OXFORD ECONOMIC RESEARCH ASSOCIATES

STRATEGIC RAIL AUTHORITY

PASSENGER RAIL SERVICES AND ECONOMIC PERFORMANCE

OCTOBER 2003

Blue Boar Court
Alfred Street
Oxford OX1 4EH
Tel: +44 (0) 1865 253000
Fax: +44 (0) 1865 251172
Email: Enquiries@oxera.co.uk

Contents

Executive Summary

This report presents the findings of a study undertaken by OXERA (Oxford Economic Research Associates) and Mott MacDonald, in association with John Bates, for the Strategic Rail Authority (SRA), examining the impact of passenger rail service performance on the wider economy. The study provides a quantified assessment of the impact of poor rail performance on passengers, employees and business.

The outputs of the study can be divided into three areas:

- a review of relevant literature and survey data;
- a desktop study, estimating the disutility incurred due to poor rail performance; and
- an extended piece of analysis examining the impact on the tourist industry.

Literature review and surveys

The literature review covered two areas: the economic and the stress and psychology fields. In addition, existing surveys were reviewed and new ones undertaken to examine the links between transport unreliability and the wider economy.

The economic literature focuses on the adaptive behaviour that travellers are likely to exhibit when faced with the expectation of delays and unreliable journeys. This literature focuses on 'utility', an economic term that describes the satisfaction that an individual gains from engaging in an activity. A seminal paper by Bates et al. (2001) argues that travellers attempt to maximise the expected value of their utility (equivalent to minimising expected disutility), and that this is affected by two factors: disutility is incurred by extended journey duration; and it is incurred when travellers do not arrive at their preferred arrival time. Ove Arup & Partners (2002) and a seminal empirical paper by Small (1982) suggest that extended journey time should be valued at a rate equal to the value of travel time saved, that arrival earlier than the preferred arrival time should be valued at half the value of travel time saved, and that arrival later than the preferred arrival time should be valued at twice the value of travel time saved. This approach is operationalised in the desktop study using industry standard values of travel time saved.[1]

The stress and psychology literature helps place the economic literature in context. Much of the work available has been carried out on car drivers and passengers, so caution needs to be exercised when generalising to rail travel, since rail travel is characterised by discrete, rather than continuous, departure times. However, high stress levels seem to be caused by travelling within congested conditions. This has a direct impact on travellers by generating disutility, but there is also evidence that it affects their productivity at work, and their general health and well-being. Empirical research on the productivity impact suggests that a stressful journey to work can reduce performance by around 12–18%,

[1] The values of travel time saved used in the study are based on those in the *Passenger Demand Forecasting Handbook* (PDFC 2002), which contains the industry standard forecasting and valuation framework.

although the duration of this impact is unclear. Further empirical work provides evidence that travelling on congested routes to work, which exhibit variable journey lengths, is negatively correlated with job satisfaction, and positively correlated with sickness and absences.

Two recent surveys were examined as part of this report. The first, carried out for the Corporation of London, surveyed directors and employees at several UK companies. Overall, the perception of rail travel reliability was poor, with employees adding around 12% to their journey times to compensate for delays. Of the employers in this survey, 97% believed that staff productivity was adversely affected by commuting problems, a finding which is consistent with the stress and psychology literature. The second survey, carried out for the British Council of Offices, examined how national rail performance affected travel behaviour into London. In general, this concurred with the first survey, but also suggested that a common response among employees was to work later to make up for rail delays, potentially reducing the output impact caused by delays, but increasing the personal disutility incurred.

In addition to the two surveys reviewed above, OXERA and Mott MacDonald carried out three consultation strands. The first survey was intended to elicit data from FTSE 100 companies to examine possible correlations between staff absenteeism and rail performance. Unfortunately a very low response rate meant that this yielded no useful results. A second survey strand targeted government departments, trade unions, and industry representatives. Responses from this survey suggested that, while most employers are sympathetic to one-off delays, employees are sometimes subject to disciplinary procedures due to transport problems. In addition, the tourist industry was felt to be at particular risk of harm due to transport problems. The final strand of the surveys involved a telephone questionnaire of staff and members of Chambers of Commerce. Perhaps the most useful result of this survey for the purposes of this study was that meetings tended to be held towards the middle of the day as a response to poor rail reliability.

Desktop study

This element of the study operationalised the approach examined in the review of the economic literature, and thereby quantified the impact on passengers of poor rail performance. It used the parameters suggested in the literature review, and combined them with industry standard estimates for the value of travel time saved and data on train performance from the SRA. The output is an estimate for the disutility generated by poor rail performance.

As mentioned above, unlike car travel, rail travel does not offer a continuous set of departure and arrival time choices. This generates disutility for travellers, which, while caused by rail travel, is not caused by poor rail performance, since even a railway operating to time would generate this disutility. To make the model results meaningful, the model outputs are subtracted from a counterfactual scenario. One of these represents a perfect-running railway, where all trains run as advertised, and there is no lateness or cancellation. Disutility estimates using the perfect-running counterfactual show the total amount of disutility attributable to poor rail performance. The other counterfactual represents the best year of actual performance that the railway has exhibited since data has been collected—data for most train operating companies (TOCs) is available from 1998. Disutility estimates using the best-year counterfactual show that the disutility is incurred due to the failure of the railway to repeat its previous best performance levels.

Table 1 outlines the key base-case estimates for the disutility incurred due to poor rail performance, disaggregated by passenger type. This demonstrates that, were each TOC to return to its best year of performance, the benefit would be nearly **£900m per annum**. A benefit of **£2.2 billion** per annum would be derived from a move from current levels of performance to the ideal of perfect punctuality and reliability.

These large disutilities are likely to be spread widely across rail users. The modelling results in Table 1 suggest that the total average disutility incurred by leisure travellers and commuters is approximately equal to 60% of the average fare that these travellers pay. However, business travellers seem to incur total disutility equal to around 85% of the average fare paid.

Table 1: Disutility due to poor rail performance per passenger journey—rational delay expectation

	Total disutility (£m per annum)		Passenger journeys (m per annum)	Disutility per passenger journey (£ per journey)		Average fare per passenger journey (£ per journey)[1]	Disutility as a proportion of the average fare (%)	
	Perfect-running	Best-year		Perfect-running	Best year		Perfect-running	Best year
Leisure	649	267	386	1.68	0.69	3.65	46.0	18.9
Commuter	500	168	424	1.18	0.40	2.48	47.6	16.1
Business	1,060	444	156	6.79	2.84	8.03	84.6	35.4
Total	2,209	879	966	2.29	0.91	3.84	59.6	26.7

Note: [1] Data for the average fares paid by each individual type of rail traveller is not available. The estimates presented here assume that all reduced-fare tickets are bought by leisure travellers, all season tickets by commuters, and all full-fare and first-class tickets by business travellers. Consequently, the average fares are illustrative.
Source: OXERA modelling for disutility, TAS (2003) for passenger journeys, and SRA for fares data.

Passengers may have different expectations regarding the expected performance of the railways. This will affect the adaptive behaviour that they exhibit. Four sets of delay expectations are modelled:

- *rational*—travellers are aware of all past train punctuality and reliability information and fully use this to determine the optimum safety margin. Consequently, the train they choose to depart on produces the lowest disutility;
- *worst*—travellers think that the railways are worse than they actually are. They assume that the railway will operate in a manner similar to the worst year of operation for each TOC, choosing a safety margin that is too large. Consequently, they will depart too early on some occasions, and will incur additional avoidable disutility.
- *best*—travellers think that the railways are better than they actually are. They assume that the railway will operate in a manner similar to the best year of operation for each TOC, choosing a safety margin that is too small. Consequently, they will depart too late on some occasions, and will incur additional avoidable disutility;
- *no delays*—travellers believe that the railway operates in a manner similar to the perfect-running counterfactual (ie, there are no delays and trains always run on time). They add no safety margin to the journey time. Consequently, they will depart too late on some occasions, and will incur additional avoidable disutility.

Tables 2 shows the aggregate estimate for disutility due to poor rail performance caused by the failure of the railway to repeats its best year of performance for each of the four delay expectations. The table shows that imperfect delay expectations, or incomplete information, may increase the benefit to be gained from TOCs returning to their previous best performance, from around £900m to **£1.2 billion**.

Table 2: Disutility due to poor rail performance with various delay expectations—best-year counterfactual

Best-year counterfactual	Disutility incurred by passengers (£m per annum)	Absolute increase over rational choice rule (£m per annum)	% increase over rational choice rule
Rational	879	n/a	n/a
Worst	1,086	206	23.5
Best	975	95	10.8
No delays	1,202	322	36.7

Source: OXERA modelling.

Various sensitivity tests were carried out on the results from the desktop study. Each is discussed briefly below.

- *Preferred arrival time*—the base-case scenario assumes that travellers have a preferred arrival time on both journey legs. Having a preferred arrival time on only one journey leg reduced disutility estimates by around £40m and £350m, depending on the scenario examined.

- *Service interval*—the base-case results assume TOC-specific service intervals. Assuming a uniform 30-minute service interval across the network yields a similar level of aggregate disutility, but increases the proportion incurred on commuter TOCs, and decreases the amount incurred on intercity TOCs. A uniform 15-minute service interval reduces the estimate by around one-quarter to one-third from the base case, while a uniform 60-minute service interval raises the estimate by around two-thirds from the base case.

- *Value-of-time assumption*—the base-case results assumed values of time based on the average distance travelled by passengers on each TOC. This assumption leads to an aggregate disutility slightly higher than assuming a 25-mile-based value of time. Using a 50-mile-based value of time yields an aggregate disutility of almost £3 billion, while using a 10-mile-based value of time yields aggregate disutility of around £1.6 billion.

In addition to the sensitivity analysis, several important caveats surround the estimated levels of disutility presented in this report.

First, a key assumption within the modelling is that train delays (on which there is good data) are a good proxy for passenger delays (on which there is not). This assumption seems reasonable for most routes, although it may not hold for some routes that operate a high-frequency ‘metro-style’ service, which may include some commuter routes into London, for example. On these high-frequency routes a delay to an individual train may be large, but a later train may arrive before the delayed train with the same or similar destination. Passengers could board this train arriving at their destination before the delayed train would. In this situation, the model estimates presented here would overestimate the disutility incurred by passengers.

Second, poor rail performance may induce a productivity loss in commuters. This may result in commuters working late to make up for lost output, or employers suffering a loss in output. At present this may not be captured in the model, thereby underestimating the impact of poor rail performance.

Third, business travellers may miss or arrive late for meetings due to poor rail performance. The impact of this depends on the number of people in the meeting and their response to the late arrival. However, this does suggest that late arrival by business travellers potentially imposes a greater amount of disutility than the model predicts.

Tourism

Additional analysis was undertaken to examine the impact of poor rail performance on the tourist industry. As a case study, the reduction in rail performance post-Hatfield, as measured by the SRA's Passenger Performance Measure (PPM), was examined. The impact of the reduction in PPM on tourist rail travel was calculated using a PPM elasticity (derived during the development of the OXERA Transport Model).[2] A diversion rate was then used to estimate the proportion of travellers that leave rail and do not travel at all (others change modes but still travel). The resultant forgone expenditure by travellers (excluding day trips), due to people not travelling to English Tourist Board areas, is shown in Table 3.

Table 3: Forgone tourism spend for each Regional Tourist Board post-Hatfield

Regional Tourist Board	Foregone spend (£m, 2002 prices)
Cumbria	0.22
Northumbria	0.67
North West	3.13
Yorkshire	1.20
Heart of England	1.18
East of England	0.55
London	2.36
South West	1.05
Southern	0.49
South East	0.36
Total across all English Tourist Boards	**11.21**

Source: OXERA analysis of data provided to OXERA by Visit Britain.

[2] The OXERA Transport Model is a strategic-level, multi-modal Great Britain transport demand forecasting tool. For more details, contact enquiries@oxera.co.uk.

The total loss described in Table 3 is around £11m per annum, which is equal to less than 0.04% of total tourist spending within the English Tourist Boards (equal to around £31 billion in 2002). In addition, some of this loss will be internalised within the rail industry, since the average spend figures include rail travel costs. However, even taking a conservative estimate for the cost of a return train ticket, it would seem that well over half of the lost spend figures shown in Table 3 should be considered as affecting third parties.

Less data was available on Scotland and Wales; however, if a similar proportion of tourists travel by rail to these destinations as in England, and the average spend is the same for all other travellers, the lost spend is equal to approximately £3.5m in Scotland and £0.7m for Wales.

Unfortunately, no detailed data was available for day trips to any of the tourist areas in the UK. However, information from the Welsh Tourist Board suggests that there may be as many as four day trips for every trip lasting more than one night away from home. This suggests that the estimates given above are fairly conservative, although it would be expected that the monetary impact on the tourist industry of a lost day trip would be much smaller than that of a lost trip consisting of one or more nights away from home.

1. Introduction

This report presents the findings of the study undertaken by OXERA and Mott MacDonald, in association with John Bates, for the Strategic Rail Authority (SRA), examining the impact of passenger rail service performance on the wider economy.

The study provides a quantified assessment of the impact of poor rail performance on employee and business productivity. It describes a credible and authoritative basis for evaluating the magnitude of impacts omitted or underestimated by conventional appraisal methods. The SRA has stressed that the quantification of orders of magnitude and the confidence placed on any estimates is important.

The study consists of three parts: a literature review; a desktop study; and a consultation exercise. The report is divided as follows.

- Section 2 provides a critical review of the literature on the impact of poor rail performance in a range of areas. This is augmented with results from the three strands of the consultation exercise, and a review of other relevant surveys. The first strand involved eliciting the views of government, employer and employee organisations via a questionnaire on perceptions surrounding the link between rail performance and economic performance. The second was a survey of the human resources departments of FTSE 100 companies, which sought to obtain quantified information on the link between rail performance and business efficiency. Finally, a telequestionnaire of Chambers of Commerce was carried out in light of the responses to the two previous strands. This section also outlines a framework for analysis, which is subsequently adopted as the basis for the desktop study.

- Section 3 provides a detailed outline of the methodology adopted for the desktop study, explaining how the framework described in the literature review is operationalised. This component portrays how travellers alter their behaviour in response to poor performance, and provides insight into the process generating the changes. Finally, this section presents and discusses the results of the desktop study, highlighting areas of harm that are not included in the OXERA model estimates.

- Section 4 concludes.

2. Literature Review and Survey Data

This section examines the relevant available economic, psychological, and stress-based literature on lateness and unreliability. Section 2.1 describes the approach that much of the economic literature takes to examining this issue. It outlines the model put forward in Bates et al. (2001)—one of the seminal works in the field—and discusses each of the key parameters within the model. Section 2.2 reviews four areas of harm resulting from uncertainty about travel time, suggested by the literature on stress and psychology. Finally, section 2.3 considers survey evidence on the links between transport unreliability and the wider economy, reviewing recent surveys for business groups and the consultation exercises undertaken as part of this study.

These three areas of research are brought together within the desktop modelling exercise, which is described in section 3.

2.1 Adaptive behaviour

Travellers dislike unreliable journey duration for several reasons. At least part of this is because they are sensitive to the consequences of variation in travel time, which include having to spend longer on the train than envisaged, and arriving at a destination at an unanticipated time.[3]

Bates et al. (2001) suggest that travellers have a preferred destination arrival time. Arriving either before or after this point will incur some level of disutility—termed 'schedule disutility'. It is often anticipated that travellers will be more concerned about arriving late to a destination than arriving early. The model elucidated by Bates et al. is based on the notion that individual travellers wish to minimise the *expected* disutility associated with travelling. The authors adopt the following utility function:

$$Utility = \alpha T + \beta SDE + \gamma SDL + \theta D_L$$

where T is travel time, SDE is early schedule delay, SDL is late schedule delay, and D_L is a lateness dummy, equal to 1 when late, and 0 otherwise. α, β, γ, and θ are model parameters. Early schedule delay is incurred when the traveller arrives at the destination before the preferred arrival time (PAT), and is defined formally as $SDE = max.\ (0, PAT - [t_h+T])$, where t_h is the departure time of the train from the starting station. Late schedule delay is incurred when the traveller arrives at the destination after the PAT, and is defined

[3] An alternative, top-down approach to calculating the external impact of poor rail performance on the UK economy is offered by National Statistics' Input–Output tables (see National Statistics, 2002). Input–output tables add an extra dimension to the national accounts by describing the intermediate transactions that take place between individual sectors of the economy. One of these sectors is 'Railway transport'. A potential method for measuring the external impact on the UK economy is to calculate the amount by which poor rail performance reduces the efficiency of the railway transport sector of the economy. The output of this sector could then be inflated to remove the calculated level of inefficiency; the effect on other industry sectors and overall UK GDP could then be calculated. These tables do not, however, distinguish between passenger and freight rail transport, making further analysis impossible.

formally as $SDL = max. (0, [t_h+T] - PAT)$. As is explained more fully below, D_L is sometimes included in the literature because some authors have suggested that there is a 'jump' in disutility associated with a service being late per se, perhaps because travellers miss important connections or experience stress associated with lateness.

In a situation of perfect reliability and zero lateness, the traveller can simply maximise their utility by choosing the train that provides them with the best combination of journey time and scheduled arrival time relative to their PAT.

