Monograph:
Nash, C.A., Fowkes, A.S., Hopkinson, P.G. et al. (2 more authors) (1993) A Review of Rail Research Relevant to the Case for Increased Rail Investment. Working Paper. Institute of Transport Studies, University of Leeds , Leeds, UK.

Working Paper 392

Published paper
Nash, C.A., Fowkes, A.S., Hopkinson, P.G., Preston, J.M., Wardman, M. (1993) *A Review of Rail Research Relevant to the Case for Increased Rail Investment.* Institute of Transport Studies, University of Leeds. Working Paper 392

UNIVERSITY OF LEEDS
Institute for Transport Studies

ITS Working Paper 392 *ISSN 0142-8942*

September 1993

A REVIEW OF RAIL RESEARCH RELEVANT TO THE CASE FOR INCREASED RAIL INVESTMENT

CA Nash
AS Fowkes
PG Hopkinson
JM Preston
M Wardman

ITS Working Papers are intended to provide information and encourage discussion on a topic in advance of formal publication. They represent only the views of the authors, and do not necessarily reflect the views or approval of the sponsors.

Funded by the Railway Industry Association.

CONTENTS

ABSTRACT

NASH, C.A., FOWKES, A.S., HOPKINSON, P.G., PRESTON, J.M., WARDMAN, M. A review of rail research relevant to the case for increased rail investment. *Working Paper 392*, Institute for Transport Studies, University of Leeds, Leeds.

The purpose of this paper is to provide a review of rail transport research which has a bearing on the case of increased rail investment. The paper focuses on research which has been conducted on the demand for rail travel, both passenger and freight, rather than the supply side or new technology. The aim is to identify where we believe there to be significant gaps in knowledge and key areas in which further research is required are outlined.

The paper deals with the following issues: the investment and funding mechanisms that currently exist for rail; the extent to which changes in the fare and service quality of rail affect the demand for rail travel and also the demand for air and road travel; the environmental and congestion benefits of diverting traffic from road and air to rail; and the links between rail investment and economic development. Where appropriate, the discussion considers inter-urban travel, suburban travel, light rail transit and freight transport separately.

Key words:

Contact: Mark Wardman, Institute for Transport Studies (tel: 0532-335349)

Executive Summary

The aim of this paper is to consider the existing research that bears on the case for increased rail investment, and to identify the extent to which further research is needed. We consider in turn the investment and funding mechanisms that exist for rail transport in Great Britain, the extent to which improved rail services or lower prices attract additional traffic and how far this comes from other modes, and the extent to which this might result in congestion, environmental or economic development benefits.

The potential inefficiencies resulting from the current differences in funding and appraisal methods are well documented. Further research in this area could usefully examine continental experience more deeply, improve on the methods for quantifying and monetising benefits, and add to the stock of case studies, for instance by means of a comprehensive cost-benefit analysis of the proposed West Coast Main Line upgrading.

What is a major area requiring research in the current political climate is the effect on investment of alternative methods of privatisation, including franchising and competitive tendering. Whilst there is little experience of this in the rail field in Britain or abroad, a certain amount can be learned from experience in other sectors.

It is found that the evidence on the effects of rail improvements on rail traffic is extensive, and suggests in general that rail traffic is quite sensitive both to fares and service quality. The evidence on the degree to which the extra traffic comes from car (or air) is less conclusive, although generally the evidence suggests substantial generation of new trips. This is an area where further work is needed, both to bring together the implications of past studies (there have been many studies of urban mode choice decisions) and to improve understanding of the inter urban market (although work on this is about to start at ITS). Further work on `soft' variables, such as rolling stock and terminals, may be particularly important in the context of privatisation.

Understanding of the freight market is much less good. Although studies have examined breakeven volumes, lengths of haul and the valuation of quality differentials between road or rail, the diversity of the market and the confidentiality of much of the data make this an underresearched area. The Channel Tunnel will provide the opportunity for a much better understanding of this area.

In principal, the effects on both congestion and the environment should be predictable once the degree to which rail investment diverts traffic from other modes is known. However, in the urban context it appears that the degree to which complementary measures to restrain road traffic are undertaken is very important; further examination of this issue using integrated transport models is recommended. In the inter urban context, further case studies, particularly examining the effects of diverting traffic from air, would be useful.

The absence of environmental costs and benefits from transport appraisals has been a longstanding concern and there is a need to remedy this situation with a programme of research to place monetary values on the environmental externalities of traffic and transport infrastructure. DOT has just commissioned a further study on valuation of traffic nuisance.

Finally, the economic development effects of rail schemes are another major area of uncertainty. Research on this issue is very difficult, but the Manchester and Sheffield light rail monitoring exercises may improve our understanding of this area.

A REVIEW OF RESEARCH RELEVANT TO THE CASE FOR INCREASED RAIL INVESTMENT

1. INTRODUCTION AND OBJECTIVES

The purpose of this report is to provide a review of rail transport research which has a bearing on the case for increased rail investment. The paper focuses upon research which has been conducted on the demand for rail travel, rather than the supply side or new technology, and the interactions with the evaluation and funding procedures, competing modes, the environment and economic development.

The aim has been to review the research which has been conducted, but without discussing this research in great detail, in order to identify where we believe there to be significant gaps in knowledge. The outline of the paper is as follows.

Section 2 considers the investment and funding mechanisms that currently exist for rail in Britain, with an assessment of their adequacy and their impact on rail investment with reference to overseas practice.

Section 3 examines the research which has been conducted to establish the effect of changes in rail price and quality of service on the demand for rail travel, whilst section 4 considers the research which has examined how changes in rail impact on the demand for air and road.

Section 5 reviews evidence on the environmental and congestion benefits of diverting traffic from road and air to rail, whilst section 6 discusses the links between rail investment and economic development.

Where appropriate, the following four areas of rail transport are considered separately:

(a)	Inter-City Travel	(b)	Suburban Travel
(c)	Light Rail Transit (LRT)	(d)	Freight Transport.

Section 7 draws together the preceding discussion and outlines the key areas in which we believe further research is required.

2. INVESTMENT AND FUNDING MECHANISMS

2.1 INTRODUCTION

This section examines the investment and funding mechanisms that exist for rail in Britain and compares them with practice abroad, particularly in the largest countries of the EEC (France and Germany). Four market segments will be considered, namely Inter-City, Suburban, Light Rail (Urban) and Freight, and a concluding section assesses the impact of British policy on rail investment and examines the implications for future policy and research.

2.2 INTER-CITY SERVICES

InterCity rail services in Great Britain are provided commercially and have been set an objective by Government of achieving a 4.75% return on assets by March 1993 and ultimately an 8% return. In 1990/91 InterCity made around a 6% return on costs but only a 1% return on assets. Given the economic down-turn, it seems unlikely that InterCity will achieve its objective unless its asset base is re-defined. Nonetheless, the achievement of this sector should not be understated given that it only covered around 80% of costs in 1984/85.

Investment in InterCity is required to show at least an 8% real rate of return and is thus consistent with the sector's ultimate commercial objective. Schemes in excess of £5 million require the approval of the Secretary of State for Transport, whilst schemes of between £0.25 million to £5 million may be examined by the Department of Transport. Investment can be constrained by the External Funding Limit (EFL) which is set by central Government and limits the amount an operator may spend in any one year from sources other than its own, internally generated finance. Recent EFL and investment figures for British Railway's operations as a whole are given by Table 2.1.

Given that up to 40% of BR investment is funded internally [1], the EFL is not always a binding constraint. However, the EFL also takes into account subsidy administered by the PSO (Public Service Obligation) system and up to 1988/89 the PSO grant alone exceeded the EFL. The big problem currently is the difficulties BR faces in internally generating investment funds, as the economic down-turn has reduced the earning capacity of its commercial rail businesses, increased the PSO requirements of the subsidised businesses and drastically reduced earnings from property (down from £412m in 1989/90 to £223m in 1990/91).

As with past investment, detailed breakdowns for future investment are not available. BR's ten year strategy document "Future Rail", published in 1991, envisages a £10 billion programme of investment over the next decade. InterCity (and its international, off shoot, European Passenger Services) is likely to account for a large share of this investment with two major projects outlined in "Future Rail".

(i)£1.5 billion of new railway needed for Channel Tunnel due to open in 1993
(ii)Upgrading of the West Coast Main Line service (InterCity 250) to be completed by 1995 and costed in excess of £0.75 billion.

Given InterCity's commercial remit, investments are appraised using financial appraisal techniques. Thus the investment in electrifying the East Coast Main Line (InterCity 225) was justified on purely commercial grounds. In exceptional circumstances, the results of the financial appraisal can be overturned by Government. For example, BR's preference for a southern route for the Channel Tunnel rail link was rejected by Government in favour of an eastern route largely on environmental and developmental grounds.

The reliance on financial appraisal to assess InterCity rail investment contrasts with the long standing use of social cost-benefit analysis to appraise trunk road investment. The resultant lack of `comparability' was first highlighted by the Leitch Committee [2] who concluded that in general social cost benefit analysis rates of return exceed financial returns and that there is therefore scope for resource misallocation. This issue was examined in more detail by Colin Buchanan and Partners [3] who used financial appraisal and social cost-benefit analysis to assess a rail electrification project. The project in question was to electrify the line from Birmingham to Paddington via Oxford, with a branch from Reading to Basingstoke, allowing the Birmingham-Paddington and Birmingham-Bournemouth services to be electrically hauled throughout. The detailed results are given by Table 2.2.

The main feature of Table 2.2 is that whereas the Financial NPV was more than (in absolute terms) - £5 million, the social NPV was around - £2 million. The Department of Transport concluded that as both results were negative, the scheme would not have gone ahead using either evaluation approach and serious resource misallocation was unlikely to occur. Colin Buchanan and Partners adopted a slightly different line in that they believed the difference in net benefits (of over £3 million) would result in resource misallocation. Nash and Preston [4] take this further in that they emphasise that Buchanan's remit only allowed a partial analysis. Conversion of suburban services between Reading and London was considered beyond the scope of the study. If suburban services were included it is likely that the difference between the financial appraisal and the social cost-benefit analysis would be much greater, although both might be more positive, reflecting the importance of economies of scope/density to rail operators and user economies of scale to rail commuters. More substantial differences emerged in a recent case study of the Midland Main Line electrification scheme, which resulted in a financial NPV of £1 million but a social NPV of £77 million [5].

In assessing comparable experience overseas, we have identified three forms of approach. Firstly, there are approaches that are superficially comparable to those of BR. The best example is possibly France where the SNCF is required to achieve an 8.2% minimum rate of return. However, grants from local, regional and central government and the EEC are treated as windfall gains. An example is provided by the Poitiers - La Rochelle Electrification study [6]. The costs of this scheme were estimated at FF939 million (1987 prices). In order to achieve SNCF's rate of return grants worth FF260m were obtained from State, Region and Department governments and from the ERDF. In this scheme SNCF would fund 72% of the total cost of the investment. Through a `contrat de plan' with the State Government, SNCF is required to fund a minimum of 34% of all investment internally, although specific projects may be as little as 20% self-financed as long as the annual average is not below 34%. Unlike BR, SNCF is authorised to borrow on the national and international financial markets and has been using bond issues to finance investment in TGV lines.

The second approach is radically different from that of BR in that it places emphasis on comprehensive social cost-benefit analysis and is best typified by Germany. National coordinated transport infrastructure plans are drawn up and assessed using a very detailed methodology that assesses time savings, reduced road congestion, the probability of getting a seat, accident savings environmental impacts and development benefits in a mix of money and physical measures. A similar ethos underpins the development of the long term strategic plans of a number of other European countries such as the Netherlands (Rail 21), Belgium (Star 21) and Switzerland (Bahn 2000) with a particular emphasis being placed on environmental impacts. Recent work suggests that rail has a significant `green' advantage over private, motorised modes [7].

The third approach is something of a hybrid of the first two approaches and has been pioneered in Sweden where railway infrastructure and operations have been separated. The body responsible for rail infrastructure, Banverket (BV), applies the same strategic approach using social cost benefit analysis techniques as the National Roads Administration, Vagverket (VV). For the inter-city, national network, the State Railway, Statens Järnvägar (SJ), is required to maximise profits, except for some routes where subsidy is received in order to achieve regional objectives. What has yet to become clear is how this system works in practice, the infrastructure requirements of the commercially minded operator are unlikely to be the same as those provided by a socially motivated track authority and clashes between SJ and BV seem inevitable.

2.3 SUBURBAN SERVICES

Suburban services in Britain are provided on a non-commercial basis. Network SouthEast was set an objective of operating without subsidy by 1992/93 but recent poor operating results have caused this objective to be dropped (in 1990/91 the sector only covered 87% of costs). Suburban services outside London are operated by Regional Railways. Regional Railways aim is to cover 42% of costs by 1992/93 (in 1990/91 it covered 37%), although much of this deficit is due to cross-country and rural services. It is likely that dense commuter services have a much better cost recovery ratio.

Suburban services are subsidised from two main sources. In London and the South East, they are financed from the Public Service Obligation (PSO). Table 2.3 shows that in real terms, support for these services decreased from £258 million to £88 million between 1986/87 and 1989/90 (down 66%) but in the last financial year for which results are available, the amount of support increased to £143 million. Outside London and the South East, most suburban services are funded by the PTEs who make payments to BR through Section 20 agreements (established by the 1968 Transport Act). Finance from this source has been relatively stable, being in real terms £94 million in 1986/87 and £101 million in 1990/91 (up 7%).

Despite the fact that suburban services receive subsidy, BR investment appraisal is based on financial appraisal with one important modification. The `do nothing' option against which the `do something' investment case is considered precludes large-scale withdrawal of services as these are prohibited by directives by Secretaries of State in 1975 and 1988 under the 1974 Railway Act. Instead, it is a `do minimum' option based on maintaining the existing service with its existing capital assets. For example, when considering investing in new rolling stock on a suburban line, BR's base comparison is maintaining the service with existing rolling stock rather than abandoning the service. In essence, this revolves around the trade-off between depreciation and maintenance costs. [The same approach applies to the core InterCity routes but not to peripheral routes eg. Shrewsbury-Wolverhampton where service withdrawal may be feasible]. The emphasis of this approach seems to be on cost reductions on existing services rather than on attempts to increase traffic and revenue through new services. In the case of new lines and stations the `do nothing' option is just that and makes justifying new services more difficult than justifying investment in existing services. The new line and station `boom' has largely been instigated by Local Authorities rather than BR.

