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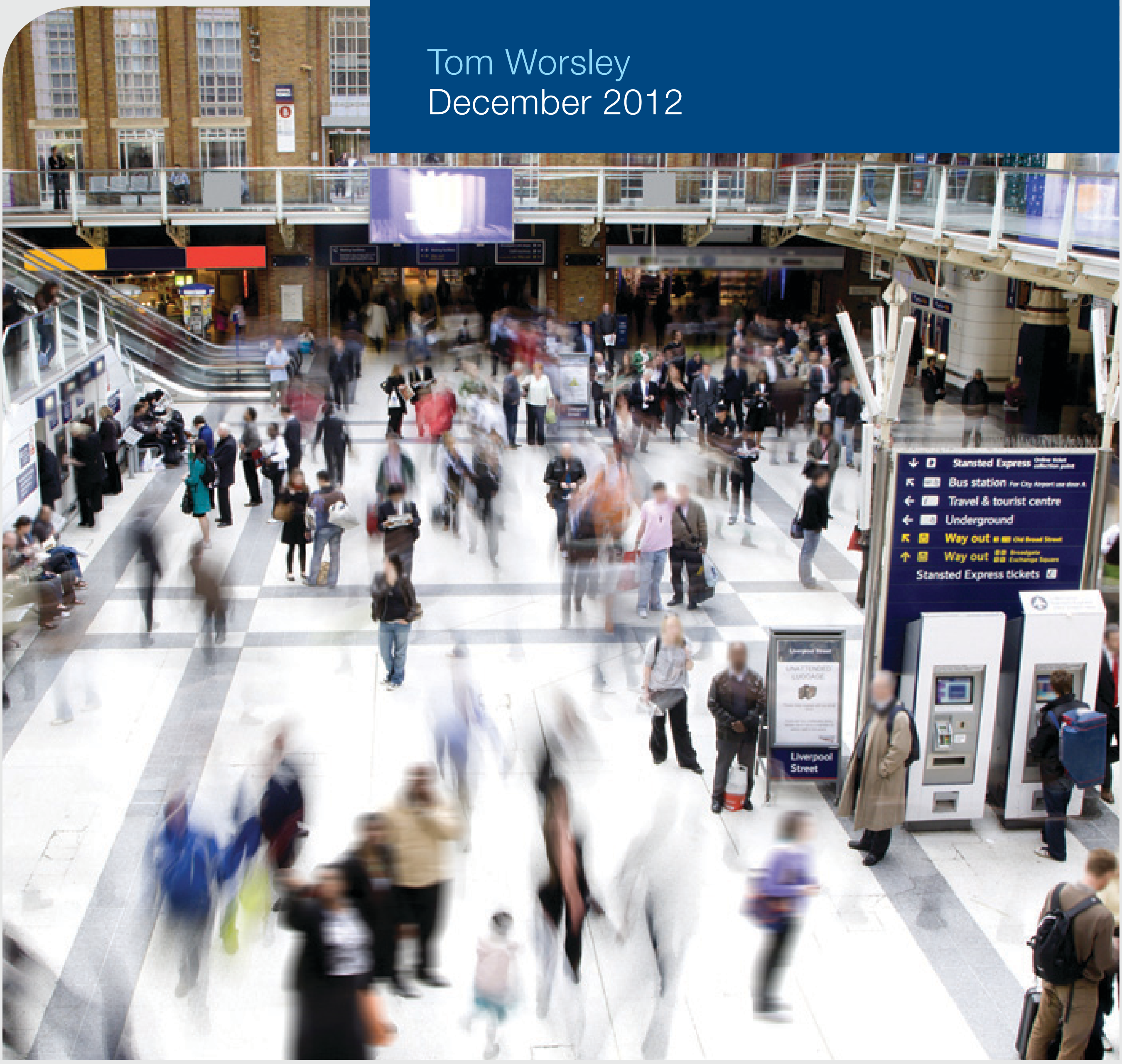
Rail Demand Forecasting Using the Passenger Demand Forecasting Handbook

On the Move – Supporting Paper 2

Tom Worsley

December 2012



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On the Move – Supporting Paper 2

Tom Worsley, University of Leeds

December 2012

This Study

The main findings of the study are reported in *On the Move: Making sense of car and train travel trends in Britain*. A series of technical reports describe aspects of the work in more detail, and are available on the sponsors' websites:

- A supporting technical compendium containing figures and tables that were prepared but have not been included in this summary report
- 'Rail Demand Forecasting Using the Passenger Demand Forecasting Handbook'
- 'National Rail Passenger Survey Data Analysis'
- A report on trends in Scotland, using both NTS data and data from the Scottish Household Travel Survey

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Disclaimer

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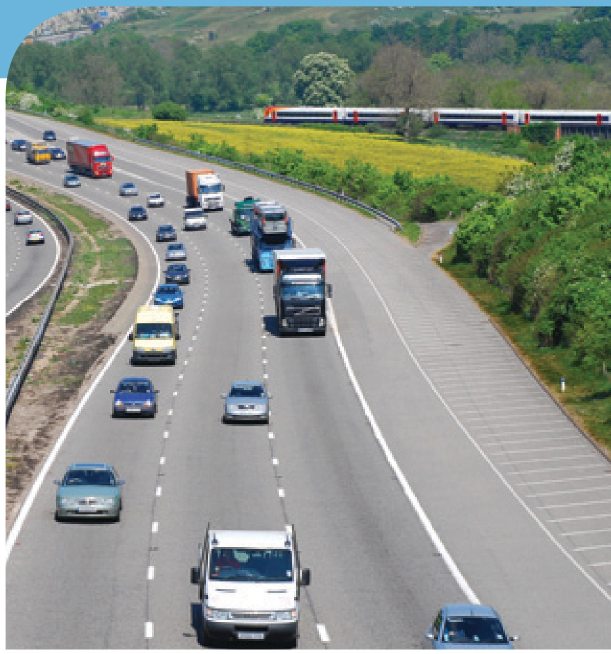
1. Introduction



The main report – *On the Move* – on the factors that have contributed to car traffic and rail patronage has identified some changes in people's behaviour which are likely to have been influenced by the opportunities they are faced with when making a trip. For example, we have noted an increase in the proportion of the population that travels by train. Transport models are a way of identifying the key factors that influence the choices people make, and estimating the strength of those influences. By combining projections of how these influences might change in the future with forecasts of the size of the population, its composition and location, a transport model provides forecasts of the trips people are expected to make, the modes they will use, the places they will go to, and the routes they are expected to take. Section 1 of this report outlines the broad principles of the conventional transport model.

Although the rail industry provides a comprehensive database of every ticket sold, which provides the station of origin and station of destination of the ticket, data on the characteristics of rail users is not generally available at the level of spatial detail that meets the rail industry's forecasting requirements. In place of a model that reflects the behaviour of individual households, rail models are based on the relationship between changes each year in the volume of passengers travelling by rail between a sample of the stations, and changes in the factors which econometric methods identify as the major drivers of rail demand. These drivers include changes in rail fares, in levels of employment in city centres, in GDP and in the quality of the rail service used. This report outlines, in Section 2, the Passenger Demand Forecasting Handbook (PDFH) and describes the rail forecasting framework as well as the set of models which provides for forecasts of flows, and which allocates these flows to the train services in the projected timetable.

Section 3 provides a brief description of the methods used to estimate the values of the elasticities that link changes in the drivers of demand with the resulting growth (or reduction) in rail patronage, and of those used to provide for forecasts of rail patronage which take account of changes to service quality, including the effects of crowding. One consequence of adopting a forecasting model based on ticket sales data and elasticity values is that it is not possible to assess the implications of our observations on the relevance of household and demographic factors, as recorded in *On the Move* for the forecasts of rail patronage.

Section 4 then assesses some of the challenges that arise in deriving estimates of the values of the relevant elasticities. It is often the case that the effects of these different drivers of rail patronage cannot easily be identified separately; another difficulty is the attribution of cause and effect. Data on past changes in some of the drivers of demand is not always available at the level of detail required. And, since the method of forecasting rail demand provides for estimates of the growth from a specific base, the assessment of the forecasting methods identifies the requirement to select a base year which is representative, not one which has been affected by any unusual features.

Without access to the models and database, it is not possible to provide a full assessment of the extent to which recent trends in rail demand can be explained by the changes in the factors that affect these trends, at a time when one of the main variables – GDP – has remained broadly unchanged. Section 5 provides a brief and very broad assessment, based on published data, of the factors that might have contributed to these trends, and the extent to which their contribution might explain the growth.

The final section, 6, provides some suggestions for possible development of the rail modelling framework and for further work that might inform such a programme.

