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# 1. INTRODUCTION

## 1.1 Summary of Findings

This study has estimated monetary valuations of various types of rolling stock and stock related attributes in relation to each other. It has used a combination of Revealed Preference (RP) and Stated Preference (SP) methods. The estimated monetary valuations of different types of rolling stock do not vary greatly and this contrasts with most of the previous quantitative research findings in this area.

The largest valuation of one stock type in relation to another was 39 pence per single trip for the comparison of Wessex electrics and Sprinters. This valuation is equivalent to 4.3% of the average fare paid.

With regard to specific rolling stock attributes, this study has examined seating comfort, seating layout, ride quality, ambience, ventilation and noise. The most important attributes were found to be seating comfort, ride quality and ambience. The largest valuation obtained for seat comfort differences was 17 pence per single trip for the comparison of Networkers and Sprinters. This is equivalent to 1.9% of the average single fare. The corresponding figure for ride quality was 13 pence for the comparison of Wessex electrics and Sprinters and for ambience it was 10 pence for the comparison of Networkers and Sprinters. The maximum differences between stock types in terms of seating layout, ventilation and noise were all valued at less than five pence.

The results can be generalised to stock types not covered in this research by obtaining ratings on a ten point scale of the relevant train types or specific rolling stock attributes and entering these into the estimated model.

## 1.2 Background

A number of Train Operating Companies (TOCs) are committed to the introduction of new or heavily refurbished rolling stock as part of their franchises. As they develop their commercial strategies, other operators are likely to be considering refurbishment of their existing fleets and possible upgrades such as the fitting of air-conditioning. The value placed by customers on rolling stock quality attributes and their priorities for improvement are therefore issues which are important to the railway industry as a whole.

A particular issue for the Office of Passenger Rail Franchising (OPRAF) is whether the benefits to passengers of improved rolling stock are sufficient to warrant fare increases. This information would be needed to help assess the extent to which increases in controlled fares should be permitted to help fund the cost of rolling stock investment.

The information available from previous research by the railway industry was not very comprehensive and there were concerns about its age and the robustness of some of the results. Accordingly, OPRAF concluded that there was a need for new research into "Rolling Stock Quality and User Willingness to Pay". This report sets out the results of the study into this issue, undertaken jointly by the Institute for Transport Studies (ITS) at the University of Leeds and Oscar Faber.

### 1.3 Study Objectives

The main objective of the study was to develop up to date estimates of the value to passengers of a range of possible rolling stock improvements and therefore the justification for quality premia in controlled fares. The main focus of the study was longer distance commuter routes in areas where controlled fares apply, although we have also collected an appreciable amount of evidence for business and leisure travellers.

### 1.4 Study Process

The first stage of the study was to carry out a review of the literature relating to rolling stock quality issues. This was designed to provide the study team with a thorough understanding of previous work in the field. It provided information on the issues that appeared to be important, ideas on methodology, the results that were obtained and apparent problems with the work that would need to be overcome in undertaking new research. It therefore provided a sound starting point for the study. The results of the literature review are outlined in section 2.

The next phase of the study was qualitative research to identify the ways in which rail passengers think about rolling stock issues. This research, described in section 3, was designed to help identify key issues and ways in which rolling stock issues fitted into overall travel choice decisions. This contributed both to the design of the quantitative stage of the research and assisted in the interpretation of the results from it.

A major programme of quantitative empirical research formed the main component of the study. This used a combination of RP and SP techniques to collect the data required to develop mathematical models of travel choices. It was designed to establish the monetary values placed by rail passengers on different types of rolling stock and on specific rolling stock attributes and to determine their willingness to pay for improvements. The design and data collection element of the study is described in section 4 whilst the empirical findings are presented in section 5. Section 6 reports on the comparison of the results for the rolling stock types and specific rolling stock attributes. The estimated valuations of rolling stock improvements are contained in section 7 and the conclusions and recommendations are provided in section 8.

## 2. PREVIOUS RESEARCH

### 2.1 Key Point Summary

We here summarise our review of British evidence relating to the valuation of rolling stock improvements, their impact on demand and attitudes towards various rolling stock issues. The main points are that previous research has tended to obtain what we believe to be too high monetary valuations of rolling stock improvement, yet the effects of such improvements expected on the basis of valuation studies have rarely been detected in the analysis of rail demand. In addition, insights are obtained into methodological issues and the rolling stock attributes which are most important to travellers.