Social cost-benefit analysis may be used for local authority sponsored schemes, providing that a section 56 grant is not required (to be discussed more fully in 2.4). As a result PTEs, in particular, have been successful in introducing new stations and services and more recently electrifying services, although in many cases these schemes were also justifiable on financial grounds.

It has been argued that this appraisal system based on the objective of fulfilling social obligations at least financial cost has led to chronic underinvestment, particularly in Network SouthEast. The Monopolies and Mergers Commission report [8] shows that London compares unfavourably with Paris in terms of investment in its suburban rail system, whilst a SERPLAN report suggests that up to £24 billion is required to be invested in the London and South East rail network alone [9].

It seems that suburban services are likely to be the focus of a major investment programme over the next decade. Network SouthEast is to adopt a strategy of "Total Route Modernisation" and the deployment of Network turbo and electric trains. In addition, four major schemes are proposed that will re-draw the map of London's railways:

- the Paddington-Heathrow Link, a joint project with BAA
- East-West Crossrail, a joint project with London Underground Limited
- Thameslink 2000
- Kent Express.

The intention is to develop a new fast regional network, centred on Kings Cross and Farringdon that might be seen as similar to the Paris RER network.

The current investment strategy in Regional Railways is likely to be completed soon, as the fleet will almost be totally renewed by 1993. Emphasis is likely to be placed on improving services, with "Future Rail" promising 150 miles of electrification, 60 miles of new route and 100 new stations over the next decade.

Furthermore, application of financially based evaluation procedures lead to the same `comparability' issues as discussed for InterCity services. Two illustrations are provided by Table 2.4. The first column examines a package six new stations built in West Yorkshire between 1982 and 1985. In this case both the financial and social NPVs are positive and comparability does not seem to be an issue. However, individual stations did exhibit financial and social NPVs that had different signs. Moreover, this example shows that definition of the agency responsible for investing in new stations affects the financial appraisal results. If the agency is responsible for both bus and train services the financial NPV is only just positive

(£23k) but if the agency is defined as being responsible just for train services (and revenue abstracted from bus is therefore treated as a net gain) then the financial NPV becomes much larger (£1597k). In these circumstances, there may be an incentive to over-invest in railway services that can abstract revenue from bus.

The second column shows a more obvious example of the comparability issue and is based on an initial evaluation of the Leicester to Burton-on-Trent rail scheme. An initial evaluation suggested that this scheme could only achieve a financial NPV of - £6 million but would achieve an NPV based on comprehensive social cost-benefit analysis of £2 million. Subsequently, this scheme was modified to include service extensions to Derby and Loughborough and has been recently given the funding go-ahead (see 2.4).

With the possible exception of Japan, a commercial approach to suburban services has been largely rejected by other countries. Practice abroad is characterised by:

(i)Suburban rail services planned as part of an integrated public transport system
(ii)The use of comprehensive social cost-benefit analysis to justify revenue support and capital investment
(iii)Much higher levels of subsidy and capital investment
(iv)A greater variety of funding mechanisms and greater involvement of local and regional governments.

In terms of suburban rail services, the opposite approach to the British is best provided by Germany and their S-bahn systems [10].

2.4 LIGHT RAIL AND URBAN SERVICES

For the purposes of this section, we shall specify that there are five urban rail systems in Britain namely:

(i)London Underground - operated by London Underground Limited
(ii)Tyne and Wear Metro - operated by Tyne and Wear PTE
(iii)Docklands Light Railway - operated by Docklands Development Corporation
(iv)Glasgow Underground - operated by Strathclyde PTE
(v)Manchester Metrolink - operated by GMML, part of the GMA Consortium.

2.4.1 Segregated Rail

The first four systems are basically heavy or totally segregated light rail systems in receipt of on-going operating subsidy, although, as in the case of BR's non-commercial sectors, reduced subsidy targets may be set. The difficulties in achieving such targets are illustrated by the results for London Underground Limited (Table 2.5). As with Network South East, Government aspired to this system being operated with zero subsidy. This was close to being achieved in 1987/88 with receipts covering 91% of costs but this figure has subsequently deteriorated to 75%, largely due to a 32% increase in costs. These cost increases are largely due to increased investment as a response to the recommendations of the Fennell report.

A detailed break-down of recent investment in London Underground is not readily to hand. Major renewals of infrastructure and rolling stock are planned on several lines - eg Central and Northern. Future investment is likely to be dominated by mega-projects such as the Jubilee line extension to Stratford (costing at least £1 billion) and a package of proposals endorsed by the London Assessment Studies valued at up to £4.2 billion. In the case of the Docklands Light Railway the £250m Bank extension and the £240m Beckton extension are under construction and the £120m Lewisham extension is at the planning stage. In the case of the Tyne and Wear Metro the £12m Airport extension has been completed and the feasibility study for extensions to Washington and Sunderland is currently being undertaken [11].

Investment in London Underground is assessed using cost-benefit analysis so as to be consistent with an objective of maximising social benefits subject to a budget constraint. Particular emphasis has been placed on assessing the benefits of improving reliability and decreasing overcrowding both on trains and at stations [12]. Similar techniques are believed to be used to assess investments by the other urban heavy rail operators. However, many investment decisions are dependent on private sector contributions (Bank extension, Newcastle Airport extension, Jubilee line).

2.4.2 Light Rail

Britain's only operational light rail system involving on street running is the Manchester Metrolink, which at an estimated cost of £115m, opened in stages in the spring of 1992. The line was funded by Greater Manchester PTA, Central Government through a Section 56 grant and a contribution from the concessionaire, the GMA group (a consortium of GEC Alstholm, Mowlem, AMEC and GMBUS). GMA won the franchise on a design, build and operate basis. The service is expected to be run commercially, with profits being used to contribute towards capital costs. GMA are free to set fares at commercial levels but minimum service levels are specified. In other words, GMA's objective is to maximise profits subject to a level of service constraint. This form of regulatory control is unlikely to lead to an optimal (in welfare terms) fare and frequency combination.

The Manchester Metrolink scheme was evaluated using a form of quasi-commercial appraisal that has become known as the Section 56 approach and is outlined in publications by the Department of Transport [13, 14]. The approach differs from social cost-benefit analysis because user benefits are specifically excluded from the appraisal on the basis that they can be captured through the fare box. This will only be possible if rail operators are capable of perfect (or first order) price discrimination, which patently they are not (although some form of third order price discrimination is normally possible in Britain; it is often prohibited by law in countries abroad).

Appropriate methods to use in Section 56 appraisals have been studied in depth by HFA in a study for PTEG [57]. The implications of a section 56 appraisal for the comparability issue are clearly illustrated by the Leicester to Burton new rail service evaluation given by Table 2.4. A comprehensive social cost-benefit analysis gives an NPV of +£2.1m but a Section 56 appraisal gives an NPV of -£2.5m. Some commentators have speculated that only commercially viable projects are likely to also have a positive Section 56 NPV [15]. This hypothesis seems to be supported by the evidence from the evaluation of West Yorkshire new stations given in Table 5.4.

The section 56 appraisal for Manchester Metrolink is given by Table 2.6. This indicates that the main benefit of the scheme is expected to be BR capital expenditure and section 20 savings as a result of light rail technology replacing heavy rail and hence reducing operating and capital renewal costs. On a pure commercial basis this scheme only showed a shortfall of £7.27m, whilst the analysis assumes revenue remains constant, whereas in practice there may be some scope for pricing-up.

However, there are likely to be some rail schemes that are not commercially viable that do show positive section 56 results. An example is the proposed Robin Hood rail service between Nottingham-Mansfield-Worksop [16]. The evaluation results for this scheme are given by Table 27.

Table 2.7 shows that at the base fare and service levels the Robin Hood line exhibits a negative NPV (-£5.0m) but a positive section 56 NPV (+£6.1m). However, the section 56 appraisal process requires that projects minimise net financial costs. The second row of Table 2.7 shows that the negative financial NPV can be reduced to -£2.7m but this also means that the Section 56 NPV is reduced to £4.9m. This is mainly achieved by a drastic reduction in train mileage (down 40% compared to the base). This contrasts with the modest decreases in fares and mileage required to maximise section NPV (given by the third row of Table 2.7). This suggests that a section 56 appraisal is likely to lead to a sub-optimal level of service. It should be noted that in this example, the section 56 and social results (assuming a break-even budget constraint) are compatible as both user and non-user benefits are assumed to be proportional to demand. If this assumption is relaxed, the issue of comparability between a social and section 56 evaluation also becomes relevant to the determination of fares and service levels.

Despite these funding difficulties there has been a boom in light rail proposals in Britain. In 1991, 47 areas had considered LRT but only five were at an advanced planning stage. Approximately, six months later around eight schemes were at the preliminary stage (Table 2.8). However, the number of schemes at the study stage decreased from 32 to 27 which is indicative of increasing realism in the field. Estimated costs are available for 14 of the cities listed in Table 5.8 and total almost £2.3b.

A study of 14 schemes undertaken in the summer of 1991 [17] indicated that funding would be 33% from section 56, 29% from local sources and 23% private. However, the two schemes that had achieved funding at the time of the study, Manchester Metrolink and Sheffield Supertram, had only achieved 5% and 2% funding respectively from the private sector. If this is the case for all other schemes the shortfall will have to be made up by Section 56 and local Government finance. Work carried out in Nottingham (Table 2.9) suggests that successful application for section 56 grants is in future likely to be crucially dependent on the extent of non-user benefits, namely congestion relief and accident reductions for road users. A key issue is how these can be accurately measured.

The extent of LRT in the United Kingdom contrasts strongly with the experience of some other developed countries. Light Rail Review listed the UK as having only two LRT systems in 1990 (Docklands and Tyne and Wear - both of which are totally segregated). By marked contrast, West Germany has 28 systems (see also [18]), the USA 14 (see also [19]), Japan 19 and France 6. Table 2.10 indicates that one of the causes of the differences is the variation in funding sources. At one extreme, many urban rail enterprises in Japan are privately owned and commercially operated, an organisational model that is attractive to the UK Government. However, commuter railways in Japan tend to be part of a vertically integrated operation that includes residential property at one end of the line and retail and commercial property at the other end. Table 2.11 shows that up to 67% of the income for Japanese railway companies comes from estate development and `other businesses'. This organisational model contributed to the growth of the London Underground in the past but it is unlikely to be revived.

More promising are public/private partnerships but recent UK experience suggests that these are fraught with problems (eg. Jubilee line extension, Paddington-Heathrow, Channel Tunnel rail link). Extracting direct contributions runs into free-rider problems and there are significant collection costs. Although optional funding mechanisms have a role to play, it seems that mandatory mechanisms may be more effective. There are three broad models:

(i)land-value taxes, assessed via benefit assessment districts. This may be supplemented by regional sales tax and is particularly common place in the US (Table 2.12)
(ii)Employer's taxes. These are used in France (see Table 2.13) and are supplemented by extensive land-use planning controls
(iii)Fuel tax, which is then used to finance urban rail transport, which is the basis for the high level of investment in West Germany.

Two principles seem to separate the UK from France, the US and West Germany. Firstly, the scope for raising local taxation in the UK is severely limited compared to the other three countries. Furthermore, in the case of EC grants the UK government fails to accept the concept of additionality; that is that EC grants should be additional to rather than in place of government funding. Secondly, again in contrast to the other three countries, the UK government does not accept the principle of hypothecation; that is raising taxes that are ear-marked (or ring fenced) for specific purposes, such as investing in rail schemes.

2.5 FREIGHT

Rail freight services in Great Britain are provided commercially and have been set an objective of a 4% return on assets by 1993 and ultimately an 8% return. Railfreight services are expected to be privatised during the course of the current parliament (ie. by 1997; at the latest). Currently, however, rail freight services were in deficit in 1990/91 to the tune of £54m, although profits have been made in previous years (Table 2.14).

Table 2.14 shows that there is a distinction between Trainload Freight which is profitable and Railfreight Distribution which is increasingly unprofitable to such an extent that some disinvestment has taken place (eg. withdrawal of the Speedlink service and the closure of some Freightliner terminals). However, it is also this area of railfreight operations that is likely to see the greatest growth post-channel tunnel and large investments are being made at multi-modal terminals such as Port Wakefield, Wilton, Moss End and Willesden.

These terminals are being developed in conjunction with private sector developers whilst the private sector is also developing its own terminals (for example Doncaster, Harwin Hall). Given this, the setting-up of Charter rail and Tiger rail and the fact that private companies own 40% of the rail freight wagon fleet (with two companies also owning locomotives) it seems that private/public sector partnerships have much more potential in the freight than the passenger business. However, the recent financial difficulties of both Tiger rail and Charter rail indicate that there are still plenty of pitfalls.

The main source of Government grants for rail freight is provided by section 8 of the 1974 Railways Act, which will provide up to 50% of the costs of rail wagons, sidings, unloading equipment and associated land and buildings. Grant is paid when it is sufficient to tip the balance in favour of rail when compared with alternative road transport. No grant is paid where schemes are commercially justified in their own right. The aim of the grant is to encourage firms to take lorries off environmentally sensitive roads.

The history of section 8 grants up to 1986 has been reviewed by Nash and Tweddle [20]. Table 2.15 shows that over a 12 year period, grants only totalled £61m, with the main recipient being the construction industry. Nash and Tweddle criticised the appraisal process for section 8 grants on two fronts, both of which have been partially addressed.

(i)Grants are based on the amount of lorry sensitive miles saved but the definition of environmentally sensitive roads was extremely narrow (essentially single-carriageways in built-up areas, National Parks and Areas of Outstanding Beauty and unclassified roads). In 1991 this was extended to include all single-carriageway roads and most urban dual-carriageway roads but motorways were still excluded

(ii)Grants were to be paid up to a maximum of 50p per lorry mile saved, although in practice the amounts paid out were between 20 and 30 pence per mile. Nash and Tweddle argued that this was insufficient to cover costs caused by heavy lorries that are not adequately taken into account by the taxation system such as wear and tear, congestion and accidents. The maximum level of grant has subsequently (1991) been raised to £1 per lorry sensitive mile.

The other source of funding for rail freight investment is the EC, although this is limited by the non-acceptance of the additionality principle mentioned earlier. In some cases, EC grants may influence locational decisions. BR's initial preference for a Channel Tunnel freight terminal in West Yorkshire was to develop the existing freightliner terminal at Stourton, near Leeds. However, this site was not eligible for EC grants whilst nearby Normanton (Port Wakefield) is and as a result is likely to attract the new freight terminal even though this may mean the loss of some economies of scale.

