-7) 5506 9349
E-Mail: michael.charles@scu.edu.au

Candidate’s Name
Nattawoot Koowattanatianchai
Southern Cross University / International Office
PO Box 42, Tweed Heads NSW 2485 Australia
Telephone: (61-4) 1271 7511
E-Mail: n.koowattanatianchai.10@scu.edu.au

NOTE: This consent form will remain with the Southern Cross University researcher for their records.

Tick the box that applies, sign and date and give to the researcher

I agree to take part in the Southern Cross University research project specified above. Yes ☐ No ☐

I have been provided with information about the purpose, methods, demands, risks, inconveniences and possible outcomes of this research. I understand this information. Yes ☐ No ☐

I agree to be interviewed by the researcher. Yes ☐ No ☐

I agree to allow the interview to be audio-taped. Yes ☐ No ☐

I understand that my participation is voluntary. Yes ☐ No ☐

I can choose not to participate in part or all of this research at any time,
PROMOTING TECHNOLOGICAL INVESTMENT IN THE AUSTRALIAN RAIL FREIGHT SECTOR:
EVALUATING THE FEASIBILITY OF ACCELERATED DEPRECIATION

without consequence.  

I understand that any information that may identify me will be de-identified after the analysis of data is completed. Therefore, I, or any information I have provided, cannot be linked to my person/company. (Privacy Act 1988 Cth)

I understand that neither my name nor any identifying information will be disclosed or published, except with my permission.

I understand that all information gathered in this research is confidential. It is kept securely and confidentially for 5 years at the University (unless there are special circumstances, that have been explained to me).

I am aware that I can contact the Supervisor or other researchers at any time with any queries.

I understand that the ethical aspects of this research have been approved by the SCU Human Research Ethics Committee.

If I have concerns about the ethical conduct of this research, I understand that I can contact the SCU Ethics Complaints Officer. All inquiries are confidential and should be in writing, in the first instance, to the following:

I understand that I will be given a copy of this consent form for my records. The researcher will also keep a copy in safe storage at the University.

I am over the age of 18 years.

Ethics Complaints Officer
Southern Cross University
PO Box 157
Lismore NSW 2480
Email: sue.kelly@scu.edu.au
Participant’s name (please print):

Participant’s signature:

Date:

Contact: Tel:

Email:

Is this email contact address the best way to send you the executive summary of the research findings?

If not, please write below the best way to send you this information.

B.4  Focus Group Discussion Guide

Project title: Promoting technological investment in rail: Investigating the feasibility of accelerated depreciation

Project date: 2010

Method: Focus group

Principal investigator: Nattawoot Koowattanatianchai (MCA)

Total participants: 6

Total participant time required: 3 hours

Total focus group time: 2 hour 40 minutes

Break: 20 minutes

Premise of this study and the purpose of the focus group

The purpose of this study is to ascertain the viability of accelerated depreciation (AD) as a means to provide incentives for rail freight operators to invest in more efficient and environmentally friendly technology. A three-stage mixed methods approach was designed to investigate the investment implications of AD in the rail freight sector. In stage 1, a series of face-to-face interviews was conducted with respondents from rail freight operators in Australia involved in making locomotive replacement decisions. This was intended to gain a
deep understanding of complexities surrounding how decisions are made regarding rolling stock replacement among rail freight firms. In stage 2, an analytical model of the effects of tax concessions on asset replacement was developed based on previous research and findings from the stakeholder interviews. This model is then used to test whether AD and other tax concessions can significantly reduce the optimal time to replace rolling stock in the Australian rail freight industry. If AD reduces the optimal age of the rail freight rolling stock, it is also likely, by implication, to increase replacement and technological investment in the sector.

An executive summary of important findings of the literature review and first two stages of the study has already been distributed to you. The focus group conducted today is the final stage of the research design. The focus group aims to:

- Examine the validity of findings from the first two stages.
- Provide in-depth expert assessments of their policy implications.
- Identify appropriate mechanisms to increase the uptake of new rolling stock in the Australian rail freight industry.

Below is a general guide for participating in our focus group. Before the group begins, the informed consent process will be conducted.