## 2.2 Background

The study commenced with a thorough review of the literature of which we were aware and a number of studies made available to us by the train operating companies. The earliest empirical studies into rolling stock quality valuation were undertaken in the mid 1980's and are amongst the pioneering SP studies in Great Britain. They came about as a result of a need for more thorough appraisal of the benefits of investment in new or improved rolling stock combined with methodological advances which allowed the detailed analysis of rolling stock attributes.

We distinguished between the following types of study:

- Valuation Studies
- Demand Impact Studies
- Attitudinal Studies

We reviewed 12 valuation studies, 7 demand impact studies and 4 attitudinal studies. Most of the studies were funded by the railway businesses and they cover a wide range of rolling stock attributes.

A distinction is also made between aggregate and disaggregate rolling stock valuations. The former represent the overall value of one rolling stock type relative to another and are particularly relevant in the case of rolling stock replacement. Disaggregate values relate to the various inherent characteristics of rolling stock, such as seating comfort and layout, internal ambience and ride quality, and these valuations are important when rolling stock refurbishment is being considered.

## 2.3 Valuation Studies

All of the studies which were primarily concerned with the valuation of rolling stock improvements employed SP exercises to elicit information on passengers' preferences between different forms of rolling stock attributes. In most cases, respondents were offered 'abstract' train alternatives, typically described in terms of rolling stock, journey time and journey cost. Early applications tended to use ranking exercises (MVA Consultancy, 1985a, 1985b) but these have largely given way to the simpler SP method of offering a series of choices between two alternatives.
The purpose of some studies was solely the valuation of a particular stock type improvement (Babtie and ITS, 1993; MVA Consultancy, 1985a; Steer Davies Gleave, 1989, 1993; TPA 1992) whilst others were concerned with disaggregate values (MVA Consultancy, 1992a; Oscar Faber TPA, 1994) and many were concerned with both and in some instances the relationship between them (Accent Marketing and Research, 1993; MVA Consultancy 1986, 1990, 1991, 1992b).

With respect to the latter, there is some evidence that the sum of the estimated disaggregate valuations exceeds the corresponding aggregate valuation. This has been termed the 'packaging effect' and it has recently been addressed by (Jones, 1997) who cites a number of possible causes. These include interaction effects, budget constraints, 'halo effects', consumer surplus effects, valuations which are influenced by the cost of provision and artifacts of the SP procedure that has been used. It could be that the process of estimating disaggregate values focuses attention on a range of very detailed attributes which leads to an overemphasis on these attributes and hence their over-valuation. The usual approach is to rescale the disaggregate valuations so that they are consistent with the aggregate valuations.

Early studies tended to estimate rolling stock valuations as constant amounts irrespective of the length of the journey (MVA Consultancy 1985a, 1985b, 1986, 1990). However, we might expect a travellers' valuation of an improvement in rolling stock to be greater for longer journeys. Allowing the value of rolling stock to vary with the time spent in it is equivalent to allowing the value of time to vary with stock type. More recent studies have tended to pay greater attention to this issue (Babtie and ITS, 1993; MVA Consultancy, 1992; Oscar Faber TPA, 1994).

In general, it seemed that the estimated rolling stock valuations, both aggregate and disaggregate, were surprisingly large. For example, aggregate rolling stock valuations or values of packages of rolling stock improvements in excess of 10% of the fare paid or which reduced the value of time by more than 20% are not uncommon.

This could be because there was a general level of overenthusiasm towards the new or improved stock, particularly stemming out of desperation with current stock that is poor. Respondents may have an incentive to overstate the benefits of new stock in order to increase the chances that the stock is improved and the magnitude of the improvement, particularly since the purpose of most rolling stock valuation SP exercises is quite transparent so that the disincentive to strategic bias is minimal. It may also be that the rolling stock valuation includes other benefits which are not an inherent feature of rolling stock but which can be associated with rolling stock improvements. Examples include reduced crowding and improved reliability. Finally, the unfamiliarity with some of the rolling stock under consideration, along with difficulties in accurately and succinctly presenting different types of rolling stock, could have had a bearing on the results obtained.