2. Principles of Transport Modelling and Forecasting

1. Transport forecasting and appraisal models are used to predict the demand to travel and, in many cases, to assess the impact of these forecasts on the level of service offered by the transport network. Such forecasting models are also used to estimate the impacts of changes in transport networks caused by investment in capacity or decisions about managing demand by means of pricing or other interventions. The form of model most widely used is referred to as a four-stage model, with the separate stages describing the processes of estimating the trips which are **generated** by the households in the study area, their choices of **mode** and of **destination**, and their **assignment** to a route.

2. The area covered by a transport forecasting model is determined by the interventions which the model is designed to address. Some models, such as the Department for Transport's (DfT's) National Transport Model (NTM), cover all modes and the entire country, and provide a platform for testing a range of policy options. Congestion on specific routes, or the transport problems of an urban area, are addressed through local models which contain a detailed representation of the available routes and options, and of the households and other places that account for the trips on the transport network of interest, but which provide no representation of travel outside the study area.

3. Most transport models include data on the population in the study area, its location, and its access to the transport network, using census and planning data, often supplemented by special surveys. The DfT's National Travel Survey (NTS) provides data on the number of trips made over a typical week by the households in the survey. The households in the transport model are broken down into several distinct household types, by number of household members and whether they include children, by employment status, and usually by whether or not they are car-owning. The categories are selected to distinguish between households according to the number of trips that they make, using evidence from local surveys or from the NTS, so as to take account of demographic change in the forecasts of travel demand. The transport model also includes data on the location of employment and of other economic activity that attracts the trips made by households.

4. The next phase links the trips which households produce with the locations that attract these trips. The choice of mode for each trip – which, in strategic models, is generally between rail, bus and car – depends for each household type on their level of car ownership; on the cost, trip duration and convenience of the modes available to them; and on the destination of the trip. The choice of destination is determined by a measure of the relative attractiveness of each area and also by the costs, duration and convenience of the trip. Trips are then assigned to the routes on the network that would provide transport users with their quickest and lowest-cost options as a means of taking account of the effects of congestion, which, by increasing the time taken for each trip affected, induces trips within the model to seek alternative routes. The costs of travel, as incorporated in the model, include both time costs – including an estimate of the value of working time, and of time to people who are not travelling in the course of work – and vehicle operating costs.

5. The estimates of the trips on the network derived from the transport model are then compared with such data as is available on actual traffic flows on the same network and, where available, records from household surveys on the trips that people make. Where, as is commonly (and unsurprisingly) the case, there are differences between the modelled flows and actual values, the former are adjusted to reflect actual volumes of traffic. The resulting modelled flows are called the 'base case'.

6. The next phase of the forecasting process is to replace the data on the existing population by household type with projections of the population published by the Office for National Statistics (ONS), the details of which are agreed with local authorities by the DfT. The model is then used to estimate the trips that this future population would make on the assumption that households in each segment of the future population – for example a car-owning two-adult pensioner household – will make the same number of trips in the future as does the typical household of that segment in the

current population. Choice of mode, destination and route is determined by predictions from the model of the time and costs, including congestion, using the same techniques as were applied to estimate mode, destination and route choice in the base case. The model can then be used to assess the effects of changes in travel time and costs arising from changes in capacity or other interventions, and to estimate the cost and time savings that transport users would gain from such interventions.

7. There are many variations on and extensions of the classic four-stage transport model and its key elements as described above. Forecasts of changes in emissions and other pollutants are regularly derived from the estimates of changes in speed and in the fuel consumption element of vehicle operating costs. Some models focus on the peak period(s), since peak demand drives initiatives to invest in or otherwise manage capacity, whereas other models (e.g. those used to estimate CO_2 emissions) make separate forecasts of demand by journey purpose and time of day, sometimes allowing for changes in travel costs to influence people's choice of the time of day at which they travel.

8. The four-stage model has the merit that it sets out to represent transport user behaviour. Its accuracy can, to some extent, be challenged through an assessment of the responses estimated in the model. Moreover, if subsequent or otherwise better data suggests a change in responses, the model can be adapted to reflect this change. One of the factors prompting this research study was the recent evidence from the NTS showing reductions in average annual distance travelled by car by several segments of the population, raising questions about whether such trends, if indeed they proved to be more than a temporary effect, are adequately represented in the DfT's forecasting models.

9. One requirement of the four-stage model is an adequate coverage of the modes and trips of interest (for the purposes for which the model is being used) in the sample of households which forms the model's database. Both long-distance trips and trips by rail are made only by a small proportion of households in most areas of the country, and many such trips are made on an infrequent basis. Rail travel makes up around 2% of all trips, while accounting for 8% of all distance travelled. The NTS uses a spatially stratified sampling framework to identify households and the number of trips they make. However, although longer-distance trips make more use of the transport network in terms of miles travelled, the survey collects data based on the number of trips made. Since longer distance trips are made less frequently than shorter trips, relatively few of the longer distance trips are picked up in the survey despite the greater use that these trips make of the network in terms of mileage travelled.[1]

1 This under-representation of long-distance trips has been recognised, and the DfT has enhanced the NTS so that it now includes details of longer-distance trips taken within two weeks of the seven-day period for which all other trips are recorded.

3. Outline of PDFH and the Associated Rail Forecasting Method

3.1 The Rail Forecasting Database – LENNON

10. Because rail has a small share of the overall number of trips undertaken by the typical household, rail travel is rarely represented in any detail in the conventional four-stage model, other than in models covering London and other conurbations where rail has a larger market share. Even Transport for London's (TfL's) LATS (London Area Transportation Study) model takes forecasts from elsewhere (by using PDFH) for rail trips with origins or destinations outside the M25.

11. Rail further differs from road travel in that there is a comprehensive database on the origins and destinations of the various separate rail stages involved in all train trips, because, where more than one operator's services are used in the course of a trip, all ticket sales are recorded for the purposes of accounting for the allocation of revenues – to train operators and between train operators. The LENNON (Latest Earnings Networked Nationally Over Night) ticket sales database comprises a matrix covering the 2,500 or so stations on the network, containing a record of all tickets sold by ticket type (first, standard ordinary, standard reduced by type of discount: super saver, ordinary saver, season and so on). Data is provided for each of the 13 accounting periods in a year, and is available for each year since 1990. The data relates to ticket sales: LENNON does not contain any information on the train service used by the ticket holder or, in most cases, about the route taken.

12. Surveys of rail passengers provide information on the number of days on which season tickets of different periods of validity are used. Data from these surveys is used to estimate trips and distance travelled per season ticket. Surveys are also used to provide data on the origins and destinations and the frequency of use of Travelcards, and of other zonal tickets. The quality and coverage of these surveys differs between conurbations; neither Passenger Transport Executives (PTEs) nor train operators have strong incentives to collect good data on rail passengers' use of Travelcards.[2]

3.2 The Passenger Demand Forecasting Handbook

13. PDFH is a handbook which identifies all of the known drivers of rail demand and provides information on the values of the elasticities of these influences on demand. These elasticity values describe the percentage change in rail patronage that can be explained by a change in the demand driver – for example, by a 1.5% increase in GDP per capita over the course of a year. In addition, PDFH provides its users with advice on how to apply the elasticity values to investigate changes in both the external environment (such as GDP, employment and fares) and changes in all of the attributes of a rail journey that influence its quality. PDFH is only one component of the rail forecasting framework. The elasticity values are combined with data on the flows on the route, or routes, from the LENNON database for which the forecasts are required, and with forecasts of the growth in the drivers of demand over the forecasting period.

14. Prior to privatisation, the analysis that supports PDFH was the responsibility of British Rail's Operations Research team and the Handbook was owned by British Rail. On privatisation, responsibility passed to the Association of Train Operating Companies (ATOC), who set up the Passenger Demand Forecasting Council (PDFC) to oversee and manage the development of PDFH and associated models, including the MOIRA (Model of Inter-Regional Activity) train service model. PDFC funds all research and development of this rail forecasting framework. A consequence of this arrangement is that PDFH is not a public document, since PDFC needs to restrict access to those who have contributed to its development, in order to reduce the opportunities for free-riding. For the purposes of this study, the researchers were given access to specific sections of the current version of PDFH. In order to maintain the confidentiality of PDFH, the elasticity values which have been quoted in this report are indicative of the broad magnitude or are restricted to those that have been published elsewhere, primarily in *Revisiting the Elasticity Based Framework: Rail trends report (DfT, 2009)*.

