Comparing Road and Rail Investment in Cost-Benefit Analysis

Discussion Paper

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Introduction

Cost-benefit analysis has long been established as a means of informing decision makers about the expected impacts of transport projects and policies. It provides a means of assessing the case for an investment proposal in circumstances in which conventional market forces are either lacking or fail to operate efficiently. In place of decisions based on commercial criteria and expectations of profit, cost-benefit analysis informs decision makers about a broader metric in terms of the social value of a project. The methods of cost-benefit analysis require an assessment of one or more of a number of options for addressing an existing or anticipated problem, for example a bottleneck in a transport network, and comparing the expected outcome of the preferred option and alternatives with a do-minimum counterfactual.

In principle the methods of cost-benefit analysis are equally applicable across all surface transport modes. Highway, rail and urban transport schemes share many common characteristics and all are aimed at improving the lot of the traveller. All require accounting of the environmental and other impacts of the project. In practice, as this report explains, there are a number of differences between the modes that decision makers need to be aware of when comparing the merits of investment between modes.

The methods of cost-benefit analysis have applications that extend well beyond the appraisal of transport interventions. The UK Treasury's Green Book (UK Government HM Treasury, 2020), provides guidelines for appraisal and evaluation for use by all government departments. The Department for Transport has taken the framework set by the Green Book and developed it in its Transport Analysis Guidance (TAG) (UK Government Department for Transport, 2019) so that it provides decision makers with information about the social value of alternative policies and investment options for addressing transport problems. Other UK Government departments have their own appraisal guidance which is specific to their responsibilities and policy objectives. Transport cost-benefit analysis is part of a cross government discipline of policy making.

The context for transport investment appraisal

The application of cost-benefit analysis takes place within the framework of the government's policy objectives. Improving accessibility, making it easier to travel and reducing road accidents have long been the aims of transport investment programmes. As environmental concerns became a priority, appraisal methods were extended to ensure that these emerging policy concerns became part of the methods used to inform decision makers about their choice of options. Decisions about how a project is funded and the extent to which those who benefit should contribute to its cost are part of the policy framework within which investment decisions are made.

The context for transport investment appraisal: Road schemes

Choices about where transport infrastructure should be built and how much money should be invested inevitably fall to public sector decision makers. Transport infrastructure is long lived and irreversible and so the risks involved in such investment make most projects unattractive to the private sector. For more than half a century cost-benefit analysis has been the preferred technique in many countries for understanding the likely effects of a project and for selecting the option that is best suited to delivering a successful outcome.

The risk involved in the provision of transport infrastructure is not the only reason for decisions about investment and broader strategy being made in the public sector. Transport infrastructure displays many other divergences from competitively provided services. The highway system is a network, with the benefits a user derives from one link depending on those derived from all other links used on the journey, while there is very limited scope for competition between potential highway providers to ensure efficient ways of meeting user demands. Most roads are free at the point of use and so lack a market-based means of ensuring a financial return to the investor. Toll roads are not an exception to these conditions: such roads are generally built and operated on a concession model, with the plans, route and often the toll levels being determined by the national or regional government, albeit financed by the private sector. However, the requirement that users pay a toll has the effect of pricing-off those potential users whose benefit from using the road would be less than the toll.

Road schemes also have effects that extend well beyond the interests of their users. External effects, including traffic noise, greenhouse gas emissions and other impacts on air quality are of concern to the people who live close to the scheme. Nor are the impacts invariably negative ones: a scheme that removes traffic from a densely populated area can have significant environmental and safety benefits, although these might be offset to a greater or lesser extent by the impact of a new by-pass on landscape and bio-diversity. While a country's regulatory and legal framework can go some way to abating the more extreme of these environmental impacts, they do not address the specific cases that arise during and following the building of new infrastructure.

As a result of these market failures, methods for applying cost-benefit techniques to highway schemes have been developed into formal guidance by many countries and by international organisations. Relationships between road design, vehicle performance and road capacity are well understood, as are the methods of analysing road users' responses to changes in road capacity. Over the past sixty years, there have been incremental advances in the methods used, in particular in the quantification and valuation of the environmental impacts of road traffic. At the same time policy makers in many countries have become accustomed to cost-benefit analysis as one of the considerations relevant to the decision making process.

The context for transport investment appraisal: Rail schemes

While there has been a long history of public provision of roads, dating back to the Romans in parts of Europe, the evolution of rail networks has followed a less consistent pattern. In many countries during the nineteenth century, when much of today's network was built, private sector companies were responsible for promoting and operating their countries' rail networks. Monopoly power was limited in many countries through government intervention in the setting of passenger fares and freight rates and in regulating first passenger and subsequently employee safety, but decisions about investments were made on the expectation of earning a profit. In other countries the state took on the role of developing the rail network, often with the aim of fostering economic development and national unity.

By the middle of the twentieth century national, devolved or regional level governments had, in most countries, taken over both ownership of and responsibility for the operation of their rail networks. However, during much of the second half of this century, there were relatively few demands for significant increases in rail capacity. While road traffic experienced rapid growth as car ownership and goods vehicle use increased, passenger rail traffic in most countries remained at broadly constant levels. So while there was a clear need for providing decision makers with a method for prioritising decisions about investment in road infrastructure, there was no comparable need to appraise enhancements to the rail network. Investment in the rail sector continued, but most expenditure was aimed at ensuring that the nationalised rail operator could continue to operate the existing level of service at the minimum full life cost to the government. Decisions about rail investment were usually based on considerations of cost effectiveness. In the case of the UK's British Railways Board, proposals to provide improvements in the quality of service, such as installing air conditioning in new trains, were required to be financially viable. Investment in upgrading assets was approved only if there was evidence that the anticipated revenue from demand generated by the improvement was sufficient to cover its incremental costs. Constraints on public expenditure provide one explanation for such a policy, under which resources for maintaining the existing network were prioritised. But it was also a political decision that rail users, who tended to be from the higher income groups, should pay for the benefits of rail enhancements rather than the typical taxpayer.