## 2.4 Demand Impact Studies

A number of studies have attempted to estimate the direct effect on the volume of rail ticket sales of the introduction of new rolling stock. The schemes examined include the Midland suburban and Great Northern electrifications (Operational Research, 1986), the introduction of High Speed Trains (Shilton, 1982), the introduction of Sprinter trains on various services as replacements for a variety of stock types (Operational Research, 1989a, 1989b, Wardman, 1993), the introduction of Wessex electrics between London and Weymouth (Wardman, 1993) and the introduction of InterCity 225 stock on the East Coast Main Line (Operational Research, 1993; Wardman, 1994).

The analysis of rail ticket sales data to discern stock type effects would seem to be a worthwhile exercise for two reasons. Firstly, rail ticket sales data has for some time been regarded to provide a reasonably accurate account of rail demand and it generally supports the estimation of robust models with plausible elasticity estimates. Secondly, SP studies suggest that the impact of rolling stock on demand could be quite high and if this is so it ought to be detectable from such analysis.
The estimated effects of rolling stock on rail demand tend to be low, and to be associated with rather large confidence intervals, although some statistically significant effects have been obtained. However, in general the findings do not support the valuations obtained from SP studies.

## 2.5 Attitudinal Studies

Many of the valuation studies contained qualitative aspects which explored travellers' attitudes to various aspects of rolling stock (Accent Marketing and Research, 1993; MVA Consultancy, 1985a, 1985b, 1986, 1990, 1992; Oscar Faber TPA, 1994). In addition, there have been some attitudinal studies which have focussed entirely on such issues (DHV Economics, 1995; Focus on Research, 1991; Oxford Research Agency, 1990; Scotrail, 1991).

Such studies are quite wide ranging yet tend to be very specific to a particular situation. Drawing general points from somewhat disparate results is therefore not straightforward. One important finding of these studies is that, amongst regular travellers, there is a high level of awareness of actual refurbishments but that this awareness is somewhat less when 'minor' improvements have been undertaken.

Another finding is that although there are clearly differences across different types of travellers in their attitudes towards actual improvements and priorities for further improvements, the most important rolling stock related features are commonly:

- cleanliness
- information provision
- seating layout, comfort and availability
- toilets

There is also evidence that the estimated valuation of a facility may well depend on experience of that facility.

## 2.6 Conclusions from Literature Review

Concerns arose in the literature review about the monetary valuations obtained from SP studies. These valuations often seem to be too large and would imply that even relatively minor changes in rolling stock variables would have noticeable effects on rail demand. For example, a rolling stock improvement equivalent to a 10% fare reduction can be expected to have a significant effect on demand given a fare elasticity of unity in the leisure market.

In contrast, studies of the impact of new stock on rail demand have generally discerned only small effects even after some quite substantial improvements in quality. Any valuation exercise based on SP methods must therefore proceed carefully and the opportunity to supplement such data with observations of actual choices amongst different types of rolling stock should be explored.

On the subject of estimating the valuation of rolling stock improvements, the Passenger Demand Forecasting Handbook (2nd edition) states:

> *Improvements in rolling stock usually occur at the same time as other major service improvements but account for only a small proportion of the total effect, making estimation difficult. Studies of High Speed Train introduction, suburban electrification and Sprinter have all tried to separate out effects which are related to journey time from those which relate to image or rolling stock effects, but all have failed to make statistically significant measurements of either one effect or the other.*

Whilst it is no longer true that statistically significant effects of rolling stock on rail demand have not been discerned, the main point is that the above problem relates to time series analysis of rolling stock introduction based on ticket sales. An alternative way forward is provided by what is essentially a cross-sectional RP approach, involving the comparison of different stock types at a given point in time and undertaken at the level of individuals rather than rail ticket sales. The judicious choice of flows should ensure that serious correlation problems do not arise and that the actual choices made by individuals yield information on the valuation of different stock types.
Although we have concluded that cross-sectional RP methods should be used in the valuation of rolling stock improvements, we are not aware of previous studies which have done this.