Rail freight investment in continental Europe tends to be at a higher level than in Britain for at least three reasons. Firstly, some road haulage industries face some form of quantity control (for example, Germany) and exhibit relatively high costs. Rail is therefore relatively more attractive.

However, there are trends towards liberalisation (for example, France), with rail losing market share (particularly for general merchandise). Secondly, rail freight businesses on the continent are not generally set explicit commercial objectives (although there are trends towards this). The principle that rail freight has social and environmental advantages over road freight is widely accepted and subsidised accordingly, particularly in terms of capital grants, for instance for inter-modal systems. Thirdly, lengths of haul on the continent tend to be longer than in the UK making rail freight more competitive and hence a more attractive investment; a large part of continental rail freight is international.

Counterbalancing this to some extent, it should be noted that road tax in Great Britain on heavy lorries tends to be much higher than in other member states of the EC (see Table 2.16), even though it is argued by some that lorries in Great Britain should face 30% increases in taxation [21]. By contrast, road taxes on heavy vehicles in Great Britain are similar to those in Switzerland (which however has widespread lorry bans) and Norway and substantially less than those in Sweden.

Trends in the European freight market suggest that in terms of regulation the rest of the EC is likely to become more like Great Britain, whilst in the case of road tax harmonisation is likely to mean that Britain becomes more like the rest of the EC. In both cases this would be detrimental to rail freight's prospects.

2.6 CONCLUSIONS

The current objectives, funding mechanisms and investment appraisal procedures for different segments of the rail market in Britain are summarised in the table below.

What emerges is an ad-hoc mixture of commercial and social objectives. By contrast, best practice on the continent involves an integrated approach with an objective of maximising social benefit, a funding mechanism that makes subsidy readily available and investment procedures that are based on social cost-benefit analysis. The nearest to this approach practised in Britain is that of London Transport with respect to Underground services but with much firmer reliance on central rather than local government raised funds.

Given the paucity of funding sources in Britain and the more stringent investment criteria, it might be expected that future investment in rail will be substantially below that in the rest of Europe. This seems to be confirmed by Table 2.17 where forecast investment in the national rail network in Britain is substantially below that in France, Germany and Italy, although projected expenditure on rapid transit is likely to be more comparable. The issue of comparability between different evaluation procedures in Britain has been well investigated and illustrates that there is substantial risk of resource misallocation. `Ad-hoc' evaluation procedures based around Section 56 (for passengers) and Section 8 (for freight) should be abandoned in favour of comprehensive social-cost benefit analysis.

The research issues that result from this analysis are manifold but include:

(i)Information on recent and future investment in railways in Britain and its major competitors remains, at best, patchy despite recent studies [22]. Detailed research is required; in part, a current project at ITS will provide this

(ii)The issue of comparability between different funding and investment regimes within the EC has only been partially researched and the implications for resource allocation are not fully understood. There should be a recognition that in some cases subsidising railways is a `second-best' solution that may be inferior to a `first-best' solution of taxing road transport, whilst mechanisms for ensuring that subsidy does not lead to X-inefficiencies in the rail industry should be explored

(iii)Application of comprehensive social cost-benefit analysis requires the development of more robust methodologies to quantify and monetise the impact of rail investment on highway congestion and accidents, and, particularly on the environment

(iv)Further case studies, for instance, of West Coast Main Line upgrading would be helpful

(v)The organisational relationships between the private and public sectors in the rail industry need further study. The impact of privatisation on rail investment in Britain needs assessing, possibly using models developed for other sectors [23]

(vi) The role of tendering and franchising arrangements in both the operation of rail services and related activities needs investigation given current government intentions in this area.

The current policy framework in Britain makes the latter two points of crucial importance.

Market segment	Objective	Funding mechanism	Investment procedure
InterCity	Maximise profits	Commercial	Financial appraisal
Suburban	Maintain service at minimum financial cost	Non-commercial - supported by PSO/ Section 20 payments	Financial appraisal - BR. Social Cost Benefit Analysis/Section 56 Evaluation - Local Authorities
Urban Heavy rail	Maximise social benefits subject to a budget constraint	Non-commercial - direct Government support (capital and operating)	Social Cost Benefit Analysis
Urban Light rail	Maximise non-user benefits at minimum financial cost	Non-commercial - Government capital grants	Section 56 evaluation
Freight	Maximise profits	Commercial - some Government capital grants	Financial appraisal. Section 8 appraisal for capital grants

The ultimate challenge is to frame policy that ensures that the technological and environmental advantages of rail transport are fully exploited. One might hypothesise that this might combine the best of the commercial attitudes that dominate the railway industry in Britain with the social awareness of the railways in the EC.

Table 2.1: British Rail (BR): EFL and Investment (£m, cash)

Year	EFL	PSO	Out-turn investment
1986/87	777	786	428
1987/88		804	543
1988/89		607	590
1989/90		587	715
1990/91		700	834
1991/92		900	1095
1992/93		1000	
1993/94		800	
1994/95		600	

Source: Department of Transport 1992 "Government Expenditure Plans for Transport". Cm1907.

Table 2.2: Birmingham-London/Basingstoke Electrification (NPV £m 1979 prices at 7%)

Low growth scenario	
Increase in passenger revenue	6.490
Reduction in operating costs	27.955
Reduction in capital and maintenance costs	-40.095
Financial NPV	-5.650
Consumer surplus to rail users (existing and new)	2.857
Consumer surplus to remaining road users	1.485
Saving in road accident costs	0.440
Tax adjustment	-1.243
Change in LT revenue	-0.063
Social NPV	-2.175

Notes:This appraisal covered intercity passenger services only. Local and suburban services were assumed to remain diesel-operated. Consumer surplus to remaining road users is shown as 1.845 in the original, but comparison with figures elsewhere in the report makes it clear that this is an error.

Source: Department of Transport, 1984 [3]

Table 2.3: British Rail Subsidy (£m, 1990/91 prices)

	1986/87	1987/88	1988/89	1989/90	1990/91
InterCity	137.4	134.1	-	-	-
Network SouthEast	258.5	263.3	155.0	87.8	142.7
Regional- PSO	534.7	512.6	472.2	431.6	428.1
- S20	94.5	97.2	89.7	100.2	100.7
Other	-	-	-	24.1	28.4
TOTAL	1025.1	1007.2	716.9	643.7	699.7
of which PSO	930.6	910.0	627.2	543.5	599.2

Source: British Railways Board, Annual Report and Accounts

Table 2.4: NPV's of 2 Rail Investments (30 year life, 7% interest rate, £k, 1986 prices)

	West Yorkshire 6 New Stations		Leicester-Burton New Service
Revenue gained from new users	997	(2800)	8897
Revenue lost due to slower journeys	166	(400)	
Costs	803		14960
Financial NPV	28	(1597)	-6063
Benefits to road users	390		5916
Tax adjustment	282		2326
Social NPV (1) - Section 56	136		-2473
Benefits to rail users	43		4582
Social NPV (2) - Comprehensive	179		+2109

Source: Nash and Preston [4]. Figures in brackets show the financial effects ignoring consequences for bus operators.

Table 2.5: London Underground Operating Results (£m 1990/91 prices)

	1986/87	1987/88	1988/89	1989/90	1990/91
Receipts	498.3	514.3	519.3	522.3	561.7
Costs	592.1	566.7	601.3	653.5	748.9
Operating deficit	93.9	52.5	82.0	131.1	187.2

Source: London Regional Transport Annual Reports and Accounts

Table 2.6: Comparison of Manchester Metrolink Expenditure (discounted 30-year totals)

Section 56 criteria	£m	£m
Capital Cost	87.00	87.00
Public sector costs avoided and non-user benefits		
BR Capital Expenditure	41.44	
Tendered Bus Services	1.31	
Section 20 Savings	36.98	
Congestion Savings	6.00	
Accident Cost Savings	2.00	
Total	87.73	87.73
Ratio		1.01

Source: Tyson (unpublished)

Table 2.7: Robin Hood Line Base Result and Best Financial and Social Results (£k, 1989)

Fare	Miles	Fin. NPV	Social NPV	S56 NPV
Base	Base	-4951	8404	6107
+25%	-40%	-2742	6462	4922
-7%	-2%	-5245	8754	6340

Source: Preston, 1992 [16]

Table 2.8: State of LRT Schemes in the UK

	Summer 1991	Winter 91/92
Act obtained	2	1
In Parliament	1	4
Detailed study	11	9
Preliminary study	21	18
Under construction/finance awaited	3	3
TOTAL	38	35
Not proceeded with	9	9

Source: Rapid Transit UK, 1991, 1992

Table 2.9: Outline Economic Appraisal for the Radford Road/Hyson Green Option (Nottingham LRT)

	Present Value (£ millions)
Cost	
Capital cost	31 - 38
Operating cost	19
Total	50 - 57
Benefits	
Operating revenue	21
Congestion savings	25 - 43
Development impact	13 - 19
Betterment effect	6 - 10
Job creation	4 - 6

Total	69 - 99

Source: Scott Wilson Kirkpatrick (unpublished)

Table 2.10: Relevant Funding Sources for Public Transport

Mechanism	Relevant application
Voluntary private undertaking	Japan
Public/private partnership	
Direct contribution (developers, contractors, operators, etc)	GB USA
Joint development (air rights lease/sell)	USA
Betterment channelling	
Benefit assessment districts	USA
Area-wide earmarked taxation	USA France Germany
Land-market intervention	France
General taxation resources	France GB Germany USA Japan

Table 2.12: USA Cities Levying Sales Taxes for Public Transport

Cities	Tax
Cleveland	
Saint Louis	Regional Transportation Sales Tax (Illinois Downstate Transportation Fund)
Kansas City	
Atlanta	Regional Transit District Sales Tax
Denver	Regional Sales Tax
San Diego	Regional Sales Tax (Local Transportation Fund)
Chicago	Regional Transportation Sales Tax
Los Angeles	Regional Sales Tax (Local Transportation Tax)

Seattle	Regional Sales Tax (King County)
San Francisco	District Sales Tax

Source: Simpson, B.J. (1990) "Urban Rail Transit: Costs and Funding", TRRL, CR160.

Table 2.11: Private Railways in Japanese Stock Markets Total Assets and Composition of Revenues (%)

Company	Asset U$m	Railway operator	Bus operator	Estate dev. (*)	Other business
Tobu R	4165.1	58	21	21	
Seibu R	2486.7	47		16	37 a,b
Sagami R	2103.8	24	9	45	22 c
Hakone R	88.4	20	60		20 a,c,h
Tokyu	5249.2	34	11	29	26 a,d
Keihin E	2696.3	40	16	31	13 a,b
Odakyu E	2808.5	64		23	13 a,b
Keio T	2508.6	56	22		22 a,b,h
Keisei E	1617.8	50	34	16	
Fuji K	537.7	3	50	6	41 a,b
Nishi-N	1062.7	18	57		25 e
Kinki N	4930.6	79	5		16 c,d,h
Hankyu	3088.6	69		31	
Hanshin E	808.2	49	9		42 b,c,e,h
Nankai E	3121.7	62	14		24 f,h
Keihan E	1790.4	53			47 c,h
Kobe E	430.2	64	3	33	
Nagoya R	3067.5	60	17	12	11 b,c
Sanyo E	438.3	66	13	21	
Izuhakone	224.8	12	27	12	49 a,g
Shin-K	301.9	53	34		13
Izukiu	262.8	40		51	9 b,c
Keifuku E	174	28	41		31 b,h

(*) includes housing and office development revenues

(a) hotel
(b) leisure
(c) retailing
(d) communication
(e) freight
(f) taxi
(g) navigation
(h) estate development

Source: Japan Company Handbook February 1987

Table 2.13: Allowed Rates of Versement Transport

Urban areas	Maximum Rate (%)	Number of Towns	Year of Introduction
Paris inner suburbs	2.0	1	1971
Paris outer suburbs	1.5	1	1971
Towns with more than 30,000 population and fixed track public transport system	1.5	8	1974
Towns in the range of 100,000 to 300,000 population	1.0	53	1975
Towns in the range of 30,000 to 100,000 population	0.5	90	1983

Source: Simpson, B.J. (1990) "Urban Rail Transit: Costs and Funding". TRRL CR160

Table 2.14: Rail Freight Financial Performance (£m, 1990/91)

	1986/87	1987/88	1988/89	1989/90	1990/91
Trainload Freight					
- Revenue	*	*	604.2	567.4	509.5
- Costs	*	*	445.8	421.7	410.8
- Profit	32.2	54.6	158.4	145.7	98.7
Railfreight Distribution					
- Revenue	*	*	200.9	193.8	172.8
- Costs	*	*	277.3	274.3	325.6
- Profit	(8.3)	(7.8)	(76.4)	(80.5)	(152.8)
TOTAL RAIL FREIGHT					
- Revenue		695.4	805.1	761.2	682.3
- Costs	701.9(E)	648.6(E)	723.1	696.0	736.4
- Profit	23.9	46.8	82.0	65.2	(54.1)

Source: British Railways Board, Annual Report and Accounts

Brackets denote losses
E - Estimated Costs
* - Break-downs not available

Table 2.15: Section 8 Grants by Year and Commodity Sector (£000's)

Year	Coal & coke	Steel & metals	Construc-tion	Chemicals Fertilisers	Food & drink	Containers & ports	General merch.	Not known	TOTAL
1975	-	285	-	-	-	200	-	-	485
1976	110	18	1125	305	7	303	-	419	2287
1977	193	1634	1010	50	-	295	376	430	3988
1978	808	2055	3232	93	13	1170	1240	364	8975
1979	607	112	2535	500	93	-	574	265	4686
1980	-	253	3475	2106	151	289	1154	154	7582
1981	1620	-	-	-	82	1290	880	458	4330
1982	238	34	1778	-	-	-	510	807	3367
1983	422	2521	420	-	32	-	1409	1247	6051
1984	202	1209	3997	-	230	43	670	1164	7515
1985	155	144	6912	258	276	-	727	475	8947
1986	-	-	-	-	226	1750	239	470	2685
Sector Total	4355	8265	24484	3312	1110	5340	7779	6253	60898
As % of Total	7	14	40	5	2	9	13	10	

Above figures do not include five grants (total £1.379m) under section 36, Transport Act 1981 (which related to waterways)

Source: Nash and Tweddle, 1988 [20]

Table 2.16: European Highway Revenue/Cost Ratios

	Fixed	Duties Fuel	Total	Revenue/Cost Ratio
Denmark	3200	1573	4773	0.41 : 1
FR Germany	4185	7026	11211	0.96 : 1
France	760	6255	7015	0.60 : 1
Italy	375	2771	3146	0.27 : 1
Netherlands	1625	2814	4439	0.38 : 1
Norway (inc km tax)	2650	132	2780	0.24 : 1
		(14060)	(16842)	1.44 : 1
Switzerland	1320	11954	13274	1.14 : 1
Sweden (inc km tax)	2000	2836	4836	0.41 : 1
		(51800)	(56636)	4.85 : 1
UK	5185	8708	13893	1.19 : 1

Notes: assumes rate of duty as per ECMT Round Table 71. Lorry averages 74,000 km per year at consumption of 2.08 kms/lt. Track costs equal £93.15 (147.71 ecu) per 1000 km.