Disutility can be incurred due to longer journey times—as travel time, *T*, rises, so disutility rises. It can also be incurred due to arriving at some time other than the PAT (late or early schedule disutility). Since trains do not offer a continuous set of departure and arrival times, it is likely that some schedule disutility will be incurred even under perfect reliability.

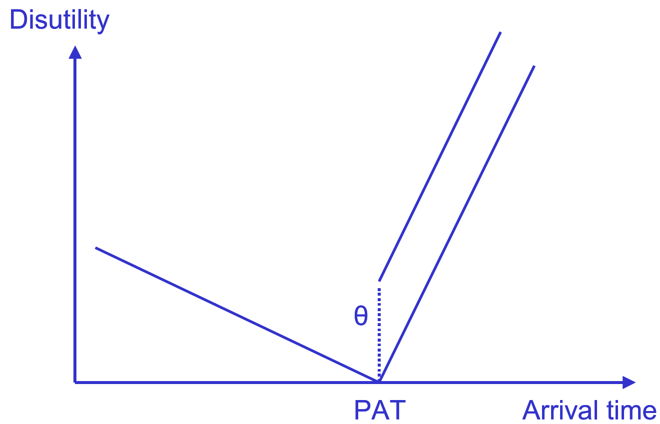
With imperfect reliability and a non-zero level of average lateness, travellers must maximise their *expected* utility, since they must choose which train to travel on before the actual journey time and corresponding arrival time are revealed. The utility function above shows that travellers can incur disutility in two ways when trains are unreliable and may be late:

- when trains are late, the journey time is increased. As *T* rises, disutility rises. Thus, late trains will incur more travel-time disutility than those that run on time;
- trains that run early or late will arrive at the destination earlier or later than the stated arrival time. This will move the actual arrival time closer to, or further away from, the PAT. Consequently, unreliability can reduce as well as increase schedule disutility.

As Knight (1974) highlights, individuals wish to use time efficiently, engaging in activities from which they derive the most utility. Also, as some acts must occur at a particular time (eg, arriving at work), certain units of time are more valuable than others, 'depending on whether they occur in such a way as to facilitate activities which yield high utility' (p. 395). Consequently, travellers are likely to build in a 'safety margin' to ensure a high probability of arriving in time for an important event.

Under the Bates et al. model, when travellers maximise their expected utility, they will use the information available to them concerning the average lateness and unreliability of the trains in order to determine an optimum safety margin to add to their journey time. Determining the optimum likelihood of late arrival sets the optimum safety margin. These points are illustrated in Figure 2.1.

Figure 2.1: Schedule disutility



Source: OXERA.

Schedule disutility falls as the arrival time gets closer to the PAT. If $\theta = 0$ then, as the arrival time passes, the PAT disutility rises, but at a faster rate than it fell—since arriving late is generally considered to be worse than arriving the same number of minutes early. If $\theta > 0$ then, as the arrival time becomes greater than the PAT, there is a jump in the disutility. Some authors (eg, Ove Arup & Partners, 2002) assume that $\theta = 0$, as they believe there is no fixed penalty incurred by simply arriving momentarily after the PAT.

Travellers will trade off the disutility associated with lateness and earliness to arrive at the optimum probability of lateness. This is derived from the extent of penalties for early and late arrival. The greater the difference between these penalties, the lower the optimum probability of late arrival—ie, the more unacceptable late arrival becomes. However, this probability will always be greater than zero as long as early schedule delay incurs some level of disutility. If $\theta = 0$ then the optimum likelihood of late arrival is given by:

$$\frac{\beta}{(\beta + \gamma)}$$

There are three areas within this model specification that require further discussion:

- estimates of the value of travel time saved (VTTS), to convert the disutility associated with journey duration into monetary values;
- values for the lateness and earliness parameters relative to the VTTS, allowing schedule disutility to be monetised;
- the distribution of PATs.

Each is examined below.

2.1.1 Value of travel time saved

There are two main estimates for the VTTS that are relevant for UK railways. The first is produced by the Department for Transport (DfT), the other for the *Passenger Demand Forecasting Handbook* (PDFH). The two sources suggest slightly different values, and adopt a different methodology when estimating the VTTS for working time. The DfT's

2001 'Transport Economics Note' provides two values of relevance to UK railways (see Table 2.1).

Table 2.1: VTTSs (pence/hour, 2003 prices)—DfT

	VTTS
Working time	2,814
Non-working time	505

Source: DfT (2001) and OXERA calculations.

The calculation of the two sets of figures for VTTS have different underlying methodologies:

- working-time VTTS is as perceived by employers. It therefore uses factor costs, which are assumed equal to the gross wage and non-wage labour costs (eg, employers' national insurance and pensions contributions);
- non-working time VTTS, which includes commuting to and from work and leisure travel, is as perceived by the individual, and is therefore based on willingness to pay. As willingness to pay varies across individuals and journey purposes, the DfT standardises it to a single 'equity' value to ensure fairness in appraisals.[4]

An alternative selection of estimates for travellers' VTTS is provided in the PDFH.

Table 2.2: VTTSs (pence/hour, 2003 prices)—PDFH

Journey purpose	Business		Leisure		Commuting	
Distance (miles)	**First class**	**Standard**	**South East**	**Non-SE**	**South East**	**Non-SE**
10	2,714	1,276	544	464	598	517
25	3,204	1,511	638	551	712	611
50	4,716	2,224	940	813	1,041	893
100	5,361	2,519	1,068	920	1,182	n/a
200	6,086	2,868	n/a	1,055	n/a	n/a

Sources: PDFC (2002), updated to 2003 prices using GDP and inflation data from National Statistics.

The PDFH values are all derived from stated-preference evaluation. Compared with the DfT's figures, they are disaggregated across a wider selection of journey purposes and locations; consequently, it is these VTTSs that are used for the modelling in section 3. The higher figures for travel within the South East are likely to be due to higher incomes in those areas. The rising value of VTTS for longer journeys may reflect a selection process whereby longer journeys are only undertaken when they carry a high value, hence

[4] For a discussion of this, see Mackie et al. (2003).

the VTTS associated with them is likely to be higher than for shorter journeys, which may be of lesser importance.

The key distinction between the two methodologies occurs for the figures that represent working time or business travel. The DfT's figures are based on average wage rates per hour, and therefore assume that the traveller achieves zero output on the train. This assumption would seem more realistic for car drivers than for rail passengers, since business travellers are likely to achieve at least some output while travelling by train. A second assumption within the DfT's figures is that an employee's wage rate (plus non-wage labour costs) equals the marginal product produced by the employee.[5]

The PDFH work is based on stated-preference studies for all types of traveller. Therefore, these figures should take into account the amount of work that travellers can do on the train. However, being stated-preference estimates, they may be biased upwards, as travellers may overestimate their willingness to pay for journey time improvements.

2.1.2 Value of lateness/earliness

Estimates of the model parameters α, β and γ allow monetary values to be placed on late and early arrival relative to the PAT. The disutility associated with journey time, *T*, is equal to the VTTS. Consequently, ratios of the model parameters can be multiplied by the VTTS to give monetary valuations of early and late schedule delay. Therefore, early schedule disutility (SDE) will be valued at (β/α)*VTTS, and late schedule disutility (SDL) at (γ/α)*VTTS.

There has been little empirical research into the value that travellers place on arriving at a destination early and late relative to their PAT. This is partly because of the difficulties in finding revealed-preference situations where trade-offs can be made, and partly because of the problems of conveying information to respondents in stated-preference studies.

Some estimates are available, however. Two alternative and often-quoted values for the parameters in the utility function are shown in Table 2.3. The most frequently cited empirical results for these parameters, according to Bates et al. (2001), are those from Small (1982), which are based on a sample of 527 commuters in the San Francisco Bay Area. Since the sample consisted entirely of those commuting to work, it is debatable whether the resulting parameter values can be generalised. Business trips and leisure trips may have significantly different values.

A paper by Abkowitz (1981), which uses a sample of 991 commuters, also in the San Francisco Bay Area, does not provide figures that are directly transferable into this framework, but corroborates the conclusion suggested in Table 2.3 that the loss associated

[5] This assumption is likely to hold as long as efficiency wages are not a significant factor driving a wedge between the marginal wage rate and marginal productivity. Efficiency wages may be paid by employers to make unemployment look more unattractive to its employees than it would were it to pay the market-clearing wage. Making unemployment more unattractive may discourage shirking by employees.

with late arrival is significantly higher than that associated with early arrival. However, Abkowitz suggests that late losses could be around eight times as large as early losses, while the figures in Table 2.3 suggest that they are around four times as large.

Table 2.3: Utility function parameter values

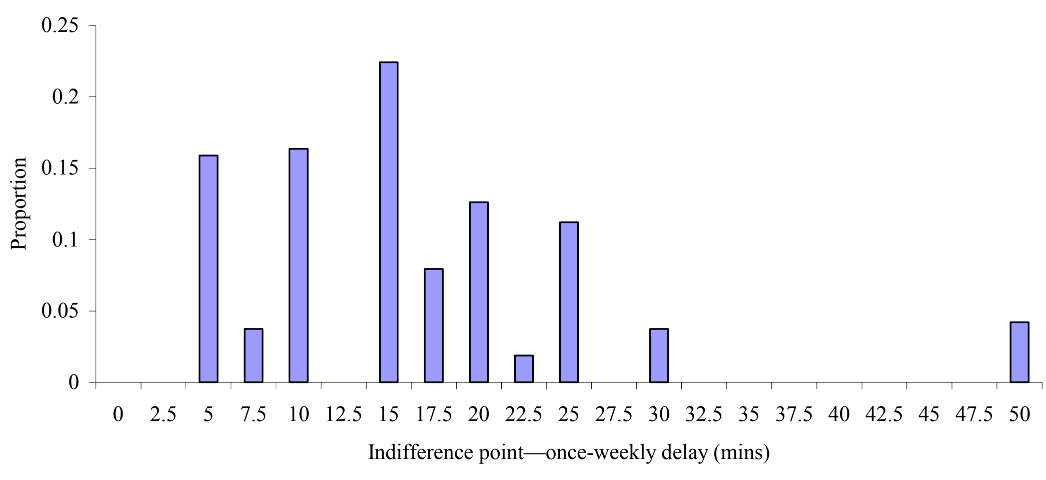
	α	β	γ	θ	**Optimal probability of arriving late[1]**
Commonly assumed values[2]	2	1	4	–	0.200
Small (1982)	2	1.23	4.79	–	0.208

Note: [1] Defined as $\frac{\beta}{(\beta+\gamma)}$. [2] These values are as suggested in Ove Arup & Partners (2002), p. B2.

These parameter values imply a similar valuation of schedule lateness as is assumed in the PDFH, which suggests that late minutes should be valued at three times in-vehicle time. The Bates et al. model framework implies that a passenger on a train arriving later than timetabled will incur disutility at the in-vehicle value of time (the VTTS). Once the PAT has been passed, the passenger will also incur schedule disutility at twice the in-vehicle rate (the ratio of $\gamma : \alpha$, which is 2). Thus, for late minutes, after the passenger's PAT, the PDFH and Bates et al. valuations of lateness are the same.

Jackson and Jucker (1981) carried out a stated-preference study requesting travellers to trade off a reliable journey that takes longer against one that takes ten minutes less, under normal conditions, but with a more variable journey time. This information was then used to determine travellers' levels of risk aversion to travel-time variability. Figure 2.2 shows the points at which the travellers surveyed were indifferent between the longer and shorter, but more variable, journey times.

Figure 2.2: Risk aversion to travel-time variability



Source: Jackson and Jucker (1982).

Lower average minutes shown in Figure 2.2 correspond to higher levels of risk aversion, while higher average minutes correspond to lower levels of risk aversion. While these results cannot be directly translated into the Bates et al. framework, they do indicate that travellers display a wide range of levels of aversion to lateness.

There are several debates within the literature that are of interest. First, Mahmassini and Chang (1986) put forward the concept of a ‘deadband’ around the PAT, within which individuals are indifferent to their arrival time. The authors suggest that this deadband could be 5–10 minutes. If such a deadband does exist, it would help to justify the practice in the British rail industry of describing a train as being on time when it arrives within five minutes (ten minutes for long-distance trains) of the advertised arrival time.

Second, there is an issue of major delay incidents. Ove Arup & Partners (2002) highlights that these may be associated with higher than predicted levels of disutility than less significant incidents of lateness. This may be because a threshold has been passed (eg, missing a meeting entirely, missing a plane departure), which invites a fixed and high level of disutility.

While both of these points are interesting in their own right, including them would substantially increase the model’s complexity. Also, neither the width of the deadband nor the point at which a threshold value of disutility would be reached is clear, making modelling problematic.

2.1.3 Distribution of preferred arrival time

A significant proportion of travellers’ disutility will be accounted for by schedule disutility, and, consequently, the distribution of PATs is important. As there is no available literature that has empirically examined PAT distributions, an assumption must be made. However, changes to the distribution of PAT can have significant effects on the disutility incurred by travellers in unreliable conditions. Three distributions are often used:

- *normal*—the normal distribution implies that the PATs are focused around some central time. This may make it a reasonable assumption when examining commuting journeys to work, since work start times are focused around a central time (eg, 9am);
- *logistic*—similar to the normal distribution, but with smaller tails. Using this distribution means that it reduces extreme, and perhaps unrealistic, arrival times;
- *uniform*—the use of uniform distribution implies that the probability of PAT being at any point within the width of the distribution is the same. Consequently, there are no times of day that are preferable to others for arrival. This may make it a reasonable assumption to use when examining PAT for business meetings—arguably, these are evenly spaced throughout the working day.

A further possible assumption is that PAT is endogenous for some or all travellers—ie, they can adjust their PAT (eg, the start time of a meeting) to fit the train schedule. This would imply that PAT is lumpy around the scheduled arrival times for trains.

A complicating feature is that some travellers may not have a PAT for some journeys. For example, a traveller on the homebound leg of a journey may not have a PAT, but wants to arrive home as soon as possible, regardless of when that actually is.

2.1.4 Criticisms of the Bates et al. model

There are several criticisms of the Bates et al. model, two of which are of particular interest:

- it is a linear model—it is plausible that the disutility associated with early and late schedule delay is non-linear, with disutility rising slowly close to the PAT, but rising much faster the further one gets from the PAT;
- it only captures the direct effects of lateness, and not the indirect impacts on third parties. However, it is possible to adjust the parameters to reduce this problem, and include at least some of these indirect impacts.

2.2 Travel stress

In addition to the direct disutility associated with travel-time uncertainty, travellers experience a range of other impacts. This section reviews the literature on the impacts on travellers of delays, unreliable journey duration, and congestion. The impacts are broadly divisible into three categories:

- stress impact;
- reductions in productivity;
- effects on health and well-being.

2.2.1 Stress impact

The stresses caused by lateness and travel-time variability are generally characterised as being 'persistent, low-intensity stressors' from everyday life (Schaeffer et al., 1988, p. 944.) One impact is to increase stress levels above those normally observed when travelling, which will directly reduce travellers' utility. Evidence from studies on car drivers in congested and uncongested driving conditions suggests that lateness and variable journey times do have a significant effect on measurable stress parameters. Hennessy and Wiesenthal (1997) studied 40 commuters driving to work in the Toronto area in Ontario, Canada. They report stress levels to be almost double under high levels of congestion, when compared with low congestion levels for people with both a high and low susceptibility to stress.

Hennessy, Wiesenthal and Kohn (2000) extend the work of Hennessy and Wiesenthal (1997) and find that higher levels of time urgency reported by the respondents are positively correlated with higher levels of stress under both high and low congestion conditions. Interestingly, the results suggest that time urgency has less impact on observed stress levels under high levels of congestion than under low levels. This result may be because the stress caused by the higher level of congestion may swamp the additional stress caused by the time urgency. The results also indicate that congestion was the most important determinant of driver stress, accounting for 64% of the observed variability. Koslowsky (1997) also reports a similar result.

Results from car driving, while interesting and informative, need to be treated with caution when attempting to transfer them into the rail context. One factor suggested by several authors to explain higher levels of driver stress in congestion is that drivers experience a lack of control of the situation. It is arguable that passengers cede a certain level of control when they choose to travel by train; therefore, there is less control to lose when the journey is delayed, and consequently less stress may be generated. However, having little or no information when trains are not running as timetabled may generate significant amounts of disutility owing to the combination of lack of control over the journey and uncertainty regarding journey and arrival times. Rail companies may be able to reduce this feeling by providing real-time information on delays and cancellations, aiding travellers to make decisions about waiting or changing route.

2.2.2 Effect on productivity

Schaeffer et al. (1988) examined the performance level of 46 car commuters (an admittedly small sample) who were asked to undertake two tasks after their journey to work under high and low congestion levels (see Table 2.4). In the first task, subjects had five minutes to proofread a short passage of text and identify the spelling, grammatical, and punctuation errors that were deliberately inserted by the researchers. In the second, subjects had to write the first letter of the colour in which a word was printed, however the words were themselves the names of colours, making the task non-trivial.