The literature review pointed to the importance of cleanliness, information provision, toilets and seating issues. Cleanliness is not an inherent feature of rolling stock and we have not pursued this issue. Nor did we further consider toilet provision since it is not an issue for longer distance services and for shorter distance services it is tied up with whether toilets are provided at stations. Information provision can be a feature of rolling stock design but there are many other aspects to it which are not intrinsically linked to rolling stock and hence this has not been pursued. However, the seating issue was subsequently addressed.

Even though there is a relatively large amount of quantitative evidence on rolling stock valuations, most of it relates to InterCity stock types, is not readily transferable and is somewhat dated. There is not a great deal of evidence relating to the various types of suburban stock and the trains typically used in other major conurbations. Hence further research in this area is warranted.

There is some evidence that the valuation of rolling stock depends upon the experience of it and this will need to be borne in mind in the design of any SP experiment. We could expect to provide a firmer base for SP exercises by offering choices between existing train types with which the respondent is familiar. However, we are unaware of studies which have examined this as the basis for a widespread comparison of different types of rolling stock.

We also conclude that the value of rolling stock improvement ought to be allowed to depend on the amount of time spent in the train.

# 3. QUALITATIVE RESEARCH

## 3.1 Key Point Summary

One of the key points to arise from a large scale qualitative research exercise was that rolling stock issues were certainly not a central concern of passengers and that the values of rolling stock improvements are likely to be low. Care needs to be taken to distinguish between inherent rolling stock attributes, of which seating arose as the most important, and factors which can be associated with different stock types such as reliability and crowding. There was little evidence that rolling stock affected travel behaviour and any RP based approach would therefore need to be carefully piloted.

## 3.2 Introduction

The qualitative stage of the research was designed to establish how rail passengers think about rolling stock issues and their priorities for improvement. This was required, firstly, to assist in the design of the quantitative surveys by ensuring that, in conjunction with the results of the literature review, they focussed on the factors of greatest importance and posed issues in a way which related to how rail customers think about rolling stock issues. Secondly, the research was designed to illuminate any complexities involved in perceptions of rolling stock. This was intended to provide information on aspects of the choice process that are hard to model mathematically and also to help in the interpretation of the quantitative results.

After this introduction, Section 3.3 outlines the methodology that was used. The central issues which emerged from the research related to seating and this is discussed in Section 3.4, while other aspects of rolling stock quality are considered in Section 3.5. Evidence from the qualitative research on user willingness to pay is summarised in Section 3.6 and the conclusions drawn are presented in Section 3.7.

## 3.3 Methodology

The qualitative research involved 992 semi-structured interviews which were carried out at stations between 30th September and 14th October 1996. The stations were Kirkcaldy, Inverkeithing, Preston, Blackpool North, Wigan Wallgate, Cardiff Central, Wolverhampton, Coventry, Ipswich, Brighton, Benfleet, Southend Central, Southend Victoria, Gillingham (Kent) and Chatham.
The locations were chosen to cover a wide range of rolling stock types, operators, geographical areas and types of service. The choice of stations was also influenced by the requirements of the subsequent quantitative work which was designed to examine situations where a trade-off exists between quality of rolling stock and other aspects of the journey such as speed and service frequency. During the survey passengers were approached at random but the scheduling was weighted towards the morning and evening peak periods to obtain the views of commuters likely to be making use of controlled fares.

An interview schedule was designed to allow passengers maximum scope for expressing their views about rolling stock issues. To many this is an unfamiliar subject to be questioned about. Open ended questions and a wide range of "trigger" pictures, followed up by probing from skilled interviewers, were employed to elicit views about rolling stock issues.

## 3.4 Seat Quality and Availability

The response of passengers on rolling stock issues was dominated by the issues of seat availability and seating quality. These are clearly linked since, for a given train, a lower seat density is likely to provide higher quality for those who obtain a seat at the expense of a lower probability of a seat being available.

Many short distance commuters, under about 20 minutes, were prepared to stand or to sit in crowded conditions although a significant number were not. There was no discernible age or sex bias here except possibly that younger men were more likely to be willing to stand. For longer journeys most passengers, including both commuters and other travellers, regarded a seat and/or comfort as paramount: for some a seat, however crowded, was crucial, for others a larger and more comfortable seat, for which they would pay a supplement, was placed above having a basic crowded seat. Others said it would be nice to have a choice.