Certain urban rail schemes provided an exception to this general rule of financial appraisal being the decision rule in the case of rail infrastructure. London's Victoria Line was a project which had no financial justification. Indeed since the structure of fares on the London Underground at that time was based on the distance travelled, the new line, which effectively provided a diagonal route across central London in place of two sides of a square, had the effect of reducing fare revenues. But an early application of the methods to an urban rail scheme, made possible by the then new multi-modal transport model for London, demonstrated transport user benefits from the time savings, relief of crowding and reduction in road congestion which persuaded a reluctant UK Treasury to continue to fund the scheme. High speed rail lines in certain other countries also provided the opportunity and need for the application of cost-benefit analysis.

Over the past two decades many countries have experienced substantial growth in rail patronage: this growth tends to be greatest on routes serving the major conurbations. While revenue from passenger fares might broadly cover operating costs and on some routes the depreciation of renewable assets, it makes little or no contribution to the initial investment, the costs of which, on the existing network, were largely reimbursed to shareholders more than a century ago.

The failure of the revenue from passenger fares to cover in full the additional costs of new rail infrastructure is not the only reason for departing from a policy under which rail users simply pay for the benefits they derive from new investment. Railways share many of the attributes of the road system which inhibit the efficient operation of market forces. New railways can also result in degradation of landscape, loss of biodiversity and noise nuisance. Offsetting such negative impacts is the beneficial effect that rail investment can have through inducing road users to shift to the more environmentally benign mode and reduce the levels of congestion experienced by remaining road users. All of these impacts need to be assessed.

The network and monopoly effects identified above as a reason for the public provision of roads is equally relevant to the rail network, as are the risks of investing in long lived assets with no alternative use. Experience of effective frameworks for the regulation of privately provided services such as water and energy demonstrates that such considerations are not necessarily a bar to the model of a regulated utility being applied to the provision of rail infrastructure and services. But there are several key differences between most regulated utilities and the railway in addition to the failure of rail revenues to cover the full costs of new infrastructure.

Railways are an essential part of any country's pattern of land use. Indeed it was the introduction of the railway and other public transport that allowed cities to grow beyond the boundaries of an area that could be covered on foot. The role of railways in influencing land use and in contributing to the delivery of a government's spatial strategy continues to serve as a prime reason for public sector involvement in rail investment. The importance that governments attach to the railway as a means of influencing policy on land use is reinforced by the extent to which governments in many countries intervene in the market for rail travel by the setting limits on the level of certain passenger fares that railway operators are permitted to charge.

Both for the reasons given above and in order to ensure comparability between modes in the decisions of policy makers, cost-benefit analysis is widely used for the appraisal of rail and other public transport schemes. Decision makers face a choice between maximising the benefits and increasing rail fares on the improved routes to ensure that the direct beneficiaries contribute to the costs. In some cases, such as airport express services, financial appraisal alone is used to make the case for the project because of the ability of the users to pay and the limited extent of any external benefits.

Investment decisions and the recovery of project costs from users

The size of an investment programme that meets a given return in cost-benefit terms is influenced by the extent to which policy makers decide that the direct beneficiaries should contribute to the costs of the project through tolls or higher fares. In the case of some rail projects the revenue from the additional demand generated by the investment will provide a source of funds sufficient to repay the costs of the scheme. In other cases a policy of cost recovery will require the scheme sponsor to increase the level of fares to meet some or all of the costs by capturing through the fare box a part of the benefits of the investment. While such a policy results in a transfer of the benefits that passengers would have gained in absence of the fare increase to the scheme sponsor or to the train operator, the effect on generated demand is reduced. The requirement to increase the level of fares or impose tolls above that assumed in the do minimum counterfactual has the effect of pricing off some or, in the extreme case, all of the generated demand which, in the cost-benefit analysis, makes up part of the benefit which can be attributed to the scheme.

The effect on user benefits of increasing fares or other user charges can be illustrated through the standard diagrams, shown below as figures 1 and 2, typically used as a teaching aid in student courses on appraisal methodology. In absence of any increase in fares (figure1), a transport project reduces the generalised cost of travel, in terms of the value of the travel time and other inconvenience saved, from GC_0 *to* GC_1 , increasing rail users' benefits or consumer surplus by $\frac{1}{2}(T_1 + T_0)$ (GC_0 - GC_1). The generated demand, (T_1 - T_0) results in additional revenues (ΔR) which make a contribution to the costs of the scheme, increasing the ratio of benefits to costs.

Figure 2 sets out the effect of policy which requires that investment is funded through an increase in rail fares, such that passengers pay for the benefits they receive. In the extreme case, as shown in figure 2, in which the increase in fares needed to fund the project is equivalent to the increase in benefits and GC_0 = GC_1, all of the consumer surplus is transferred to the rail operator. The increase in fares suppresses all of the demand that would otherwise have been generated by the scheme, eliminating a source of benefit that forms part of the cost-benefit case.