2 Train operators, when bidding for a franchise, base their bid on the share of the Travelcard revenue they anticipate they will be allocated by the PTE, rather than an estimate of the passenger kilometres travelled by Travelcard holders and the average fare. Unlike bus services, train kilometres operated in the Travelcard area are not affected by the revenue allocated, and so PTEs have no incentive to increase the share of the 'pot' allocated to train operators.

3.3 EDGE – Exogenous Demand Growth Estimation

15. The EDGE database provides forecasts of the growth rates of the demand drivers identified in PDFH on a geographical basis, which can be matched with the station-to-station flows for which the forecasts of rail patronage are required. The PDFH elasticities, combined with the LENNON base year data on passenger flows on the corridor and the EDGE-based forecasts of the exogenous demand drivers, provide an initial estimate of future rail patronage. The forecasts of the variables that influence rail demand are the same as are used in the DfT's road traffic and other forecasts.

3.4 MOIRA – Specification of rail services and capacity

16. The linking of demand with supply, represented through measures of the capacity and quality of the network, is a fundamental part of most transport models. This process enables policymakers to understand the impact of congestion or crowding, which, if capacity is not increased while demand grows, will inhibit the growth in demand. In addition, forecasts are often used to estimate the impact on demand, revenues and rail-user benefits of changes to the services specified in the base case, to inform decision-makers about the case for investment in capacity.

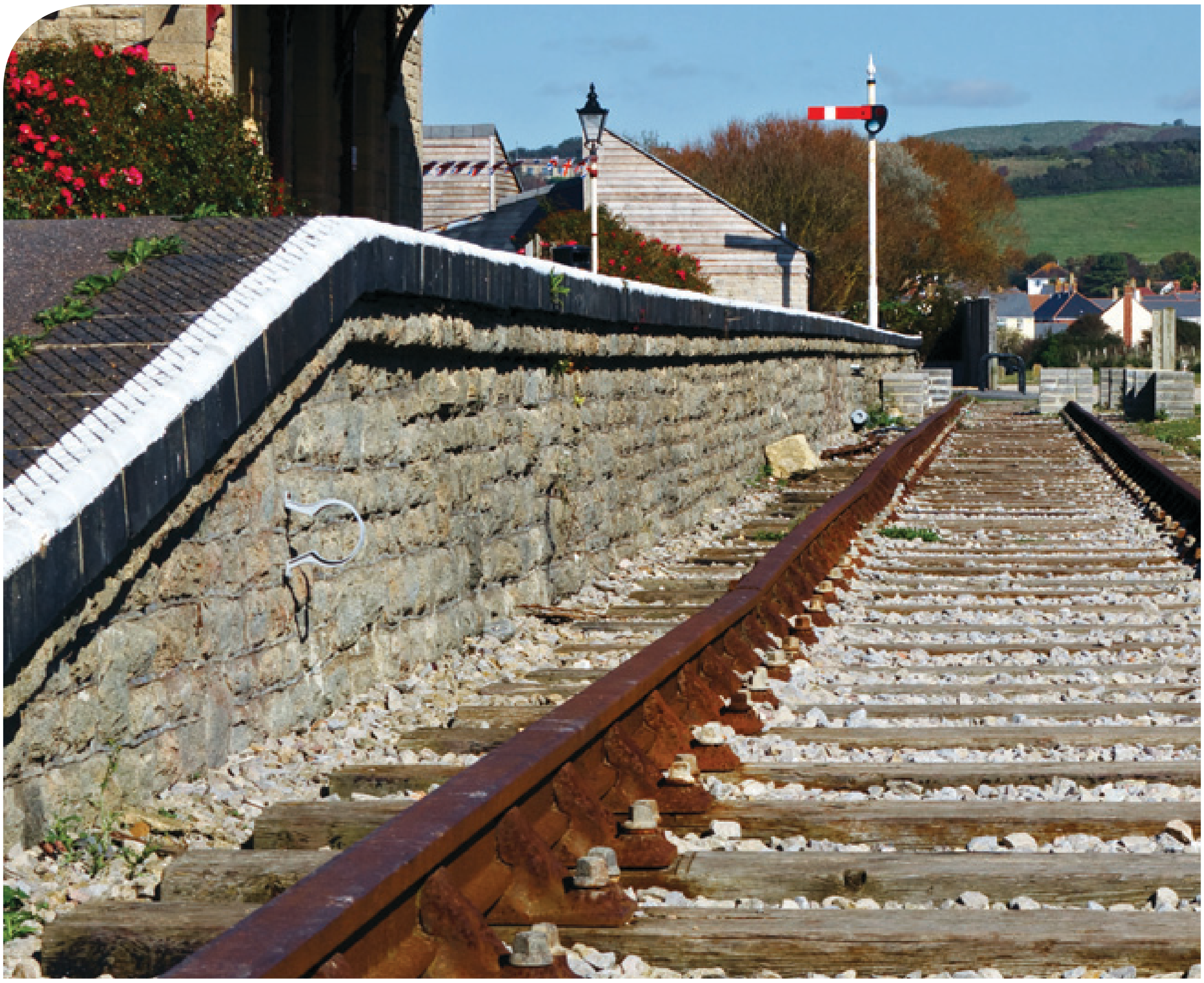
17. The supply side of the rail network is represented through the MOIRA model, which is composed of the base year and future year timetables, with any options for change set up in a separate future year timetable. The timetable includes data on train capacities. The model allocates passengers travelling between the origins and destinations identified in LENNON in both the base year and the future year flows, forecast through the PDFH elasticities in combination with the EDGE forecasts, to the trains operated in the timetable. MOIRA includes a feedback loop whereby an increase in crowding both suppresses overall demand and encourages rail users to switch to less-crowded trains despite the inconvenience of having to change their schedules. An option which increases capacity will result in passengers reverting to their preferred schedule as well as an overall increase in demand. MOIRA is also used to show the effects on demand of changes in journey time and in other attributes of the journey. These effects are expressed in the model in units of generalised journey time (GJT), with each attribute being valued in relation to what its equivalent would be if taken in terms of additional travel time. Thus a journey of 10 minutes spent in crowded conditions might have a GJT of 15 minutes (see paragraph 29 onwards). MOIRA includes a representation of passengers' preferred departure times and can thus show the effect on demand of changes in the timetable.

18. There are therefore two elements of the rail forecasting framework which influence the projections of demand growth. The first relates to the identification of the key drivers of demand and the estimation of the

elasticities for those drivers. The second is the representation, through the concept of GJT, of the combined impact on demand of the quality-of-service attributes – it is changes in these attributes which influence demand to an extent which is determined by the various elasticity values.

3.5 The geographical coverage of the rail forecasts

19. The rail forecasting framework composed of PDFH, EDGE and MOIRA can be operated at varying levels of spatial aggregation. Existing or potential train operators are concerned with services operated within the boundaries of their franchise, and need know much less about services operated elsewhere. The framework can be adapted to omit or amalgamate services which are of little interest to the user of the model, in order to reduce the time devoted to operating the model and to reduce the risk of error. The DfT's strategic analysis makes use of the Network Modelling Framework, a version of the rail forecasting framework which covers the entire network but amalgamates smaller stations to form a representative small station, so as to reduce the number of origin–destination pairs in the model.



4. PDFH Estimation Methods

20. The size of the LENNON database and the large number of variables that influence rail travel present a number of challenges. Some influences, such as changes in fares, tend to affect either all passengers or one or more segments – season ticket holders, for instance. Other influences, such as service improvements, are route-specific. The effects on demand and fare revenues of network-wide changes, such as increases in fares, will vary between routes because of different levels of crowding and a different mix of journey types and purposes, again reinforcing the need for a fairly detailed network-based model. Historical data on some of the factors that make up changes in the components of GJT (e.g. timetabled journey times) is available, while data on others, such as changes in reliability, is rarely available on a service- and route-specific level without significant additional work. LENNON data is available on a consistent basis from 1990, although 1994 data is omitted because demand during that year was affected by industrial action. Many of the values reported in PDFH are derived from the period 1990–9, supplemented in the more recent editions by an extension of the dataset to 2005 for the purpose of estimating some elasticities.

21. Time series econometric methods are used to estimate the PDFH elasticity values. Deciding the extent and nature of segmentation of passenger flows requires a mixture of analysis and judgement. Segmentation by journey purpose – key to many rail forecasting studies aimed at addressing the problem of peak capacity – is done by ticket type, with data from the National Rail Travel Survey being used to map ticket type (anytime, off-peak or season) to journey purpose. In addition, the data is segmented into six flow types – the London Travelcard area, the South East, the rest of the country to and from London (with GDP elasticities differing by direction), non-London inter-urban, non-London short-distance (<20 miles) and airport-related flows. Each segment typically contains data relating to around 700 origin–destination flows, and the data for each flow in the segment is pooled in order to reflect both overall changes in the drivers of demand over time and geographical differences, as the economies of different regions grow at different rates.