Source: Fowkes et al, 1990 [21]

Table 2.17: Investment Prospects to 2000 (£m, 1989)

	National Rail Total 1989-2000	Rapid Transport Total 1989-2000
Austria	3430-4410	340-440
Belgium	4350	660-990
Denmark	1530-1650	180-270
Finland	2025	
France	18390	4090-5100
Germany	20700	3450
Greece	330+	44+
Ireland	46-230	
Italy	34400-49150	4950-7370
Luxembourg	140	
Netherlands	2600	150-460
Norway	1140-1615	170
Portugal	1460	90-130
Spain	9730	830-1110
Sweden	2730-2940	100-200
Switzerland	6260-6650	780-1180
UK	8250-11000	3850-4950
TOTAL	**118000-137000**	**19700-25900**

Source: Kennedy Henderson, 1990 [22]

3.IMPACTS OF RAIL PRICE AND QUALITY OF SERVICE ON RAIL DEMAND

3.1 INTRODUCTION AND BACKGROUND

Measurements of impacts on rail demand are usually considered in terms of demand elasticities, representing the proportionate change in volume (V) after a proportionate change in some relevant variable. For marginal changes, the point elasticity of demand (η) with respect to price (P) is defined as:

$$\eta = \frac{\delta V}{\delta P}\frac{P}{V} \qquad \mathbf{1}$$

For larger changes, the arc elasticity is defined as:

$$\eta = \frac{\Delta V}{\Delta P}\frac{P}{V} \qquad \mathbf{2}$$

where Δ denotes a difference. Exceptions to this are made in the case of qualitative improvements (eg. station refurbishment) where a consequential % increase in demand would be used.

One approach to estimate elasticities is through the analysis of ticket sales and this is termed the aggregate approach. Such models are commonly used in the analysis of inter-city travel demand but less so for suburban travel, where the data tends to be less reliable, and not at all in the case of LRT schemes because of the absence of such systems and hence ticket sales data.

In contrast, what are termed disaggregate methods are based on the choices made by individuals, groups or firms rather than collective measures of behaviour. They can examine travel demand in more detail than aggregate methods and are more suited to exploiting alternative data sources such as stated preference. They are often developed on the basis of mode choices and therefore automatically incorporate the effects of competition, whereas aggregate models typically make little reference to the competitive situation. Disaggregate mode choice models have not seen widespread application to inter-city trips, partly because the infrequency of long distance trip making makes data collection expensive, especially in comparison with relatively cheaply available ticket sales data. However, they have seen widespread application to the analysis of suburban travel and LRT schemes because data collection is here less expensive and because aggregate data is either unavailable or unreliable.

What follows concentrates on the response to improvements in rail services. It must also be said that the case for rail investment depends on the underlying trends in demand. Here there are a number of adverse factors - rising car ownership, population movement away from cities - which lead most studies to conclude that in a do-nothing situation rail demand will decline (see for instance the time trend in Owen and Phillips [26]), although this may be partly the result of reducing data capture over time. Demographic trends are less clear cut. They favour business travel, whilst in the leisure market, the declining number of young people is being offset by rising numbers of pensioners. Both are traditionally strong rail markets, but the cohort effect of a higher proportion of pensioners having driving licences, and the increase in very elderly are unhelpful [56]. On the freight side, the decline in heavy industry has also damaged the position of the railways, although increased international trade and the opening of the Channel Tunnel will help. A recent, so far unpublished, study by ITS for DOT has looked at the scope for producing more disaggregate freight demand forecasts which would be helpful in assessing prospects for rail.

3.2 INTER-CITY TRAVEL

The main method of deriving estimates of elasticities in this area has been the consideration of past experience. Jones and Nichols [24], Fowkes, Nash and Whiteing [25] and Owen and Phillips [26] all report complex econometric time series analyses of BR ticket sales data, with demand elasticities estimated for price and GDP, and effects quantified for such things as electrification, introduction of `InterCity 125' and coach service deregulation. Studies undertaken for BR by its Operational Research Division have examined the changes in ticket sales due to changes in price, service quality (represented by a composite variable which includes journey time, interchange and frequency effects) and stock type. Recent work at ITS has extended such analysis to examine how rail elasticities vary with the degree of competition from other modes by collecting detailed information on the price and service quality characteristics of car, coach and air.

These studies typically produce highly plausible estimates of the main effects upon demand. The Owen and Phillips study is the largest and most recent of the published research, so it may be of interest to note that the median fares elasticity was found to be -1, with the median % growth factors attributable to IC125 (including speed and frequency effects) being 32% for first class and 16% for standard class. However, these models are not well suited to the analysis of travel variables other than price, journey time, frequency and interchange.

Disaggregate mode choice models have rarely been developed in the context of inter-city travel. Two studies, relating to business and leisure travel, have been conducted for British Rail but these are confidential. Another study was undertaken at ITS in 1984 and examined the mode choices and values of time of long distance business travellers [29].

The most significant application of this approach to inter-city travel was in the recent TransPennine Rail Study conducted by Transportation Planning Associates for a consortium of PTE's and local authorities. Information was collected on the characteristics of the chosen and best alternative mode of travel for an actual cross-Pennine journey. The sample was segmented according to whether the individual was choosing between train and car, train and coach, or car and coach, with models developed to explain the choices of the first two groups of travellers. The car-train model was based on more than 3000 observations whilst the train-coach model was based on around 1000 observations. The latter figure is regarded as large for studies of this type.

The elasticities implied by mode choice models are not constant but vary with, amongst other things, market share. The TransPennine models complicate matters further since they found that individuals' responses to time and cost variations depended on the level of time and cost. Further research is required to draw firmer conclusions regarding the appropriate form of the model. However, it must be remembered that mode choice models only capture that component of an elasticity due to switching between modes and an allowance for generated trips is required. This usually takes the form of adding x% to the modal transfer and more sophisticated analysis is required as to the appropriate allowance to make for trip generation in different contexts.

Table 3.1 presents the mode choice elasticities obtained for rail variables for the car-train and coach-train samples. These are point elasticities, averaged across the sample of individuals and based on their current travel situation.

The elasticities obtained are generally plausible with, as expected, a higher sensitivity to time amongst the car-train sample. They indicate that, even in the absence of trip generation effects, rail demand is sensitive to the level of rail fare and quality of service.

Table 3.1: Rail Mode Choice Elasticities

	CAR-TRAIN	COACH-TRAIN
In-Vehicle Time	-0.78	-0.20
Access/Egress Time	-0.71	-0.13
Interchange	-0.56	-0.20
Cost	-0.80	-0.81
Headway	-0.32	-0.25

The most common use of disaggregate methods in the inter-city market is in conjunction with stated preference data to estimate the effects of variables that are not readily estimated using ticket sales or actual choice data. These models tend to be 'mode specific', that is they involve an evaluation of different scenarios which all relate to rail travel. British Rail has been one of the pioneers in the application of stated preference methods to the analysis of travel demand, but most remain commercial-in-confidence.

The first application on BR is reported in Sheldon and Steer [27] and involved the valuation of interchange, time and frequency effects. Lessons are still being learnt in the use of stated preference methods and extreme care must be exercised in their use, particularly in `new' areas. They were successfully used in the Department of Transport's Value of Time Project [28], receiving the Department's blessing, and since then have been widely used in a variety of circumstances.

The effect of journey time on rail demand is now fairly well understood, with the main results publicly available. Rail values of time were given for commuters and leisure travellers in [28] and values for business travellers in [29]. In both cases values of time vary strongly with travellers incomes, being roughly equal to the wage rate for business travellers, and about one quarter of the wage rate for non-business travel.

The next major area to be tackled was valuations of the disbenefits of overcrowding. Values have now been derived for all three of BR's passenger sectors, but are only publicly available for InterCity [30]. This latter study also found values of adjustment time necessitated by trains not being timetabled at ideal times. From these values the effect on demand of an increase (or reduction) of service frequency can be derived. Not much progress has been made in determining the effect on demand of unreliability, this being a difficult concept to pin down, and present to respondents. The key paper here is Benwell and Black [31], but values for `maximum delay' are also presented by Marks and Wardman [32], which also gives direct estimates of the value of reduced headways between trains (ie. increased frequency). Improving the understanding of user valuations of service reliability is generally regarded as the next area which needs to be thoroughly tackled, current estimates being treated with some caution.

Valuation of attributes such as cleanliness and staff helpfulness have been tried but are extremely difficult. On showing respondents photographs to illustrate the questions being posed, even perfectly clean old stock can be judged `dirtier' than littered and grubby new stock. Valuations of the presence of station staff cannot be disentangled from the fact that many passengers do not find staff helpful and others have various reasons for wishing staff not to be present. Furthermore, respondents indicating a willingness to pay something each for a range of improvements are usually only indicating a willingness to pay for some improvement, and not that they would be willing to pay the sum of their valuations to have all the improvements. This shows that such valuations always depend on the starting position, and so are particularly difficult to generalise and transfer. Safety and security are special issues which can attract very high valuations, particularly from non-travellers.

A significant amount of research has been conducted on the valuation of improvements to stations, rolling stock, on-board facilities and information provision. However, this is of a confidential nature, whilst some of the results suffer from analytical problems which have been discovered in the methodology used.

3.3 SUBURBAN TRAVEL

There are relatively few published elasticity measures for underground travel, although we are aware that numerous stated preference studies have been conducted on various aspects of travel on London's underground. The violent fare changes related to the fares-fair policy gave a good opportunity to estimate fares elasticities and Collins [61] reports a figure of -0.16. However, later work [62] found higher values, namely -0.2 in the short term and -0.4 in the long term.

A sizeable body of work is now publicly available dealing with the introduction of new suburban rail services and the opening of new stations. The strong interest in re-opening or improving suburban rail services has led to considerable research effort in this area, and the relatively high frequency of such trip making and thus relative ease of data collection has encouraged the use of disaggregate methods using both revealed preference and stated preference data.

ITS has been closely involved with developments in this area. Initial studies of new services and stations in West Yorkshire [33] provide revealed preference mode choice and aggregate models.

A study of the re-opening of the line serving Brighouse and Elland also developed a disaggregate revealed preference mode choice model. Stated preference mode choice models have been developed to examine new services between Leicester and Burton-on-Trent, Nottingham and Mansfield, Blackburn and Clitheroe, and at 10 potential new station sites in Lancashire. Stated preference models have also been developed by transport consultants for a number of possible new or improved services (for example, re-opening the Walsall-Hendesford line, several new station sites in Merseyside and the West Midlands, and electrification schemes such as Shrewsbury-Wolverhampton). The aggregate models which have been developed for suburban travel contrast with those for inter-city travel in that they are based on an analysis of variations in trips across routes; they therefore potentially suffer from the problem of distinguishing between cause and effect. The development, advantages, shortcomings and predictive accuracy of the various models are discussed in Preston [34].

Experiences, and estimated elasticities etc, have been varied. Recent experience has been collected together at ITS in a manual of advice [34]. Values of time, in mid 1990 prices, were found typically to be in the range 2 to 3 pence per minute. The stated preference fare elasticities vary according to whether traders are omitted or not and thus they are difficult to interpret. Aggregate revealed preference fare elasticities from two studies of -0.66 and -0.83 are given. The figures from two disaggregate revealed preference models were -0.26 and -0.34. Care is needed in the application of such figures: the last figure relates only to work trips and the last two will vary according to rail market share and fare, whereas the first two are constant elasticities but do include trip generation. However, models do exist which can provide elasticity estimates for a range of variables tailored to the particular situation under consideration.

Table 3.2 shows the sources of traffic for four new rail services. Generally only about 15% of trips on the new services were direct replacements for car trips and trip generation is not trivial.

Table 3.2: Sources of Traffic for New Rail Services (%)

	Birmingham (Cross City)	Glasgow (Argyle)	Liverpool (Link & Loop)	West Yorks (6 New Stations)
Bus	36	70	46	56
Car	11	15	20	16
Rail	27	0	0	13
Ferry/Other	0	0	10	2
Generated	26	15	24	13

Source: Preston [33]

3.4 LIGHT RAIL

The position with regard to Light Rail is similar to that for suburban rail; indeed the very strong interest in LRT schemes in the UK in the past 10 years has, if anything, led to more applications of disaggregate mode choice models in this area than in any other. It has become the norm to have a separate data collection and modelling stage for each of the lines within an overall scheme (eg, Manchester Metrolink Lines 1, 2 and 3, Midland Metro Lines 1, 2 and 3, Leeds LRT Lines 1, 2 and 3) or for each of the rival potential operators (Manchester Metrolink). The main distinguishing feature is the reliance on stated preference methods since, unlike the suburban case, no such systems exist upon which to obtain actual choice data to develop a revealed preference model. There is, however, a need to draw together the findings from the various studies to learn from the experiences and to consolidate the body of evidence in this area.

Of interest is the monitoring study of Manchester Metrolink current being undertaken by TPA and ITS for the Department of Transport. One of the aims of this study is to validate the models and procedures which are involved in the evaluation of an LRT scheme. The previous forecasts will be compared with out-turn behaviour. However, a revealed preference model which would be of use for future forecasting needs, and which could be estimated on the actual choices which are now being made between the new system and car and bus, is not being developed. A similar study of the Sheffield scheme is to be conducted but we are not aware of the precise details.

3.5 FREIGHT TRANSPORT

Stated preference techniques are particularly useful in valuing the attributes of freight movements since `real' data is highly confidential and, in any case, much sparser than for passenger transport. Relative valuations of cost, journey time reductions, reliability improvements and intermediate handling, for a range of long distance (over 100 miles) freight movements were obtained by Fowkes, Nash and Tweddle [35]. In summary, compared to price, service quality attributes were of least importance for deliveries from a firm's factory to its own warehouse, of most importance for deliveries to other firms in the production chain (`just-in-time'), with deliveries to retail outlets and final customers coming inbetween. Some goods did not take kindly to intermediate handling and so were inherently unsuitable for rail. For most goods, however, the reason they do not travel by rail is explainable in terms of higher cost (including that of intermediate handling) and worse service quality offered by rail. Some limited quantification is available for these effects, some of it commercially confidential. The main emphasis of the analysis of freight transport by rail has been in terms of the competition with road and the potential for capturing such traffic. This is further considered in section 4.5.