Figure 1. Appraisal using cost-benefit analysis

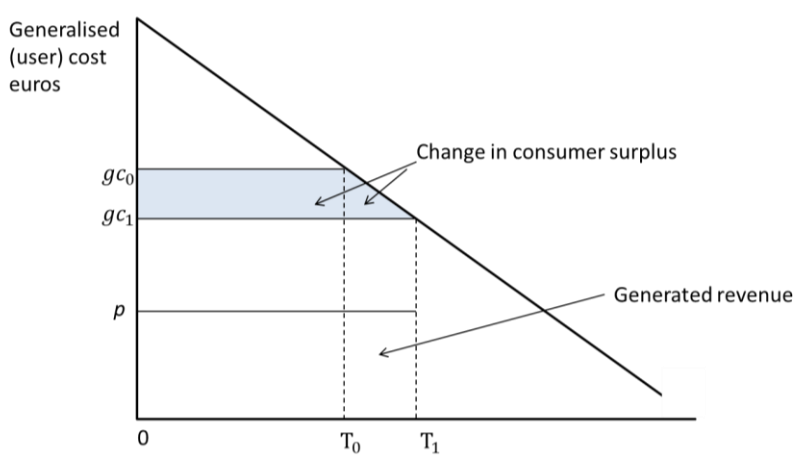
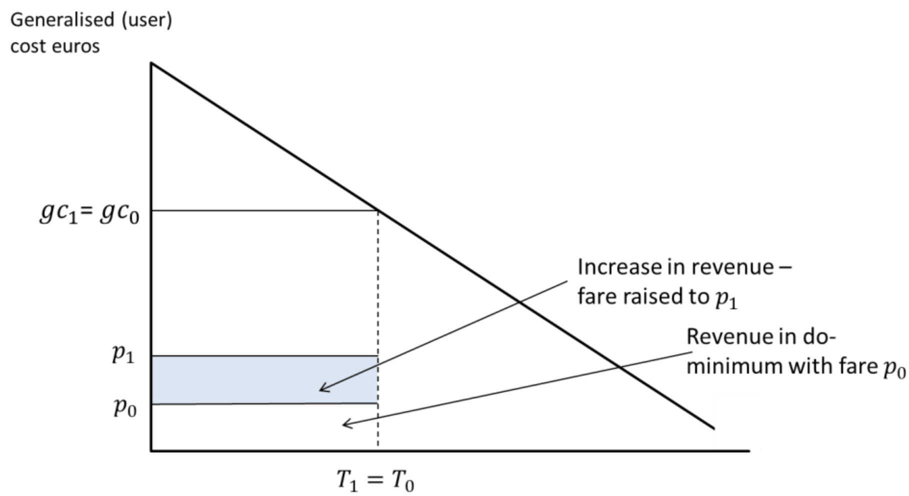


Figure 2. Financial appraisal



Where opportunities for price discrimination exist, some of the demand priced-off under a standard fare might be captured through fares which differentiate between different users. Moreover, the assumption in the simple cost-benefit analysis that the level of fares remains unchanged is open to challenge. Decision makers might well use the opportunity to set an above average increase in fares for the improved services to ensure that passengers make some contribution to the costs. Such decisions are often made in the run-up to the opening of the scheme, long after the appraisal has been completed.

In some cases, such as investment in rail freight facilities in the UK, sponsors of schemes for which the decision to invest is based on financial appraisal are eligible for public sector grants to cover certain external benefits, such as road congestion relief on account of the mode shift induced by the project. This represents a hybrid approach, combining a mix of cost-benefit appraisal for impacts outside the scheme promoter's interests with the objective of earning a financial return on the investment. But this does not change the principle that financial appraisal may require an increase in the price paid by the user when compared with the do-minimum and that this increase reduces the demand generated by the scheme, an effect which is not a feature of appraisal using cost-benefit analysis. Thus the 'pass mark' for a cost-benefit based project is generally lower than for one based on a financial appraisal because of the deterrent of the increase in fares to potential users.

When do road and rail projects need to be compared?

The circumstances under which there is a need to compare road and rail schemes differs between countries and between the different institutions responsible for transport infrastructure. Road and rail projects are rarely if ever complete substitutes for each other. Rail's market share is greater for long distance trips and for commuter flows into larger urban areas. Rail has traditionally been the mode chosen for heavy freight flows, such as coal, ores and construction materials. While road is no longer seen as the solution to urban transport problems, it remains the dominant mode for all journey purposes and is the only mode that can meet the demands of dispersed patterns of land use. In some cases, such as the UK's Oxford to Cambridge corridor, road and rail investments are seen as complementing each other in a comprehensive programme for increasing housing supply and employment opportunities, shifting economic activity away from more congested, 'over-heated' locations. But it is only in exceptional circumstances that a decision maker will face the choice between rail and road as a means of resolving a specific transport bottleneck.

Informing the choice of mutually exclusive options is only one of cost-benefit's functions. The method also helps decision makers to set priorities between projects within the transport budget or, in countries where road and rail draw on separate budget allocations, to decide on the distribution of funds between the two modes. And cost-benefit analysis provided decision makers with evidence on whether, because the benefits of a specific scheme exceed its costs, it represents value for money. There are therefore good reasons for ensuring that decision makers who are conversant with the methods of cost-benefit analysis appreciate the similarities and the differences when this technique is applied to the different modes. The following sections of this report review the differences between the modes and between their users which have the resulted in certain distinctions in cost-benefit methods when applied to the different modes and consider the relevance of these differences for decision makers.

Critical differences between road and rail and their treatment in cost-benefit analysis

There are two sources of differences between rail and road schemes of relevance to cost-benefit analysis. The users of rail projects, who tend to drawn from a smaller and more urban population, are not necessarily typical of the population of road users in countries where road travel is the dominant mode. And there are many differences in the services supplied. Road investment is concerned with the provision of highway capacity and has no influence on the vehicles which drivers and firms choose to use. Investment in rail and public transport generally comprises some mix of track and vehicle improvements, often with upgrading of stations and increased service frequency. The methods used to appraise and model transport users' responses to investment in the different modes have been adapted and extended so as to account for these differences.