22. A number of different estimation methods have been used in the past to derive the elasticity values. In general, the more recent estimates have allowed the GDP, fares and GJT elasticities to be estimated together from the same dataset in an attempt to identify the separate effects of each of these drivers of demand. There remains a risk of error in the attribution of some of these causes – for example, while an increase in the number of services provided makes rail more attractive, and hence increases demand, such a change in rail's attractiveness is also due to a response by the train operator to the increase in passenger numbers that is attributable to the growth in GDP. In such cases, it is not always possible to distinguish between the effects of each driver of demand, and there is a risk of incorrectly attributing to one elasticity value an effect which is caused by a different driver which has changed in broadly the same direction as the effect being estimated.

23. The derivation of the elasticity values published in PDFH has been an evolutionary process. The values reflect a combination of econometric analysis of a sample of flows from the current LENNON dataset, and the judgement of analysts informed by other sources and previous LENNON-based values. There are a number of challenges that justify the modification of the values that are derived directly from the econometric analysis. Among these are:

a. Broadly similar estimation techniques have resulted in significant differences in the elasticity values when the run of years included in the analysis is changed, as it has done when more recent years have been added, suggesting an unexpected element of instability, suggesting greater changes in behaviour than seem plausible.
b. LENNON provides inadequate coverage of rail travel in most of the conurbations, and the attempts to augment the data are imperfect.
c. Some of the aspects of GJT – reliability, for example – are excluded from the estimation process because historical data on changes in these influences on demand is not readily available.
d. Other data – for example, on changes in car journey times or in the costs and convenience of travel by air – is often based on informed estimates because of the absence of good data.

4.1 GDP elasticities

24. The PDFH GDP elasticities identify the relationship between changes in GDP per capita in the nine NUTS 1 (formerly Government Office) English regions plus Scotland and Wales, and changes in rail passenger kilometres, with each flow allocated either to the region in which the trip started or to the region in which its end lay. The elasticities for business trips are estimated using data on GDP per capita at the *destination* of the trip, whereas changes in GDP per capita at the *origin* end explain the income-related elasticities for leisure trips. The weighted average GDP elasticity for all flows is above unity, as might be expected in the light of the 77% growth in rail patronage over the past 15 years, during which GDP per capita has grown by 33%.

4.2 Fares elasticities

25. Estimates of fares elasticities were derived from several separate studies which analysed flows that had experienced significant increases in fares levels. PDFH v5.0 fares elasticity values range from –0.5 in the case of commuting within the London Travelcard area to –1.2 in the case of leisure trips from the rest of the country to London. (Note the negative elasticities, which indicate that an increase in fares leads to a decrease in travel.)

26. A separate model, the Strategic Rail Authority's Strategic Fares Model, which has been updated and revised by the DfT since the abolition of the SRA in 2006, provides the basis for the guidance in PDFH on the likely switching between ticket types that occurs when the prices of different ticket types increase at different rates.

4.3 Employment and population elasticities

27. The relationship between commuting by rail and employment has been of key importance in making decisions relating to investment in rail capacity, and was the focus of the 2007 High Level Output Specification (HLOS – the statutory document in which the government indicates to the Office of Rail Regulation – the ORR – and the rail industry the level of services that it wants to see achieved by the industry from the funding it provides during a five-year railway Control Period), and a major part of the 2012 HLOS. Employment elasticities are above unity for London and around unity for other cities. The higher-than-unity value for London might be explained in terms of the greater distance from central London at which each additional worker is likely to live as demand for housing is met by development taking place further from the centre. Thus the probability of using rail as a mode increases for each additional worker. In part this might also be accounted for by an income effect, as increasing income leads London's workers to relocate in locations further from the centre and benefit from more space, leading to a greater probability that they

will commute by rail. The employment elasticities were based largely on a judgement that the values for the growth in employment would be somewhat in excess of unity for the reasons given above. The 1990–9 dataset which served to inform the fare, GDP and GJT elasticities excluded data on season ticket flows and thus did not provide the data needed to make estimates of employment elasticities. For the majority of passenger flows, rail patronage is assumed to increase in line with population growth at the origin of the trip, with an elasticity of unity[3]. Since commuting flows are determined by employment at the destination end of the trip, population growth has no direct effect on such flows. However, if population on a given route is forecast to increase more rapidly than the regional average, then commuting demand is predicted to increase at the same rate (i.e. with an elasticity of 1.0). No corresponding reduction is made on those routes with a below average rate of population growth.

4.4 Effects of other modes

28. Competition from other modes can have a significant effect on route-specific flows, and guidance is therefore provided in PDFH on assessing the impacts of changes in other modes on these flows. Analysis of the influences on rail demand, which includes a broad estimate of changes in car journey times, shows that an increase in road congestion is one of the factors that has contributed to the growth in rail demand, helping to explain the more rapid growth in rail trips to the increasingly congested London area. PDFH provides a series of cross elasticities for use in forecasting rail demand in response to changes in car ownership, fuel costs and journey times; and bus costs, journey times and headway. Changes in the costs of air travel and the frequency of flights influence only the longest-distance trips. Car cost and journey time elasticities are typically between 0.1 and 0.3, as are the equivalent elasticities for bus: fares and travel times. Advice is also provided on the application of diversion factors to estimate modal shift in those circumstances where rail's market share is atypical and the standard cross elasticities are therefore unreliable. Estimates of these cross elasticities have come from a number of sources.

3 That is, an expectation that a given percentage increase in population will result in exactly the same proportionate increase in patronage.

4.5 Changes in journey quality – generalised journey time

29. PDFH identifies several characteristics of a rail journey which, if changed, are likely to influence demand. These attributes are expressed in broad terms of generalised cost, a unit of measurement used throughout the four-stage transport modelling process, which provides a means of putting travel time and the money costs of a trip on a common basis through use of a money value of time. The approach in PDFH differs from the conventional method, in that it omits the money element of the journey, which generally comprises the fare paid; this is both to facilitate computation and because train operators regard changes in unregulated fares as being of commercial interest, and often develop their own modelling methods in relation to this area rather than rely on PDFH. The values quoted in PDFH come from a range of stated preference studies[4] carried out at various points in time.

30. PDFH uses the concept of GJT in terms of elapsed time rather than in money values, with penalties or multipliers attached to time spent outside the rail vehicle or within a crowded vehicle. PDFH gives guidance on the weights or penalties to be put on the various attributes of a rail journey – for example, season ticket holders on a journey of less than 15 miles perceive an interchange as having a value equivalent to around 10 minutes of additional travel time, whereas for a leisure traveller from King's Cross, the penalty incurred on account of having to changing trains at Newcastle, in the 200–300-mile distance band, might be as much as an hour. Further penalties are applied to modify these values according to whether or not the connection is guaranteed, and the environment of the interchange station. Values are attributed to waiting and walking time for application to those schemes which affect either service frequencies or station design, and to quality of rolling stock. The effect of changes in station facilities and the overall station environment is modelled through an uplift on the initial estimate of demand – for example, a shift from the absence of any information about disruptions to one in which current information is displayed might add 5% to commuter demand and 10% to business and leisure patronage.

31. The effect of changes in reliability is taken into account through putting a multiplier greater than unity on each minute by which a train is late. PDFH provides guidance on the weights on minutes travelled in crowded conditions, which vary both by level of crowding (measured in terms

4 According to the then Department for Transport, Local Government and the Regions (DTLR), "Stated preference techniques rely on asking people hypothetical questions, rather like a market research interview. The aim is to see how people respond to a range of choices, and thus to establish the extent of collective willingness to pay for a particular benefit (or their willingness to accept payment in exchange for bearing a particular loss). Stated preference questionnaire-based techniques can be contrasted with revealed preference analysis which aims to deduce people's willingness to pay from observed evidence of how they behave in the face of real choices" (DTLR, 2002: 7).

of passengers standing per square metre of available floor space) and sector (London and SE, Regional and Intercity), with the penalty varying according to the number of standing passengers and by sector (intercity and regional).

32. PDFH also provides guidance on modelling the effects of new stations or services. Much of this guidance is aimed at developing specific models based either on a conventional four-stage multimodal transport model or using a simplified gravity model[5] to estimate demand at a new station and to determine the extent to which that demand is likely to have been transferred abstracted from other stations. A final section of the Handbook provides estimates of the impact on ticket choice in the case of competition from non-franchised open access or other operators who offer tickets with restricted availability at lower fares and with longer journey times, with the extent of passengers choosing to buy restricted tickets depending on the extent of any saving, and the additional travel time.