3.6 CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

As far as passenger demand is concerned, there has been a considerable amount of research conducted on the effects of rail fare and service quality on the demand for rail travel, and an appreciable amount is in the public domain. Experience with regard to new stations and services has been set down in a manual of best practice [34], although there is no equivalent publicly available document for inter-city travel or LRT schemes. There is certainly scope for drawing together the results of the many LRT schemes into a consistent body of evidence and guide to best practice, which at the least would be useful in the initial planning stages of LRT schemes and which could potentially avoid the waste of resources involved in continually repeating stated preference mode choice studies for each scheme under consideration.

Our recommendations regarding further research into the determinants of the demand for rail fall into two areas. Firstly, there is a need to examine some of the already researched issues in more detail. Secondly, there is a need to advance research into areas where little or nothing is known.

(i)There is a need to more fully understand how elasticities with respect to fare, time, interchange and frequency vary. The constant elasticity model is too restrictive and too often adopted by default. How does the elasticity to variable X vary with the level of X, the level of some other variable Y, the degree of competition, distance and the size of the change in X. For example, current models may seriously understate the benefits of investment in high speed rail if the journey time elasticity is larger for larger journey time reductions

(ii)Disaggregate models allow more detailed analysis but more sophisticated methods than simply adding x% are required in order to appropriately allow for trip generation in different contexts. Moreover, the relationship between the perceived and actual characteristics of each mode, along with how publicity can mediate these, requires further attention, as do the factors which determine which modes will be considered (ie. enter the choice set) in the first instance and the nature of the choice process

(iii)Further research is required into the effect of what are often termed soft variables, that is, variables other than time, cost, interchange and frequency. Reliability is an important factor where more work is needed, whilst there are also gaps in knowledge with regard to the effect on demand of features such as stock type, on-board facilities and information provision. There is also increasing interest in how other soft variables, such as attitudes and expectations, images and lifestyles moderate the influence of other variables on demand or indeed influence demand in their own right

(iv)Given the government's current interest in privatisation and franchising, research is required of the implications in terms of ticket transferability, connections, general timetabling and the level of service on offer, advertising and perceptions of rail services, in addition to an analysis of the supply/cost side implications.

Our recommendations concerning further freight research largely relate to the interaction between rail and road and hence they are outlined in section 4.6.

4.IMPACTS OF RAIL PRICE AND QUALITY OF SERVICE ON DEMAND FOR AIR AND ROAD

4.1 INTRODUCTION AND BACKGROUND

The impact of changes in the characteristics of one mode on the demand for another mode is often summarised in terms of a statistic referred to as the cross-elasticity of demand. This is defined as the proportionate change in the demand for mode i (V_i) stemming from a proportionate change in the price or service quality of mode j. For a marginal change in, say, the price of mode j (P_j), the point cross-elasticity of demand for mode i (η_{ij}) is defined as:

$$\eta_{ij} = \frac{\partial V_i}{\partial P_j}\frac{P_j}{V_i} \qquad 3$$

An arc cross-elasticity is used to represent non-marginal changes. It takes the form:

$$\eta_{ij} = \frac{\Delta V_i}{\Delta P_j}\frac{P_j}{V_i} \qquad 4$$

where Δ denotes a difference.

There are two means by which cross-elasticities can be directly estimated. The first is through the use of aggregate models which are based on the number of O-D movements. These can take the form of market share models, which seek to explain variations in the market shares of different modes according to their relevant travel characteristics, or else direct demand models, which incorporate terms representing competing modes. The second approach involves the use of disaggregate models, which aim to explain the mode choices made by individuals, groups or firms, that is discrete choices are the unit of observation rather than aggregate measures of travel behaviour.

A good deal of caution is required in the interpretation and application of cross-elasticities. It is to be expected that the cross-elasticity of, say, car demand with respect to rail price will depend on market characteristics. For example, we would expect this cross-elasticity to be higher where car has a lower share. Indeed, one of the reasons advanced for TGV Sud-Est introduction in France achieving higher time elasticities than HST introduction in the UK is that the air market available to be captured was greater in the former case.

Dodgson [36] provides a relationship between a cross elasticity, own elasticity, relative market shares and a 'diversion' factor of:
where η_{jj} is the absolute value of the own elasticity, m_j is the market share of mode j and D_{ji} is

$$\eta_{ij} = \eta_{jj}\frac{m_j}{m_i}D_{ji} \qquad 5$$

the diversion factor defined as the ratio of the transfer to/from mode i and the change in demand on mode j. Even if the own-elasticity is approximately constant, it is unlikely that the other terms will vary in such a way as to imply an approximately constant cross-elasticity across different market situations.

The logit model is the most common of the disaggregate form of models mentioned above. In its simplest (and commonest) form, the cross-elasticity of, say, car demand with respect to rail fare is:

$$\eta_{ij} = - \beta \, COST_r \, P_r \qquad \mathbf{6}$$

where $COST_r$ is the cost of rail, β is the (negative) coefficient associated with cost and P_r is the market share of rail. Thus the logit model will provide different point cross-elasticities according to the rail cost and market share. For a β of -0.05, a cross elasticity of 0.2 is implied for a $COST_r$ of 10 and P_r of 0.4. This falls to 0.1 for a $COST_r$ of 20 and P_r of 0.1.

Thus given the fact that the cross-elasticity relevant to a particular situation will depend on the market characteristics in that situation, we have avoided presenting cross-elasticities here other than for illustrative purposes to indicate general orders of magnitude. We instead refer to the research which provides the functions from which cross-elasticities for a particular situation may be derived.

In addition to the two general methods for directly estimating cross-elasticities, equation 5 allows deductions of the likely order of magnitude of the cross-elasticity. Since the 'diversion' factor D_{ji} lies between zero and one, equation 5 can be rewritten to indicate maximum values of the cross-elasticity as:

$$\eta_{ij} \leq \eta_{jj} \frac{m_j}{m_i} \qquad \mathbf{(7)}$$

with notation as for equation 5. Sensitivity analysis can be conducted with equation 5 to examine how the cross-elasticity varies with different assumptions concerning D_{ji}. There is also scope for improving the estimates of D_{ji} either through stated preference methods or else by 'after' studies which aim to determine where new traffic originated from.

According to Dodgson [36], little account is taken of competing modes in the forecasting procedures adopted in the UK for road passenger traffic, road freight traffic, coach traffic and air traffic. Indeed, British Rail makes little explicit allowance for the competitive environment, although we are here interested in the effect of changes in rail on the demand for other modes, rather than the impact of changes to other modes on the demand for rail.

Domestic air traffic forecasts produced by the Civil Aviation Authority do not account for inter-modal competition, although the Department of Transport's 1988 forecasts do allow the Channel Tunnel to impact on air demand. The British Airport's Authority also produces forecasts for their airports and whilst their methodology has attempted to allow for major improvements in rail services, it has done so only in rather broad terms.

Road (passenger and freight) volume forecasts at the national level take no account of competition. The main area where allowance is made for competition is in the forecasting of urban trips, particularly within conurbations, with a modal split stage sequenced within trip generation, distribution and assignment. It is suspected that the forecasting procedures adopted by coach companies are not very sophisticated and do not explicitly contain competitive interaction terms.

There are three reasons why there is less published evidence on cross-elasticities of demand than there might otherwise be. Firstly, the commercially sensitive nature of the results militates against publication. Secondly, the relevant data may not exist or else it is too expensive to collect and hence the analysis has not been conducted. Rail ticket sales data is obviously available to railway operators, but they do not have such access to coach ticket sales data whilst equivalent car O-D data is not collected. Even where O-D data is available, as in the case of the air flow data published by the CAA, there is the expense of collecting detailed data to represent the attractiveness of competing modes in order to be able to estimate cross-elasticities. Although disaggregate methods are based on purpose collected data, and therefore overcome some of the problems of the aggregate approach, it is expensive to collect in the case of inter-urban travel due to the infrequency of trip making. Indeed, the most common area in which cross-elasticities are available is for urban and suburban travel where the relatively high frequency of relevant trip making makes this approach a more attractive proposition. Finally, competitive effects have a somewhat lesser influence on the number of trips by a particular mode than its own characteristics and factors such as income, and they are also out of the control of a particular operator, and these reduce the chances that the resources required to estimate competition effects can be justified.

4.2 INTER-CITY TRAVEL

There is a dearth of relevant studies in the inter-urban travel market. The most significant research into inter-urban travel behaviour which provides cross-elasticities of the sort of interest here is that recently conducted by Transportation Planning Associates concerning cross-Pennine travel by car, train and coach. This was discussed in section 3.2.

Models were successfully developed to explain travellers' choices, and the large sample sizes achieved would no doubt have been a contributory factor. Table 4.1 provides the cross-elasticity estimates obtained from the preferred revealed preference model developed for those choosing between car and train. They are point cross-elasticities averaged across individuals' current situations.

Table 4.1: Inter-City Car Cross-Elasticities of Demand with Respect to Rail

Train In-Vehicle Time	0.12
Train Access/Egress	0.11
Train Interchange	0.04

Train Cost	0.08
Train Headway	0.04

Whilst we have argued caution in the use of such figures, since they will vary with the market situation, they are given to illustrate the order of magnitude of cross-elasticity effects and also to denote the relative importance of cross-elasticities for different variables.

It can be seen that the cross elasticities are small in relation to own elasticities and that, as might be expected, in-vehicle time and access/egress time are more important than cost and headway. The coach-train sample was, as would be expected, found to be somewhat more sensitive to cost in relation to time than the car-train sample.

However, the study would have been somewhat less feasible had it not been for two features which considerably reduced data collection costs and which would not generally be a feature of such studies. Firstly, a parallel study involved a large scale roadside interview survey, and this enabled large numbers of car travellers making relevant journeys to be easily contacted. Secondly, permission was obtained to survey on National Express coaches, thus considerably simplifying the task of sampling inter-urban coach travellers.

The main limitation of the study lies in its treatment of multiple availability of modes. The models developed were of a binary form, for those choosing between train and car and between train and bus. At the least, this requires estimates to be made of the composition of the market in terms of choice set for each flow of interest. Moreover, whilst it is possible to estimate the effect on those car users in the car-train model of a change in rail fare or service characteristics, it is not possible to estimate what the effect of improvements to train would be on the sub-group of travellers specified as choosing between coach and car. The argument can be extended to include the inability to estimate other competitive effects which might be of interest.

Although the CAA reports the number of travellers between airports, we are not aware of any published studies which quantify the effect of changes in rail fare or service quality on the demand for air travel in the UK. However, we can cite evidence from the context of European international travel and also widely held beliefs concerning the effectiveness of rail competition to air.

Table 4.2 gives an impression of the position in which rail finds itself in relation to air. It is clear that rail's competitive position is strongly influenced by the journey time (terminus to terminus) difference.

Whilst we are not aware of models which will translate rail and air characteristics into relative market shares and cross-elasticities, it is widely held that two thresholds exist in the business market. The first threshold is that rail will hardly be considered if it cannot accommodate the business trip in a single day when air can. This requires a round trip journey time of less than six hours. An example of where rail is not competitive is the route between London and Edinburgh where, until recently, the rail journey time was around four and a half to five hours in relation to eighty minutes for air. Air captured approximately 80% of the business market (as opposed to the total market in Table 4.2), with the remainder being split fairly evenly between daytime and sleeper trains.

The second threshold is where rail becomes competitive with air and can hope to attract around half of the business market. Providing that other aspects of service quality and fare are not drastically different between air and train, this is at a terminus to terminus journey time difference (rail-air) of around two hours. An example of this in the UK context would be London to Newcastle. For journey time differences less than this, rail starts to dominate the business market, as is the case between London and Leeds with a one hour difference.

Some other evidence is available on the impact of rail on air demand from analyses of the proposed high speed train developments in Europe. According to Airbus Industrie [38], "Over short distances in Europe, the emergence of HST systems will capture part of the short-haul traffic of up to 1 hour of flight time between densely populated urban areas. The expected diversion of potential air-traffic demand will be noticeable in cases where the total train-trip time is similar to the total air-trip time .... of the order of 50%". The chairman of Air Inter, who has experienced the introduction of TGV competition, claimed that some European airlines did not appreciate the effect that a new high speed rail service would have on their market share [39].

Table 4.2: Rail Share (As % Of Rail And Air) And Time Difference

	Time Difference	Rail Share
Amsterdam-Dusseldorf	1.50 Hours	95%
Brussels-Paris	1.75 Hours	95%
London-Manchester	1.75 Hours	90%
Tokyo-Osaka	2.00 Hours	80%
Amsterdam-Brussels	2.00 Hours	95%
Amsterdam-Koln	2.25 Hours	95%
Brussels-Dusseldorf	2.75 Hours	70%
London-Edinburgh	3.50 Hours	40%
London-Glasgow	3.75 Hours	45%
Koln-Paris	4.25 Hours	70%
Paris-Rotterdam	4.50 Hours	55%
Amsterdam-Paris	4.75 Hours	60%
Dusseldorf-Paris	4.75 Hours	60%
Brussels-Hamburg	5.25 Hours	30%
Munchen-Rotterdam	6.00 Hours	70%
Munchen-Paris	6.25 Hours	50%
Brussels-Munchen	6.75 Hours	20%
Munchen-Amsterdam	6.75 Hours	70%

Notes: Times are terminus to terminus and one way. Taken from Wardman, [37].

The UK Civil Aviation Authority certainly regards high speed rail as a threat. It believes [40] that the impact of high speed rail would be a loss of 60% of short haul business traffic and close to 100% of the short haul leisure market. However, a dissenting viewpoint is cited in [38] which reports that the results of a study conducted for IATA surprised senior executives with the small impact that a high speed rail network would have on air carryings.

British Rail have undertaken studies which have examined the competition between rail, air, car and coach and which provide cross-elasticity estimates in the business and leisure markets. However, these studies are of a confidential nature.

Further research is required into the effect of changes to rail price and quality of service on the demand for car and air in the inter-city market. It is in recognition of this need that ITS submitted a proposal to the Economic and Social Research Council to conduct further analysis in this area. The research has received funding and will involve the development of both aggregate and disaggregate methods in order to examine the potential of improved rail services for diverting traffic away from air and road.