I. Introduction

- Welcome participants and introduce the moderator.
- Talk about the premise of this study.
- Explain the general purpose and process of the focus group.
- Explain that the participants were chosen because of their expertise in transport and energy policy pertaining to rail operations.
- Discuss the purpose and process of the focus group.
- Explain the presence and purpose of recording equipment.
- Talk about general ground rules and discussion guidelines, emphasising the informality of the discussion, the importance of everyone speaking up, the importance of interaction in the group, and possibilities of being interrupted by the moderator to assure that all topics can be covered.
- Review breaks schedule and location of the restrooms.
Address the issue of anonymity and confidentiality of the discussion.

Inform the group that all information published will be represented as overall discussion and that participants’ real identity (apart from their role or position within the organization) will not be identified in any research publications. This is to encourage participants to speak openly and honestly.

II. Warm-up

Let’s begin by getting to know a little bit about each other. Please introduce yourself (name, current position within your organisation, and your experience in transport and energy policy pertaining to rail operations).

Are you aware of the lack of investment in modern rolling stock equipment currently faced by the rail industry? (i.e., the rail industry operates under very large long investment periods for rolling stock and even longer periods for track infrastructure)

Probes:
- In your opinion, what are the causes of the problem?
- In your opinion, what are the possible and appropriate ways to deal with this problem?
- In your opinion, is the government doing enough to help?

III. Main discussion

[Assessment of early findings]

(1). First, we need your feedback on whether you agree with the important findings found from the first two stages of this study. (Encourage participants to look at the summary of the findings section by section and discuss).

Probes:

(a) Are there any results that are not applicable to the practices of rail freight firms in Australia? If so, could you explain why?

(b) Are there any results that are biased towards the rail freight industry? What would be a more balanced explanation?
(c) Does anybody want to comment to any particular results?

(d) During the first stage of the research, an interesting theme emerged; that is “Tax implications are not the main driver of a replacement decision, but they may bring a financial incentive to the decision.”

What is your opinion on this result?

(e) During the first stage of the research, an interesting theme emerged; that is “the ETS is unlikely to be effective at encouraging the modernisation of rolling stock equipment.”

What is your opinion on this result?

(f) During the first stage of the research, an interesting theme emerged; that is “accelerated depreciation is a blunt investment with slow results and limited financial benefit, and therefore is not very attractive politically. While being useful, it does not meet political or industry requirements well. Accelerated depreciation can assist long term incremental change, but only applies when companies are in a tax-paying position.”

What is your opinion on this result?

(g) Another interesting but confusing theme emerged during the second stage of investigation: “accelerated depreciation allowed to existing equipment is unlikely to affect the replacement strategies of the Australian rail freight firms, which tend to hold on to their rolling stock even after they are totally depreciated. Even worse, if the asset is partially depreciated upon its termination or replacement, allowing accelerated depreciation to apply to existing equipment has the potential to encourage the firm to postpone replacement decisions.”

Do you agree with this finding? Why?

[Policy implications of findings]
(2). Based on the results found so far, what are their implications for policies and business strategies.

**Probes:**

(a) In your opinion, can accelerated depreciation be used to increase the modal share of rail transport (i.e., modal shift to rail) and cater for natural growth, and to reduce environmental impact by increasing the use of environmentally friendly rolling stock?

(b) Is accelerated depreciation a politically attractive policy? In particular, is the Australian Tax Office likely to agree with this proposal?

(c) Apart from accelerated depreciation, could you please identify other (appropriate) government mechanisms to increase the uptake of new rolling stock in the Australian rail freight industry?

**IV. Closing**

(3). In your own words, could you please provide a summary of what has occurred from the discussion?

(4). Is there anything that we haven’t discussed that seems relevant? (Would anyone like to make any final comments, either add to your previous comments or raise new issues?)

The moderator then summarises the discussion on his own understanding, and then seek the participants’ endorsement of his interpretation.

Thank participants and end the discussion.

**B.5 Consent Form for Focus Group Participants**

(This consent form is based on the National Statement on Ethical Conduct in Human Research (National Statement/NS)

Promoting Technological Investment in Rail: Investigating the Feasibility of Accelerated Depreciation

**Researchers:** Dr Michael Charles
PROMOTING TECHNOLOGICAL INVESTMENT IN THE AUSTRALIAN RAIL FREIGHT SECTOR: EVALUATING THE FEASIBILITY OF ACCELERATED DEPRECIATION

Senior Lecturer
Graduate College of Management, Faculty of Business and Law,
Southern Cross University, Brett St, Tweed Heads, NSW 2485
Telephone: (61-7) 5506 9349
E-Mail: michael.charles@scu.edu.au

Candidate Name
Nattawoot Koowattanatianchai
Southern Cross University / International Office
PO Box 42 Tweed Heads NSW 2485 Australia
Telephone: (61-4) 1271 7511
E-Mail: n.koowattanatianchai.10@scu.edu.au

NOTE: This consent form will remain with the Southern Cross University researcher for their records.