Differences between road and rail users: Leisure, commuting and business trips

Road and rail tend to serve different markets. As noted above, rail's share is greatest over longer distances and for commuting into the larger urban areas where road congestion and lack of car parking space reduce the attractiveness of the car. Workers in the largest cities and those who travel greater distances tend to have higher incomes: thus in most countries the average incomes of rail passengers are higher than those of the average road user. Research into the value transport users put on time savings shows that those in higher income groups tend to place a higher value on such savings, suggesting a difference between the two modes in the value of time saved. These differences apply to both trips made in the course of work, including briefcase travellers travelling to meetings and conferences, and trips made for commuting and leisure purposes.

For most travellers the quality of the time spent on a journey varies according to the mode used. Some rail passengers find an uncrowded trip enables them to use time as productively as at their workplace. For others, such as households with small children, the convenience and privacy of a car may outweigh any advantage of public transport. The influence of technology on the value of time savings was the subject of a recent ITF Roundtable (ITF, 2019).

Despite these differences in travellers' willingness to pay for time savings, most countries have adopted a national average value of time savings for use in appraisal that varies only by journey purpose when appraising publicly funded projects. For commuting and for leisure travel, a national average value is used for each of the two purposes which does not differentiate between modes, regions or other characteristics of a scheme and its users. This practice of using national average appraisal values for commuting and for leisure purposes is often described as an 'equity' value on the grounds that it treats all transport users as equal. Whether the adoption of a national cross-modal average for the value of time savings when there is evidence of a higher willingness to pay on the part of rail users constitutes a bias against rail investment is debatable. For schemes that are financially viable and are financed by the private sector, willingness to pay based values will provide the investors with an indication of the expected return on their investment.

Projects aimed at relieving overcrowding on rail and metro networks provide an exception to the practice of treating all travel time as of equal value. Many countries with dense urban transport networks have derived from surveys or other methods a set of multipliers for the national average value to represent the benefit of the reduction in discomfort passengers experience when, instead of travelling in crowded conditions, the new scheme delivers a better travelling experience. Values of up to 3 times the national average value are used in the case of crush level loadings when many passengers are standing. In this respect appraisal differs between rail, a mode for which crowding values are a well establish source of benefit, and roads, for which a change in driving conditions from congested to free flow is rarely part of the appraisal method, despite evidence of road users' willingness to pay a premium to avoid congested conditions. The UK Department for Transport is currently researching the effects on highway appraisal and on the modelling of route choice of values of time that vary by congestion level.

The United Kingdom and some other countries have taken a different approach to valuing savings in the time spent by business travellers when using the different modes. Business time savings have generally been valued using the cost savings approach, whereby the time saved is valued at the average wage rate of the traveller. Travel survey data can provide evidence of the distance-weighted earnings of business travellers by mode. With the inclusion of a mark-up on earnings to allow for employment related costs borne by employers, this results in a measure of the value to the economy and hence to society of a unit of business time savings on each mode.

Recent research into the value of business time savings has shifted the focus away from the cost savings approach to a willingness to pay basis. One of the reasons for this change was a growing appreciation of the difference between modes in both the characteristics of the traveller and the attributes of the journey. In particular, there is a strong perception that the relative attractiveness of the two modes has changed because of the opportunity that the rail passenger now has to use the time spent on the journey in a wider variety of ways than is possible for the car driver. However, the surveys of business travellers carried out in the case of the United Kingdom study showed that rail passengers put a higher value on travel time savings than did car drivers. Rail business travellers tended to be in higher paid jobs and their employer derived more value from the activity carried out at the trip's destination than in the case of car users, an effect that more than offset the differences in their use of in-vehicle time. In addition, there was clear evidence of the values being higher for the longest distance trips, which are more likely to be made by rail. It is now UK practice to differentiate by distance bands for rail and road business time savings and, in the case of the longer distance bands, to use higher values for rail than for road.

Consistency between road and rail is therefore achieved by the use of a standard national average value for time savings for commuting and leisure journey purposes, with road and rail business values differing to reflect their impact on productivity. The practice of adopting mode specific willingness to pay based multipliers on the national average values in the case of projects aimed at reducing overcrowding on rail networks reflects both the benefit that passengers derive from improved commuting conditions and of the priority that decision makers attach to addressing extreme levels of crowding on the railway. Comparable treatment of road conditions is still at the research stage.

Differences between road and rail in the services supplied to users

The application of cost-benefit methods to transport projects is concerned primarily with the assessment of transport users' responses to changes in the supply of transport services, quantifying and valuing those responses in terms of the benefits to existing users and to those who are induced to travel on account of the change. There are significant differences between highway authorities and rail and other public transport operators in the nature of the services provided. A well conducted economic appraisal provides a comprehensive assessment of the costs and benefits of these services and of transport users' responses to changes in their provision.

Appraising and modelling increases in road capacity

The services provided by a highway authority are made up of the physical capacity of the road space and the design of that infrastructure, together with controls on the use of that space through traffic signals, speed limits and other restrictions. Methods for modelling road users' responses to these increases in highway capacity against a counterfactual of retaining the existing network or alternative upgrade options are well established. Models permitting different levels of granularity are applied according to the level of detail required. These range from models which provide no more than a representation of lane capacity through a link based on speed/flow relationships to the detailed modelling of complex intersections and the inter-relationships between a series of signalled junctions. Software for highway models is available commercially or from international organisations such as the World Bank. Many traffic models allow for the volume of trips to vary with the speed and hence the cost of the trip, so as to account in the model and in the appraisal for this induced demand.

Urban transport models differ according to the purpose which they have been designed to meet, whether for the planning of multi-modal strategies or the optimisation of a city's traffic signals. Recently urban models have been extended to include provision for cycle lanes and the appraisal methods augmented to include the benefits of active travel. Urban models tend to be specific to the city for which the model was designed and, while the responses and appraisal values are common at a national level, they rely on a detailed network and specification of public transport services and so are not immediately transferable between locations.