Table 2.4: Task performance after commute to work

	Proofreading scores (% of errors found)[1]	Colour-discrimination scores (no. of items completed)[1]
Low congestion[1]	72.3	202.9
High congestion[1]	59.5	177.0
Proportionate reduction in performance due to high congestion[2] (% of low congestion)	17.6	12.8

Note: The higher the percentage of errors found and number of items completed, the better the performance of the traveller in the tests.
Sources: [1] Schaeffer et al. (1988), table 1, and [2] OXERA calculations.

These results suggest that commuting during times of high congestion reduces performance by around 12–18%. However, as there does not appear to be robust evidence on the persistence of these productivity effects, the overall impact cannot easily be calculated.

2.2.3 Effect on health and well-being

There is evidence that travellers who experience a high level of impedance on their journey to work (ie, their journey is on a congested route with a variable journey length) exhibit greater levels of sickness and have a lower level of overall job satisfaction. A selection of relevant significant (at the 10% level) correlations from work by Novaco, Stokols and Milanesi (1990) is shown in Table 2.5. The study examined 82 individuals' journeys to work in southern California, and considered age, smoking, weight and alcohol consumption in an attempt to isolate the impact of the impedance to travel. The strength of the correlation varied according to the measure used to describe the impedance to travel. When a subjective measure was used, impedance to travel was strongly related to job satisfaction. Indeed, the researchers concluded that 'job change in this sample was primarily related to commuting satisfaction' (p. 254).

Table 2.5: Correlation of reported impedance to travel with health and well-being variables

Measure	Reported impedance to travel
Job satisfaction	Negative
Illness-related work absences	Positive
Sick day	Positive
Occasions cold/flu	Positive

Note: All reported correlations were significant.
Source: Novaco, Stokols and Milanesi (1990).

2.2.4 General impact of stress

More general work examining the impact of all causes of stress (not just poor transport performance) suggests that high stress levels are positively correlated with a range of variables (see Tangri, 2003, for a detailed discussion), including:

- reduced productivity;
- morale problems;
- absenteeism;
- alcohol and substance abuse;
- poor quality of work;
- illness;
- high staff turnover;
- accident rates.

These results are not specifically related to stress caused by poor transport performance; rather, they arose from situations in the workplace, and may therefore be of a substantially different nature to that caused by transport sources. Due to the general nature of this strand of research, it is not possible to draw any substantive conclusions.

2.3 Survey evidence

This part of the report reviews evidence from two recent publications, one by Oxford Economic Forecasting (OEF, 2003) for the Corporation of London, and one by the University of Westminster (2003) for the British Council of Offices. Each report used survey methods to analyse the impact of transport unreliability on businesses and their employees. The details and results of the consultation exercise undertaken by OXERA and Mott MacDonald, to support the analysis of the third-party effects of rail delays, are also presented below.

2.3.1 Corporation of London study

This report provides a 'conservative' estimate of the cost of transport delays to the City of London of £230m per annum. This figure was arrived at by multiplying (for each transport mode) the number of journeys made by the average delay per journey and an appropriate cost for the time lost. For average delay on rail, a figure of 26.4% of peak services in 2001/02 in London and the South East arriving late was used (based on the Passenger Performance Measure, or PPM, definitions). It was then assumed that these late services were each overdue by 15 minutes, providing an overall figure of 4 average delay minutes. This 'unweighted' figure was adjusted to account for the additional perceived costs of waiting at a station. A weighted average delay figure of 5.9 minutes was therefore calculated by assuming that half of any delay was spent waiting for an overdue train and half in extra travelling time, with station waiting valued at twice the same amount of time spent travelling.

Using leisure values of time from the DfT for commuting, and excluding the estimated 44% of inbound delays that affect work time (which are valued at average hourly wages in the City), the authors arrived at a cost for rail-only delays of £33m. Adding in combined rail/Underground trips brings this figure up to £90m. While these figures do not include time allowed in case of delays (12% on top of average journey times, according to the survey), or impacts on health and family life, business operations, or pay and productivity, they do assume that no work is carried out on business trips. That said, most meetings are elsewhere in London, and working on taxis or on the London Underground is not really practical.

The main benefit of this study is the extensive survey used to back up this costing. 15 companies agreed to participate and circulated the survey to their employees, and 273 responses were received. In addition, a further survey was sent to around 800 Directors of Human Resources or CEOs of companies in the City and the Central London Business District, to which 139 responses were received. The findings of these surveys were as follows.

- *Perceptions of the extent of transport problems in London*—90% of employees in the survey thought that the problem was at least quite serious, and 62% considered it very serious or critical. 99% of companies reported that they were affected by problems experienced by their staff in commuting. Around half of employers thought that journey times had become both longer *and* more uncertain in journey time in the previous five years, with the remainder asserting that either journeys took more time or had become more unpredictable. This covered all journeys, to meetings in London or elsewhere in the UK, or travel to London airports.

- *Frequency of delays*—29% of employees suffered a significant delay on their journey to work on the survey day. Given the high market share of heavy rail, the majority of delays occurred on this mode. 23% of employees were delayed on their outbound journeys. Employees were delayed six days per month, on average, with no apparent difference between in- and outbound journeys. Despite being able to adapt their schedules to delays, employees were still, on average, late for work four times per month. Further evidence from the survey suggests that 37% of employees reported allowing 22 minutes extra time for travelling to work in case of delays. Across all commuters, this equates to an extra 7.3 minutes on all commuter journeys, which average around one hour in length.

- *Business travel*—given the location of the survey, there is not a large sample (9%) of respondents who travelled on business on the survey day. However, 18% of respondents suffered delays on the journeys they made, with 12% arriving late. 28% of incoming visitors were late as a result of transport delays. In addition, 100% of those who were late for an appointment thought that it mattered, while only 64% of those whose visitors were late reported that this mattered. The survey of companies provided similar results. When asked how serious a list of problems was for their organisation, 36% (22%) of respondents believed transport delays causing staff to be late for/miss meetings with clients (their organisation) to be a critical or serious problem. 48% of companies considered it a critical or serious problem that longer journey times mean staff waste time travelling, while 31% stated that it is a critical or serious problem that transport delays cause clients to be late when visiting their organisation. More than 90% of respondents found each of these issues to be somewhat of a problem or worse for their organisation.[6]

- *Impacts on health and family life*—74% of employees believe that transport delays lead them to arrive at work stressed or tired. Nearly all companies, in contrast, believe that stress/tiredness caused by commuting is a serious problem (28%) or somewhat of a problem (70%). Interestingly, 'a number' of individual respondents argue that the uncertainty associated with commuting causes the stress and worry. 40% of employees believe there is an impact on their health from their commuting, while nearly half of employers believe there is an impact on staff sickness as a result of commuting difficulties. 62% of employees consider there to be an effect on family life as a result of problems with London's transport system.

- *Impact on productivity*: 97% of employers believe that staff productivity is affected by commuting problems. However, many workers believe they can compensate for the impact of poor commutes, although nearly half of employees still believe there is a problem.

- *Changes to working practices and other responses*—when asked what their response would be to transport delays becoming worse over the next few years, 58% stated they would consider looking for a job closer to where they lived, and 63% that they would consider looking for a job outside London. 51% would consider asking for a pay rise to compensate for additional commuting time, and 43% would consider moving closer to where they worked. However, 52% would consider 'grinning and bearing it'. 69% of employers operate flexi-time working for some or all staff (of which 39% claimed this was in response to transport delays), while 90% allow working from home (of which 30% claimed this was in response to transport delays). 80% of employers offer season-ticket loans (32% stated this measure was introduced in response to transport delays, although the paper does not examine why firms responded in this way), but virtually no employers subsidise staff commuting costs.

2.3.2 British Council of Offices study

This research, undertaken by the University of Westminster in conjunction with the British Council of Offices, examined how the performance of the national rail system serving London affects the travel behaviour of office employees in central London.

In July 2002 seven companies in central London took part in a survey. Responses were received from 190 individual employees (who answered 'Questionnaire A') and 19 senior managers (who answered 'Questionnaire B'). The findings of this research were as follows.

[6] Company responses are 'employment-weighted'.

- *Employee responses*—two-thirds of respondents used rail for their commute. 47% had either moved house, changed their means of transport to work, or changed their place of work before October 2000 (ie, since before Hatfield). However, less than 3% indicated that they had done so for reasons relating to the transport system they used. This should be compared with research published by Reed in May 2002, which found that 16% of workers in London had *considered* changing their workplace due to travel conditions—the authors of the University of Westminster report note that Reed did not identify a proportion known to have actually carried this out.

- The typical *total one-way journey time* for those with a rail element to their commute was 1–1.5 hours, although the rail stage lasted only up to an hour for the vast majority of respondents. Some evidence was found of a slightly longer commuting journey time since Hatfield for rail users versus non-rail users, but this was not particularly conclusive, especially given the magnitude of the fall in PPM over the period. Turning to variability in journey times, 36% of rail users who used the same rail journey for their daily commute both at the time the survey was undertaken and before Hatfield indicated that there had been an increase in variability. This compares with 15% of non-rail users who indicated an increase in journey time variability.

- 41% of respondents had *changed the time they aimed to arrive at work* since October 2000, with 60% of these respondents indicating that this was for reasons relating to the transport system. The sample was broadly split 50/50 between those arriving later and those arriving earlier. 33% had changed the time they aimed to leave the office, but the majority said this was not due to the transport system. Considering just rail users, an average increase in the length of time spent at the office (for those who had not moved job, home or means of transport) since Hatfield was calculated at just over five minutes, although 59% of these respondents had not changed the amount of time planned to be spent in the office.

- *Senior managers* were asked to provide views on the *impact of rail performance on their businesses*. 85% thought that the impact of the punctuality and reliability of trains on their business was either moderate or severe. These results compare with a survey carried out by the London Chamber of Commerce and Industry in January 2001, which suggested that the 'rail crisis' (Hatfield) was having a severe or moderate impact on 64% of businesses. The discrepancy in the results is most likely due to the location of the companies surveyed for the University of Westminster study, which were situated in Travelcard Zone 1, and typically estimated that at least 50% of their employees travelled to work by rail. In contrast, the Chamber's survey included responses from a wide range of businesses, not necessarily situated in central London.

- Senior managers were also asked to rate *the impact of rail delays on business meetings*. 74% described the impact as moderate, while 21% considered it to be slight. There was no clear correlation between the type or location of the firm and the impact on meetings. A similar question asked managers to rate the potential for national rail performance to enhance staff productivity. All except one respondent indicated that an increase in punctuality and reliability would improve productivity, with 12 of the 19 believing there would be a little improvement, and six suggesting there would be a great improvement. The report makes the interesting point that the extent of positive responses to this question is at odds with the previous responses to the impact on meetings. It suggests that it may be inferred that other factors, such as stress or tiredness, relating to punctuality and reliability, have an effect on staff productivity. To back this up, the finding by Reed's 2002 survey that 49% of London workers felt their journey to work had become more stressful in the past four years was considered relevant.

- *The response to travel delays by employees* was considered in both questionnaires. Both managers and employees shared the view that it did not matter how delays were responded to as long as the work got done. However, it appeared that employees were more likely to leave work later or make up time by reducing break length than managers would prefer. Making up time by adjusting hours over a period of days and taking work home were ranked the lowest in terms of preferred options.

2.3.3 Consultation exercise

Part of the brief for the current study required consultation with government, employer and employee organisations in order to elicit their views on perceptions surrounding the link between rail performance and economic performance. Three strands of consultation were undertaken.

- The first, a survey of human resources departments of FTSE 100 companies, was intended to provide data that could be analysed to determine whether there was a correlation between staff absenteeism and deteriorating rail performance. It also attempted to elicit information on whether there are explicit company policies on meeting times; how much margin to allow in case of delays on the way to meetings; home and flexible working; and attitudes towards lateness caused by travel delays. Finally, the survey asked whether meeting times are dependent on the train timetable—this was designed to test the validity of the independence assumption in the Bates et al. framework. The response rate to this survey was, however, very low, making the results received unusable.

- The second exercise was a more targeted set of questions to individuals at government departments, the Trades Union Congress (TUC), the Confederation of British Industry (CBI) and the British Chambers of Commerce (BCC). Transport organisations, such as Rail Passengers Councils (RPCs) and Passenger Transport Executives (PTEs), were also contacted. Responses were received from the TUC; the Departments for Work and Pensions, Health, Trade and Industry and Transport; seven representatives from Chambers of Commerce across the country; two RPCs; and one PTE. Questions were designed to ensure that the literature review reflected current thinking, and to provide information on issues where the Bates et al. framework cannot quantify third-party impacts of poor rail performance.

- The final part of the consultation exercise involved following up the respondents from the Chambers of Commerce in an attempt to elicit further information to assist with the Bates et al. modelling in the desktop study.

Copies of all the questionnaires are reproduced in the Appendix to this paper, as is a summary of responses to parts two and three of the consultation exercise. However, the main points are outlined here.

- The TUC respondent stated that there is some evidence that people base their decision to take a job on actual travel to work times, so delays inhibit the labour market. In addition, although most employers are sympathetic to one-off delays, there are literally thousands of cases where employees have been disciplined as a result of persistent delays.

- Respondents from the RPC network mentioned crowding as a dimension of performance with health effects. They noted that there is some spreading of the peak in response to peak commuting conditions, but potential mitigants of performance impacts, such as flexi-time, lead to 'churning' within the peak, as this affects the marginal passenger, not the average. One response noted that information had been received from a Regional Tourist Board on the deleterious effects of the rail network on overseas visitors in particular.

- The respondent from a PTE noted the importance of reliability in attracting new business to development areas. He also observed that tourism is more directly affected by the quality of long-distance services, but the quality of local transport is an important factor in any decision to return to that tourist destination.

- Respondents to the initial questionnaire to Chambers of Commerce suggested that meetings have migrated towards the middle of the day, with meetings either finishing without business being transacted fully or individuals having to leave early to avoid expensive unscheduled overnight stops. The responses also indicated that home and/or flexible working is only possible in a minority of cases, such as sales. It is not relevant for business travellers. Laptops are only suitable for 'second-order' tasks, while mobile phones are only of use for informing people about delays. One respondent called for two pairs of tracks between all Principal Urban Areas (which may include diversionary routes) as a solution to performance-related problems.

Government department responses were generally in accordance with the findings of the literature review. One respondent noted that, at present, the appraisal of road schemes includes a *qualitative* assessment of improvements in reliability, and suggested that a *quantitative* value on reliability be added to cost–benefit analyses of transport projects.

2.5 Summary

This section summarises the literature review and survey information on four areas of harm, as described in the SRA's Invitation to Tender and the consortium's proposal:

- the direct impact on business;
- the indirect impact on business, primarily via reductions in employee productivity;
- the impact on individuals, mainly commuters; and
- the impact on leisure and tourism activities.

In each section there is an examination of what the impacts are likely to be.

2.5.1 Direct impact on business

Businesses are likely to suffer from poor rail performance in several ways. Extended journey times due to lateness will reduce the working time available to employees, since they will spend more time travelling. The scale of this impact will partly depend on how productive an employee is while travelling, compared with when they are not. Also, an employee's productivity while travelling may fall if the journey is longer than expected, since the employee may only have access to enough resources to perform a limited range of tasks. On the other hand, the DfT's VTTS figures assume that workers produce no useful output while travelling (see section 2.1.1). This is likely to be an overestimate of the effect, but may be useful as an upper bound. Also, travellers may make up lost hours at another point during the day, perhaps by extending their working hours.

Extended and unreliable journey times may also mean that fewer meetings can be scheduled per day than would otherwise be the case. This would again reduce an employee's productivity. However, the impact may not be proportional to the number of meetings that do not take place, since it is likely that the least valuable meetings would be dropped, in favour of the most valuable ones.

Unreliable journey times will create problems in addition to spending a greater amount of time on trains. Many business train journeys involve attending meetings with others; arriving late for these meetings could affect all the attendees of the meeting. These effects may be mitigated if the meeting time can be easily rearranged, and those disrupted can continue to make productive use of their time. It is not clear whether the rates of schedule disutility outlined in the literature review are applicable here.

The PAT for business passengers may be random, or it may take the published timetable into account. Intuitively, it seems likely that, for meetings with more attendants, the PAT will be exogenous for the individual traveller, but will be endogenous for smaller meetings. Results from the consultation exercise suggest that meeting times may migrate to the centre of the working day as rail performance worsens, to allow all participants extra time for travel to and from the venue.

2.5.2 Impact on business via effects on employees

As well as the direct impact on businesses, poor rail performance has an effect on employees' productivity in the workplace.

The literature review emphasised that variations in commuting journey times increase stress levels. It also suggested that this might have a noticeable impact on employee productivity, reducing the efficiency of businesses. The literature does not, however, provide an estimate of how long the effect on productivity lasts. The literature review also suggested that commuting stress has a cumulative effect, making people more stressed in all situations and reducing productivity over the longer term.

Additionally, the literature review suggested that commuting stress tends to reduce job satisfaction, which is likely to reduce motivation, consequently lowering productivity and increasing staff turnover. Tangri (2003) suggests that turnover costs average around 1.5 times the annual salary of the individual affected. This ratio rises to around 2.5 for more senior staff members. Consequently, even a small increase in staff turnover due to commuting stress may have a significant monetary impact.