The most frequently expressed preference was for face to face seating and most people also preferred a table. However, a strong second preference was expressed for airline style seats especially when trains were crowded or the respondent was travelling alone. The complexity of people's seat choice strategies is illustrated by the following comment:

> *"When I'm on my own I prefer the bus style seats, but when I'm with friends I prefer the ones with tables - as long as you don't have to share them with strangers. If that happens and I'm with the wife we tend to move to the bus seats. It's quite an art getting it right".*

In view of this, it is not surprising that most people preferred there to be a choice of seat types. Accordingly, the modelling of seating issues needs to allow for the fact that many customers do not have a fixed preference for a particular type of seating; much depends on the circumstances of the journey and the degree of crowding on the train. A number of other specific points were raised in relation to seat design.

Movable arm rests between seats were almost universally preferred to either fixed or no arm rest, partly because it provided demarcation on crowded trains. The issue of personal space was a frequently recurring theme.

Most people preferred individual airline style seats but a few preferred bench seats, especially those travelling with children or shopping. The other advantage of bench seats in crowded commuting conditions was that the number of seats available was flexible, although to some extent this a contradictory finding to the notion of personal space. Eye contact was also disliked and designs which discouraged this whilst maintaining surveillance were preferred. Most people preferred head rests although a small minority found them claustrophobic.

Although soft upholstery gives a sense of luxury when new, as it ages it is perceived as being in need of 'deep cleaning'. Consequently, harder upholstery received favourable mention, especially for heavily used commuter trains and was also preferred by many people with disabilities as easier to slide in and out of seats.

## 3.5 Other Aspects

Although seating issues dominated most respondents' views on rolling stock issues, a wide range of other points were raised when prompted by interviewers. These are summarised in the paragraphs that follow.

Most people dislike being separated from their luggage unless they know that it is secure and consequently there were very ambivalent feelings about luggage spaces at the ends of the carriage. However, people also liked the corridors kept free as it enabled both them and the trolley service to pass easily through the train.

Overhead luggage racks were not liked as they were perceived as difficult or impossible to use, and also dangerous because of bags falling on to people, whilst there was a general feeling that there was not enough ground level luggage space. In general, people preferred space either behind or under their seat.

In the view of cyclists, bicycles were generally inadequately catered for and indeed were not allowed on some commuter trains.

Toilets were almost universally condemned as dirty, although many respondents recognised the physical limitations of train lavatories. Many respondents thought that this was an area where modern technology could be used to create more pleasant toilets.
Access to trains and between carriages was seen as an issue. The step heights between the coach and platform presented a problem for many, and in the double step design the interim step was often not wide enough to get the foot on. Access with buggies, for wheelchairs and with wheeled luggage was usually found very difficult, although easier with wide sliding doors. The gap between the train and the platform was found frightening by some respondents.

Automatic locking doors were liked in general, while old style lean-out to unlock doors were very unpopular and 'slamming' doors were especially disliked. However automatic doors on some trains were seen as too slow. Automatic doors between carriages were disliked by some respondents.

Air conditioning was generally preferred to opening windows "when it works", partly because it was seen as less contentious than windows. Points against air-conditioning were that it can be too cold and therefore needs a degree of personal adjustment, with the coach analogy used here, whilst many people felt that it picked up cigarette smoke and recycled it.
Although windows were liked by many people because they offered fresh air, a degree of control over the environment and flexibility, it was recognised that people have differing perceptions of draughts. Sliding windows were preferred to those that open wide. Some people perceived opening windows as dangerous.

Information systems were perceived as being only intermittently good, with very varying standards. Many respondents suggested that announcers needed training in clarity and diction. More electronic information was considered desirable, not just for deaf people, but to standardise the information output and make it available at all times, even on noisy trains and in tunnels.

Many people considered the lighting harsh and depressing, "too bright to sleep too dim to read". Individual spotlights were suggested, as in First Class and on coaches.

Although most respondents thought it was expensive and boring in the choices provided, there was nevertheless a general demand for a catering service on most journeys. Trolleys received frequent favourable mention, and were seen as more convenient and cheaper than the buffet.

Noise levels and ride quality were not raised as an issue very often except in connection with older rolling stock particularly on the Southend line.