The traffic models that are used to estimate changes in vehicle flows and speeds will in most cases provide estimates of the changes in environmental impacts. These include changes in greenhouse gases (CO_2), in local air quality (NOx, PM10s and SO_2) and in noise levels. It is common practice to include the monetised values of these changes in environmental impacts in a highway cost-benefit analysis.

While government and international regulations on road vehicles impose conditions which ensure that vehicle owners comply with safety and environmental standards, the provision of vehicles is a market based decision made by each of the large number of road users who might benefit from a project. Thus considerations such as the comfort and quality of a road vehicle are not part of a highway scheme appraisal. Nor is it assumed that a road improvement will induce households to buy new or better cars from which they might enjoy more than a marginal increase in consumer surplus that could be attributed to the scheme.

Road traffic models represent the geography of the area where changes are expected to take place through a structure of zones which produce or attract the trips. These trips are then assigned to the highway network, usually with a simplified process for modelling the local road network. The numbers of trips produced by or attracted to each zone depends on factors such as the number of households and of jobs in each zone.

Rail capacity – infrastructure and the timetable

The supply of passenger benefits from a rail project is delivered through a rather different process. Indeed, the fixed infrastructure, in terms of the civil engineering, track, power supply and train control system is of no value to the passenger in absence of a train service. And most rail projects are aimed at enhancing the train service to ensure that passengers benefit from the increase in the capacity of the track and in the speed at which trains can be operated. Higher speeds allow for journey time savings: in this respect a rail project delivers benefits that are comparable to those from a road investment.

Additional capacity on the railway, either from longer trains or more frequent services, usually results in passengers being able to travel in less crowded conditions. As noted above, many countries make use of a multiplier on the value of time savings to reflect the additional benefit that passengers perceive when crowding is reduced, a multiplier which applies even if the overall journey time remains unchanged.

Investment in greater frequency of rail services provides passengers with a greater choice over the time of day at which they travel. Rail passengers value greater service frequency, either in terms of reduced waiting times in the case of intensive metro style systems or in terms of the greater choice in the case of long distance routes. The use of a value for waiting time, usually valued at double the national average in vehicle time, in the case of public transport schemes is well established in many countries' appraisal methods.

In some cases new rail or metro vehicles offer an improvement in the quality of service when compared with the alternative of retaining or upgrading the existing rolling stock. Access to Wi-Fi, more comfortable seats and improved in-vehicle information about station stops, delays and options for mitigating their effects all form part of the change in the quality of service that investment in public transport can deliver. Public transport providers need to know the value that passengers place on such attributes in order to justify the additional costs when ordering the rolling stock or when bidding for public funding of the services they provide.

There is no equivalent in the case of road appraisal to changes in rail vehicle quality. Changes in service frequency are also a rail specific attribute, although some urban transport models allow road users to gain a benefit from changing the time of day at which they travel in the case of a scheme which reduces peak period congestion and thereby attracts traffic back into this period.

A further difference between rail and road investment is in the role of the station at the start and end of each part of the journey. Investment in improving rail services frequently requires increased capacity at stations to accommodate increased demand and to improve the quality of a journey. The benefits of Transport for London's GBP 640 million Bank Station Upgrade scheme were estimated using a model of pedestrian flows between the underground platforms and both the street level and the other platforms in the case of passengers changing trains at the station. The cost-benefit analysis made use of specific values for walking and waiting time spent in crowded conditions on the level, on stairs and on escalators: there was no change to the train services using the station.

Modelling the effects of investment on the supply of rail services

There is no equivalent on the rail network of the generic relationship between increases in road capacity and traffic flows and speeds and hence savings in travel times. The capacity of any part of the rail network is specific to the route, the signalling and control system in place, the mix of train types and services operated. The process of estimating what investment is required to increase the capacity of a specific service or to reduce journey times on that route requires detailed route based engineering knowledge.

The modelling of rail patronage and the linking of changes in the supply of rail services with their effect on passenger demand also tends to be specific to the route and the aim of the project rather than of general application. Initial modelling and appraisal of a new high speed line might focus on time saving benefits and mode shift effects. A policy aimed at reducing peak hour congestion will adopt a model which includes the relationship between train capacity, train frequency, passenger demand, waiting times and crowding levels subdivided into short time periods on the route to be improved. Some models allow for passengers' responses to the reduction in crowding to include the generation of new trips and a shift of trips from the shoulder to the peak hour. The benefits will be made up of overcrowding relief, shorter waiting times in more pleasant conditions and a greater ability to travel so as to depart or arrive at the passenger's preferred time, rather than having to make a compromise about arrival or departure times because of the trains being so crowded. In those cases in which a decision has been made to recover part of the cost of the project from an increase in fare levels, the model used to forecast changes in demand will need to make provision for the relevant fares increases and elasticities as part of the responses to the change in service provision, adding a further dimension of complexity to the rail model and subsequent appraisal.

Most rail models are based on data from ticket sales on station to station flows. They therefore lack the information on the access and egress stages of the journey which influence passengers' choices for all trips which start or end at some distance from the station. Linking data on station to station flows with estimates of how rail travellers reach and leave the station and whether a scheme might induce them to choose a different station for the trip is challenging. In this respect rail models differ from those used for road and urban public transport schemes, for which adequate household survey data exist to populate the models with more specific origin and destination data.