4.3 SUBURBAN

In his paper concerning the forecasting of inter-modal interaction, Dodgson [36] reviews the evidence regarding cross-elasticities in the urban context, although only a few of the numerous studies considered are of relevance in this context and the large body of empirical evidence in the form of disaggregate models which has been built up in recent years is not examined.

Section 3.3 has noted the large amount of research in this area and that typically mode choice models are developed with the explicit purpose of estimating the demand for the new or improved service resulting from abstraction from other modes, although they can be used to test the sensitivity of rail demand to changes in the levels of rail fare and service.

In seeking to present figures to 'typically represent' the impact of a new rail service, it became clear to us that even this is too much of a generalisation. The precise figures depend on the details of the proposed rail service and the characteristics of existing modes. Rail generally attracts less than 5% of all trips originating from the corridor it serves, but the figure varies according to journey purpose, whether the trips are inner or outer suburban, whether trips are to a congested centre and according to the current mode share since the impact on bus is higher than for car.

Nonetheless, models exist which can be used to estimate the abstraction from other modes and to estimate cross-elasticities for a particular set of circumstances under consideration.

4.4 LIGHT RAIL

The development of models to be used in the evaluation of LRT schemes has been considered in section 3.4 and the situation is very similar to that for suburban travel. The models therefore exist to produce cross-elasticities and abstraction rates for a particular situation of interest, although further work is required to draw together the diverse evidence and to examine the results obtained in the light of varied experiences and outcomes.

4.5 FREIGHT

Little research has been conducted on the subject of cross-elasticities between rail and road freight transport. This is in part due to the lack of data on freight flows and also because of the commercially sensitive nature of the subject.

It is clear that some sectors of road transport are not susceptible to switches between modes, for example, retail distribution and short distance traffic. Pryke [41] states that the distance at which rail becomes competitive with road has been increasing. For individual lorry load sized consignments, the breakeven distance exceeds 250 miles if collection is required at both ends, whereas bulk trainload transits of 20 miles can be profitable. Rail generally performs better over longer distances but only about 13% of freight tonne miles in the UK are of distances of 250 miles or more and not all of this is suitable for transfer to rail.

As a result of the more heterogeneous nature of the freight market, the absence of data and the generally low level of susceptibility of road freight traffic to switching to rail, it is clear that forecasting needs to be conducted on a more specialised basis than for passenger demand, examining particular cases where the potential for transfer to rail is highest. This has generally been the approach adopted by Fowkes, Tweddle and Nash in their freight research at ITS.

Fowkes et al [42] have used stated preference methods to estimate the monetary values which shippers place on the service quality attributes of transit time, reliability, and the need for transhipment. Trade-offs were presented amongst the latter variables and freight rates. Subsequent analysis [35] has examined the distances over which different types of rail system are competitive with road for different types of freight traffic.

The Channel Tunnel has stimulated research into the likely diversion from road to rail. The results of this work are confidential, but Dodgson [36] provides a discussion of the procedures involved. A nested mode choice logit model was calibrated to the Department of Transport's 1987 origin and destination survey of international freight movements to explain choices between six modes. Six commodity groups were considered. The three variables which were found to be most important in influencing mode choice were price, transit time and reliability.
Research in North America has provided estimates of road and rail price and service own and cross-elasticities both in aggregate and for specific freight flows. There is evidence of substitutability between modes with, as expected, higher elasticities for rail flows and higher service elasticities for higher value commodities.

In general, however, the extent of research into freight mode choice has been limited and there is scope for considerable further research in this area. Whilst the cross elasticities in the freight sector as a whole will be low, and there is little evidence as to what these are, the application of a low cross-elasticity to the freight market as a whole, or even to different commodity groups, can be misleading since there will be particular instances, according to length of flow, rail facilities, nature of the product and volume, where improvements to rail will be somewhat more effective in transferring traffic from road. The Channel Tunnel is the major but only one example of this.

4.6 CONCLUSIONS AND RECOMMENDATIONS FOR FURTHER RESEARCH

The practice of estimating cross-elasticities in the suburban and Light Rail markets is well established. There is a relatively large amount of published evidence on cross-elasticities, and it is likely that more could be publicly available. Research of this nature in this area has been stimulated by the relative ease of data collection for disaggregate modelling.

The only further research we would recommend in this area is a survey of existing models which provide cross-elasticities with a view to building up a consistent body of evidence, assessing alternative approaches in the light of the varied experiences and explaining how cross-elasticities vary according to relevant factors.

Some research has been conducted in the inter-city market which allows an assessment of the impact of changes in rail quality of service and fare on the demand for car and coach. There is also a body of widely accepted evidence on the impact of rail changes on the demand for air, although this takes on a more 'ad-hoc' nature. Further research is required to examine the impact of changes to rail on the demand for air and car in the inter-city market. However, the recent ESRC award to ITS to quantify these impacts along with the research that has already been conducted leads us to conclude that at this stage no further studies are required. Clearly, proposals for large scale investment in high speed rail in the UK would appreciably alter the research requirements.

The area of research which we feel has been most neglected in terms of the examination of competition between modes is that of freight. Dodgson [36] suggests that previous research in the freight area provides a firm basis, but that the collection of better statistics on freight movements is required. His detailed recommendations for further freight research are:

(i)A survey of all the various studies on freight forecasting and modal split in connection with the Channel Tunnel, to give a realistic assessment of the scope for inter-modal transfers. This can be combined with the ITS freight mode split study results
(ii)Collection of data on freight movements on specific congested parts of the trunk road network
(iii)A study of the capacity and environmental consequences of mode switching
(iv)Assessment of the financial regimes for encouraging inter-modal transfers
(v)Assessment of the impact of freight traffic transfers on specific parts of the road network.

To these recommendations we would add the following:

(a)A study of the social and political aspects of how to limit the environmental disbenefits of heavy lorries. Restraints on lorry traffic might be generally more welcome than measures to reduce car use
(b)A study of the infrastructure/services that would need to be provided by government such that freight could be transferred to rail at minimum cost to the economy, that is, without general operating subsidies to rail freight movements

(c)A study of the institutional safeguards that might be put in place to overcome the historic disadvantages of rail freight use deriving from a single operator, but without significant diseconomies of duplication

(d)A study of the costs and benefits of providing UK freight routes with various increased loading gauges.

Although we have argued that recent and planned future research will provide the necessary details for inter-city travel, a new international dimension is introduced by the opening of the Channel Tunnel. This presents new and important research opportunities, both for passenger and freight, although it is unlikely that the out-turn impact of such a major infrastructure project will be under-researched. Important issues to address are: the accuracy of forecast usage; the impact of the new rail services on the size of the travel market, particularly short stay trips, on business trips, particularly where thresholds are broken, and on the redistribution of trips; and the effects on other modes. The new rail services would also present the opportunity to develop choice models across several alternatives for a wider range of competitive situations than now exist.

5.ENVIRONMENTAL AND CONGESTION BENEFITS OF RAIL TRANSPORT

5.1INTRODUCTION

In this section, we examine the proposition that various classes of rail transport convey environmental and congestion benefits, discuss the difficulties of evaluating the environmental benefits of rail transport and highlight important issues and future research requirements. Whilst recognising the growing importance of air transport, much of this section will focus on road transport.

The case for greater investment in, and improvements to, railway infrastructure and services is often made on relief of road congestion and environmental grounds. These arguments usually have two related propositions. The first is that railway transport has a lower environmental impact overall than road or air transport. The second is that investing in railway transport and making it more attractive and convenient would encourage a switch from road and air to rail, thereby reducing both the environmental impact of road and air transport and the need for further investment in environmentally damaging road and air infrastructure. Linked to this second proposition is the method of evaluating road and rail projects and the different benefits which enter the investment appraisal. We have previously discussed the different outcomes which arise from financial versus social cost-benefit appraisal and do not intend to comment on this further.

5.2 Background: Modal Transfer and Congestion and Environmental Benefits

The realisation of the environmental and congestion benefits of rail will rely to a large extent on the ability to attract traffic to the railway. One way to assist this process is to ensure that all the environmental costs and benefits of transport are properly valued and introduced into investment appraisal decisions and that the prices of different modes of transport reflect their marginal social costs and not just their marginal private costs. Section 4 reviewed the empirical evidence on how changes to rail impact on other modes. Here we examine the interaction between modal transfer and its environmental and congestion effects before proceeding to further discuss issues relating to environmental and congestion amelioration.

5.2.1Suburban Rail

Investment in new rail services, such as station re-opening, can in urban and suburban areas be expected to attract a proportion of travellers currently using private and other public transport. If sufficient numbers of private motorists are prepared to switch to the new rail service then, particularly in congested urban conditions, this may lead to various congestion and environmental benefits. The difficulty is that the number of people who must switch for there to be a noticeable improvement in congestion or environmental conditions, means the level of investment in rail services needs to be sufficiently high. Moreover trips abstracted from a congested or near congested road network may quickly be replaced by other motorists who had previously been suppressed by the conditions. Work by Preston [34] has shown that the additional traffic generated by the opening of new rail services typically comprises only 15% previous car travellers whilst section 4 states that rail attracts less than 5% of the trips that are made in the corridor served. However, if there is no suppressed demand, relatively large time savings can be achieved from relatively small transfers of car trips to rail where roads are operating near capacity due to the shape of the speed-flow relationship in such circumstances. Assessment of the potential attraction of a re-opened rail line between Leicester-Burton indicated that over 1000 car drivers and car passenger trips per day via two main corridors might be abstracted. Inclusion of these benefits in a social cost benefit appraisal produced a positive net present value whereas excluding them, as is usually the case in financial appraisal, produced a negative rate of return. For investment appraisal decisions therefore the identification and valuation of congestion benefits is crucial. Environmental benefits were not included in this evaluation. However, the size of change needed to produce a noticeable change in environmental conditions, such as noise, is much greater, given the relationship between traffic volume and noise. It would of course be relatively straightforward to apply data on emissions and energy efficiencies to calculate some of the net environmental benefits from modal switching. This would require assumptions to be made about speed/flow relationships, equilibrium conditions etc. The use of some simple shadow price could then be applied to illustrate the potential monetised benefit which might arise from various forms of rail investment. To some extent, this is being undertaken through various city wide integrated transport strategy studies.

5.2.2High Speed Rail

There is a growing interest in, and a series of proposed and actual developments of, high speed rail services in Europe. One of the benefits put forward for investment in High Speed Rail is taken to be congestion and environmental benefits. The evidence for the level of traffic diversion from road or air to High Speed Rail in this country is mixed, and the conclusions far from clear [48]. As stated in section 4, care must be taken in defining the exact market circumstances and the characteristics of the proposed new service in estimating the likely transfer to rail from other modes.

The evidence from TGV experience is important. It stimulated overall growth in rail traffic on the corridor of 75%. Surveys suggested that of this traffic some 33% had diverted from air, 18% from road and 49% was generated [47]. Nash [48] suggests that High Speed Rail may be more successful at competing with air than car, and also shows there to be a high degree of trip generation. We understand that an Environmental Assessment of a European wide High Speed Rail Network has recently been completed but we have been unable to obtain this.

5.2.3Freight

One of the areas where environmental impact plays a significant role in railway appraisal is in the freight sector in determining the eligibility of projects for grants under Section 8 of the 1974 Railways Act. These grants are made for rail freight projects where, in the absence of the grant, freight would be transported by road. The basis for the grant assistance is the number of sensitive lorry miles `transferred' from road to rail if the grant is awarded. This was discussed in section 2.5 above.

Whilst changes have recently been made to the Section 8 grant system, it was concluded by Nash et al [49] that they were unlikely to give a major boost to the development of inter-modal freight systems.

5.2.4Light Rapid Transit

One of the areas where rail investment might be expected to produce significant environmental and congestion benefits is Light Rapid Transit. Evidence for the actual benefits of LRT resulting from modal shift are however largely unreported, although it is not clear that this is because there are any restrictions on publication of the results. Clearly, the monitoring of and results from the recently opened Manchester LRT system will be invaluable in demonstrating how far LRT can be expected to divert traffic from road to rail. It should be noted however that rail investment by itself is unlikely to be successful in restricting or reducing the growth in road traffic, especially in urban areas, in the absence of other policies.

5.3CONGESTION

The benefits of removing road traffic from existing roads obviously depend on the capacity of the road and the volume of traffic. Fowkes et al [43] updated the work of Colin Buchanan and partners and Table 5.1 illustrates this issue.

Table 5.1: Resource Cost Saving From Road Congestion Per PCU Km (In 1989 pence)

Road Type	Capacity Utilisation		
	70%	90%	100%
Rural			
Motorway	2.57	3.22	5.15
All purpose dual carriageway	1.93	2.57	3.22
Single carriageway (10m)	2.57	3.86	5.15
Single carriageway (7m)	2.57	3.22	3.86
Urban			
Suburban dual carriageway	5.15	8.37	10.94
Suburban single carriageway	8.37	14.16	18.66
Urban non-central	10.30	17.38	23.17

Urban central	19.95	37.97	53.41

There is a further problem however. In urban areas where roads are operating close to capacity, public transport improvements may simply create space for traffic to grow again for a few years, after which congestion will settle down to its original level (this is in marked contrast to the argument of Mogridge [44], that public transport improvements lead to a new equilibrium in which speeds are higher on both modes). If the gloomier view is true, then public transport improvements will only achieve higher road speeds in combination with other measures such as road investment and/or traffic restraint. A number of cities (London, Birmingham, Edinburgh, Bristol) have undertaken studies to come up with integrated transport strategies, often combining road pricing with nil investment [45]. Road pricing both adds to the case for rail investment by diverting traffic from the road, and provides a possible source of revenue to pay for it. However, development of an integrated package of transport investments makes the need for a comparable method of investment appraisal all the more crucial [46].

The models used in such integrated studies could form a valuable source of evidence on the degree to which seeing nil investment as part of a package of measures improves the case for it. It is recommended that the evidence from these studies be examined and if necessary further model runs undertaken.

Congestion benefits are included in a form of appraisal that has become known as the Section 56 approach and which was discussed in section 2.4.2. This has now seen application to a number of suburban and LRT schemes. The procedures still seem to be evolving and the monetary benefits are strongly influenced by the assumptions made, but the inclusion of congestion benefits are an important part of the appraisal. Recommendations on how to tackle these and other issues in a Section 56 appraisal were produced by a study undertaken on behalf of the PTE Group [57].