It is unlikely that the valuations of lateness and earliness given in section 2.1.2 take these factors into account since the interviews were with employees (commuters), who do not bear the costs directly. On the other hand, employers may be able to incentivise their employees to take these factors into account through disciplinary measures. If this is the case, employees may be considering these factors when estimating their valuations of lateness and earliness.

2.5.3 Direct impacts on individuals

Late and unreliable trains result in a loss of utility, since individuals are unable to engage in other activities with a higher utility attached to them. In addition, unreliable trains may mean that passengers cannot allocate their time optimally, as they may miss activities that have predefined start times.

The stated-preference results reported in section 2.1.2 are taken from commuters, thus the relative importance of late and early schedule delays is likely to be reported fairly accurately by these studies, albeit imperfectly. These studies focus primarily on the consequences of late and unreliable travel.

Travellers may, however, place a value (disutility) on variability per se, independent of its consequences. This may be caused by anxiety, stress and the additional planning burden of dealing with variable travel time, all of which tend to reduce utility. For example, a slower travel pace can induce stress (see Hennessy and Wiesenthal, 1997). The literature review also suggests that these factors may have a cumulative effect, making people more stressed generally, and thus further reducing utility.

2.5.4 Impact on leisure and tourism trips

Poor rail performance may have an impact on the decision to consume other services, as travel is generally an intermediate good. A significant proportion of this intermediate consumption will be in the form of leisure travel, with the ultimate good being leisure trips. Poor rail performance increases the generalised cost of a particular journey. Individuals can react to this in several different ways, by:

- deciding that other leisure trips by rail are more attractive, switching their destination, but continuing to travel by rail;
- switching away from rail travel to another mode of travel, perhaps car, plane, or coach, but still travelling to the original destination;
- choosing not to consume leisure goods at all, reducing trips to leisure destinations, and consuming other goods in the UK;
- choosing to consume leisure goods overseas.

The key issue here is how large the increase in generalised cost (disutility) imposed by poor rail performance is compared with the total utility derived from leisure trips. It is impossible to measure directly the utility from a leisure trip; however, for certain leisure trips, such as holidays, the total cost can serve as a proxy—a proportionately more expensive holiday, relative to the individual’s income, can be expected to derive more utility to the individual than a proportionately less expensive one.

If the disutility incurred due to poor rail performance is small as a percentage of total trip costs, it can be assumed that the impact in terms of the substitutions described above will also be small, since the overall change in utility associated with the leisure trip will not have changed by a large proportion.

There are two other issues of interest when examining leisure trips. First is the rate at which leisure travellers incur schedule disutility. The issue is whether leisure travellers have a PAT. If they do not, they will only incur disutility from an extended journey time. If they do have a PAT, for most journeys it is reasonable to assume that leisure travellers incur disutility at a rate no higher than commuters because they display a lower willingness to pay for reductions in journey time. For journeys to airports, a different assumption may be required, since failure to make a flight may ruin a leisure trip if the traveller cannot easily change flights.

Second, leisure travellers tend to make journeys relatively infrequently, therefore it is plausible that they are more likely to misperceive the distribution of train arrivals, and thus mis-specify the optimum safety margin. If the safety margin is too large then, on average, they will tend to arrive more often before their PAT than if they correctly perceive the safety margin, implying additional disutility; if it is too small, they will arrive more often after their PAT, also implying additional disutility.

This second point highlights the importance of accurate information being provided to rail travellers. If people have an incorrect perception of the variance and expected journey time, they will make suboptimal decisions. Accurate information about engineering works may assist in this process.

3. Desktop Study

The aim of the desktop study is to quantify the losses that poor levels of punctuality and reliability impose on passengers. It has been demonstrated in the previous section that the Bates et al. method can provide insight into the four areas of harm under consideration: the direct impact on business; the indirect impact on business; the impact on individuals; and the impact on consumption activities. Accordingly, this section sets out how the model is operationalised and provides details of its outputs: section 3.1 presents an outline of the model and its various segments; section 3.2 describes and analyses the results; and section 3.3 applies these results to the tourism industry.

3.1 Model outline

As noted, the purpose of the modelling exercise is to quantify the losses that poor levels of punctuality and reliability impose on passengers. The model described in Bates et al. (2001) provides a useful starting point for this work.

Table 3.1 outlines the six key stages in the modelling.

Table 3.1: Description of modelling stages

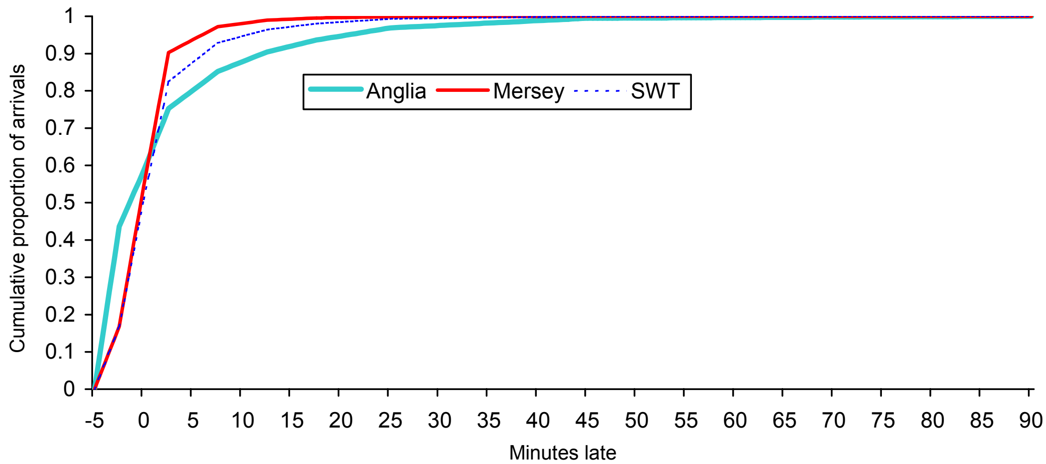
Stage	Description	Outputs
1	Analysis of SRA punctuality and reliability data	Proportion of trains late, early, on time, and cancelled
		Penalty (in minutes) for late, early, and cancelled trains
2	Utility model determines optimum safety margin	Optimum safety margin
3	Determine optimum departure time in continuous time	Optimum departure time with continuous departure time choice
4	Use utility model to determine train choice	Optimum departure time with discrete departure time choice
5	Calculate costs under the actual scenario with the counterfactual	Monetary penalty (per passenger) of early arrival, delays and cancellations
6	Aggregation	Aggregate the per-passenger penalties to provide total disutility for the railway

Source: OXERA analysis.

Stage 1: Analysis of SRA punctuality and reliability data

The SRA punctuality and reliability data can be used to form a cumulative distribution of lateness (see example in Figure 3.1). This can be used to find the appropriate safety margin that travellers will add to their journey time if faced with *continuous* departure time choice, by moving along the cumulative distribution until the cumulative proportion of arrivals is equal to 1 minus the optimal probability of arriving later than the PAT. From this, the optimum safety margin can be read off.

Figure 3.1: Cumulative proportion of trains arriving at their destinations within the specified numbers of minutes of advertised time



Sources: SRA punctuality and reliability data, and OXERA calculations.

Stage 2: Utility model determines optimum safety margin

As noted in the literature review, when $\theta = 0$, the optimum probability of late arrival relative to the PAT is given by:

$$\frac{\beta}{(\beta + \gamma)}$$

Typical values for the parameters in the utility function were shown in Table 2.3. Both sets of values suggest an optimal late arrival proportion of approximately 20%. In the modelling, the 'commonly assumed values' form the base-case scenario.

The optimal probability of lateness relative to the PAT is combined with the cumulative distribution of actual lateness derived in stage 1 by reading off the point at which 80% (100% – the optimal probability of lateness) arrive earlier than the number of minutes behind schedule shown in the cumulative arrival chart. This number of minutes is the optimal safety margin for departure in continuous time. Some examples are shown in Table 3.2.

Table 3.2: Optimum safety margins for selected TOCs (minutes)

TOC	Optimal safety margin
Anglia Railways (intercity services)	7.1
Anglia Railways (local services)	1.4
Arriva Trains Merseyside	2.1
South West Trains	3.1

Note: Safety margin calculated using all data available.
Sources: SRA punctuality and reliability data, and OXERA calculations.

The optimum safety margin changes with the data used to create the cumulative arrival chart. The figures in Table 3.2 use all the data available from period 1 in 1998 to period

13 in 2002. If subsets of the data are used, the optimal safety margin changes significantly; for example, Anglia Railways' (intercity) lowest safety margin of 2.4 minutes was achieved in 1999, while its highest of 16.7 minutes was in 2001.

Stage 3: Determine optimum departure time in continuous time

The optimum safety margin is combined with the choice about PAT and expected journey length to provide an optimum departure time in continuous time. The following equation is used:

Optimum departure time = PAT – expected journey length – safety margin

The safety margin is calculated in stage 2, the expected journey length is calculated in stage 1 using the SRA data, and the PAT is assumed to follow some probability distribution. A Monte Carlo simulation procedure is used to simulate the PATs once the appropriate distribution is chosen.[7]

An assumption needs to be made about the travellers' expectations when calculating their optimum departure time, and hence their train choice. Four sets of delay expectations are discussed in section 3.2.

Stage 4: Use utility model to determine train choice

Determining the optimal departure time in continuous time is useful for certain transport modes, such as car, where the traveller can leave at any point. With trains, there are only a limited number of discrete departure time choices. To deal with this, the model converts the continuous departure time choice produced in stage 3 into a choice about which train to catch, by comparing the utility associated with:

- the last train scheduled to leave before the optimum departure time; and
- the first train scheduled to leave after the optimum departure time.

It is not necessary to compare any other trains since, assuming that trains are not scheduled to overtake one another, they will arrive either earlier or later than the two trains described, and will therefore be associated with a lower expected level of utility. When calculating the optimum train choice, an assumption needs to be made about the representative frequency of train service for each TOC. The base-case scenario assumes a 30-minute service interval for all TOCs. This assumption is also tested for sensitivity by using 15- and 60-minute service intervals.

Stage 5: Calculate costs under the actual scenario with the counterfactual

Once the choice of trains is determined, the monetary penalty associated with lateness and unreliability can be calculated. Two forms of monetary penalty are incurred within the model:

[7] Monte Carlo simulation makes hundreds of random draws from a specified probability distribution, providing in this case a range of PATs.

- *additional journey time*—the average increase in journey times caused by late running increases the disutility incurred by travellers. The monetary value of this is represented by the VTTS. Two alternative VTTSs are available and in general use in the British rail industry (described in section 2.1.1 of the literature review);

- *arriving before or after the PAT*—passengers incur disutility when they arrive earlier or later than their PAT. Ove Arup & Partners (2002) suggests that passengers' disutility per minute of arriving earlier than the PAT is equal to 0.5 times the VTTS, and that the disutility per minute of arriving after the PAT is equal to 2 times the VTTS.

The PDFH provides value-of-time data for leisure, commuter and business traveller types, differentiating between London and the South East, and other areas. This data is used to monetise the disutility incurred by an individual traveller. The output from this stage is a per-passenger journey level of disutility for a particular traveller type on a particular TOC.

Stage 6: Aggregation

To calculate the total disutility for the railway of poor rail performance, it is necessary to aggregate across the per-passenger journey disutilities for each traveller type and each TOC. This is done by running through steps one to five for each of the three traveller types for each of the 25 TOCs' profiles of reliability. The resulting disutilities are then multiplied by the number of passenger journeys of that traveller type on that TOC to provide a total level of disutility per TOC. Finally, the disutilities from each TOC are aggregated to provide a final estimate for the total level of disutility generated by the railway per annum. Detailed data used in these aggregation calculations can be found in Appendix 2, which describes the number of passenger journeys, the proportions of each traveller type, and whether the London and South East value of time was used.

3.2 Model output

As the descriptions of stage 5 and 6 of the model indicate, the primary outputs of the model are values for the monetised disutility per passenger journey and for the whole railway per annum.

Because trains do not offer a continuous choice of departure times, most services will incur some level of schedule disutility, even with 100% reliability and no lateness. This is because the frequency of service means that most travellers will not be able to arrive at their PAT. Thus, to make the model outputs meaningful, it is necessary to compare them with a counterfactual level of disutility. The figures and tables presented below in this section therefore show the *difference* between the counterfactual level of disutility and the base-case scenario—this is referred to as the disutility due to poor rail performance. The data is shown in this manner to extract disutility incurred purely as a result of the discrete nature of departure time choice on the railway.

Changing the counterfactual allows various comparisons to be made. The OXERA model calculates the disutility incurred due to lateness and schedule disutility (arrival at times other than the PAT) for two counterfactual scenarios, defined as follows:

- *perfect running*—this counterfactual assumes that trains run exactly as scheduled, with no lateness or earliness. Subtracting this counterfactual from the test scenario provides the absolute level of disutility due to lateness and unreliability, as it removes schedule disutility that is purely associated with discrete departure time. However, while this counterfactual shows the absolute level of disutility incurred due to lateness and unreliability, it is impossible to remove all lateness on the railway. As such, this counterfactual may be too demanding when examining policy options for reducing lateness;

- *best year*—this counterfactual assumes that trains run with the lateness and unreliability characteristics that they exhibited during the best year within the available data. The best year is defined as the year with the fewest weighted average late minutes per train. This comparison shows the increase in disutility caused by a TOC's failure to repeat its best year of performance. It has the advantage that the rail industry has been able to achieve this level of reliability in the past, and therefore could arguably repeat this achievement.

Within these two *counterfactuals*, travellers are assumed to act rationally (see first bullet point below) using all available data to calculate the optimum departure time.

The *base-case scenario* uses the full dataset of reliability data to model the performance of the railway. Within this, four 'sets of delay expectations' that travellers may adopt in attempting to minimise the impact of poor rail performance are modelled.

- *Rational*—travellers are aware of all past train punctuality and reliability information and fully use this to determine the optimum safety margin, and consequently the train they choose. This results in estimates of the safety margin that are exactly optimal, minimising disutility; therefore, the traveller incurs the minimum disutility possible, given the data and choices available.

- *Worst*—travellers think that the railways are worse than they actually are. They assume that the railway will operate in a manner similar to the worst year of operation for each TOC, choosing their safety margin and train appropriately. This results in estimates of the safety margin that are too large; therefore, the traveller departs too early in some instances and incurs disutility that could have been avoided.

- *Best*—travellers think the railways are better than they actually are. They assume that the railway will operate in a manner similar to the best year of operation for each TOC, choosing their safety margin and train appropriately. This results in estimates of the safety margin that are too low, and therefore the traveller departs too late in some instances and incurs excess disutility that could be avoided.

- *No delays*—travellers believe that the railway operates in a manner similar to the perfect-running counterfactual (ie, there are no delays and trains always run on time). They choose their safety margin and trains appropriately. The traveller estimates a zero safety margin, and therefore departs too early in some instances and incurs excess disutility that could be avoided.

The results of the base-case test scenario of the modelling are presented below. The following sections examine some of the modelling assumptions, and some of the external effects that may not be captured within the results.

3.2.1 Base-case scenario

This section outlines the main results of the modelling for the base-case test scenario. It assumes that all travellers have a PAT on all journeys, and therefore incur schedule disutility on homebound as well as outbound journeys. It also assumes TOC-specific service intervals and VTTSs (summarised in Appendix 1). The VTTSs are based on those from the PDFC (2002) and are a function of whether the TOC is considered to operate within the London and South East region, and the average passenger journey length.[8]

The disutility due to poor rail performance calculated under the perfect-running counterfactual shows the total level of disutility incurred due to lateness and unreliability on the UK rail network. Under all four sets of delay expectations, the disutility is greater than £2 billion (see Table 3.3). To put this figure into context, the total farebox revenue in 2002 was approximately £3.7 billion.[9]

The four sets of delay expectations, which attempt to show the impact on disutility imposed by different passenger perceptions of the railway, result in varying levels of disutility. The rational choice rule minimises disutility, but requires a high level of knowledge on the part of travellers. If the other, less optimal, delay expectations are actually used by individuals, then disutility could be significantly higher than the rational delay expectation suggests.

If the 'worst' delay expectation is used then travellers will tend to depart earlier than is optimal, incurring more early schedule delay than is necessary given the choice of trains available. On the other hand, if the 'best' or 'no delays' delay expectations are used, travellers will tend to depart later than optimal, incurring more late schedule delay than is necessary given the train choice available. Disutility is minimised when the 'rational' delay expectation is used. Interestingly, the impact of the 'worst' and 'no delays' expectations is similar in size, despite incurring disutility in a different manner.

Table 3.3: Disutility due to poor rail performance per annum with various delay expectations—perfect-running counterfactual

Perfect-running counterfactual	Disutility incurred by passengers (£m per annum)	Absolute increase over rational choice rule (£m per annum)	% increase over rational choice rule
Rational	2,209	n/a	n/a
Worst	2,415	206	9.3
Best	2,304	95	4.3
No delays	2,531	322	14.6

Source: OXERA modelling.

[8] The distance part of the VTTS calculation linearly interpolates between the distance-based estimates of VTTS given in PDFC (2002).
[9] Data provided to OXERA by the SRA.