Tick the box that applies, sign and date and give to the researcher

I agree to take part in the Southern Cross University research project specified above.
Yes ☐ No ☐

I have been provided with information about the purpose, methods, demands, risks, inconveniences and possible outcomes of this research. I understand this information.
Yes ☐ No ☐

I agree to participate in the focus group discussions in this research
Yes ☐ No ☐

I agree to allow the discussions to be audio-taped
Yes ☐ No ☐

I understand that my participation is voluntary.
Yes ☐ No ☐

I can choose not to participate in part or all of this research at any time, without consequence.
Yes ☐ No ☐

I understand that any information that may identify me will be de-identified after the analysis of data is completed. Therefore, I, or any information I have provided, cannot be linked to my person/company. (Privacy Act 1988 Cth)
Yes ☐ No ☐

I understand that neither my name nor any identifying information will be disclosed or published, except with my permission.
Yes ☐ No ☐

I understand that all information gathered in this research is confidential. It is kept securely and confidentially for 5 years at the University (unless there are special circumstances, that have been explained to me).
Yes ☐ No ☐

I am aware that I can contact the Supervisor or other researchers at any time with any queries.
Yes ☐ No ☐

NATTAWOOT KOOWATTANATIANCHAI 284
I understand that the ethical aspects of this research have been approved by the SCU Human Research Ethics Committee.  

Yes ☐ No ☐

If I have concerns about the ethical conduct of this research, I understand that I can contact the SCU Ethics Complaints Officer. All inquiries are confidential and should be in writing, in the first instance, to the following:

Yes ☐ No ☐

I understand that I will be given a copy of this consent form for my records. The researcher will also keep a copy in safe storage at the University.

Yes ☐ No ☐

I am over the age of 18 years.  

Yes ☐ No ☐

Ethics Complaints Officer  
Southern Cross University  
PO Box 157  
Lismore NSW 2480  
Email: sue.kelly@scu.edu.au  

Participant’s name (please print):  

Participant’s signature:  

Date:  

Contact: Tel:  

Email:  

Is this email contact address the best way to send you the executive summary of the research findings?

If not, please write below the best way to send you this information.
PROMOTING TECHNOLOGICAL INVESTMENT IN THE AUSTRALIAN RAIL FREIGHT SECTOR: 
EVALUATING THE FEASIBILITY OF ACCELERATED DEPRECIATION 

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**APPENDIX C**

**SCENARIO ANALYSIS: RESULTS**

Table C.1: Percentage increases in the value of (3.16) under hypothetical tax codes 1–6, with parameters $T = 0.3$, $M(0) = $5.5 million, and $\alpha = 0.1$. $c$ denotes the optimal replacement age of the existing locomotive. $s$ denotes the optimal replacement age of the new locomotive. The first figure in each cell represents the value of (5) when $r = 0.01$. The second figure in each cell is the value of (5) when $r = 0.06$. The last figure in each cell is the value of (5) when $r = 0.11$.

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Table C.2: Parallel evaluations to those done in Table C.1, but with the 150% diminishing-balance depreciation method used instead of the straight-line method. Other parameter values are the same.

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PROMOTING TECHNOLOGICAL INVESTMENT IN THE AUSTRALIAN RAIL FREIGHT SECTOR: EVALUATING THE FEASIBILITY OF ACCELERATED DEPRECIATION

Table C.3: Percentage increases in the value of (3.16) under hypothetical tax codes 1-6, with parameters $M(0) = $5.5 million, $r = 0.06$, and $\alpha = 0.1$. $c$ denotes the optimal replacement age of the existing locomotive. $s$ denotes the optimal replacement age of the new locomotive. The first figure in each cell represents the value of (5) when $T = 0.15$. The second figure in each cell is the value of (5) when $T = 0.3$. The last figure in each cell is the value of (5) when $T = 0.5$.

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Table C.4: Parallel evaluations to those done in Table C.3, but with the 150% diminishing-balance depreciation method used instead of the straight-line method. Other parameter values are the same.