The relationship between the purpose of the intervention, the policy objectives it aims to address and the transport model used dictates the coverage of the appraisal. In the United Kingdom most passenger rail services have been procured through bids to operate a specific franchise, with the bidder proposing and costing enhancements to the basic specification. Improvements in the quality of service include options such as the provision of Wi-Fi, on-train sales of food and drink, staffing of stations and operation of more trains than in the specification. Values for each attribute derived from survey and stated preference studies are used to compare bids and reach a decision about the award of the franchise based on, among other considerations, the costs and benefits of each bid. Similar considerations apply to the specification of a concession to operate a service.

Differences between road and rail: The modelling and appraisal of unreliability

In those cases where adequate data are available, the modelling and appraisal of transport schemes is extended to include the effect of the investment on reducing the likelihood of unexpected delays. There is a variety of approaches to estimating and valuing changes in reliability on the different modes, assessment of which goes well beyond the scope of this report. Relevant to the issue of comparability are the differences between the two modes in users' perception of unreliability, with rail journeys generally running to a schedule set by the operator, while the expected duration of a road journey depends on the experience of the driver. In the United Kingdom rail appraisal has made use of estimates of the reduction in the average minutes of lateness that a scheme can be expected to deliver, with a multiple of the standard value of time savings, which varies by journey purpose and other characteristics of the trip, to represent the additional inconvenience of a late arrival at the passenger's destination.

There are various options for estimating changes in reliability for road schemes. A measure of the expected change in the standard deviation of typical journey times is made for inter-urban road projects in the United Kingdom. A monetary value, derived from the same survey methods as are used to determine the value of time savings and defined as the reliability ratio, is then applied to the measure of the standard deviation. A reliability ratio of 0.4 of the value of time savings for the relevant journey purpose is currently used by the UK's Department for Transport.

The benefits of reducing unreliability for public transport projects other than heavy rail schemes, which are described above, are estimated using one of two methods. A value of the average lateness, set at 2.4 times the appropriate value of time savings is used in some cases, with an alternative of following the highway based approach of estimating the change in the standard deviation of journey times but adopting a higher reliability ratio of 1.4.

A consequence of using different methods for road and for rail when quantifying and valuing reliability is that road users place a larger value on occasional substantial delays than on a series of frequent small delays of the same total duration. And, while early train arrivals are neither detrimental nor beneficial, road users put a value on predictability. The difference in the methods used in the United Kingdom can in part be explained by the different institutions responsible for delivering road and rail services, with average minutes lateness one of the indicators used by the Department for Transport to manage the performance of the franchised train operators.

Both quantifying and valuing changes in reliability on road, rail and other public transport are subject to uncertainty. The cost to the traveller of an unexpected delay differs according to the purpose of the trip. Even the best designed survey will elicit a wide range of values. At the same time, the extent to which an increase in the capacity of a road or a rail service will reduce the variance of average journey times depends on a complex interaction of factors, many of which are uncertain. For this reason the UK Department for Transport excludes estimates of the value of reliability benefits from the quantified benefit cost ratio and considers them only at the stage in the decision process at which all of the less certain impacts are addressed.

Differences between road and rail: Taxation and revenues

A change in consumer spending on road travel, such as might be induced by a highway scheme, has a different impact on overall government revenues from that of an equivalent change in expenditure on rail travel. A well conducted cost-benefit analysis will account for these differences and the consequent changes in government revenues with any shadow price of public funds used to mark-up project costs being equally applicable to these changes in government revenues.

In most countries road fuel is taxed at a higher level than the average rate of taxation on consumer spending. So a road project which reduces travel times and thereby increases the number of trips, shifting motorists' spending from other goods and services to fuel, will increase total tax revenues. For this reason, cost-benefit analysis treats an increase in tax receipts as a benefit: motorists value the fuel they use at the market price, including tax, while the additional tax revenue allows the government either to reduce other taxes or to increase public spending. Normally though, taxes are transfers and a simple increase in taxes that would lead to increase of tax receipts would be treated as a transfer. If the Marginal Cost of Public Funding were considered, raising taxes also incurs a cost in terms of disincentive to economic activity. This discussion though is outside of the scope of this discussion.

Rail and other public transport services are generally taxed differently, paying a rate of tax which is often lower than the average rate on other goods and services. A rail scheme which results in more rail travellers will reduce overall tax revenues as consumers shift their spending from a typical mix of goods and services to low or zero taxed rail fares.

As noted above, the treatment in cost-benefit analysis of revenue from rail fares is a further source of difference between road and rail schemes. Incremental revenue from the demand induced by the scheme will, to a greater or lesser extent, offset some of the costs of the scheme. The extent of the offset depends on the contractual and commercial arrangements under which train services are procured. Under some models of private sector provision, some of the revenues generated might be part of the profit earned by the operator. Where services are procured through competitive franchising or through a concession arrangement, an assumption that all generated revenues accrue to government is usually made.

As noted above, revenues from the users of rail and other public transport schemes provide a potential source of funding and an opportunity for managing demand, by, for example, charging higher fares for peak period travel. In those cases in which policy makers decide to increase fares on the improved part of the network as a contribution to the funding of the scheme, the modelling of passengers' responses to this change in the money cost of travel needs to take account of the effect of such a change on demand when compared with the Do-Minimum counterfactual. The interaction between capacity, demand and a policy of optimising overall fares revenue through yield management, subject to whatever constraints a government might place on increases in specific point to point fares, results in further challenges to the modelling and appraisal of rail schemes. In many cases, such as the UK's HS2 scheme, the appraisal assumes no change in the level or structure of fares between the do-minimum and with scheme scenarios. This assumption helps to simplify the appraisal of the scheme: it does not anticipate the situation that might occur if, when the new line opens, the train operator decides to raise the fare to reflect the improved quality of service.