The disutility due to poor rail performance calculated under the best-year counterfactual shows the level of disutility incurred due to the failure of TOCs to repeat their best year of performance (see Table 3.4). This is significantly smaller—at around £0.9 to £1.2 billion per annum—than the disutility due to poor rail performance under the perfect-running counterfactual. However, it is still large, representing around one-quarter to one-third of the total cash receipts of the railway from ticket sales.

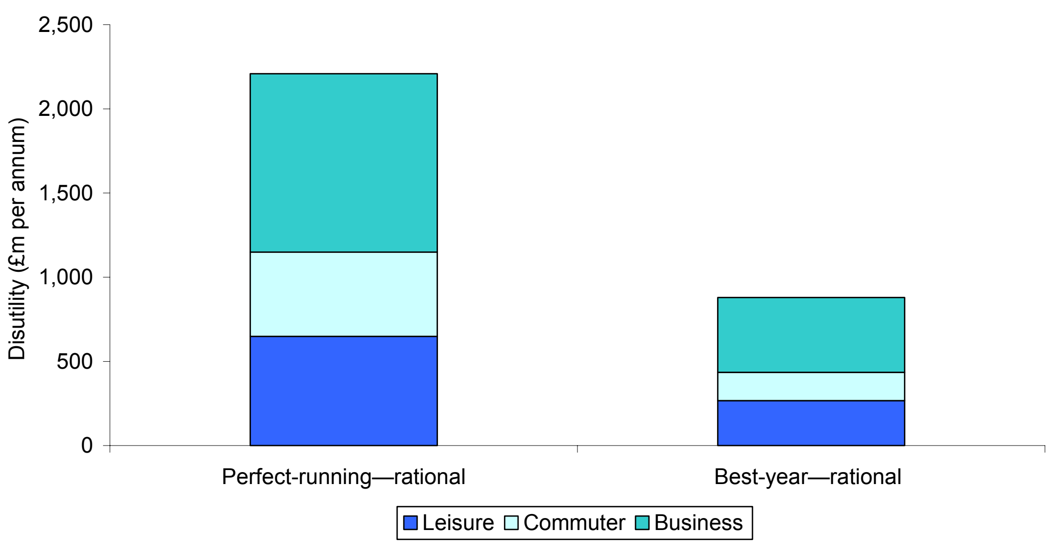
Table 3.4: Disutility due to poor rail performance per annum with various delay expectations—best-year counterfactual

Best-year counterfactual	Disutility incurred by passengers (£m per annum)	Absolute increase over rational choice rule (£m per annum)	% increase over rational choice rule
Rational	879	n/a	n/a
Worst	1,086	206	23.5
Best	975	95	10.8
No delays	1,202	322	36.7

Source: OXERA modelling.

Figure 3.2 compares the disutility due to poor rail performance incurred under the two counterfactuals when rational expectations are used. The figure illustrates that disutility under the best-year counterfactual is approximately a third as large as that incurred under the perfect-running counterfactual. It also illustrates that almost half of total disutility is being incurred by business travellers, although they make up only around one-sixth of all passenger journeys (see TAS, 2003 and Table 3.5).

Figure 3.2: Disutility due to poor rail performance under the two counterfactuals



Source: OXERA modelling.

The average disutility due to poor rail performance per passenger journey varies considerably by traveller type (see Table 3.5). The figures show that leisure and commuter travellers incur similar levels of disutility due to poor rail performance per journey, while business travellers incur almost four times as much. The differences are primarily due to the differing values placed on time by each of the three groups of traveller examined. They are also affected by the proportion of each traveller type on each TOC (eg, long-distance TOCs tend to have worse levels of performance and high proportions of business travellers), and whether it was assumed that the London and South East values of time should be used. Appendix 2 provides a detailed breakdown of the per-passenger journey disutility due to poor rail performance by TOC.

Table 3.5: Disutility due to poor rail performance per passenger journey—rational choice rule

	Total disutility (£m per annum)		Passenger journeys (m per annum)	Disutility per passenger journey (£ per journey)		Average fare per passenger journey (£ per journey)[1]	Disutility as a proportion of the average fare (%)	
	Perfect-running	Best-year		Perfect-running	Best year		Perfect-running	Best year
Leisure	649	267	386	1.68	0.69	3.65	46.0	18.9
Commuter	500	168	424	1.18	0.40	2.48	47.6	16.1
Business	1,060	444	156	6.79	2.84	8.03	84.6	35.4
Total	2,209	879	966	2.29	0.91	3.84	59.6	26.7

Note: [1] Data for the average fares paid by each individual type of rail traveller is not available. The estimates presented here assume that all reduced-fare tickets are bought by leisure travellers, all season tickets by commuters, and all full-fare and first-class tickets by business travellers. Consequently, the average fares are illustrative.
Source: OXERA modelling for disutility, TAS (2003) for passenger journeys, and SRA for fares data.

The large values of disutility attributable to poor rail performance calculated by the OXERA modelling might imply that large numbers of people would be willing to make significant changes to their work, commuting, and leisure plans due to poor rail performance. However, the disutility is likely to be spread very widely across rail users, which means that, while the total disutility is large, the disutility incurred by any one individual traveller is quite small.

Table 3.5 includes indicative values of the average fare paid by rail travellers in 2002. These suggest that the total disutility incurred by passengers, represented by the perfect-running counterfactual, is equal to around half of the fare paid for leisure and commuter travellers. However, it is equal to around seven-eighths of the fare paid by business travellers. Disutility under the best-year counterfactual is equal to around one-fifth of the average fare paid by leisure and commuter travellers, but around one-third for business travellers.

3.2.2 Preferred arrival time assumption

It is arguable that some travellers may only have a PAT on one leg of their journey. For example, commuters may have a PAT only for journeys *to* work, but not *from* work to home. If a traveller does not have a PAT on a journey leg, they do not incur schedule disutility, but still incur journey time disutility due to lateness.

Assuming a PAT on outbound trips only halves the *total* disutility incurred in the perfect-running counterfactual, since the lack of consistent train arrival times affects only the inbound journey. If travellers do not have a PAT on either leg of their journey, no disutility is incurred under the perfect-running counterfactual since train journey times are never extended due to lateness. However, this change does not necessarily halve the *difference* between the counterfactual and the test scenario, since both the counterfactual and the test scenario will display reduced levels of disutility.

Tables 3.6 and 3.7 show the impact that assuming a PAT on only one leg of the journey has on the total disutility, and compares this with the base-case scenario. It is important to reiterate that the figures in the table show the *difference* between the disutility incurred under the counterfactual, and the disutility incurred with delays and unreliability imposed. Under the base-case scenario and the counterfactual, the absolute level of disutility incurred falls, consequently the difference between the two scenarios does not change as much—it falls by between 5 and 18%.

Table 3.6: Impact of PAT assumption—perfect-running counterfactual (£m/annum)

Perfect-running counterfactual	PAT on one leg of journey only	PAT on both legs of journey (base-case scenario)	Difference (%)
Rational	2,024	2,209	–8
Worst	2,078	2,415	–14
Best	2,074	2,304	–10
No delays	2,179	2,531	–14

Source: OXERA modelling.

Table 3.7: Impact of PAT assumption—best-year counterfactual (£m/annum)

Perfect-running counterfactual	PAT on one leg of journey only	PAT on both legs of journey (base-case scenario)	Difference (%)
Rational	838	879	–5
Worst	889	1,086	–18
Best	885	975	–9
No delays	981	1,202	–18

Source: OXERA modelling.

3.2.3 Service-interval assumption

The base-case scenario assumed different service intervals for each TOC (summarised in Appendix 1). The data available on delays was only disaggregated to the TOC level, therefore the service interval chosen had to represent all the TOCs' services. Each TOC displays different service intervals on each of their service groups; ideally, therefore, the modelling would have taken place at this level of aggregation. Without this level of disaggregation, the results are sensitive to this assumption.

To test the sensitivity of the results to the service-interval assumption, three additional sets of scenarios have been run. One sets the service interval at 15 minutes for all TOCs, which possibly reflects more closer the high-frequency, metro-style services run by some commuter TOCs. The second sets the service interval at 30 minutes, while the third sets it at 60 minutes, perhaps providing a better representation of long-distance intercity TOC services. Tables 3.8 and 3.9 show the impact of changing the service-interval assumption on both counterfactuals, and compares it with the base case.

Table 3.8 shows that the service-interval assumption has a significant impact on the results when using the perfect-running counterfactual. Assuming a 15-minute service interval across the network results in approximately half the disutility incurred if a 60-minute service interval is used. The table also shows that adopting TOC-specific service-interval assumptions results in a level of aggregate disutility similar to that when a 30-minute service interval is assumed across the network. However, the difference between these two cases is that, under the base case, greater levels of disutility are being accrued on intercity services (assumed to have a 60-minute service interval), while lower levels are being incurred in commuter services (assumed to have 15-minute service intervals).

Table 3.8: Impact of assuming different service intervals—perfect-running counterfactual (£m/annum)

Perfect-running counterfactual	Shorter case: 15-min service interval	Middle case: 30-min service interval	Longer case: 60-min service interval	Base case: TOC-specific service intervals
Rational	1,719	2,342	3,613	2,209
Worst	2,054	2,657	3,966	2,415
Best	1,789	2,420	3,713	2,304
No delays	2,091	2,666	3,983	2,531

Source: OXERA modelling.

Table 3.9 shows that the impact of the service-interval assumption is slightly greater under the best-year counterfactual. For the rational delay expectation, the 15-minute service interval yields just over one-third of the disutility incurred when compared with the 60-minute service interval. Similar to the perfect-running counterfactual, assuming TOC-specific service intervals gives similar levels of disutility to assuming a uniform 30-minute service interval across the network under the best-year counterfactual.

Table 3.9: Impact of assuming different service intervals: best-year counterfactual (£m/annum)

Best-year counterfactual	Shorter case: 15-min service interval	Middle case: 30-min service interval	Longer case: 60-min service interval	Base case: TOC-specific service intervals
Rational	566	868	1,490	879
Worst	903	1,183	1,843	1,086
Best	637	946	1,589	975
No delays	937	1,192	1,860	1,202

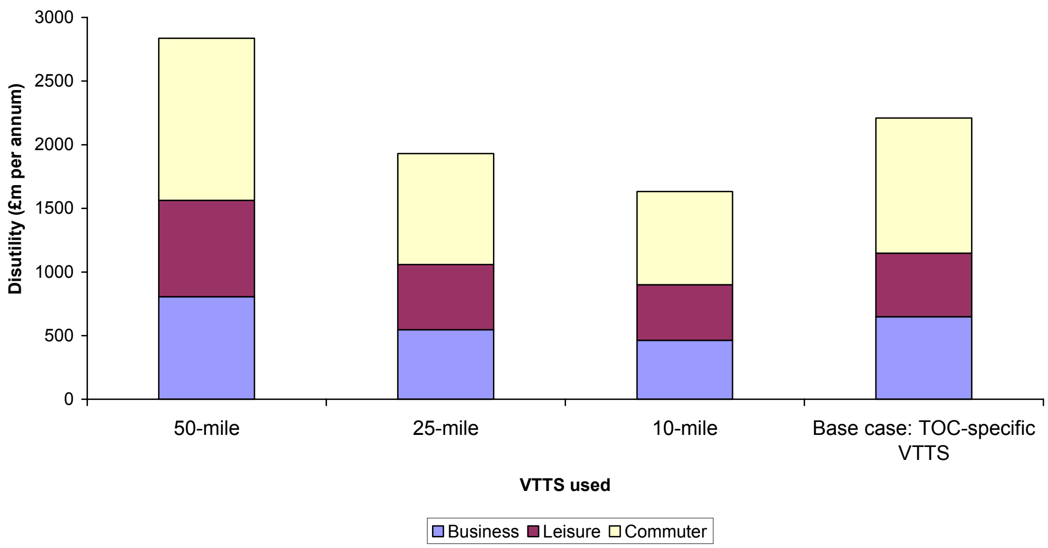
Source: OXERA modelling.

3.2.4 VTTS assumption

The base case assumes different VTTSs for each TOC, using the PDFH values. These are based on whether the TOC is considered to carry passengers in the London and South East region, and the average distance travelled on the TOC per passenger journey. Adopting different assumptions about the VTTS for passengers changes the results significantly.

Figure 3.3 assumes TOC-specific service intervals, and adopts three distance assumptions for the average journey length. The base-case scenario, which uses TOC-specific distance assumptions, is also shown. Figure 3.3 might suggest that the disutility function is non-linear. This is not the case: the disutility function is linear, but the VTTS rises non-linearly with distance (see Table 2.2).

Figure 3.3: Impact of assuming different VTTSs—perfect-running counterfactual



Source: OXERA modelling.

Tables 3.10 and 3.11 provide a breakdown of the aggregate disutility incurred under the two counterfactuals and the four delay expectations. Table 3.10 indicates that the VTTS assumption has a more significant impact on the aggregate disutility than the delay expectations used by rail travellers for the perfect-running counterfactual: the 10-mile VTTS results in around a 40% reduction in disutility from the 50-mile VTTS; while the rational delay expectation results in a reduction of around 15% in disutility from the no-delays expectation.

Table 3.10: Impact of assuming different service intervals—perfect-running counterfactual (£m/annum)

Perfect-running counterfactual	50-mile VTTS	25-mile VTTS	10-mile VTTS	Base case: TOC-specific VTTS
Rational	2,836	1,931	1,633	2,209
Worst	3,069	2,089	1,767	2,415
Best	2,944	2,004	1,695	2,304
No delays	3,240	2,206	1,866	2,531

Source: OXERA modelling.

In contrast, Table 3.11 shows that the VTTS assumption has a similarly sized impact on the aggregate disutility as the delay expectations used by rail travellers for the best-year counterfactual; switching from the 10- to the 50-mile VTTS results in a reduction in disutility of around 30%, as does switching from the no-delays expectation to the rational delay expectation.

Table 3.11: Impact of assuming different service intervals: best-year counterfactual (£m/annum)

Best-year counterfactual	50-mile VTTS	25-mile VTTS	10-mile VTTS	Base case: TOC-specific VTTSTOC-specific
Rational	1,067	727	615	879
Worst	1,300	885	749	1,086
Best	1,175	800	677	975
No delays	1,472	1,002	847	1,202

Source: OXERA modelling.

3.2.5 Train and passenger delays

Owing to data availability, a key assumption within the modelling is that train delays are an accurate proxy for passenger delays. There are potentially three issues raised by this assumption.

- *Train delay changing throughout a journey*—a train may suffer increasing amounts of delay as it progresses along its journey. For example, an initial cause of delay may result in a slot being missed later in the journey, resulting in further delay. This would tend to imply that passengers alighting from the train early in its journey suffer less delay than the final-destination delay data suggests they suffered, implying that the model estimate is too large. However, a train may be able to reduce the amount of delay during the journey due to slack being built into its running timetable. Consequently, passengers alighting at intermediate stations would suffer more delay than suggested by the final-destination delay data, implying that the model estimate is too small. Therefore, overall, it is arguable that final-destination data provides a reasonable proxy for delays as perceived at stations along the route.

- *Reduced reliability during peak hours*—data for the London and South East TOCs indicates that they exhibit lower levels of reliability during peak hours than at off-peak times. The model here uses aggregate figures for reliability. Since a greater than proportionate amount of people travel during peak hours than off-peak, this implies that the model may be underestimating the impact of poor performance on commuters in particular.

- *High-frequency service routes*—some routes on the rail network offer a metro-style level of service. There is a high frequency of trains (generally more than four per hour), most of which follow the same route and stop at the same stations. Consequently, passengers are less likely to target a specific train, and will adopt 'random arrival' characteristics, catching the first available train to their destination. In turn, this implies that delays to trains do not accurately proxy for delays to passengers, since passengers can board an alternative train if theirs is delayed.

  While this issue would tend to reduce the total disutility incurred, data on the extent of this effect is not available. An accurate estimate would require data on the proportion of travellers who use metro-style services, and on the form of the delays. This second piece of information will have a very significant impact on the level of disutility of metro-style services. On the one hand, if trains are all delayed by approximately the same amount (in effect making the 08:15 into the 08:30, the 08:30 into the 08:45, and so on), each train will report delays of 15 minutes, while passengers will only suffer ill effects if they intended to catch the first train that suffered delays. The other passengers will suffer no delays, and no resulting disutility. Therefore, at this extreme, the existence of the metro-style service means that the model significantly overestimates the disutility incurred by passengers.

On the other hand, the delay to the first train may result in services becoming bunched, so that there is a long delay to the first train arriving, but then several trains arrive within a short space of time thereafter. In this case, several trains' worth of passengers may attempt to board the first train, resulting in the disutility due to lateness being reduced below the level predicted by the model. However, in this case, greater levels of crowding are likely to be observed on the first train, potentially increasing total disutility.

3.2.6 Business travellers and meetings

The penalty applied to business travellers may be larger than the model predicts, since arriving late may affect more than the person travelling. If the traveller is going to a meeting then, depending on the status of the meeting, the traveller's importance, and the response of the other persons at the meeting, the effect of lateness could be considerable.