Colour was not frequently mentioned as an issue. Some people however mentioned that they found Standard Class seat colours and decor harsh and garish in comparison with that in First Class. Others found the colour schemes dark, and for some this contributes to doubts about cleanliness. Overall, the impression of First Class is of space, and soft colouring with the use of greys and pinks in comparison with the more serviceable colours used in Standard Class. It is possible that the softer colours are associated in peoples' minds with comfort and lack of crowding.

Cleanliness of trains was a big issue, as it tends to be in most research related to rolling stock, especially on older style trains. The tendency of older stock, in particular, to be upholstered in dark colours encouraged the view that "they cannot be seen to be clean" and can affect perceptions of reliability, comfort and personal security. There was a feeling that it was better not to have carpets unless they were thoroughly cleaned. Disposable headrest covers or anti-macassars were considered desirable by many travellers. The perception on the commuter lines was that no cleaning was carried out during the day, so that by the evening the trains were described as "disgusting".

## 3.6 Willingness to Pay for Improvements

A finding that repeatedly emerged was that a substantial group of people were open to the idea of paying more for a larger and guaranteed seat, although "it depends how much" was often cited. This was often tied in with ideas that the existing First Class was either "too expensive" or "not worth it for shorter journeys".

There is a common perception that First Class carriages are often almost empty when the Standard Class are full, while the price differential between the two means that many of those who would pay more for greater comfort balk at the price. There appears to be considerable scope for some sort of intermediate class.

There is a widely held view that buying a ticket should ensure a seat of some sort for the duration of the journey and thus there are some suggestions that failure to obtain a seat should result in a rebate paid on the spot. One respondent commented:

> *"I think it's a disgrace to pay all this money and not get a seat. I'd pay more for comfort but then I'd definitely expect a seat or my money back"*

When asked directly whether additional payment would be made for specific items of improvement, most people say no with the exception of improvement to seating. When considering the cumulative effect of a number of improvements to rolling stock there was a willingness to pay more, often expressed in terms of 'value for money'. There is therefore the possibility of a synergy existing between a series of improvements, some of which may be related to the design and upgrading of rolling stock and others relating to the punctuality, reliability and general presentation of services which lies beyond the scope of this research.

However, there is a group who are resolutely opposed to paying any more and some of these people feel that the existing service is overpriced. In some cases this can be attributed to existing poor service levels in terms of crowding, dirtiness, age of rolling stock and also unreliability of services. Whilst even in these cases there may be scope for charging extra if the problems causing the resistance can be rectified, nevertheless there is probably a group who will always be resistant to paying more.

In spite of some passengers' stated willingness to pay for improved rolling stock, there was little evidence from the qualitative research that passengers plan or delay their journeys in order to gain access to superior rolling stock. This suggests that the value placed on rolling stock improvements is relatively low, otherwise respondents' behaviour would tend to be influenced to a greater extent by rolling stock issues. However, it should be remembered that choices will be conditioned by the rolling stock package as a whole. It could be, in some circumstances, that the good and bad features of different train types cancel each other out so that the lack of a strong preference for a particular rolling stock type does not necessarily imply a low value for a particular attribute that is not currently on offer. In addition, a range of other key variables influence choice of train, such as crowding and reliability in addition to cost, time and frequency, and these would have to be accounted for.

### 3.7 Conclusions from the Qualitative Research

Overall, the qualitative stage of the research suggested that rolling stock issues were not at the centre of passengers' concerns about the service they received. Other issues which are associated with rolling stock but are not an intrinsic feature of it, such as crowding and reliability, were considered more important.

In relation to rolling stock, the most important issues were seen as seat quality and availability. Customer preferences in relation to seat design tended to vary depending on the level of crowding and the purpose of the journey but there was a widely held view that adequate seating should be available for all passengers, although many passengers were willing to stand for up to 20 minutes.

A substantial number of passengers indicated that they would be willing to pay for a larger and more comfortable seat, although they balked at the price differential between First and Standard Class. However, few were willing to pay extra for other rolling stock improvements.
There was some indication that there would be a greater willingness to pay extra for a package of improvements incorporating better punctuality, reliability and presentation of services as well as upgraded rolling stock. Accordingly there could be synergy benefits from total route upgrades.