33. The values for the various multipliers and uplifts to demand resulting from changes in journey quality are derived from a wide range of sources. Some, but not all, of these effects have been identified and incorporated in the estimate of changes in GJT which forms part of the econometric estimation of the drivers of rail demand. Others have come from studies intended to determine the impacts on demand of a specific improvement, such as might be needed to inform decisions about a programme of station improvements. There is a risk, however, that such improvements, if they have occurred in the past, might already be accounted for in another of the demand drivers, or that the application of such values recognises only improvements and fails to take into account the effect on demand that might occur over time as the quality offered by the improvements deteriorates, whether in absolute or relative terms.

5 A gravity model makes forecasts based on the population of potential rail users in the station's catchment area, defining the catchment area in terms of the costs and time of accessing the station, with increasing distance from the station reducing the proportion of potential users.

5. Critical Assessment of PDFH

5.1 The lack of data on the characteristics of the passenger or trip in LENNON

34. The LENNON database does not permit any analysis of the particulars of the ticket holders or of the trips that they make beyond the station-to-station leg recorded. It does not therefore provide the basis for developing a traditional four-stage transport demand forecasting model. The NTS, the only other regular national survey of travel patterns, does not provide sufficient coverage of rail trips to support a database which would give the spatial detail required for rail scheme investment appraisal and forecasting purposes. A further potential source of information, the National Rail Travel Survey (NRTS), is a one-off survey of rail passengers, carried out between 2004 and 2005, with data on London trips taken from the 2001 LATS survey. While the NRTS has the potential to enhance the NTS dataset, the absence of any income data from the London surveys, and the failure to repeat the survey to cover further years, puts limits to the value of the information in this survey for modelling and forecasting rail patronage.

35. The absence of data on the precise origins and destinations of the trips (as opposed to simply which train stations mark the start and end of the rail leg of the journey) makes it impossible, without modification, to directly identify the effects on rail patronage of changes in access and egress to or from stations. Nor is it generally possible within the rail modelling framework to estimate the effects of any shift in the location of employment in urban areas from the urban fringe to sites close to stations. The MOIRA model has been enhanced in the case of London flows, and now includes a representation of the Underground and DLR (Docklands Light Railway) networks so as to identify the impact on demand, and on the choice of mainline station, of changes in the Underground network. This part of the model is also used to show how changes in the location of jobs within central London affect the stations which commuters use, and their choice of route.

36. The rail modelling framework therefore cannot identify, without *ad hoc* modifications, the extent to which an improvement on one route might encourage existing rail users to shift from a broadly parallel route. It does not provide a means of separating the transfer from other rail routes from that part of the increase in demand that are new trips or have switched from modes other than rail.

37. The conventional four-stage transport model allows transport users to change the destination of their trips on account of changes in the relative attractiveness of different destinations, or as changes in transport networks encourage them to make the switch. Part of the explanation of the recent growth in rail demand might be that destinations well served by rail but difficult to access by car, such as large urban centres, now attract a higher proportion of trips than in the past. This would be consistent with the finding from our NTS analysis in *On the Move* that there has been an increase in the proportion of the population that travels by train.

38. Beyond this, however, it is not possible to link the continuing increase in rail patronage with the trends in people's travel patterns which make distinctions by age group, gender and other characteristics that we have observed in our analysis of the NTS, as noted in section 4.4 of *On the Move*. And because the rail forecasting framework is confined to the single mode, albeit with cross elasticities to provide a broad indication of the effects of changes in motoring costs on rail patronage, it has not been possible to establish the extent to which those groups in the population whom we observed to have increased their rail use – in particular, men living outside London but travelling to London for work-related purposes, who have at the same time reduced the amount that they drive – have contributed to this growth. However, the rail forecasting framework contains a level of geographical detail covering flows between individual stations which meets the requirements of train operators, and which is more accurate than the estimates made of the origins and destinations of the traffic flows observed on the highway network.

5.2 Elasticity values

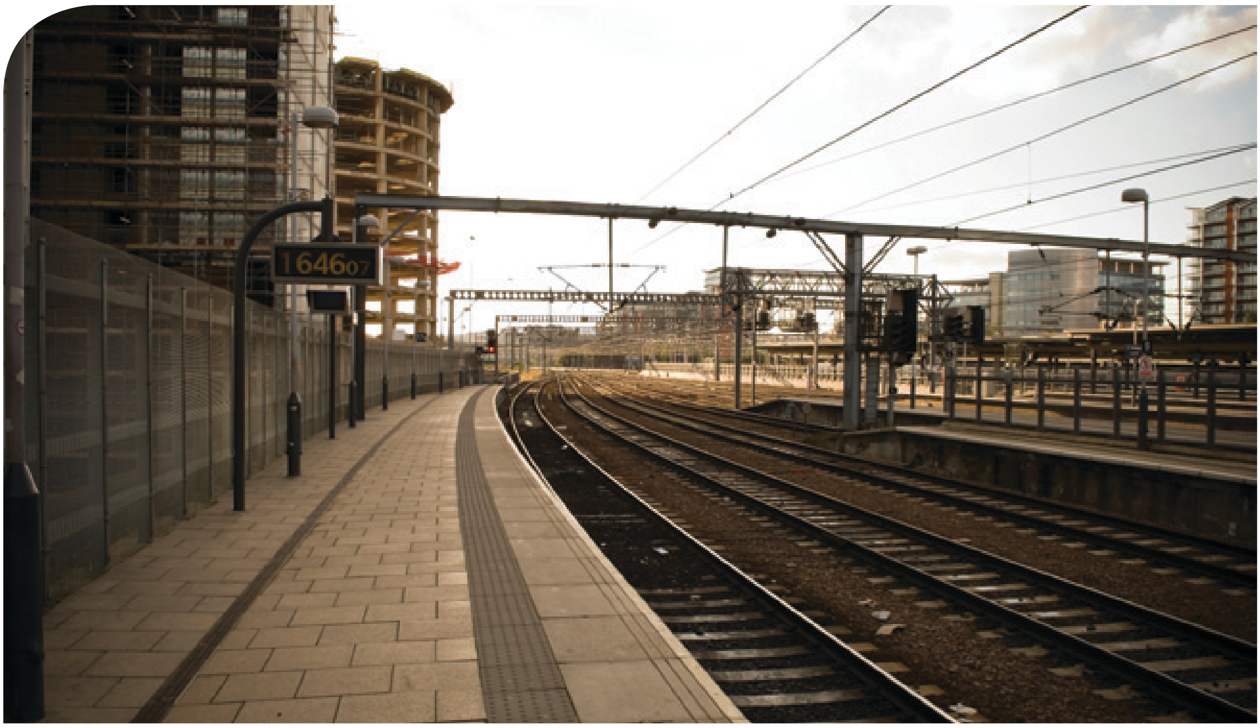
39. Estimation of the PDFH elasticities presents econometricians with a number of technical challenges. Elasticity values are estimated using time series data on station-to-station flows for the appropriate flow group and market segment (e.g. commuting within the London Travelcard area). This is combined with ONS data and other sources on changes in the main drivers of demand, with the analysis also serving to identify which of the possible drivers best explains recent trends. The time series data is then pooled across all origin–destination pairs in each flow group and market segment.

40. Potential sources of error arise because the drivers of demand cannot be mapped directly onto the station-to-station flows. For example, data on gross value added (GVA) per capita[6], the variable which is a major contributor to changes in rail leisure travel, is available over the period from 1990, the first year of the LENNON database, but only at the level of

6 GVA is a measure used for the purposes of drawing up estimates of GDP for national income accounting purposes. Regional GVA measures the value added by all firms in the region by deducting from the value of what each sector based in the region produces the value of the goods and services purchased from other industries.

the nine English regions. The differences in economic growth over time between two different places served by a station within a region may well be as great as – or greater than – the differences in growth between regions. The local economies of Hull and Leeds, for example, have developed at very different rates, which would be expected to result in differing rates of growth in leisure or business rail travel from or to these cities. However, the regional GVA data provides only a single estimate for the entire Yorkshire & Humberside region, thus implying that broadly similar rates of growth in rail patronage would be expected for the two cities. Data on GVA and GVA per head has been published by ONS at both the NUTS 2 sub-regional and at the 139 NUTS 3 local area levels since 1995. There is a strong case for investigating the use of more local GVA data in deriving the GDP elasticity values.