The telequestionnaire carried out by Mott MacDonald revealed three useful indicative statistics about business meetings:

- business meetings with external persons present are usually attended by between five and 20 people. This suggests that lateness caused by rail unreliability could affect a significant number of other people;
- there is a wide range of responses to lateness. The majority of respondents indicated that meetings would rarely (around 25% of occasions) be delayed. However, the remaining respondents suggested that meetings would often (on around 75% of occasions) or always be delayed;
- the decision about whether to delay the meeting was in almost all cases related to the importance of the person that had been delayed.

These responses suggest that, while a large number of people could be affected by the late arrival of a traveller, it seems that, on a significant proportion of occasions, meetings will not be delayed, particularly if the person delayed is not of a high level of importance.

These figures suggest that the number of additional people affected by the lateness of a business traveller for a meeting may range from around one (four people multiplied by 0.25) up to around 15 (20 people multiplied by 0.75). Due to the small sample size of the telequestionnaire, the results are only indicative, but they do suggest that the impact of rail delays on business travellers could be significantly larger than that calculated by the OXERA model alone.

A key factor here is the appropriate value of time for non-travellers affected by the travellers' lateness. It is arguable that the non-travellers' value of time may be lower than that of the traveller, since the former is likely to be more able to switch to other productive tasks while waiting for the arrival of the traveller. In the extreme, the non-travellers' effective value of time associated with a delayed meeting start time could be close to zero if they are able to reorganise tasks throughout the day. However, this may only occur in flexible environments, and depends on the nature of the tasks. If this is correct then the external impact of the traveller's lateness, while affecting several non-travellers, may not result in a significant economic loss due to the reorganisation of time.

On the other hand, the non-traveller may have a similar value of time to that of the business traveller. If so, the results presented above will significantly underestimate the economic impact of rail lateness and unreliability by excluding external business meeting effects.

3.2.7 Commuters and productivity loss

The penalty rate applied to commuters excludes the impact that stress caused by poor rail performance has on employees' productivity. Reductions in productivity are not included in the above estimates from the model.

OEF (2003) reports that 97% of employers believe that staff productivity is affected by commuting problems. Reed (2002) also found that 49% of London workers felt that their journey to work had become more stressful over the past four years. Also, literature discussed in section 2.2.2 suggested that unreliable travel could reduce productivity by around 15%.

However, OEF also reports that many employees believe that they can compensate for poor commutes, although nearly half of employees believe that there is a problem. Partly in response to transport delays, 69% of companies have flexible working for some or all workers, while 90% offer the option to work from home (OEF, 2003, Table 10). Flexible working is likely to reduce the impact of lateness on the business, since workers are likely to arrive less stressed if they are late, but their work start time is flexible. This will reduce the overall economic impact of poor rail performance. Working from home lowers the importance of commuting, as workers have to commute less often, again lessening the economic impact.

Despite its small sample size, the Mott MacDonald telequestionnaire did reveal some useful indicative statistics about the strength of the impact on productivity. The majority of respondents felt that poor rail performance did have such an impact, although there was considerable variation in the perceived length of this impact. Some felt that it lasted a full day; others considered that the impacts were confined to one hour or less. Interestingly, the survey results also suggested that around half of the respondents felt that poor rail performance had an impact on their colleagues' productivity. One respondent suggested that this might be because tasks cease to be synchronised. These responses suggest that, while it is not possible to quantify the size of the effect, lost productivity due to poor rail performance may have a significant economic impact.

On the other hand, all but one of the respondents indicated that they worked late or through their lunch break in order to make up time lost due to poor rail performance. This suggests that, from the firm's perspective, the productivity per hour may fall, although the productivity per day does not, as the working day is extended to make up the shortfall. If the firm pays a fixed salary, there will be little or no impact from its perspective. From the individual's perspective, the loss in productivity caused by poor rail performance compounds the impact of the poor rail performance itself, since they incur an additional amount of disutility associated with the lost leisure time they are now spending working to make up for the lower level of productivity during the day. This suggests that there is additional disutility incurred by commuters that is not being captured within the model results above.

3.3 Tourism

It was argued in section 3 that the impact on tourism of poor rail performance will be a function of its impact on the generalised cost of the trip, relative to the total utility derived from the leisure trip, which may be approximated by the total cost of the trip. It was argued that there are four possible responses to a perceived high generalised cost of the rail element of a leisure trip:

- choose another mode for the same trip;
- choose another destination, but still travel by rail;
- choose a destination outside of Britain; or
- consume other goods at home.

In addition, section 2.3.3 highlighted the importance of rail performance to tourism, with views expressed by the Heart of England Tourist Board, which suggest that poor rail performance is having a deleterious impact on overseas visitors.

This section examines the impact of poor rail performance on tourism, starting with some background on tourism in Great Britain, and the importance of rail in facilitating tourism.

Table 3.12 provides high-level statistics on the volume and value of tourism to England, Scotland and Wales in recent years.

Table 3.12: Volume and value of tourism to England, Scotland and Wales, 2002

	England	Scotland	Wales[1]
Trips (m)			
UK tourists	134.9	18.5	11.6
International tourists	20.6	1.6	0.9
Nights (m)			
UK tourists	415.8	64.5	44.6
International tourists	175.3	15.1	5.8
Spend (£m, current prices)			
UK tourists	20,788	3,683	1,664
International tourists	10,313	812	248

Note: [1] Data for 2001. This means that figures will have been suppressed by the foot-and-mouth outbreak in 2001, and by the response of international visitors to September 11th.
Source: UK Tourism Survey, data provided to OXERA from Visit Britain; and Office of National Statistics Social Service Division, 'International Passenger Survey'.

The table demonstrates that spending by UK and international tourists to Great Britain amounted to just over £37.5 billion in 2002, although travel costs are included in these figures. Thus, this figure cannot be taken in full as the contribution of tourism to British GDP, as it includes, for example, flights purchased by international tourists with non-UK airlines. Day trips are not included in these figures—the last survey of day trips for which data is available took place in 1998. The latest survey has been completed, but its results were not available in time for inclusion in this report.

Table 3.13 shows the types of transport used by overseas visitors to the UK (not just Great Britain) in 2000.

Table 3.13: Types of transport used in the UK by % of overseas visitors, 2000[1]

Origin of overseas visitor	Europe	Long-haul West	Long-haul East
Coach/bus	38	44	44
London Underground	34	48	48
Rail	23	36	30
Taxi	34	49	41
Hire/own car[2]	36	44	45
Air	2	5	5
Other	6	6	6

Notes: [1] These percentages are not modal shares, and should be interpreted as showing the proportion of total overseas tourists who have taken at least one trip on that particular mode on their visit to the UK. Of course, they may have made a number of trips, each using a different mode. [2] Here, 'own car' relates not only to drivers who have brought their own vehicle with them, but also to tourists using the cars of friends and relatives they are visiting.
Source: International Passenger Survey data, available on http://www.tourismtrade.org.uk/uktrade/Docs/html/42_11058.htm, accessed on August 5th 2003.

The table confirms the intuitive result that overseas visitors are most likely to use taxis, the London Underground and coaches on their visits to the UK. Rail is used more by those who have arrived from long-haul destinations—this is to be expected, given the longer staying times of these visitors. When this data is split by journey purpose, it can be seen that rail is used most by visitors on study trips (39%), and least by business visitors (23%). Again, this is likely to be due to average lengths of stay and the more focused nature of business trips (business visitors will typically fly as close to their final destination as possible).

Turning now to UK visitors, the next four tables use data provided by Visit Britain from the UK Tourism Survey, which disaggregates the number of trips by UK tourists to English Regional Tourist Boards by mode, spend, journey purpose, and socioeconomic group. This will provide an indication of the influence of poor rail performance on tourism.

Table 3.14: Modal shares (%) for UK visitors to English Regional Tourist Board destinations, 2002

	Rail	Bus/coach	Car (own/hired)	Other personal	Air	Sea	Other[1]	Total trips (m)
England	13.1	5.9	73.9	1.3	3.0	0.3	2.2	**134.9**
Cumbria	4.7	2.3	88.4	n/a	n/a	n/a	2.3	**4.3**
Northumbria	12.5	6.3	75.0	n/a	4.2	n/a	2.1	**4.8**
North West	14.5	6.9	71.7	1.4	2.8	n/a	2.8	**14.5**
Yorkshire	10.7	7.4	75.4	1.6	1.6	n/a	3.3	**12.2**
Heart of England	9.4	4.5	80.1	1.2	1.6	n/a	2.0	**24.6**
East of England	9.7	3.4	79.3	1.4	3.4	n/a	2.8	**14.5**
London	34.8	6.8	49.1	n/a	6.8	n/a	1.9	**16.1**
South West	7.6	6.7	79.5	2.9	1.9	0.5	1.9	**21.0**
Southern	9.6	6.2	77.4	0.7	2.7	0.7	2.1	**14.6**
South East	13.8	6.4	70.6	1.8	5.5	n/a	1.8	**10.9**
Total trips (m)	**17.7**	**8.0**	**99.7**	**1.8**	**4.1**	**0.4**	**3.0**	**134.9**

Note: [1] 'Other' includes lorry/truck/van, hitchhiking, walking, and 'other mode' categories.
Source: OXERA analysis of UK Tourism Survey data provided by Visit Britain.

The table demonstrates that rail has a market share for tourism by UK residents of around 13% on average, although this ranges from 4.7% for trips to Cumbria, where car is much more dominant, to 34.8% for trips to London, where car has less than 50% of the market. As noted, however, the UK Tourism Survey does not cover day trips—only trips of one or more nights are included in the sample.

Further background information is provided in Tables 3.15 and 3.16, which show journey purposes and socio-economic groups as a proportion of trips by mode for UK travellers to England.

Table 3.15: Tourist journey purpose as a proportion of trips by mode (%) for UK visitors to English Regional Tourist Board destinations, 2002

	Holidays				Other		
	1–3 days	4–7 days	8+ days	Total	Visiting friends and relatives	Business	Not categorised
Total	38.0	16.4	4.7	59.2	25.0	14.2	1.6
Rail	38.4	11.9	2.8	53.1	27.7	18.1	1.1
Bus/coach	29.8	23.1	11.6	64.5	20.7	12.4	2.5
Car (own/hired)	39.3	16.8	4.3	60.4	25.2	13.1	1.3
Air	19.5	14.6	26.8	63.4	9.8	24.4	2.4

Note: 'Other personal', sea and 'other' travel have been omitted due to a lack of sufficient data.
Source: OXERA analysis of UK Tourism Survey data provided by Visit Britain.

Table 3.16: Tourist socioeconomic groups as a proportion of trips by mode (%) for UK visitors to English Regional Tourist Board destinations, 2002

	AB	C1	C2	DE
Total	33.2	31.4	18.0	17.4
Rail	29.4	36.2	14.7	19.8
Bus/coach	28.1	28.9	17.4	24.8
Car (own/hired)	35.4	31.1	18.1	15.5
Air	46.3	31.7	12.2	12.2

Note: 'Other personal', sea and 'other' travel have been omitted due to a lack of sufficient data.
Source: OXERA analysis of UK Tourism Survey data provided by Visit Britain.

Of interest from these tables are the relatively high proportions of rail travel by business tourists (ie, those attending conferences, etc), those visiting friends and relatives, and those from socio-economic group C1 (skilled or educated lower managerial and professional personnel). In contrast, and perhaps understandably, rail is used less by those going on longer holidays than those taking short breaks.

The remainder of the analysis provided in this section deals with two questions:

- what is the extent of disutility for tourists using rail to travel to their destinations?;
- to what extent does poor rail performance lead to reduced tourism in a particular area?

Table 3.17 begins this analysis by showing average amounts spent (including travel costs) by mode by UK tourists travelling to English Regional Tourist Boards.

Table 3.17: Average spend (£, 2002 prices) by mode for UK visitors to English Regional Tourist Board destinations, 2002

	Rail	Bus/coach	Car (own/hired)	Air
England	168	164	143	323
Cumbria	151	172	161	n/a
Northumbria	192	161	143	250
North West	171	175	153	285
Yorkshire	160	122	124	240
Heart of England	131	175	122	328
East of England	116	109	113	190
London	189	176	137	329
South West	194	180	184	326
Southern	167	163	131	334
South East	122	162	113	245

Note: [1] 'Other personal', sea and 'other' travel have been omitted due to a lack of sufficient data.
Source: OXERA analysis of UK Tourism Survey data provided by Visit Britain.

The table demonstrates that, given the inclusion of travel costs in spend data, air travellers on tourism trips spend most. In addition, the location of the destination is an important factor in average spend—the less accessible the area, the higher the spend, particularly for rail travel.

Table 3.18 compares the average spend per person per trip by rail travellers (which includes travel expenditure) with TOC-specific estimates of the average disutility incurred by a traveller undertaking a return journey. The traveller's total expenditure can be interpreted as the lower-bound estimate of the utility that they gain from undertaking the trip—the actual utility will be higher, otherwise they would not undertake the trip, but is unobservable. The leisure travel disutility assumes that the traveller has a PAT in both directions of their journey, and that they do not adapt their behaviour to delays, adopting the 'no delays' choice rule.

Consequently, Table 3.18 presents a high estimate of the disutility from the rail journey, and a low estimate of the total utility gained from undertaking the leisure trip. Therefore, the poor rail performance disutility as a proportion of total expenditure can be interpreted as an upper bound.

Table 3.18: Average spend (£) by rail travellers compared with disutility caused by poor rail performance

Regional tourist board	Rail traveller's expenditure	Example TOC 1	Leisure disutility from TOC 1 (£)[1]	Disutility as % of expenditure	Example TOC 2	Leisure disutility from TOC 2 (£)[1]	Disutility as % of expenditure
Cumbria	151	Virgin West Coast	10.20	6.8	Virgin Cross Country	12.30	8.1
Northumbria	192	Arriva Trains Northern	3.94	2.1	GNER	12.64	6.6
North West	171	Arriva Trains Northern	3.94	2.3	Virgin West Coast	10.20	6.0
Yorkshire	160	GNER	12.64	7.9			
Heart of England	131	Midland Mainline	7.14	5.5	Virgin Cross Country	12.30	9.4
East of England	116	Anglia (Intercity)	6.92	6.0	Anglia (Locals)	1.98	1.7
London	189	Silverlink	5.54	2.9	GNER	12.64	6.7
South West	194	First Great Western	8.68	4.5	South West Trains	4.56	2.4
Southern	167	South Central	4.78	2.9	South West Trains	4.56	2.7
South East	122	Connex South Eastern	4.78	3.9			

Notes: TOCs are chosen for illustrative purposes only, as there is no information on the origin of trips to these tourist board areas. [1] This assumes that travellers make a return journey, have a PAT in both directions, and adopt the 'no delays' choice rule.
Source: OXERA analysis of UK Tourism Survey data provided by Visit Britain.

The disutility incurred by rail performance as a proportion of trip expenditure varies considerably by region. This variation is driven mainly by the different disutilities incurred on individual TOCs, rather than by differences in the expenditure in each region. However, in only one instance is the proportion less than 2% of expenditure, and in several it is more than 5% of expenditure. This suggests that, at the upper bound of estimates, poor rail performance may have an impact on tourism by significantly increasing the generalised costs of a trip.

This static analysis concerns the disutility experienced by existing rail travellers making tourist trips. However, it may be of less concern to the SRA and rail industry stakeholders than a dynamic analysis, since the travellers incurring disutility have revealed their preference to travel by rail, despite this disutility. Hence, the next stage of analysis has been to consider the impact on Regional Tourist Boards of the fall in PPM post-Hatfield.

Table 3.19 shows the post-Hatfield reduction in 10-minute PPM for intercity TOCs selected to be representative of rail journeys to each Regional Tourist Board.

Table 3.19: Fall in 10-minute PPM, 2001/02 relative to 2000/01

Regional Tourist Board	TOC[1]	% decrease in PPM between 2000/01 and 2001/02
Cumbria	Virgin West Coast	–21.1
Northumbria	GNER	–16.7
North West	Virgin Cross Country	–25.2
Yorkshire	GNER	–16.7
Heart of England	Midland Main Line	–11.3
East of England	Anglia Railways (intercity)	–9.7
London	Silverlink	–6.4
South West	First Great Western	–9.8
Southern	South Central	–6.1
South East	Connex South Eastern	–5.8

Note: [1] TOCs are chosen for illustrative purposes only, as there is no information on the origin of trips to these tourist board areas.
Source: OXERA analysis of PPM data.

Next, a PPM elasticity may be applied to the decrease in PPM experienced by travellers using these TOCs to give the percentage reduction in rail journeys implied by the fall in PPM. As part of the development of its Transport Model, OXERA derived elasticities for PPM for each rail sector—regional, intercity and London and the South East. For this analysis, the intercity PPM elasticity of 0.38 has been used.

Once the elasticity has been applied to give the percentage reduction in journeys, a diversion rate can be used to estimate what proportion of travellers who decide not to travel by rail will decide not to travel at all. The evidence on diversion rates for UK travel is limited to the MSc dissertation by Vicario (1999), as interpreted by Preston (2000), which suggests that, of intercity travellers leaving rail, 9% will decide not to travel at all (others will switch to other modes and still make the same journey, which will leave the Tourist Board and its stakeholders in a neutral position).[10] The Vicario work does not

[10] Two assumptions are made here. The first is that the figure derived by Vicario for price changes can be used for other increases in generalised cost, such as performance. The second is that the Tourist Board and its stakeholders are

offer a proportion of travellers that divert to an alternative destination, but still travel. Thus, this method may overestimate the trips lost to tourism as a whole, since some travellers may choose to take their holiday in a different Tourist Board area, rather than not travel at all.