5.4THE ENVIRONMENTAL BENEFITS OF RAIL TRANSPORT

Rail, road and air transport each give rise to a wide range of environmental impacts resulting from new infrastructure construction and various forms of pollution nuisance arising from the movement of traffic. In addition, new transport infrastructure can give rise to a range of indirect impacts, including the provision and disposal of materials (eg. quarrying for limestone, oil extraction/refining, the scrapping of used vehicles) and development pressures. Whilst there are many environmental impacts arising from rail, air and road transport, the most important are often considered to be noise, land use and ecology, resource consumption and air pollution.

In trying to compare the environmental impact of different types or forms of transport such as rail and air or rail and road, the primary difficulty is defining an appropriate level or scale of analysis. For example, does it make more sense to look at aggregate effects, say at a national level, or at the level of individual trips by different modes. The difficulties with the latter are numerous. Often different modes are not in direct competition or substitutes for many types of trip. Many short trips for example cannot be made by rail transport. Many rail trips also require or involve travel to and from the rail point. If this is by motorised transport then this should enter the analysis. Furthermore, a comparable assessment requires assumptions to be made about load factors. Should then one choose typical or maximum load factors; for example, in the case of energy use the comparison between modes look very different depending on which modes are considered. Finally it has to be decided whether the unit of assessment is based upon vehicles or passengers.

Nonetheless, despite these difficulties various attempts have been made to analyse or model the relative environmental performance of road and rail transport at a specific project level as well as at the aggregate level. Less effort seems to have been given to comparing the environmental effects of rail and air.

Looking at each of the impact categories listed above, we can comment upon the current knowledge and understanding of the relative performance of road and rail at either the specific project or aggregate level.

5.4.1Noise

Noise is one of the most studied effects of transport. Various studies have shown noise from road transport to be a source of nuisance, much more so than rail noise, although this is largely due to the much more extensive road network. Numerous studies have been carried out to measure human response to rail, road and air transport noise, although only a few have attempted to compare responses to different types of noise. In a major study by Fields and Walker [50] it was found that at equivalent noise exposure levels people find railway noise less annoying than road transport noise. Explanations for the difference have included the intermittent nature of railway noise and a greater tolerance to railway transport. Other studies, however, have contradicted these findings. Japanese studies have shown that the noise from the High Speed Shinkansen is more annoying than road traffic noise at equivalent levels. Studies reported by TEST [51] suggested that road noise was less annoying than rail.

Whilst many more people are exposed to road transport noise, and in general may find it more annoying than railway noise, railway noise may not necessarily always have a noise advantage over road transport. In a study of High Speed Rail for example it was concluded that a new motorway and a high speed rail route would create approximately the same level of noise measured in terms of L_{Aeq} [52].

If human response is more tolerant of railway noise then the rail project has the noise advantage, if not then the comparison is more equal. If the comparison was between a new High Speed Rail route and adding additional lanes to an existing motorway then it could be shown that the rail route is less favourable than the road option, in terms of additional noise nuisance, unless it can be located in an existing noisy transport corridor or away from centres of population [48]. In summary, a great deal is known about the incidence and effects of railway and road transport noise. The critical issue is the basis of the comparison.

5.4.2 Land Use and Ecology

At the current time the total length of the road network is approx 350,000 km compared to 38,000 km for the rail network including sidings. Figures quoted in [51] estimate a total land-take for surfaced roads of 2600 km^2 or 1.15% of the land area in Great Britain. In contrast the rail network covers 227 km^2 or 0.01% of the total area of land in Great Britain.

Various calculations to show the relative efficiency of road and rail systems in terms of land-take per passenger or tonne of freight have been undertaken. These enable differences in land-take for the road and rail network to take account of differing modal-split. As a simple comparison, figures have been produced to show a 3 lane motorway requiring twice as much land than for a 4 track railway, despite the latter's much greater carrying capacity. Various studies have shown rail to be more efficient than road transport in terms of land-take. A modern suburban rail system is around 13 times more efficient in terms of land-take than an equivalent road network to convey the same number of people [53]. It would be relatively straightforward to provide similar comparisons for different classes of travel (eg. freight, long distance).

It has been reported that new road construction presents a threat of damage to a large number of sites of national conservation interest [54]. The scale of the damage is due in part to the expansion of the roads programme announced in "Road for Prosperity" as well as the tendency for schemes to be attracted to low priced land, typically underdeveloped open space. Rail transport infrastructure is not immune to the potential damage to sites of ecological and/or landscape value, and any expansion of the rail network would inevitably also impact on some sites of conservation interest. The advantage of rail over road however is in its lower land-take (see above) and that investment in rail would reduce the expansion of the road network. Where the investment is in the intensification of rail services rather than additions to the network, this clearly provides advantage to rail over road.

5.4.3Resource Consumption

In 1987 nearly 29% of all delivered energy was consumed in the transport sector. Over 99% of all energy use in the transport sector is from oil based sources. Nearly half of all petroleum consumption is by cars and taxis [55].

Various studies have attempted to calculate the relative energy efficiency of rail and road based transport in terms of energy per passenger and petroleum use in litres/100km (see Table 5.2). Whilst different studies have provided different sets of figures based on different sets of assumptions, the general relationship between modes is the same. In general rail transport is between 2-4 times more energy or fuel efficient than cars and 4-5 times more efficient than air transport. These figures do not include energy usage involved in vehicle manufacture and maintenance. Were these to be included then the overall efficiencies of road and air transport would be even less relative to rail [51].

Table 5.2: Petroleum use by Transport Mode (litres per hundred pass-km)

	Current Load Factors	Fully Loaded
Commuting Car	9.2	3.0
Aircraft	9.0	5.8
Off-peak car	4.2	2.4
Rail - DMU	5.4	1.2
High speed train	2.0	1.0
Express coach	0.9	0.7

One of the major difficulties with such an analysis is that rail transport is increasingly powered by electricity and therefore its overall efficiency is dependent upon the efficiency of the energy delivered. With time the efficiencies of delivered electric power are likely to improve thereby increasing the energy efficiency of rail over road and air. A detailed comparison of the relative energy efficiency of different modes has been made in [51]. Readers are directed to this study for more information. The general observation, however, is that transfer of passengers or freight from air or road to rail reduces overall energy consumption. Attempting to speed up existing services however, as energy consumption rises with speed, means that energy consumption increases for existing travellers [48].

5.4.4Air Pollution

Motorised forms of transport give rise to various airborne emissions. Air pollution from transport has two components, local and global. Global air pollution problems include global warming, destruction of the ozone layer and acid deposition. In the UK the transport sector accounts for nearly 20% of all CO_2 emissions, the major contribution to global warming. Figures from Hughes [56] show road transport to emit nearly 50 times the quantity of CO_2 compared to rail, due in part to the much larger size of the sector but also due to the relative energy efficiencies of the different modes. Figures from TEST [51] show the relative emission efficiencies of rail and road transport. Standardised figures (in terms of g/pkm) show that road transport emits 4 times more CO, 2.4 times more VOC and 1.3 times more NO_x than rail but that rail has 1.9 times more SO_2 than road. For freight (g/tkm) road produces 35 times more CO, 5.9 times more VOC, 3.1 times more NO_x and 1.3 times more SO_2. German studies suggest that the most beneficial modal shift would be freight from road to rail. Per freight kilometre, road was found to emit 123 times more CO_2, 16.5 times more NO_x and 160 times more HC. Whilst such figures are impressive, they do contain a sting in the tail. With the rapid increase in emissions with declining speeds, one view promoted by those contending with the problem of air pollution is that emissions can be significantly reduced by increasing the average speed of traffic, in other words building more roads.

As a way of illustrating how the information described above can be used to compare the environmental impact of different transport projects TEST [51] have presented a series of mini-case studies. These include the M40 extension, Docklands Light Rail, East Coast Motorway and the Channel Tunnel Link to assess the schemes' environmental impacts with an alternative road or rail scheme, for example, in the case of the East Coast Motorway they have looked at a situation whereby its traffic was carried by a railway line. As the authors openly admit, this involves making many assumptions about travel patterns and environmental impact calculations. For example, the study assumes all the traffic which would use the motorway would use a new railway service instead, if it were provided. Whilst such assumptions are clearly unrealistic, they nonetheless are useful as a means of illustrating the likely order of magnitude of advantage between road and rail. A similar analysis could easily be made for rail and air using similar assumptions.

As an example of the analysis carried out by TEST, Table 5.3 reproduces a summary of the comparison between an East Coast Motorway and an alternative hypothetical rail option. The comparison includes accidents, air pollution, landtake, resource consumption, noise, ecology and land-use. It can be seen that the rail option has considerable advantages over the road option on most of the impact categories under the assumptions used by the authors.

Table 5.3 East Coast Motorway (50 000 vehicles per day)	ROAD			RAIL		
	Car	Buses & Coaches	Goods Vehicles	Diesel Freight	Diesel Passenger	Electric Passenger
Network length (km)	386			386		
Passenger km/year	7.85 billion	1.68 billion	-		9.53 billion	
Tonne km/year	-	-	13.8 billion	13.8 billion		
Passenger Modal Split (%)	82.0	17.7	-		100.0	100.0
Accidents						
deaths annually	32.2	0.7			16.2	
annual cost (£ million)	17.8	0.4	-		8.9	
casualties annually	2 559.0	388.0	-		781.0	
annual cost (£ million)	31.2	4.7	-		9.5	
Air Pollution						
CO_2 (kilotonnes per year)	994.6	58.8	3 799.1	397.4-527.2	792.9-1055.9	651.8-1115.0
CO (kilotonnes per year)	43.9	0.5	35.9	0.3-17.9	1.2-5.9	0.1-0.3
NOx (kilotonnes per year)	12.3	0.7	64.9	9.9-10.5	8.4-19.7	3.0-4.7
SOx (kilotonnes per year)	0.6		1.0	0.8	1.4-1.7	8.6-14.9
HC (kilotonnes per year)	4.8	0.1	5.4	1.1-1.2	0.6-2.5	0.1-0.2
Landtake (km^2)	19.3			3.9		
per billion pkm (km^2)	2.0			0.4		
per billion tonne km (km^2)	1.4			0.3		
Resource Consumption						
energy - infrastructure and maintenance (billion MJ)	0.26			0.11		
use (billion MJ)	10.2-39.2	0.5-0.7	16.6-110.8	7.7-9.7	4.0-34.1	
aggregate	24.3			2.1		
Noise	Typically continuous			Typically discontinuous, 5-10 dB quieter than road, electric quieter than diesel		
Ecology	Loss and modification of natural and semi natural systems. Damage to protected areas plants, and animals, throughout primary					

populations, habitats	landtake and disturbance through the effects of hydrology, severance and polluting run-off.
Land Use severance, secondary development	Severance of agricultural, urban and ecological systems leading to loss of production + effects of human welfare and urban form. Secondary development in transport corridors leading to inflated land prices, changes in land use and urban sprawl.

5.5COMPARING AND VALUING ENVIRONMENTAL IMPACTS

The previous sections have illustrated the differences in the environmental effects of different modes of transport, and some of the problems in directly comparing the environmental benefits or advantages of one mode in relation to another. Part of the difficulty in comparing the environmental costs and benefits of different transport modes lies in the widely different units in which different impacts are measured. Many of these effects, or externalities, are not formally incorporated within conventional appraisal procedures, and thus many of the costs of environmental decay are not taken into account at any planning or design stage. Whilst the development of environmental impact assessment (EIA) procedures is helping to ensure that environmental impacts are identified for individual projects, they do not involve comparisons across different transport modes.

Table 5.4: Marginal Social Costs for Road and Rail Transport

Mode	Impact	Category	Charge per 1000 pkm or tkm, ECU (1987)
Road[1]	Air Pollution	Passenger Vehicle Freight Vehicle	4.0 7.8
Rail[1]	Air Pollution	Passenger Trains Freight Trains	0.9 0.4
Road[2]	Noise	All Vehicles	0.2
Road[3]	Noise	Private Car Bus/Coach HGV's	1.5 0.3 0.6
Rail[4]	Noise	All Units	0.7
Road[5]	All Environmental Effects	Urban Car Urban Trucks Urban Bus	29ore* 68ore* 161ore*
Rail[5]	Air Pollution	Diesel Powered	27/ore litre*

[1] = FRG (1982) [2] = Netherlands (1984) [3] = France (1981)
[4] = Switzerland (1984) [5] = Sweden (1987) * 100 ore = 9 pence

One of the ways to correct this problem is to place monetary values on the environmental impact of transport systems. In places such as West Germany and Sweden this is common practice. Underlying this approach is a belief that transport pricing should reflect its marginal social cost. Numerous techniques have been put forward and a lesser amount of evidence to show the value of environmental benefits and disbenefits arising from different projects. Table 5.4 shows a summary of a number of studies. These figures provide a basis for determining a series of changes for road and rail transport. Whilst we agree in principle with this approach, we remain to be convinced of its reliability. Such calculations could be used to assign costs and benefits to marginal changes in the number of car, lorry, bus, air or rail vehicle kilometres or cross-modal transfer resulting from a project or a proposed change in the size of the network.

5.6 CONCLUSIONS AND KEY ISSUES

This section has concentrated on comparisons between rail and road transport, largely due to the lack of attention to the environmental impact of air transport. Road and Rail transport give rise to a large number of environmental impacts, many of which have been widely researched. The greatest difficulty lies in applying this information in a comparative analysis and demonstrating the environmental costs and benefits in a form that can be sensibly and reliably used in investment appraisal.

The areas where we believe there to be greatest need for further research are as follows:

(i)Quantification and comparison of the environmental and congestion benefits of rail transport relative to air transport

(ii)Valuation of the environmental costs and benefits of road, rail and air transport and their application in investment appraisal

(iii)Further development of illustrative case-studies preferably based on projects actually built, such as Manchester LRT, to demonstrate the relative environmental and congestion benefits of rail investment

(iv)Work on developing the necessary associated policy measures needed to ensure the benefits of rail investment realised and maintained

(v)In the urban context, it appears that the degree to which rail investment diverts traffic from other modes, and hence the congestion and environmental benefits, depends on the extent to which complementary measures are introduced to restrain road traffic. Further examination of this issue using integrated transport models is recommended.

6.RAILWAY INVESTMENT AND ECONOMIC DEVELOPMENT

6.1INTRODUCTION

This section considers the extent to which investment in railway transport results in economic development, above that which would be measured and captured through a standard social cost-benefit analysis. Whilst railway projects are not currently appraised using cost-benefit analysis, we have already discussed in section 2 the differences between financial and cost-benefit analysis.

A cost-benefit analysis of a transport project would compare the value of the project benefits with the value of resources used. The benefits typically include time-savings, operating cost savings and safety benefits. This approach rests upon the measurement of the primary benefits of a project and taking these as a proxy for the final economic benefits of a scheme. The claim that transport investment has economic development benefits beyond these primary benefits rests on two arguments.