41. The employment elasticities, which constitute the main influence on commuter traffic, do not distinguish between office and other employment. Evidence from the NTS suggests that the propensity to use rail for commuting varies by income and type of job. A study carried out by Segal et al. (2010) for PDFC of the recent growth of rail demand in a number of major cities in England and Wales observed a growth in city-centre office employment in locations close to stations, which tended to encourage longer-distance rail trips, while more traditional blue-collar jobs on the fringes of the city centre were declining. A model based on the net growth of employment, without distinguishing between sectors more or less likely to travel by rail, would tend in such cases to underestimate demand. The study also identified a reduction in the availability of city-centre parking, further increasing rail's share of the market.



42. Estimation of the elasticity values is made more difficult on account of the large number of variables which affect rail demand, and the fact that some of these influences on demand, such as levels of crowding and service frequency, are both a *cause of* increased demand and an *influence on* demand. Population growth is closely correlated with the growth in GVA per capita, as faster-growing regions attract the more productive jobs.

43. While data on most of the train service quality variables is available – and so the effects of changes in these variables can be taken into account when estimating the fare and GDP elasticities – data on changes in car journey times for each of the station-to-station flows has generally not been obtainable, and various assumptions have been made on the basis of published data on vehicle speeds by road type and region. There are therefore some limits to the reliability of these estimates of the cross-modal effects. They do not, for example, provide a basis for estimating the extent to which the recent growth in rail patronage might be attributed to increasing road congestion. More recently, a database on car journey times has been derived for the Revisiting Study, a study commissioned by the Department for Transport to review some of the elasticity values used in PDFH (DfT, 2009). In practice, though, for many of the users of the rail modelling framework, a broad indication of the extent to which the future cost of car travel is likely to affect a franchise bid, or the case for an enhancement of rail capacity, is likely to be adequate.

44. Estimation of fares elasticities, and the representation of the fares that passengers pay, presents a challenge as various forms of advanced purchase tickets are increasingly used. Inclusion of these tickets in a measure of fares changes, which is based on a weighted basket of fares, ignores the inconvenience that passengers are willing to accept when using a ticket which is restricted to a specific train. As far as we are aware, there is no published research which would help to quantify the trade-off between fare and flexibility, and thereby provide a better measure of the passenger's perception of the cost associated with the acceptance of these restrictions.

45. Elasticity values estimated directly from the LENNON database have, over time, provided some counterintuitive results. For example, an analysis of the data for the period 1990–8 (Wardman & Dargay, 2007) showed a negative distance value for the GDP elasticity, suggesting a tendency to shorten trips as income increased, which is contrary to the evidence from the NTS and other studies. The elasticity values published in PDFH are based on a combination of the econometric analysis of the LENNON dataset and judgement derived from other sources, including meta-analysis of a wide range of studies. However, although some information is provided in the section of PDFH which discusses the sources of evidence, evidence about the weight attached to the various values, and the balance between the LENNON analysis and the other studies, often remains unclear.

5.3 The choice of the base year

46. PDFH forecasts are of the growth in rail patronage on a specific station-to-station flow. Because they are constrained to specific origin-to-destination pairs, the change in passenger kilometres is generally the same as the change in the number of trips. The base year to which the growth factors are applied is a key element in providing a reliable forecast. In the case of HS2, for example, the use of a 2007 base year for the initial modelling showed what many critics claimed were implausibly high forecasts of growth on the corridor. However, the introduction of new, faster and more frequent trains on the West Coast Main Line early in 2008 increased patronage on most of the long-distance flows by more than one third. While the HS2 forecasts took these changes into account, this was not immediately apparent to critics of the scheme, who were confused a second time when new forecasts, with a 2010 base reflecting the current service pattern, showed a slower rate of growth but higher overall demand. The potential for errors on account of the base year being affected by special unidentified factors is an issue that needs to be managed in the case of specific flows. In the past, such factors have also had an impact on the aggregated forecasts. For example, forecasts using as a base one of the years immediately after the Hatfield accident (of October 2000) tended to underestimate growth if they failed to make allowance for the catch-up in patronage once service levels were resumed and passenger confidence restored.

5.4 Segmentation by ticket type and flow group

47. The segmentation of PDFH markets into the three categories 'business', 'commuting' and 'all other purposes' would seem to go as far as is feasible, given the limitations of the data and the absence of any information about the characteristics of rail passengers. The segmentation into the six flow groups[7] is based on judgement and on evidence from the econometric analysis, which shows, for example, elasticities for long-distance trips to/from London differing by direction and (although this is not in the current version of PDFH) a GDP elasticity which varies by distance. It is possible that alternative aggregations of flows would provide more reliable estimates of the elasticities. The Revisiting Study, for example, added flows from the Eastern region to the flows from the rest of the South East when estimating the elasticities for season tickets to or from London.

7 The London Travelcard area, the South East, the rest of the country to and from London (both with GDP elasticities differing by direction), non-London interurban, non-London short distance (<20 miles) and airport flows.

5.5 Changes in technology

48. As is common in other forecasting models, no specific account is taken in PDFH of changes in technology. For most modelling purposes, technical progress moves broadly in line with GDP and is thus subsumed within the GDP elasticity. However, there is a strong case for taking some specific account of recent changes in technology which would seem to make travelling by train relatively more attractive than in the first years of the data used to estimate the elasticities. There are two aspects of the effects of technical change on rail travel. The first relates to changes in the ease of access to rail services, by which means options are provided for online booking, and passenger information is furnished to travellers both before and during the journey; this is promoted mainly by the train operators (although often with private sector involvement in developing and marketing the apps). The second is an external effect whereby technology has, over the past decade or so, enabled passengers to make better use of their time when travelling by rail.

49. Furthermore, many of those who submitted evidence to the Independent Transport Commission to inform this research drew attention to the recent adoption of technologies which have enabled a level of communication and entertainment while travelling by train which is broadly comparable in terms of quality with that available in the office or at home. Their conclusion was that this has made train travel, other than on the most crowded services, an activity that has become more attractive relative to other activities and, in particular, relative to car travel. This reduction in the disutility of GJT is likely to be one of the causes of the recent rapid growth in rail patronage, and a reason that this growth has generally continued throughout the recession.

50. Despite the plausibility of this explanation, we can see no way of estimating the size of this effect or its impact on rail forecasts. Even if surveys were capable of identifying the reduction in the disutility of travel time brought about by the availability of technology, we have no means of forecasting how this aspect of technology is likely to develop in the future. Moreover, in the longer term, if the driving of cars becomes automated, then car users may be able to use their travel time equally productively, thereby eroding the advantage temporarily gained by rail.

6. How Successfully Does PDFH Represent Recent Trends in Rail Patronage?

51. Data on rail travel is published by the ORR at higher, or simply different, levels of aggregation (journeys and passenger kilometres for London & the South East, inter-urban and regional, and journeys by Government Office Region) than would be required to apply the PDFH elasticities to estimates of the drivers of these flows and validate their values against more recent data. Data on past values for some of the main drivers of demand, including those defining changes in GJT, is not available from published sources. It is therefore not possible, without access to the LENNON dataset, to attribute the recent growth of rail patronage to the drivers of demand, and reach any firm conclusion about the model's ability to explain recent growth in the circumstances of the recession.

52. Some broad assessment of recent trends is possible. Part of the recent growth in rail patronage, which has taken place during a period when GDP per capita has remained almost unchanged, can be explained by the increase in car fuel costs. The PDFH car fuel cost elasticity varies between 0.19 and 0.34, with the value for most flows being set at 0.25, other than a value of zero for commuting flows to London. Car fuel costs increased by 24% between 2007 and 2010 and have remained broadly stable since then; if the elasticities were to hold for such substantial increases in costs, this would account for growth in rail patronage of around 6% over the three years 2007/8–2010/11, a period during which actual growth was 16%. However, the year-to-year changes in fuel costs and rail patronage over this period did not match closely, with fuel prices falling between 2008 and 2009, a year in which rail patronage grew by 1%. It would appear that rises in car fuel costs explain only around a third of the growth in rail patronage unless the interaction between the two modes is much stronger than the evidence used in PDFH suggests. Changes in car journey times also have an impact on rail demand – although, when compared with fuel costs, such changes tend to be small over a short period. Data on traffic speeds since 2007 shows a slight increase in speeds, which might offset some of the transfer from car accounted for by higher fuel costs.

53. Recent years have also seen improvements in reliability and service, amongst which the most significant were those introduced on the West Coast Main Line early in 2008; these were significant enough to have had an impact at an aggregate level. The increases in capacity specified in the 2007 HLOS will also have had an impact on demand, although these increases in capacity may have done no more than offset the impact of increased crowding which resulted from a growth in demand. The effect of these improvements on aggregate demand cannot be estimated without access to the modelling framework and a full set of data.