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Table C.5: Percentage increases in the value of (3.16) under hypothetical tax codes 1–6, with parameters $T = 0.3$, $M(0) = 5.5$ million, and $r = 0.06$. $c$ denotes the optimal replacement age of the existing locomotive. $s$ denotes the optimal replacement age of the new locomotive. The first figure in each cell represents the value of (5) when $\alpha = 0.1$. The second figure in each cell is the value of (5) when $\alpha = 0.3$. The last figure in each cell is the value of (5) when $\alpha = 0.5$.

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Table C.6: Parallel evaluations to those done in Table C.5, but with the 150% diminishing-balance depreciation method used instead of the straight-line method. Other parameter values are the same.

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PROMOTING TECHNOLOGICAL INVESTMENT IN THE AUSTRALIAN RAIL FREIGHT SECTOR: EVALUATING THE FEASIBILITY OF ACCELERATED DEPRECIATION

Table C.7: Percentage increases in the value of (3.16) under hypothetical tax codes 1–6, with parameters $T = 0.3$, $M(0) = $0.4 million, and $\alpha = 0.1$. $c$ denotes the optimal replacement age of the existing wagon. $s$ denotes the optimal replacement age of the new wagon. The first figure in each cell represents the value of (5) when $r = 0.01$. The second figure in each cell is the value of (5) when $r = 0.06$. The last figure in each cell is the value of (5) when $r = 0.11$.

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Table C.8: Parallel evaluations to those done in Table C.7, but with the 150% diminishing-balance depreciation method used instead of the straight-line method. Other parameter values are the same.

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Table C.9: Percentage increases in the value of (3.16) under hypothetical tax codes 1–6, with parameters 
\( M(0) = \$0.4 \text{ million} \), \( r = 0.06 \), and \( \alpha = 0.1 \). \( c \) denotes the optimal replacement age of the existing 
wagon. \( s \) denotes the optimal replacement age of the new wagon. The first figure in each cell represents 
the value of (5) when \( T = 0.15 \). The second figure in each cell is the value of (5) when \( T = 0.3 \). The last 
figure in each cell is the value of (5) when \( T = 0.5 \).

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Table C.10: Parallel evaluations to those done in Table C.9, but with the 150% diminishing-balance 
depreciation method used instead of the straight-line method. Other parameter values are the same.

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Table C.11: Percentage increases in the value of (3.16) under hypothetical tax codes 1–6, with parameters $T = 0.3$, $M(0) = $0.4 million, and $r = 0.06$. $c$ denotes the optimal replacement age of the existing wagon. $s$ denotes the optimal replacement age of the new wagon. The first figure in each cell represents the value of (5) when $\alpha = 0.1$. The second figure in each cell is the value of (5) when $\alpha = 0.3$. The last figure in each cell is the value of (5) when $\alpha = 0.5$.

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Table C.12: Parallel evaluations to those done in Table C.11, but with the 150% diminishing-balance depreciation method used instead of the straight-line method. Other parameter values are the same.

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Table C13: Percentage increases in the marginal opportunity cost of holding the current locomotive when the marginal tax rate is 50% reduced. Based parameters are $T = 0.3$, $M(0) = 5.5$ million, $r = 0.06$, and $\alpha = 0.1$. Initial optimal lives of 20, 25, and 30 years are considered.

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Table C14: Parallel evaluations to those done in Table C.13, but with the 150% diminishing-balance depreciation method used instead of the straight-line method. Other parameter values are the same.

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Table C.15: Percentage increases in the marginal opportunity cost of holding the current wagon when the marginal tax rate is 50% reduced. Based parameters are $T = 0.3$, $M(0) = 0.4$ million, $r = 0.06$, and $\alpha = 0.1$. Initial optimal lives of 25, 35 and 35 years are considered.

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<tr>
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<tr>
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<td>35</td>
<td>3</td>
</tr>
</tbody>
</table>

Table C.16: Parallel evaluations to those done in Table C.15, but with the 150% diminishing-balance depreciation method used instead of the straight-line method. Other parameter values are the same.

<table>
<thead>
<tr>
<th>Optimal Lives</th>
<th>Sensitivity to Changes in $r$</th>
<th>Sensitivity to Changes in $\alpha$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$c$</td>
<td>$s$</td>
<td>$r = 0.01$</td>
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</tbody>
</table>