Firstly, that in addition to the primary benefits, there are some secondary benefits that are not counted in the appraisal. These include induced employment and local income multipliers. Within Britain the view usually taken is that secondary benefits are likely to be small [57, 58], and that new road infrastructure achieves little other than a limited amount of relocation at a local level. For the reduction in transport costs to lead to significant economic development benefits (ie. increased output by existing firms expanding or new firms starting up) a number of conditions are likely to be needed [58].

(i)Unemployed resources eg labour
(ii)transport costs have to be a high proportion of total production costs
(iii)the change in transport costs brought about by the road have to be large.
(iv)the demand for the goods being produced has to be sensitive to a fall in price as a result of lower production costs.

The empirical evidence cited in [58] finds that these conditions rarely hold in Britain. A typical example where it might be more appropriate to estimate induced production, income and employment effects is the construction of a feeder road in a developing country which opens up land for production of market rather than subsistence crops [59]. Of course, for the measurement of primary benefits to stand as a proxy for economic development it is important that all the relevant cost components of travel are included. These cost components typically include in-vehicle travel time but also wait/delay time. We return to this point later.

The second argument is that transport investment can result in a change in the distribution of economic development and activity which may be considered desirable but which does not show up in the appraisal. The usual counter arguments to these points are that the main purpose of economic appraisal is to compute the magnitude of the benefit rather than the distribution and secondly that it is too difficult to trace through the project inputs to their final incidence. This is not to say that local relocation of business and industry is unimportant. If this is an objective of the transport investment then it is important that it is identified. Evidence cited in [58] suggests that sites in the vicinity of motorway interchanges often attract development, though this is at the expense of other nearby inner city areas. Various evidence has shown that local accessibility can be a determinant of the local distribution for activity although the evidence is far from conclusive.

6.2 RAILWAY INVESTMENT DEVELOPMENT BENEFITS

Overall, the evidence suggests that the economic development benefits of road investment are relatively minor, once direct user benefits have been accounted for. Investment in railways are likely to have an even smaller impact than new roads. Even with improved services, rail will be used for a smaller proportion of business trips.

Two forms of rail investment where economic developments might be expected are High Speed Rail and Inter-Modal Freight technology.

Much of the argument for the extension of the French TGV to extra regions, for the development of High Speed links through the Channel Tunnel, and for the development of High Speed links from the Channel Tunnel to the North of Britain has largely rested on regional development benefits.

Bonnafous [47] undertook surveys both of business travellers and a large sample of enterprises in the Rhone-Alps region. He found the effect of TGV on industrial location to be marginal. Effects on tourism and service industries were more marked. The surveys showed a big increase in day trips to tourist attractions and a growth in Lyon based service trades with clients in the Paris area. There was no evidence however of Paris based firms making greater use of the Lyon market. In a review of the case for High Speed Rail, Nash [48] concludes that whilst there is some evidence of regional development benefits to the service sector, it is doubtful whether this should be a major consideration when considering investment in high speed trains.

Recent work by HFA, ITS and PA Cambridge Economic Consulting evaluating proposals for a European High Speed Rail Network examined the economic benefits to businesses. It was argued that a number of potentially important business efficiency impacts needed to be considered in addition to in-vehicle time savings and fare levels. These impacts or attributes were in-travel work capability, access time savings between plane/train and origin-final destination, new opportunities for day-return trips, higher service frequencies and improved service reliability. The inclusion of these business efficiency impacts within an economic appraisal has a significant effect on the likely viability of the High Speed rail network. Net benefits increase by 25 Billion Ecus, whilst the NPV of the project doubles to 48 Billion Ecus. The benefit to cost ratio of the project is increased from 1.35 to 1.64 [60].

6.3 CONCLUSIONS

The case for economic development benefits of rail investments is strongest for links to peripheral regions, where social and integrational benefits may also be apparent, but even here it is still likely to be weak. In general, however, the economic development benefits of rail schemes are a major area of uncertainty. Research in this area is not straightforward, particularly where monitoring exercises with the specific purpose of collecting relevant data to analyse the potential impacts have not been put in place.

Questionnaire based methods enquiring as to companies likely responses to rail investments are fraught with difficulties. The most feasible way forward is in the monitoring of relevant schemes, either at the local level, such as with the Manchester and Sheffield light rail schemes, or at an inter-regional or even international level, as with the Channel Tunnel and its high speed services.

7. RECOMMENDATIONS FOR FURTHER RESEARCH

This paper has considered the existing research that bears on the case for increased rail investment. We have examined in turn the investment and funding mechanisms that exist for rail transport in Great Britain, the extent to which improved rail services or lower prices attract additional traffic and the extent to which this comes from other modes, and the extent to which this might result in congestion, environmental or economic development benefits.

The sections dealing with each of these issues have concluded by outlining areas where additional research is needed. In summary, what we believe to be the key recommendations for further research are:

(i)Analysis of the effect on investment of alternative methods of privatisation, including franchising and competitive tendering

(ii)More detailed examination of the factors influencing rail elasticities

(iii)Further analysis of what have been termed 'soft' variables, such as reliability, rolling stock, station and on-board facilities, attitudes, images and expectations

(iv)A survey of the numerous mode choice studies in the urban context in order to build up a consistent body of evidence and explain how elasticities and cross-elasticities vary in different contexts

(v)Analysis of the interactions between modes in the inter-city passenger market, although work is about to start on this at ITS

(vi)There is considerable scope for further research of the freight market, particularly rail-road interactions, given the diversity of the market and the need for better data. Opening of the Channel Tunnel will offer considerable potential in this area

(vii)Valuation of the environmental costs and benefits of road, rail and air transport and their application in investment appraisal

(viii)Integrated transport studies have a role to play in examining the need for measures complementary to rail investment in achieving the environmental and congestion advantages of rail use. Further case studies of the effects of diverting traffic from air are also needed

(ix)The issue of the development benefits of rail investment is a complex one. What seems to be the best way forward is to put in place appropriate data collection procedures and to monitor the development impacts of various categories of rail investment.

REFERENCES

STEER DAVIES AND GLEAVE (SDG) (1992). "Financing Public Transport: How Does Britain Compare?". A Report for the Bow Group, Centre for Local Economic Strategies, Eurotunnel, Railway Industry Association and Transport 2000, p.26.

LEITCH, SIR GEORGE (Chairman) (1978). "Report of the Advisory Committee on Trunk Road Appraisal". HMSO.

DEPARTMENT OF TRANSPORT (1984). "Economic Evaluation Comparability Study - Final Report".

NASH, C., and PRESTON, J. (1991). "Appraisal of Rail Investment Projects: Recent British Experience". 11, 4, 295-309.

W.S. ATKINS and STEER DAVIES AND GLEAVE (SDG) (1990). "Midland Main Line Strategy Study".

STEER DAVIES AND GLEAVE (SDG) (1992). Op cit. p.14.

TEST (1992). "Wrong Side of the Tracks? Impacts of Road and Rail Transport on the Environment: A Basis for Discussion".

MONOPOLIES AND MERGERS COMMISSION (1987). "British Railways Board: Network South East. A Report on Rail Passenger Services Supplied by the Board in the South East of England". HMSO.

SERPLAN (1991). "Rail Investment: A Strategy for the South East".

NASH, C.A. (1985). "Policies towards Suburban Rail Services in Britain and the Federal Republic of Germany - A Comparison". Transport Reviews, 5, 3, 269-282.

RAPID TRANSIT UK (1992). Issue 7. TAS, Preston.

HARRIS, N.G., and GODWARD, E.W. (1992). "Planning Passenger Railways". TPP, Matlock.

DEPARTMENT OF TRANSPORT (1989). "Section 56 Grant for Public Transport". Circular 3, 89.

DEPARTMENT OF TRANSPORT (1991). "The Role of Investment Appraisal in Road and Rail Transport".

BATES, J., and LOWE, S. (1989). "Criteria for Public Sector Support in Urban Public Transport". PTRC Summer Annual Meeting.

PRESTON, J.M. (1992). "Financing New Local Rail Services". Presented to World Conference on Transport Research, Lyons.

RAMOS PAIM, L.C. (1991). "Funding of LRT in the UK: The Scope for Private Participation". MSc Dissertation. Department of Civil Engineering, University of Leeds.

HALL, P., and HASS-KLAU, C. (1985). "Can Rail Save the City". Gower, Aldershot.

SMERK, G.M. (1991). "The Federal Role in Urban Mass Transportation". Indiana University Press.

NASH, C.A., and TWEDDLE, G. (1988). "Private Railway Sidings: The Use of Section 8 Grants". Presented to "Freight: Planning for the 1990s", Town and Country Planning Association, London.

FOWKES, A.S., NASH, C.A., and TWEDDLE, G. (1990). "The Track and External Costs of Road Transport". Working Paper 312. Institute for Transport Studies, University of Leeds.

KENNEDY HENDERSON (1990). "West European Railway Component Industry Market Study. Final Report". Department of Trade and Industry.

HELM, D., and THOMPSON, D. (1991). "Privatized Transport Infrastructure and Incentives to Invest". Journal of Transport Economics and Policy. 25, 3, 231-246.

JONES, I. and NICHOLS, A. (1983). "Demand for InterCity Rail Travel". Journal of Transport Economics and Policy.

FOWKES, A.S., NASH, C.A. and WHITEING, A.E. (1985). "Understanding trends in InterCity rail traffic in Great Britain". Transportation Planning and Technology.

OWEN, A. and PHILLIPS, G.D. (1987). "The characteristics of railway passenger demand". Journal of Transport Economics and Policy.

SHELDON, R. and STEER, J. (1982). "The use of conjoint analysis in transport research". PTRC Summer Annual Meeting.

MVA, ITS UNIVERSITY OF LEEDS, and TSU, UNIVERSITY OF OXFORD. (1987). "Value of travel time savings". Policy Journals, Newbury, Berkshire.

MARKS, P., FOWKES, A.S. and NASH, C.A. (1986). "Valuing long distance business travel time savings for evaluation: A methodological review and application". PTRC Summer Annual Meeting.

WARDMAN, M. and FOWKES, A.S. (1987). "The values of overcrowding and departure time variations for InterCity rail travellers". TN 229, Institute for Transport Studies, University of Leeds.

BENWELL, M. and BLACK, I. (1985). "User valuation of reliability in inter-urban travel: some problems of modelling and measurement". PTRC Summer Annual Meeting.

MARKS, P. and WARDMAN, M. (1991). "Leisure travel". Analysing demand for Rail Travel, edited by A.S. Fowkes and C.A. Nash, Avebury Press.

PRESTON, J. (1987). "The Evaluation of New Local Rail Stations in West Yorkshire". PhD Thesis, School of Economic Studies, University of Leeds.

PRESTON, J. (1992). "Draft Manual of Advice for Passenger Demand Forecasting for New Rail Services". Working Paper 355, Institute for Transport Studies, University of Leeds.

FOWKES, A.S., NASH, C.A. and TWEDDLE, G. (1991). "Investigating the Market for later - Modal Freight Technologies". Transportation Research.

DODGSON, J. (1990). "Forecasting Inter-Modal Interaction". Paper Presented at Department of Transport Seminar on Longer Term Issues.

WARDMAN, M. (1992). "The European Passenger Travel Market: Niches for High Speed Rail". Working Paper 359, Institute for Transport Studies, University of Leeds.

AIR TRANSPORT WORLD. (1990). "HST: Threat or Alternative". Vol 7, pp 42-44.

INTERAVIA AEROSPACE REVIEW. (1989). "Air Inter's Eelsen Confronts Challenge". Vol 11, pp 1103-1105.

CAA (CIVIL AVIATION AUTHORITY). (1990). "Traffic Distribution Policy and Airspace Capacity for the Next 15 Years". CAP 570.

PRYKE, R. (1990). "Transport" in Public Domain 1990: A Yearbook for the Public Services, edited by P. JACKSON and F. TERRY. Public Finance Foundation.

FOWKES, A.S., NASH, C.A. and TWEDDLE, G. (1989). "Valuing the Attribution of Freight Transport Quality: Results of the Stated Preference Survey". Working Paper 276, Institute for Transport Studies, University of Leeds.

FOWKES, A.S., NASH, C.A. and TWEDDLE, G. (1990). "The track and external costs of transport". Working Paper 312, Institute for Transport Studies, University of Leeds.

MOGRIDGE, M. (1990). "Travel in towns". Macmillan Press, London.

MAY, A.D. (1991). "Integrated Transport Strategies: A new approach to urban transport policy formulation in the UK". Transport Reviews. 11(3) pp 223-247.

INSTITUTE FOR TRANSPORT STUDIES AND MVA CONSULTANCY (1991). "The development of a common investment appraisal for Urban Transport projects". Report to Birmingham City Council and Metro.

BONNAFOUS, A. (1987). "The regional impact of the TGV". Transportation. 14, pp 127-137.

NASH, C.A. (1991). "The case for high speed rail". Working Paper 323, Institute for Transport Studies, University of Leeds.

NASH, C.A., HOPKINSON, P.G., PRESTON, J.M. and TWEDDLE, G. (1991). "Railway investment appraisal. Issues and new developments". In: Road and Rail Policy, Institute for Public Policy Research, London.

FIELDS, J.M. and WALKER, J.G. (1980). "Reactions to railway noise: a survey near railway lines in Great Britain". ISVR Technical Report no 102, Institute of Sound and Vibration Research, University of Southampton.

TEST (1991). "Wrong side of the tracks". Impacts of road and rail transport on the environment.

HUGHES, P. (1990). "Transport and pollution. What's the damage?" Local Transport Today Conference on Environmental Policy in Local Transport.

BOWERS, J., HOPKINSON, P.G. and PALMER, A. (1992). "The implementation of sustainability into the roads programme". Final Report to English Nature.

WORLD WILDLIFE FUND FOR NATURE (1989). "Atmospheric emissions from the use of transport in the UK".

RICKARD, J. and HILL, E. (1991). "Socio-economic and demographic factors", in A.S. Fowkes and C.A. Nash, Eds, Analysing Demand for Rail Travel, Avebury 1991.

HFA (1991). "Criteria for section 56 Grants". Final Report to the PTE Group.

COLLINS, P.H. (1983). "The effects of recent LT fares changes. PTRC Summer Meeting Seminar N.

FAIRHURST, M.H., LINDSAY, J.R., and SINGHA, M. (1987). "Traffic trends since 1970". Economic research report R266. London Regional Transport.

G:\...\wptnlist\wp392.mw