Finally, the percentage of lost trips is applied to the number of trips made to each English Regional Tourist Board area in 2002.[11] This number of lost trips is then combined with average spend per rail traveller to estimate the cost of the drop in performance post-Hatfield to each destination (see Table 3.20).

Table 3.20: Tourism spend lost to each English Regional Tourist Board post-Hatfield

English Regional Tourist Board	Lost spend (£m, 2002 prices)
Cumbria	0.22
Northumbria	0.67
North West	3.13
Yorkshire	1.20
Heart of England	1.18
East of England	0.55
London	2.36
South West	1.05
Southern	0.49
South East	0.36
Total across all English Regional Tourist Boards	**11.21**

Source: OXERA analysis.

The total loss described in Table 3.20 is very small, equal to less than 0.04% of total tourist spending within the English Tourist Boards (equal to around £31 billion in 2002, see Table 3.12). In addition, some of this loss will be internalised within the rail industry, since the average spend figures include rail travel costs. However, even taking a conservative estimate for the cost of a return train ticket, based on twice the average fare for GNER (£22.63, taken from TAS, 2003), it would seem that only one-third to two-fifths of average spend per trip is made up by rail travel costs. Hence, it would appear that well over half of the lost spend figures shown in Table 3.20 should be considered as affecting third parties.

indifferent between modes of travel used to arrive at a destination—as long as the trip is made, then additional environmental costs from non-rail modes, for example, are assumed to be of second-order importance.

[11] This percentage should really be applied to trips made in 2000/01, to be consistent with the pre-Hatfield number of trips, however this data is not available. This assumption will bias downwards the cost of the post-Hatfield drop in performance.

The above analysis does not provide all the information required for the full impact of Hatfield on tourism spend to be measured. In particular, the following areas have not been addressed.

- *The impact on tourists from overseas*—it is arguable that tourists from overseas will be little affected by poor rail performance, since the destination is likely to be the major factor in the decision to travel once in the UK. The travel company organising trips around the country will either allow more time for travelling to the destination, or switch modes away from rail in the face of poor rail performance; alternatively, a particular journey may be affected, resulting in inconvenience and potentially less spending at the destination. In any case, the impact on tourism to any given destination is likely to be small.

- *Spending on non-tourism activities*—with regard to the figures presented in Table 3.20, if potential visitors stay at home some of the lost spend will still occur, but in a different area. In this case, the impact on Britain as a whole is likely to be mitigated, although it could be argued that the accommodation and food elements (ie, the majority) of spending on a trip are probably much greater when on holiday than at home. In addition, if it is assumed that part of the 'do not travel' proportion in Vicario's results is accounted for by tourists who choose to go on holiday abroad rather than in Britain, (non-travel) expenditure will occur outside the UK.

- *The impact on Scotland and Wales*—no information is provided in Table 3.20 for these two parts of Britain, as the data provided by Visit Britain did not cover these. However, some inference may be drawn by using the same methods as for Table 3.20, assuming a similar proportion of visitors from the UK arrive by rail as for England (13%), and that the average spend by rail travellers equates to the average spend for all travellers. Carrying out this calculation provides an estimate of lost spend of £3.5m for Scotland, and £0.7m for Wales.

- *The impact on day trips*—as mentioned above, there is no equivalent up-to-date data on day trips, which are not covered by the UK Tourism Survey. However, the following points may usefully be made:

  – information from the Wales Tourist Board suggests that there were four times as many day trips made in 1998, relative to trips lasting one or more nights (as measured by the UK Tourism Survey);
  – the choice of destination is likely to be the first to be made (unless there are special circumstances such as reduced fares)—this suggests that most of the impact of poor rail performance on day trips will be distributive;
  – once the destination has been chosen, the individual or group will then choose which mode to use, based on generalised cost considerations, including price, ease of access to the destination (eg, parking), and journey time and predictability;
  – if rail is perceived to be *relatively* unreliable (whether rationally or not), this will only affect individuals if this perception is sufficiently out of touch with the actual probability of delays that they sub-optimally choose another mode or not to travel;

– if rail is the chosen mode, and the individual or group is seriously delayed on the outbound trip, this will have a significant impact on the enjoyment of the destination and on the spending that takes place there.

This qualitative analysis suggests that perceptions about rail delays are very important to those considering whether to use rail for day trips. It also suggests that the experiences of those who do use rail for day trips are very important, as the volume of day trips suggests that there is likely to be a significant market for return trips to that tourist location. In light of coverage by the media of the August 2003 bank-holiday possessions, it is important to recognise that these points apply equally to the timing and location of restrictions of use of the network.

4. Conclusions

This paper has used a literature review, questionnaires and surveys, and a desktop study to examine the economic effects of poor rail performance. From this analysis four broad areas of harm have been identified—direct harm to business; indirect harm to business; harm to commuters travelling to and from work; and harm to leisure travellers and the tourist industry. Each is examined separately below.

- *Direct harm to business travellers and business*—estimates from the desktop study suggest that business travellers incur approximately £1 billion of disutility per annum due to poor rail performance, which is equivalent to nearly £6.80 per single journey. This estimate takes into account adaptive behaviour by business travellers seeking to reduce the harm by choosing earlier trains to try to compensate for delays and unreliability. If travellers do not adapt their behaviour, the disutility is increased by around 15%. Neither of the business disutility estimates takes into account the impact that late arrival at business meetings has on the non-travellers at the meeting. It has not been possible to obtain a robust estimate of the size of this secondary impact, but the telequestionnaire results suggest that significant numbers of non-travellers may be adversely affected by delayed business travel, potentially raising the damage estimate. Severe disruption to business travel may incur greater losses than the desktop study estimate suggests, as meetings may have to be cancelled, and business opportunities may be lost. While it may be possible to mitigate the effects of poor performance through working on the train—to the extent that only 'secondary' activities can be undertaken under such conditions—this would not be expected to alter substantially the results of the desktop study.

- *Indirect harm to business*—evidence from the literature review suggests that employees' productivity is reduced by around 13–18% after undertaking an unreliable and congested journey. However, it is unclear how long this reduction in productivity lasts. The telequestionnaire did not provide conclusive results on this issue, with some respondents suggesting that the productivity impact would last all day, while others suggested it would last less than an hour. However, there was clear evidence that employees generally work during lunch breaks, and later in the evening in order to catch up with work, potentially negating the productivity reduction from the business perspective.

  The literature review also suggested that difficulty travelling to work reduced job satisfaction, potentially raising staff turnover, and increased absences due to illness. Increased staff turnover and more frequent absences due to illness will have costs to business, although the evidence was not detailed enough to provide a robust estimate of the magnitude of these effects.

- *Commuters*—in addition to productivity effects, unreliable travel has a direct impact on commuters. Evidence from the literature review indicates that unreliable and congested travelling conditions can double the observed stress levels among travellers. The desktop study estimates that commuters incur approximately £500m of disutility per annum due to lateness and unreliability. This estimate assumes that commuters are well informed about the likelihood of delays to the trains that they catch, adapting their behaviour accordingly, and that they care about the arrival time of both inbound and outbound services. The adaptive behaviour reduces the disutility incurred by around 13%. While the estimate for aggregate disutility is large, it is spread over a wide number of individuals, and is approximately equal to £1.18 per commuter rail trip.

- *Leisure travel and tourism*—the desktop study estimates that leisure travellers incur around £650m of disutility per annum due to poor rail performance. This equates to between £1.68 and £1.92 of disutility per passenger journey, depending on whether individuals adapt their behaviour to delays. Failure to adapt increases the average level of disutility. It may be expected that leisure travellers are less likely to have accurate expectations of the pattern of delays for a particular journey, and so would be less likely to adapt their behaviour accordingly.

  Evidence from the desktop study suggests that disutility caused by poor rail performance may be as high as 10% of average tourist expenditure on trips within the UK. Further analysis examining the drop in PPM after Hatfield suggests that around £11m of tourist spending may have been lost in England due to leisure travel not taking place. As this figure includes lost income for the railway industry, the lost spend to third-party organisations will be less. However, the figure does not include the impact on day trips, which account for a greater number of overall trips and on which poor rail performance may be expected to have a proportionately greater effect. On the other hand, the lost spending may still take place, but be used for other activities, and is not necessarily lost to the UK economy.

Overall, the evidence presented in this report shows that poor rail performance has a significant impact on individuals, the economy, and society in general. The desktop study estimate for total disutility (relative to an ideal world of zero delays) is equal to around £2.2–£2.5 billion per annum, which is approximately equal to two-thirds of the total annual ticket sales of the railway. Arguably, this is a conservative estimate, as it does not include some external effects, such as the effect on business meetings, several of which were outlined above.

Consequently, improvements in rail performance have a significant value attached to them, which may not be properly accounted for in the current project appraisal process. For example, if each train operator were to reproduce its best year of performance, total disutility, as calculated by the OXERA model, is likely to fall by around £900m per annum.

Appendix 1: TOC-level Journey Data and VTTSs

Table A1.1: Passenger journeys and traveller types by TOC

		Proportion of journeys (%)			
	Passenger journeys (m per annum)	Commuter	Business	Leisure	Use London and South East value of time[1]
Anglia (Intercity)	9.5	16	27	57	Yes
Anglia (Locals)	9.5	16	27	57	No
Arriva Merseyside	23.8	37	8	55	No
Arriva Northern	41.8	35	11	55	No
C2C	28.2	66	4	30	Yes
Central	29.6	30	15	55	No
Chiltern	11.7	37	19	44	Yes
Connex South East	132.6	59	14	27	Yes
FGE	58.4	66	14	20	Yes
FGW	20.2	16	31	53	Yes
FNW	28.0	49	2	49	No
Gatwick Express	4.1	9	26	65	Yes
GNER	13.7	5	34	61	Yes
Midland Mainline	9.4	14	34	52	Yes
ScotRail	56.4	28	10	62	No
Silverlink	35.6	54	12	34	Yes
South Central	115.0	50	16	34	Yes
SWT	141.2	45	19	36	Yes
Thames	37.3	40.1	17.1	42.8	Yes
Thameslink	41.4	47.8	16.7	35.5	Yes
Valley Lines	10.0	25.3	7.2	67.5	No
VWC	15.2	10.5	23.3	66.2	Yes
VXC	17.4	10.6	20.9	68.5	No
WAGN	66.3	46	26	28	Yes
Wales and West	10	25.3	7.2	67.5	No
Total/weighted average	**966**	**43.9**	**16.1**	**40.0**	**n/a**

Note: [1] Based on OXERA assumptions.
Sources: OXERA modelling; passenger journey data taken from TAS (2003).

Table A1.2: TOC-specific VTTSs

	Use London and South East value of time[1]	Service interval (mins)	Average journey length (miles)	TOC-specific VTTSs Commuter	Business	Leisure
Anglia (Intercity)	Yes	60	55[2]	3,507	951	1,053
Anglia (Locals)	No	30	55[2]	3,507	821	893
Arriva Merseyside	No	15	7	1,197	278	310
Arriva Northern	No	30	20	2,237	522	580
C2C	Yes	15	18	2,189	594	659
Central	No	30	23	2,285	533	593
Chiltern	Yes	15	30	2,536	687	765
Connex South East	Yes	15	15	2,116	575	636
FGE	Yes	15	20	2,213	601	666
FGW	Yes	60	79	3,733	1,012	1,120
FNW	No	30	17	2,164	504	561
Gatwick Express	Yes	15	27	2,402	650	725
GNER	Yes	60	161	4,268	1,068	1,182
Midland Mainline	Yes	60	78	3,733	1,012	1,120
ScotRail	No	30	20	2,237	522	580
Silverlink	Yes	15	17	2,164	588	651
South Central	Yes	15	15	2,092	569	628
SWT	Yes	15	18	2,189	594	659
Thames	Yes	15	17	2,164	588	651
Thameslink	Yes	15	20	2,237	607	674
Valley Lines	No	30	21	2,237	522	580
VWC	Yes	60	120	4,047	1,068	1,182
VXC	No	60	101	3,945	922	893
WAGN	Yes	15	20	2,213	601	666
Wales and West	No	30	35	2,758	645	713

Notes: [1] Based on OXERA assumptions. [2] Data for Anglia (Intercity) and Anglia (Locals) individually was not available. Both use the Anglia Railways average journey length.
Sources: TOC-specific VTTSs calculated by OXERA using PDFC (2002), as this offers greater disaggregation than the alternative DfT figures. Service interval minutes and average journey length taken from TAS (2003).

Appendix 2: TOC-level Modelling Results

Table A2.1: Disutility due to poor rail performance per passenger journey—base-case results using perfect-running counterfactual (pence per passenger journey)

	Anglia Intercity	Anglia Locals	Arriva Merseyside	Arriva Northern	C2C	Central	Chiltern	Connex SE	FGE	FGW	FNW	Gatwick Express	GNER	MML	ScotRail	Silverlink	South Central	SWT	Thames	Thameslink	Valley Lines	VWC	VXC	WAGN	Wales and West
Leisure																									
Rational	425	96	39	118	100	109	87	94	73	533	78	95	868	445	92	105	92	97	103	111	126	616	734	102	156
Worst	462	99	39	127	111	111	89	96	84	555	80	99	1,093	501	109	111	94	99	103	123	129	709	789	119	159
Best	431	97	39	121	103	112	88	95	75	543	79	99	971	465	94	108	94	101	103	116	128	637	798	110	157
No delays	461	100	43	126	114	120	95	109	79	597	82	110	1,046	491	97	122	108	113	119	130	139	702	886	115	171
Commuter																									
Rational	475	104	43	130	110	126	94	104	83	605	84	107	947	496	102	115	102	110	114	122	137	673	716	115	169
Worst	513	108	43	140	125	129	97	106	94	629	85	111	1,206	565	121	122	104	112	114	135	140	777	775	133	171
Best	483	105	44	134	115	128	95	105	84	617	85	110	1,054	514	104	118	104	114	114	128	139	697	781	124	170
No delays	521	109	49	140	125	138	102	122	89	671	88	124	1,137	546	107	130	118	128	134	143	151	761	860	129	182
Business																									
Rational	1,555	406	168	508	363	474	319	351	270	1,969	331	357	3,446	1,645	398	380	335	364	381	406	537	2,343	3,153	377	667
Worst	1,671	420	168	548	408	483	327	358	309	2,037	334	373	4,373	1,887	475	402	343	371	381	448	551	2,715	3,417	443	679
Best	1,575	409	171	518	378	482	324	354	275	2,008	334	369	3,826	1,706	407	391	342	377	381	425	544	2,425	3,452	409	671
No delays	1,703	422	187	543	419	515	343	410	292	2,200	345	412	4,169	1,803	420	431	388	428	445	474	587	2,666	3,850	428	722

Note: The TOC-specific VTTSs and service-interval assumptions used for the base case are listed in Table A1.2 in Appendix 1.
Source: OXERA modelling.

Table A2.2: Disutility due to poor rail performance per passenger journey— base-case results using best-year counterfactual (pence per passenger journey)

	Anglia Intercity	Anglia Locals	Arriva Merseyside	Arriva Northern	C2C	Central	Chiltern	Connex SE	FGE	FGW	FNW	Gatwick Express	GNER	MML	ScotRail	Silverlink	South Central	SWT	Thames	Thameslink	Valley Lines	VWC	VXC	WAGN	Wales and West
Leisure																									
Rational	144	36	11	52	36	46	25	16	32	165	25	36	541	246	53	30	22	34	6	39	44	256	388	59	33
Worst	181	39	11	61	48	47	27	18	42	187	26	39	766	302	70	36	24	36	7	51	47	349	444	76	36
Best	150	37	12	54	40	48	26	17	33	175	26	39	644	266	55	34	24	38	6	44	46	277	453	67	34
No delays	181	40	16	60	51	56	33	31	37	229	29	51	719	292	58	47	38	50	22	58	57	343	540	72	48
Commuter																									
Rational	160	39	13	57	40	53	27	18	36	189	26	40	591	277	59	34	24	38	7	43	47	281	382	65	36
Worst	197	42	13	67	55	56	30	20	47	213	27	44	851	345	79	41	27	40	7	56	50	385	441	84	39
Best	167	40	14	60	45	55	29	19	37	201	27	44	698	294	61	37	26	42	7	49	49	305	447	74	37
No delays	205	43	18	67	55	65	36	36	42	254	30	57	782	326	64	49	40	56	27	63	61	369	526	80	49
Business																									
Rational	526	152	50	223	132	199	93	60	116	611	103	137	2,153	920	231	112	80	126	23	142	187	982	1,657	214	141
Worst	643	167	51	263	177	209	101	67	156	679	106	152	3,081	1,161	308	134	88	133	24	184	202	1,353	1,921	280	153
Best	547	155	53	233	146	207	98	63	122	650	106	149	2,534	981	240	123	87	139	24	161	195	1,064	1,956	246	145
No delays	675	168	70	258	188	240	117	119	138	842	117	192	2,877	1,078	253	163	133	190	88	210	237	1,305	2,353	265	196

Note: The TOC-specific VTTSs and service-interval assumptions used for the base case are listed in Table A1.2 in Appendix 1.
Source: OXERA modelling.