54. The influence of increases in rail fares on recent trends in rail demand is not easy to establish without access to more detailed information than is published and to the rail modelling framework. While average real revenue per passenger kilometre has remained broadly flat since the recession, the ORR fares index shows an increase in real fares of 7%. Applying the fares elasticities in PDFH suggests that this would offset perhaps half of the increase in demand attributed to the rise in car fuel costs.

55. These broad indicators of the extent to which the rail forecasting framework appears to explain recent trends in demand suggest that a significant unexplained factor remains. A comparable situation arose prior to the 2007 recession, when demand was increasing more rapidly than was explicable by PDFH. A study commissioned by PDFC showed that responses to income growth were lagged. Demand for rail was catching up following the reduction in passenger kilometres after the disruption in services as a consequence of the Hatfield accident in 2000, and in the longer run PDFH could account for most of the growth in demand over the previous decade. However, there is no recent equivalent to the Hatfield effect, and it might be argued that enough time has passed since the start of the recession to rule out an explanation relying entirely on the possibility that rail users take time to adapt their travel patterns. Some hypotheses, such as the inflexibility of the housing market, might furnish a reason for the commuter sector to hold up during the first few years of a recession.

But it seems unlikely that the continuing growth across all sectors and all regions can be attributed to a number of short-term factors which, while a feature of the recession, are not directly related to GDP. Further work, using the latest PDFH elasticities and current versions of the EDGE and MOIRA models, would be needed to reliably demonstrate the strength of any additional effects and the extent of any remaining unexplained factor, and to explore whether the solution might lie in updating and improving the current framework or in developing a model which more closely reflects rail passenger behaviour, or indeed in some combination of the two, depending on the questions which the model is required to inform.

56. The focus of this study on PDFH should not be taken to imply that Network Rail and other project sponsors rely exclusively on the published version of PDFH, or that all rail forecasts are derived from elasticity-based models. The forecasts of growth in commuting demand to certain English cities (see paragraph 41 above), which underpin the options assessed in Network Rail's Route Utilisation Strategies, have taken into account factors such as the change in the composition of employment and the increase in office space close to stations, modifying the PDFH estimates over the period during which these changes are expected to occur. As noted in paragraph 32 above, PDFH recommends that forecasts for new stations and other applications with little or no demand in the base year, are based on a full four-stage model, or a simplified version thereof.

7. Options for Further Analysis

57. We recommend following up a number of options. The development and implementation of an alternative modelling framework, based on a more disaggregate behavioural approach, will take time and resources. It is not clear whether a model of this form could be set up and maintained, or how successful such a model might be in providing new insights into people's choice of mode and destination to better inform transport policy and investment decisions. We recommend that options for developing an alternative model, probably based on the DfT's NTM rail module, should be investigated, since we believe that there would be benefits from access to a model that better reflected individual behaviour and had the potential to assess more than marginal changes. We anticipate a continuing requirement for a PDFH-based elasticity forecasting framework, which has many uses and is capable of being adapted to suit train operators' specific requirements. There are many cases of train operators developing bespoke versions of PDFH to incorporate their understanding of the commercial and local circumstances of their operations. The recently published DfT project *Revisiting the Elasticity Based Framework* provides an alternative set of elasticity values, and the reconciliation of these values with those in PDFH would seem to be one of the priorities for developing a better understanding of the most recent trends in rail demand.

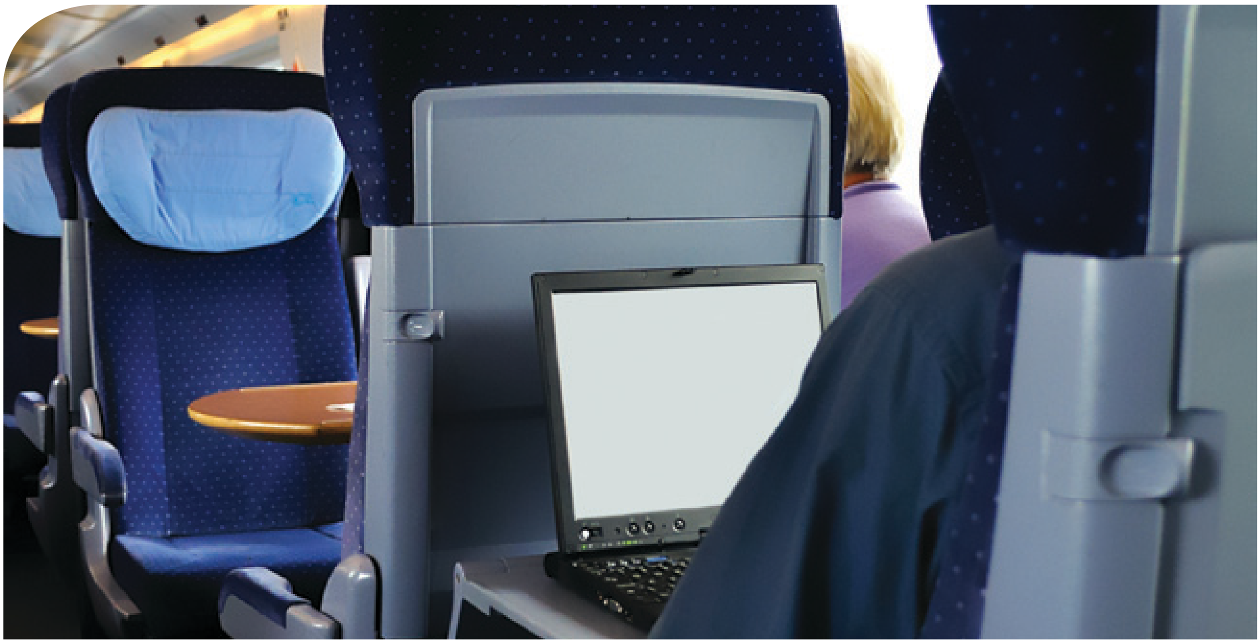
7.1 Options for a behavioural rail model

58. Most models of how people travel in major conurbations, all of which are based on the principles of the behavioural four-stage model described at the beginning of this report, include rail as one of the modes from which people can make their choice to travel. Such models have tended to focus on the journey to work (which in practice defines the peak), since investment in new capacity is determined by the peak, although many have now been updated to cover the inter-peak period. A further limitation of these urban models as a means of forecasting rail patronage is their geographical coverage. Many rail trips made to conurbations come from places at a greater distance from the city than is covered by the area where the household surveys which provide the underlying data for the model were carried out. In London's LTS (London Transportation Studies) model, which is a conventional four-stage model, estimates of rail travel from outside the London area are taken from LENNON and forecasts from PDFH. These estimates are not part of the behavioural model, which explains travel decisions and forecasts in terms of the individual and the choices faced. These limitations suggest that, while essential for the analysis of transport options in conurbations, the existing urban transport models are not a substitute for the PDFH-based forecasting framework.

59. The DfT's NTM includes a rail module derived from the CAPRI (Computer Analysis of Passenger Revenue Information) database, the predecessor of LENNON. The details of the model are complex and go beyond the scope of this study. Very broadly, the CAPRI database was used to supplement the limited NTS data on trips made by rail. The database was converted from a station-to-station basis to a trip origin and trip destination basis using estimates of access and egress costs and distances from NTS and other sources. The stations in CAPRI were then allocated to each of the area types that underpin the NTM's geography. The household and person-type characteristics of NTS rail users were assumed to be the same as the ticket holders in CAPRI for journeys between the same area types.

60. The NTM rail module provides one opportunity for investigating the scope for a rail forecasting model which better reflects traveller behaviour. The case for carrying out such an investigation would be strengthened if the model provided forecasts which looked plausible and reflected recent trends. However, as with other four-stage models, the forecasts from the NTM-based rail module show growth rates for business and leisure rail travel well below the rates experienced over the past 15 years. In place of the GDP elasticity in PDFH, the growth in rail demand is driven mainly by the reduction in the value that travellers put on a given amount of money when compared to time, which is caused by increases in incomes over time. Longer-distance trips, of which rail has a greater share, tend to have a higher money cost component relative to the time component. There are a number of reasons for this, including the often-fixed costs of access and egress, which carry a time-related penalty but no money costs, and which therefore take a larger share of the costs of a short trip. The NTM rail module replaces the model's own forecasts with forecasts based on PDFH for the purposes of DfT's policy and strategic cross-modal analysis.