Treatment of mode shift effects between road and rail

Road and rail are, at the margin, substitutes: certain trips which, if not made by one mode, can be made with little inconvenience by the other. In many cases land use patterns and low spatial densities eliminate public transport from the set of available choices but, where alternatives exist, investment in one mode will result in a shift in traffic from other modes. Mode shift effects can result in impacts, for example the benefits of a reduction in pollution and congestion on account of road traffic diverting to rail, and there are well established methods of modelling and valuing these effects.

Mode shift effects – road schemes

Experience in the United Kingdom has shown that the extent to which investment in highway improvements induce rail travellers to change their mode of travel is generally very limited. Road schemes are rarely primarily aimed at serving only the long distance and city centre commuter markets in which rail's market share is greatest. Only a very small proportion of the car drivers on a typical inter-urban scheme are likely to be making trips that have been shifted from rail. In urban areas many of the interactions between car traffic and other modes occur through the re-allocation of road space between public transport, active travel modes and private vehicles. Urban transport models can be used to show the impacts on journey times and on delays for the different modes as a result of different options for prioritising public transport. An appropriate multi-modal transport model will also show, given the changes in travel times for each mode for each option and the values of time savings for the different user groups, the benefits of each of the options to inform decision makers about their relative merits.

Mode shift effects – rail schemes

Rail schemes generally have a more significant effect on mode choice for the limited markets in which they compete. Part of the benefit that can be attributed to rail investment is the reduction in road traffic as a result of the trips that switch modes on account of the improvement in rail services. The benefits of mode shift to rail are made up of any reduction in road congestion on the routes from which the trips have transferred, together with the reduction in environmental damage, such as changes in air quality, greenhouse gases and noise, and changes in road accident rates. Mode shift effects can also be the result of a shift to a different destination because the rail investment makes it a more attractive choice.

Estimating the magnitude of such changes requires either a multi-modal transport model, which can provide details of the route and destinations from which car drivers have transferred, or a less detailed method. An example of the latter is provided by the UK Department for Transport's recently updated TAG Unit A5.3 Rail Appraisal (UK Government Department for Transport, 2019). Details of diversion factors by flow category show, for different parts of the country and for different distance bands, the proportion of the new trips induced by a rail scheme which are likely to have been diverted from car driver trips. The diversion factors are derived from surveys of travellers' intentions and from the UK's National Transport Model. Estimates of the benefits of this shift from road have been taken from the UK's National Transport Model: a spreadsheet in the Department for Transport's TAG databook (UK Government Department for Transport, 2019), gives estimates of the marginal external costs of a car km by road type, area type and time of day. In absence of a multi-modal transport model, the analyst is required to reach a judgement, based on the estimates of the rail trips generated by the investment, about the roads and time periods from which these trips have been diverted. The data in this guidance make it possible to estimate the benefits, in terms of congestion relief, environmental damage and accident reduction, from mode shift to rail without access to a full multi-modal transport model.

Most major urban public transport schemes are appraised using the changes in travel patterns derived from a multi-modal model. Such models, usually estimated using local household and other survey data, are aimed at explaining the observed choices that people in different parts of the urban area make and how these choices are influenced by personal and household characteristics and by the set of travel options they face. The benefits of mode shift are estimated directly within the transport model: there is no requirement for externally estimated diversion factors. As noted above, such models also serve to estimate the impacts of urban highway improvements and of the re-allocation of urban road capacity.

Freight appraisal

In some countries, including the UK, decisions on investment in rail freight infrastructure are made using different criteria from those that are applied to road freight haulage. In such cases the financial viability of the investment in rail freight is an influence on the decision. There are several reasons for this practice. Whereas rail freight projects, such as improved access to container ports or the construction of passing loops on busy lines, are designated exclusively for the use of freight trains, the road network is an asset which is shared between all classes of traffic.

A further consideration is the relationship between the infrastructure provider and the freight user. There is no commercial relationship linking the provider of highway infrastructure and services with road freight hauliers and their customers. The benefits from a highway scheme to road goods vehicles are appraised using the same methods as for car driver and car passenger travel, using values of time savings and vehicle operating cost changes specific to the road freight sector, with some countries including in the estimate of cost savings the benefit of reducing the time taken to deliver the commodity carried. Similar considerations apply to the external costs caused by heavy goods vehicles.

In most countries rail freight is operated as a commercial enterprise. There is a business relationship between the owner of the freight and the company responsible for moving that consignment. In this respect, rail is no different to road. But unlike the road sector, the freight haulier enters into a commercial contract with the infrastructure operator and owner for the right of access to the infrastructure and for the provision of a path or series of paths on the network which can be used to move trainloads of goods between one location and another. The train operator pays the infrastructure owner an access charge to fund the investment and to meet any additional operating and maintenance costs incurred on account of the additional freight trains.

The train operator's revenue comes either from the sale of the commodity transported at its destination or from charging the owner of the freight for transporting it. While the outcome of the freight project might be a reduction in the cost paid by consumers of rail hauled goods, this outcome is delivered through market forces rather than through public sector intervention. In most countries the infrastructure owner's potential to exercise monopoly power over the right of access and the access charges levied is restricted by an independent rail regulator so as to incentivise the network owner to ensure efficient allocation of capacity, an institutional model which applies even when the infrastructure owner is a public sector entity.

It is practice in the United Kingdom to attribute to a rail freight scheme the benefits of any shift from road to rail as a result of that scheme. The method of quantifying and valuing the mode shift benefits follows the approach outlined above for car driver diversion, with account taken of the greater congestion and environmental impacts caused by heavy vehicles. Typical values are given in the UK Department for Transport's TAG Databook (2019). As in the case of car mode shift, changes in tax revenues on account of reductions in road fuel consumption are included in the appraisal. Diversion factors in the case of freight mode shift are specific to the scheme.

These external benefits are appraised because of a UK government scheme which provides grants to firms which implement schemes which result in mode switch and which would not be commercially viable without a government grant. Award of a grant is subject to several conditions, including a requirement that the benefits of the switch exceed the level of grant required.