Appendix 3: Consultation Exercises

This appendix provides more information on the consultation exercises carried out by the project team. Appendix 3.1 is a selection from the questionnaires sent by OXERA to various government department, employee and employer organisations and transport industry representatives. Appendix 3.2 presents the results of a number of teleconferences carried out by Mott MacDonald following up respondents to the original OXERA questionnaire sent to the Chambers of Commerce network.

A 3.1 Questionnaires

This sub-section reproduces questionnaires sent to business organisations, the Trades Union Congress (TUC), and government departments.

Business organisations

This questionnaire was sent to business organisations, including the British Chambers of Commerce, who circulated the questionnaire to their network of more than 100 chambers.

SRA Study: The Economic Impact of Rail Punctuality and Reliability

FAX REPLY FORM

TO	**ANDREW MEANEY, OXERA**
FAX NO	**01865 251172**
FROM	
COMPANY	
DATE	
NO OF PAGES	

Please use extra sheets if your answers require more space. If you would like an electronic copy of this questionnaire, or have any questions, then please contact Andrew Meaney on 01865 253028 or andrew_meaney@oxera.co.uk. The closing date for responses is Monday July 14th.

Personal data is gathered in accordance with the Data Protection Act 1998. Your details will be held for the purposes of this questionnaire and the related SRA study only.

Background information

Your name and contact details...

....

Your position ....

Name of organisation...

Impact of passenger rail performance on businesses

Has your organisation (or any other that you are aware of) analysed the impact of the reliability of transport more generally, and passenger rail in particular on:

Business productivity? ....

Costs to businesses from reduced productivity, absenteeism etc.? ....

Employee stress levels, and general health conditions? ....

Local economies? ....

The national economy? ....

Tourism? ....

If the answer to any of the above questions is yes, or if you have any comments to make on the links between the reliability of transport and these factors, please give details below.

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

....

Has your organisation received submissions from members drawing your attention to these issues, for example, after the derailment at Hatfield in October 2000? What was the nature of such submissions and what are the general conclusions from them?

....

....

....

....

....

....

....

....

....

....

....

....

....

In light of recent declining performance on passenger rail, do you know of any companies that have recently changed their policy on:

	Yes	No
The times between which meetings should be held		
Appropriate leaving times for meetings, if travel is required		
Flexible working (eg, if an individual arrives late, can they stay late and make up the time lost?)		
Home working		
The acceptability of travel delays as a reason for lateness		

Please give further details on each of these issues:

Meeting times..

....

....

Departure times..

....

....

Flexible working..

....

....

Home working ....

....

....

The acceptability of travel delays ....

....

....

Technologies and work practices that reduce the impact of poor rail performance

Has your organisation (or any other that you are aware of) examined the impact of laptops and mobile phones on business productivity? If yes, please give details.

....

....

....

....

....

....

....

....

Has your organisation (or any other that you are aware of) evaluated the costs and benefits of home working and flexible working? If yes, please give details.

....

....

....

....

....

....

....

....

Do you have any other comments to make that you feel would assist in the completion of this study?

....

....

Many thanks for taking the time to complete this questionnaire.

TUC

This questionnaire was sent to the TUC, and was designed to address the impact on rail punctuality on employees.

SRA Study: The Economic Impact of Rail Punctuality and Reliability

FAX REPLY FORM

TO	**ANDREW MEANEY, OXERA**
FAX NO	**01865 251172**
FROM	
COMPANY	
DATE	
NO OF PAGES	

Please use extra sheets if your answers require more space. If you would like an electronic copy of this questionnaire, or have any questions, then please contact Andrew Meaney on 01865 253028 or andrew_meaney@oxera.co.uk. The closing date for responses is Friday 14th July.

Personal data is gathered in accordance with the Data Protection Act 1998. Your details will be held for the purposes of this questionnaire and the related SRA study only.

Please feel free to pass this questionnaire on to other colleagues who are involved with other areas of work relevant to this research.

Background information

Your name and contact details ....

....

Your position ....

Name of organisation ....

Impact of passenger rail performance on employees

From your organisation's point of view, what importance is attributed to transport-related problems that impact on members' lateness at work and absenteeism?

....

....

....

....

Have there been past cases associated with any employer's decisions for dismissal or differential treatment of any of your members, subject to problems associated with failures from transport services? Please explain.

....

....

....

....

Are there any areas of employment which you think are more vulnerable to poor transport systems that have attracted your attention in the recent past? Explain.

....

....

....

....

Has your organisation received submissions from members on how the reliability of modes of transport is affecting them?

....

....

....

....

Has your organisation (or any other you are aware of) analysed the impact of the reliability of transport more generally, and passenger rail in particular, on employee health? If yes, please give details, and indicate whether you would be willing to share this analysis with us.

....

....

....

....

....

....

....

....

....

How have your perceptions (or your organisation's perceptions) about the impact of the reliability of rail passenger services on employees changed in light of the recent poor performance of train services?

....

....

....

....

....

....

....

Do you have any other comments that you feel would assist in the completion of this study?

....

....

Many thanks for taking the time to complete this questionnaire.

Government departments

A number of similar questionnaires were sent to the Departments for Transport, Health, Trade and Industry, and Work and Pensions. The version sent to the Department for Trade and Industry is reproduced below.

SRA Study: The Economic Impact of Rail Punctuality and Reliability

FAX REPLY FORM

TO	**ANDREW MEANEY, OXERA**
FAX NO	**01865 251172**
FROM	
COMPANY	
DATE	
NO OF PAGES	

Please use extra sheets if your answers require more space. If you would like an electronic copy of this questionnaire, or have any questions, then please contact Andrew Meaney on 01865 253028 or andrew_meaney@oxera.co.uk. **The closing date for responses is Monday 14th July.**

Personal data is gathered in accordance with the Data Protection Act 1998. Your details will be held for the purposes of this questionnaire and the related SRA study only.

Background information

Your name and contact details ....

....

Your position ....

Name of organisation ....

Impact of passenger rail performance on businesses

Has your department (or any other that you are aware of) analysed the impact of the reliability of transport more generally, and passenger rail in particular on:

Overall business productivity? ....

Employee health, employee productivity, employee performance, etc? ....

Local economies and the national economy? ....

And, more specifically, tourism? ....

If the answer to any of the above questions is yes, please give details below and indicate whether you would be willing to share this analysis with us.

....

....

....

....

....

....

....

....

....

Technologies and work practices that reduce the impact of rail punctuality on the wider economy

Has your department (or any other that you are aware of) examined the impact of laptops and mobile phones on business productivity? If yes, please give details.

....

....

....

....

....

....

Has your department (or any other that you are aware of) evaluated the costs and benefits of home working and flexible working? If yes, please give details.

....

....

....

....

....

....

....

....

Do you have any other comments to make that you feel would assist in the completion of this study?

....

....

Many thanks for taking the time to complete this questionnaire.

A 3.2 Results of telephone questionnaire

Following the consultation exercise by OXERA, where questionnaires were sent to various business organisations, TUC and transport organisations, a follow-up exercise was conducted by Mott MacDonald to gather further information from respondents which could assist in the scenario analysis.

Mott MacDonald returned to the respondents from the first survey of the Chambers of Commerce to ask members a set of questions relating to meetings and productivity, designed specifically to fill the remaining gaps about the impact of performance on employee productivity, and to guide the scenario analysis (eg, by asking what proportion of meeting times are set according to the rail timetable—a key variable in the Bates et al. framework).

Eight members completed the telequestionnaire and their overall responses given are summarised below.

Meetings

An overall average of six meetings were held per week among respondents, of which an average of 38% were based in the usual office location. The number of attendants at the meetings was typically between 10 and 20, although respondents indicated that this varied according to the reason for the meeting. Respondents advised that 72% of attendees at these meetings were not based at the location where the meeting was held. Furthermore, although the majority of meetings whereby attendees were late were not delayed, some respondents indicated that a delay of the meeting was necessary due to the importance of the person who was delayed.

Number of meetings per week

	1–2	3–5	6–10	10–20	20+
Respondent 1		✓			
Respondent 2	✓				
Respondent 3		✓			
Respondent 4					✓
Respondent 5	✓				
Respondent 6		✓			
Respondent 7		✓			
Respondent 8		✓			

Source: Mott MacDonald.

Meetings based at usual office location

	10–20%	30–40%	50–60%	70–80%	90–100%
Respondent 1			✓		
Respondent 2					
Respondent 3					✓
Respondent 4			✓		
Respondent 5	✓				
Respondent 6			✓		
Respondent 7		✓			
Respondent 8		✓			

Source: Mott MacDonald.

Proportion of attendees not based at meeting location

	10–20%	30–40%	50–60%	70–80%	90–100%
Respondent 1			✓		
Respondent 2					✓
Respondent 3	✓				
Respondent 4					✓
Respondent 5				✓	
Respondent 6			✓		
Respondent 7					✓
Respondent 8				✓	

Source: Mott MacDonald.

Average size (in terms of attendees) of the meeting

	1–2	3–5	6–10	10–20	20+
Respondent 1				✓	
Respondent 2				✓	
Respondent 3				✓	
Respondent 4		✓			
Respondent 5				✓	
Respondent 6		✓			
Respondent 7			✓		
Respondent 8		✓			

Source: Mott MacDonald.

If attendees are late arriving is the meeting delayed?

	Always	Often	Sometimes	Rarely	Never
Respondent 1		✓			
Respondent 2				✓	
Respondent 3				✓	
Respondent 4	✓				
Respondent 5				✓	
Respondent 6				✓	
Respondent 7				✓	
Respondent 8		✓			

Source: Mott MacDonald.

Decision on whether to delay meeting due to:

	Importance of delayed person	Expected extent of delay	Proportion of attendees late	Other
Respondent 1				✓
Respondent 2	✓			
Respondent 3	✓			
Respondent 4	✓	✓		
Respondent 5	✓			
Respondent 6	✓	✓	✓	
Respondent 7	✓			
Respondent 8	✓	✓	✓	

Source: Mott MacDonald.

Productivity and team performance

The majority of respondents questioned worked with a team of people, and half of respondents stated that if a significant delay occurred it would affect not only on their productivity once they arrived at work, but also their colleagues' ability to perform their tasks satisfactorily. Those who did not think that a significant delay would have an impact on them believed that it would not have an effect on their colleagues' productivity.

Asked how large an impact would be if they were significantly delayed, only two respondents stated that it would severely disrupt their whole working day. The remaining respondents indicated that they would be able to catch up with their workload in such a short space of time as to be negligible.

Do you work with a team of people, if so how many?

	1–2	3–5	6–10	10–20	20+
Respondent 1					✓
Respondent 2					
Respondent 3		✓			
Respondent 4					
Respondent 5		✓			
Respondent 6			✓		
Respondent 7		✓			
Respondent 8	✓				

Source: Mott MacDonald.

When significant delays occur, do you think it has an impact on your productivity once you do arrive at work?

	Yes	No	Don't Know	Sometimes
Respondent 1	✓			
Respondent 2	✓			
Respondent 3	✓			
Respondent 4		✓		
Respondent 5	✓			
Respondent 6		✓		
Respondent 7		✓		
Respondent 8		✓		

Source: Mott MacDonald.

When you arrive late at work, do you think it affects the ability of your colleagues to undertake their work?

	Yes	No	Don't know	Sometimes
Respondent 1	✓			
Respondent 2		✓		
Respondent 3				✓
Respondent 4	✓			
Respondent 5	✓			
Respondent 6		✓		
Respondent 7		✓		
Respondent 8		✓		

Source: Mott MacDonald.

Reaction to delays

In terms of respondents' reactions to delays, six of the eight respondents stated that they were rarely delayed over the course of a month, as they were wary that their job position was sufficiently important to warrant allowing extra journey time as well as indicating that they were accustomed to a particular journey pattern as part of their daily routine.

Of the two respondents who indicated experiencing delays over the course of a month, only one reported that they were subject to routine delays, but felt this might be due to ongoing problems with train services in their locality. Asked what extent of delay they would feel constitutes an incident that would not be recoverable in time to arrive at work or a meeting, the response was too varied to discern a pattern. Most respondents felt that the question was dependent on the importance of the meeting or whether they had a good reason to be at work at a designated time. Of those delayed on their journey to work, all but one responded that they would work later in the evening or through lunch if necessary to catch up on their workload.

What extent of delay do you feel constitutes an incident that would not be recoverable in time to arrive at work or to a meeting?

	5 mins or less	10 mins	20 mins	30 mins	45 mins	60+ mins	60+ mins
Respondent 1						✓	
Respondent 2				✓			
Respondent 3	✓						
Respondent 4	✓						
Respondent 5	✓						
Respondent 6							✓
Respondent 7	✓						
Respondent 8	✓						

Source: Mott MacDonald.

If you are delayed on your journey to work, do you recover the delay by working later in the evening or through lunch hours?

	Yes	No	Don't know	Sometimes
Respondent 1	✓			
Respondent 2	✓			
Respondent 3	✓			
Respondent 4	✓			
Respondent 5		✓		
Respondent 6	✓			
Respondent 7	✓			
Respondent 8	✓			

Source: Mott MacDonald.

References

Abkowitz, M.D. (1981), 'An Analysis of the Commuter Departure Time Decision', *Transportation*, **10**, 283–97.

Bates, J., Polak, J., Jones, P. and Cook, A. (2001), 'The Valuation of Reliability for Personal Travel', *Transportation Research Part E*, **37**, 191–229.

DfT (2001), 'Transport Economics Note', Department for Transport.

Hennessy, D.A, Wiesenthal, D.L. and Kohn, P.M. (2000), 'The Influence of Traffic Congestion, Daily Hassles, and Trait Stress Susceptibility on State Driver Stress: and Interactive Perspective', *Journal of Applied Biobehavioral Research*, **5**:2, 162–79.

Hennessy, D.A. and Wiesenthal, D.L. (1997), 'The Relationship Between Traffic Congestion, Driver Stress and Direct Versus Indirect Coping Behaviours', *Ergonomics*, **40**:3, 348–61.

Jackson, W.B. and Jucker, J.V. (1981), 'An Empirical Study of Travel Time Variability and Travel Choice Behaviour', *Transportation Science*, **16**, 460–75.

Knight, T.E. (1974), 'An Approach to the Evaluation of Changes in Travel Unreliability: A "Safety Margin" Hypothesis', *Transportation*, **3**, 393–408.

Koslowsky, M. (1997) 'Commuting Stress: Problems of Definition and Variable Identification', *Applied Psychology: An International Review*, **46**:2, 153–73.

London Chamber of Commerce and Industry (2001), 'London Monitor Survey 2000', January.

Mackie, P.J, Wardman, M., Fowkes, A.S., Whelan, G., Nellthorp, J. and Bates, J. (2003), 'Values of Travel Time Savings in the UK—Summary Report', report to the Department for Transport, January. Available at www.its.leeds.ac.uk

Mahmassani, H.S. and Chang, G.L (1986), 'Experiments with Departure Time Choice Dynamics of Urban Commuters', *Transportation Research Part B*, **4**, 297–320.

National Statistics (2002), 'United Kingdom Input–Output Analytical Tables, 1995', web edition.

Novaco, R.W., Stokols, D. and Milanesi, L. (1990), 'Objective and Subjective Dimensions of Travel Impedance as Determinants of Commuting Stress', *American Journal of Community Psychology*, **18**:2.

OEF (2003), 'The Economic Effects of Transport Delays on the City of London', July, Oxford Economic Forecasting.

Ove Arup & Partners (2002), 'Journey Time Variability', a report for the DTLR (ITEA division), May.

PDFC (2002) *Passenger Demand Forecasting Handbook*, Fourth Edition, August, Passenger Demand Forecasting Council.

Preston, J. (2000), 'A Summary of Antonio J. Bejarno Vicario (1999) Diversion Factors and Cross Elasticities', Dissertation for MA in Transport Economics, Institute for Transport Studies, University of Leeds, mimeo, Transport Studies Unit, University of Oxford.

Reed (2002), 'Travel to Work Report', May. Available at www.reed.co.uk

Schaeffer, M.H., Street, S.W., Singer, J.E. and Baum, A. (1988), 'Effects of Control on the Stress Reactions of Commuters', *Journal of Applied Social Psychology*, **18**:11, 947–57.

Small, K.A. (1982), 'The Scheduling of Consumer Activities: Work Trips', *American Economic Review*, **72**, 172–81.

Tangri, R.P. (2003), 'What Stress Costs', a special report presented by Chrysalis Performance Strategies Inc., March. Available from www.StressCosts.com

TAS (2003), *Rail Industry Monitor*.

University of Westminster (2003), 'London Commuter Survey: Rail Transport and the Office Worker', July, report prepared for British Council of Offices.
Vicario, A.J.B. (1999), 'Diversion Factors and Cross Elasticities', Dissertation for MA in Transport Economics, Institute for Transport Studies, University of Leeds.