61. The failure of the conventional four-stage model to provide estimates of the growth in rail travel that represent recent trends is a concern that requires investigation in advance of any work to review the case for enhancing and improving the NTM's rail module as the basis of a behavioural policy rail model. We recommend that such an investigation be undertaken. It would appear that the concept underlying the process for driving changes in trip length in the model – namely, that time becomes more valuable relative to money – might not hold true for a mode on which time spent can be deployed increasingly usefully as technology progresses. Alternatively, the modelling of trip attractions in the model might fail to account for the increased attractiveness of locations served by rail. We have noted that an increase in the proportion of the population which travels by train accounts for most of the recent growth in demand. These are some of the possible explanations of the growth in rail patronage which could be used to challenge the assumptions in the traditional model that result in its underestimation.



62. The Long Distance Model developed by consultants for the DfT provides an alternative to the NTM, although covering only a minority of rail trips. A comparison of the NTM rail module's forecasts of longer-distance rail trips with those in the Long Distance Model would be instructive, since this might indicate opportunities for possible improvements to the NTM rail module.

63. There are certain sources of data on rail passengers and their characteristics which have not been extensively exploited and which might be of value in developing a behavioural rail forecasting model. These include the National Rail Passenger Survey dataset collected by Passenger Focus and the NRTS referred to in paragraph 34 above.

64. The inability of the PDFH framework to throw any light on the characteristics of the passengers whose journeys the model is used to forecast would appear to provide a sound reason for investigating the potential for developing an alternative approach to forecasting rail patronage. This would be based on the datasets referred to above, supplemented perhaps by a survey to repeat and update the existing NRTS database. The analysis we have reported in *On the Move* shows how our analysis of the NTS data on changes in rail patronage over time can provide a deeper understanding of the possible causes of recent trends. While the approach taken in PDFH meets the requirements of many of the users of rail forecasts, in particular in respect of flows on specific routes, we believe that policymakers would be better informed by having access to a framework which provided them with a different appreciation of the causes of the growth in rail patronage, one which was linked to the social and demographic changes, the influence of which we have observed in the other parts of this study.

7.2 Improvements to PDFH

65. Any alternative to PDFH will take time to develop, and it is unlikely that an alternative will meet all of the applications to which PDFH is put. A programme for updating and improving PDFH might start from a review of a selection of flows and segments within the LENNON dataset to gain a better understanding of why these flows have changed in a way which was at variance with the PDFH-based forecasts. The study of recent growth in the English cities carried out for PDFC (paragraph 41 above) explained the rapid growth of rail commuting through the changes in the composition of employment from blue to white collar jobs and in the location of jobs away from the fringe of the urban centre to offices close to mainline stations. Forecasts of rail patronage based on the net change in the number of jobs, while following the PDFH methodology, underestimated patronage because of the failure to identify changes between sectors of employment. A restrictive policy on car parking was a further factor. One of the insights provided by this study was the nature of the change, which was unlikely to be sustained once the shift in the composition of employment had worked through.

66. The understanding provided by the English cities project suggests that future work might usefully focus on atypical but significant flows in an attempt to understand why such flows differ from the average. The West Coast Main Line upgrade provided a good example of substantial reductions in GJTs delivered over a short period. It would be reassuring to know that the PDFH elasticities and values for changes in GJT broadly explained the growth experienced on that route. There is also a case for reviewing flows which have remained broadly unchanged over a period of overall growth to reach an understanding about the factors that have suppressed the growth that has occurred elsewhere. There is, of course, a risk that no obvious explanation can be found. The lack of any significant growth on the London–Paris and London–Brussels corridors, while rail travel between London and places elsewhere in the UK has continued to increase, provides a conundrum which has cost the British taxpayer dearly.

67. The case for updating PDFH and re-estimating the income elasticities in the model using local area GVA data is discussed in paragraphs 70 and 71 below.

68. Rail patronage has increased more rapidly since the start of the recession than have real revenues from ticket sales and other sources, despite the policy of fares rising at RPI+1%. Passengers have traded down to lower-priced tickets, accepting a reduction in flexibility or in comfort for a saving in price. Real revenue per passenger kilometre has fallen since 2009. There is no provision in PDFH for such a response, which might account for part of the recent growth in patronage over a period when GDP has remained flat. The scope for modelling such a response in each market, since the potential for such down-trading is greater in the long-distance sector, would be worth examining.

7.3 Other models of aggregate rail demand

69. Two alternative aggregate models of travel demand have been developed in recent years. The Independent Transport Commission commissioned a long-distance model (Dargay, 2010) for all modes which provides elasticity values that are alternatives to some of the PDFH values. A more comprehensive alternative set of rail elasticities and alternative segmentation of passenger flows was provided by the ARUP/OXERA study commissioned by the DfT and PDFC *Revisiting the Elasticity Based Framework*. Despite the publication of reports on both of these studies and, in the case of the DfT/PDFC study, extensive supporting information and the offer of access to the Arup/OXERA database compiled by the consultants for the study, there is no evidence that the findings from these studies have been used to challenge PDFH by opening up a debate on the elasticity values. The DfT published an assessment of the differences between PDFH and the Revisiting values (DfT, 2011), but it would appear that this has not been taken further. Since the database used in the Revisiting Study extended only to 2007/8, there is no available evidence to

suggest that the recent growth in rail patronage is better explained by the Revisiting model than by PDFH.

70. Both the Revisiting Study and PDFH take data on regional GVA per capita as the main economic variable, with the Revisiting Study using disposable income per capita for most flow groups. As suggested in paragraph 40 above, there is a strong case for using NUTS 3 data and matching each station in the LENNON database to one of the 139 NUTS 3 local areas. This would change the first year of the data used in the estimation of the elasticities from 1990 to 1995, which is the first year of the NUTS 3 data, but addition to the dataset of the most recent years would result in a longer run of data than the 1990–9 data from which most of the PDFH elasticities were estimated. While GVA is only a proxy for the underlying causes of demand, it is a variable for which historical data and official forecasts are available, and can be linked to the LENNON database. There is a case for investigating alternative specifications of the income variable – for example, the Revisiting Study found that disposable income per capita provided a better explanation of growth than GVA per capita.

71. There are therefore grounds for updating both the Revisiting model and PDFH through initiating a more formal review than has been possible in this report of their performance against post-2007 rail patronage. Such a review should investigate whether there is a *prima facie* case for replacing regional GVA as the variable that explains the income-related changes in rail demand with the more local NUTS 3 estimates of income growth, whether in terms of GVA or an alternative measure of income growth. If there is evidence that intra-regional differences in the growth in GVA have some bearing on the patronage generated by different parts of the region , then there would be a strong case for re-estimating the income elasticities in both PDFH and the Revisiting models. Reducing the errors that might be introduced by the incorrect specification of the income variable in the model should help to improve the confidence that can be placed on the

other elasticity values in the framework, and perhaps also help to identify factors influencing demand which have been omitted from previous analysis on the grounds that they were then shown to be insignificant.

72. The PDFH elasticity values are based on a range of evidence, in which the econometric analysis of the LENNON database has formed a key role. As noted in paragraph 21 above, expert judgement is used to decide on the weight to be attached to various different estimates in reaching a decision about the values published in PDFH. The Revisiting Study, either in its present form or updated as proposed above, should now form part of this evidence base, as should the values from the two long-distance models referred to above.

7.4 Creating an opportunity for change

73. If further work on identifying the scope for updating and improving the rail forecasting framework is to provide worthwhile returns, the rail industry and those responsible for sponsoring it must be provided with the resources to deliver change. Moreover, making changes to modelling and forecasting methods is rarely welcomed by those responsible for implementing policy – this has resulted in the DfT delaying the adoption of recent updates to PDFH. The implementation of change is best delivered through an established process for managing change, as has been implemented in the DfT's process for updating WebTAG (the DfT's *Transport Analysis Guidance*), which involves issuing documents for consultation and in draft prior to their adoption as mandatory guidance. Agreement on a formal process for updating PDFC and adopting the changes will need to take into account the differing interests of the wide range of users, including DfT, Network Rail, the ORR and the train operators. We believe that policymakers would benefit from the greater understanding of the social, demographic and other factors which have resulted in the growth of rail patronage, and which we expect the alternative approach that we have suggested above would deliver.

74. As has been shown in this report, PDFC has been active in commissioning research aimed at updating PDFH, and the DfT has also taken a leading role, both as a member of PDFC and in its support for the Revisiting Study. However, the research and analysis that we have proposed above goes well beyond the recent programme undertaken by PDFC. The making of changes to appraisal and forecasting advice is resource-intensive and requires the input of expert advice and of specialist staff to manage its implementation. These resources are already at a premium when government and the industry are focused on delivering the outputs and policy objectives which the government has specified. It is unrealistic to expect that even the soundest of proposals for change can be implemented without some increase in the funding for research, and in the provision of specialist staff capable of implementing the changes.

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