Decisions about major new freight infrastructure investments, such as Alpine tunnels or schemes to accommodate the growth in cross boundary transit traffic are generally based on the use of more comprehensive cost-benefit analysis. Environmental objectives, primarily mode shift effects provide much of the justification for such projects. In addition, rail freight transport cost savings on account of fewer delays and national policies such as the development of a strong logistics sector can help to strengthen the case for investment in rail freight infrastructure.

Urban transport programmes and projects

While the values and methods used for the appraisal of road and of rail projects are equally applicable to urban transport projects, decision makers will often draw on a wider range of policies than the improvement of a single mode. Demand management, road space reallocation and the promotion of cycling and walking as active modes all form part of the set of policies aimed at improving mobility and making cities better places for residents, workers, businesses and visitors. A variety of transport models are used in the appraisal of urban transport policies, ranging from the detailed representation of traffic movements in congested conditions at different types of road junctions to more strategic level multi-modal models to depict the interactions between different categories of road vehicle, heavy and light rail, bus and active travel. The relationship between transport and land use is also relevant to urban planning and policy. A land use transport interaction model, such as London's LONLUTI model (Transport for London, 2014), is often part of the hierarchy of models used to help formulate urban investment programmes and policies.

Appraisal methods have been modified or enhanced in a number of ways to accommodate specific urban policies. Schemes for congestion charging have adopted values of time savings segmented by income band to represent the extent to which charging reduces demand by pricing off those with a greater choice of options and with a lower than average ability to pay. Evidence from studies of the relationship between physical fitness and human health has been used to derive appraisal values for those investments in active travel which induce people to take up cycling and walking and hence promote good health and reduce hospital admissions and working time lost to sickness.

Comparing road and rail: Some conclusions

Cost-benefit analysis has long been used as a means of providing decision makers with information about the social value of investments in road and rail transport. Road and rail are rarely complete substitutes. They differ in the problems that new infrastructure is intended to resolve. An understanding of the extent to which appraisals of the different modes can be compared is desirable because policy makers need to decide on priorities, on the allocation of budgets and on whether the benefits of any project exceed its costs.

Many features of cost-benefit analysis are common to the appraisal and modelling of road, rail and other public transport schemes. This includes as the use of time savings as the major source of transport user benefits. But the rail 'offer' to the transport user differs in a number of respects from the service a car driver derives from new or improved infrastructure. The link between road traffic congestion, road capacity and journey times which is an inherent part of any highway model does not apply in the context of rail investment. A rail service requires rolling stock, a timetable and stations, each of which might be part of the investment package. The quantification and value of time savings has been augmented to include the benefits that rail passengers gain from improvements in the attributes of the rail service, with values derived from passenger surveys and other approaches, such as stated or revealed preference methods. At the same time rail demand models have been enhanced to take account of passengers' responses to such changes. In this respect there are differences between road and rail appraisal, but there are good reasons for these differences.

There remains a risk that, where such methods and models have not been developed and the benefits of a rail scheme are restricted to in-vehicle time savings, the appraisal will omit some of the benefits. Without good evidence on passengers' willingness to pay for reductions in crowding and other service improvements, decision makers would lack the information they need to weigh up the benefits and costs of such projects. Of equal relevance to the decision is the reliability of the model used to predict the changes in demand that the project will induce. A model which fails to perform adequately when tested against observations and against predictions of transport users' behaviour from other sources will not provide decision makers with the evidence they need for a sound choice of project. If comparability between modes is a requirement, then performance of the models used for the different modes must be broadly similar.

Decision makers have the option, when assessing the cost-benefit case for new infrastructure, of recovering part of the project costs from users. Exercising such an option reduces demands on public sector funding and might satisfy a policy objective that users pay for the benefits they receive. Such policies are more readily applied to rail and other public transport schemes as there is already a requirement that users pay to access the network. The practice of tolling roads differs between countries and those countries with a history of tolling generally restrict charging to the high quality interurban network.

A policy of requiring users to pay for the benefits they gain has the effect of pricing off some or most of the demand generated by the scheme and reducing overall benefits. Moreover, unless the external benefits of the scheme, such as its contribution to promoting sustainable land use and economic development, are identified, valued and funded by the public sector, much of the rationale for the project will be lost to decision makers.

Policy on the funding of rail freight schemes in the United Kingdom provides one example of the infrastructure provider, the train operator and the customer making a commercial decision about case for upgrading specific parts of the network. Schemes which are not financially viable are eligible for a public sector grant which does not exceed the quantified mode shift benefits. But countries with major transit flows use full cost-benefit analysis to inform the business case.

The cost-benefit appraisal is only one part of the business case that a decision maker will want to understand before being in a position to reach a decision. Policy objectives that are not directly part of the cost-benefit appraisal will influence the process of project selection. Decision makers might wish to strengthen links between the more and less prosperous regions of the country, or to rebuild de-industrialised cities. Cost-benefit analysis can show decision makers the extent of any benefits that transport users in a high income region have to forego if a decision is made to opt for a scheme with lower net benefits in a region of policy priority. Well informed decision makers will understand the differences between modes, in terms how they benefit transport users, their costs and the circumstances under which they are likely to offer the best solution to a problem. A well conducted cost-benefit analysis is part of the process of ensuring that decision makers understand the strengths and weaknesses of the business case put to them.

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Comparing Road and Rail Investment in Cost-Benefit Analysis

This paper examines whether the results of cost-benefit analyses (CBA) for road and rail projects can be compared with each other. Road and rail projects address different transport needs and aim to solve different problems. This does not make comparisons between CBAs for each mode impossible, but requires a nuanced approach.

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