In general, the results of the qualitative phase of the research indicate that the value of specific rolling stock improvements is likely to be low.

## 4. QUANTITATIVE RESEARCH: DESIGN AND DATA COLLECTION

### 4.1 Introduction

Given that the main objective of this study is to provide up to date estimates of rail passengers' valuations of a range of rolling stock improvements, we embarked upon a large scale data collection exercise to provide suitable information for quantitative analysis.

The approach adopted was influenced by the findings of the literature review and by the qualitative research. A detailed justification of the approach adopted along with a thorough description of the survey procedure is contained below. Section 5 deals with the modelling approach and the empirical findings obtained.

The broad range of rolling stock categories which have been examined in this study are given in Table 1.

**Table 1: Rolling Stock Categories**

| Group | Class of Rolling Stock | Brief Description |
|---|---|---|
| C1 | 150 156 | Sprinters - Non Air Conditioned, Sliding Door |
| C2 | 158 159 | Express Sprinter - Air Conditioned, Sliding Door |
| C3 | 302 310 312 411 421 423 | South East Stock - Non Air Conditioned, Slam Door |
| C4 | 315 319 321 323 455 | South East Stock - Non Air Conditioned, Sliding Door |
| C5 | 165 465 | Networker - Non Air Conditioned, Sliding Door |
| C6 | 442 | Wessex Electrics - Air Conditioned, Sliding Door |
| C7 | Mk3 | InterCity Train - Air Conditioned |
| C8 | Mk2 | InterCity Train - Air Conditioned |

## 4.2 Methodology

### *4.2.1 Overall Approach*

The methodology adopted in this study had three particular features:

i) A Revealed Preference (RP) approach involving the collection and modelling of information regarding travellers' actual choices between different train types.

ii) A Stated Preference (SP) approach which is directly equivalent to the RP approach.

iii) A second SP approach whose purpose is to examine the detailed attributes which distinguish different types of rolling stock.

The reasoning behind this overall approach is quite straightforward. Firstly, the RP approach is used because of concerns raised by the literature review that SP studies can provide values of rolling stock improvement which seem very high. If the values are truly high, it ought to be possible to discern these in RP models and indeed it would be highly desirable to obtain corroboration of high SP values. Secondly, the first of the two SP exercises is a direct equivalent of the RP exercise thereby allowing a straightforward comparison of the results derived by the two methods as well as exploiting the advantages of SP in terms of its ability to control what is offered to individuals and its larger sample sizes. Finally, the second SP exercise examines rolling stock attributes at a more disaggregate level and in turn these can be compared with the aggregate rolling stock values.

The strengths of the cross-sectional approach that we have adopted are that, unlike the time series approach based on analysis of ticket sales, it is possible to analyse behaviour at the level of the individual. This is the so-called disaggregate approach. It allows detailed analysis of rolling stock issues and also a joint RP-SP approach which combines the attractions of the two forms of data. In particular, the correlation problems often apparent in time series data are avoided. However, the cross-sectional approach does have its limitations. In the form we have adopted, it can tell us about the impact of rolling stock improvements on the choice between different types of train but it tells us nothing about the effect on the overall demand for rail travel. Nor does it handle the need to improve rolling stock quality in line with peoples expectations along the lines that retail outlets have an ongoing programme of refurbishment and upgrading.

### *4.2.2 Revealed Preference Methodology*

In certain circumstances, travellers can reveal information about their preferences towards different rolling stock types through the actual choices that they make. Clearly, this means that the routes where travellers are surveyed are chosen judiciously. At the least, we require that there are two different types of train operating on a route between which the traveller can express a preference. Additionally, we require that this preference can be expressed relative to some other transport variable, such as time or cost, and hence trade-offs between rolling stock and other transport variables are needed.

The most common relevant trade-offs faced are between rolling stock and journey time and between rolling stock and headway whilst egress time is an issue where different destination stations are concerned, cost can be an issue where different operators or routes are concerned and access time can be an issue where different origin stations are involved. However, the choice of train might also be influenced by other factors which are less easy to model, such as crowding and reliability issues, but whose effect must nonetheless be isolated.

The RP analysis is based on the intended choice of train, that is, the type of train the respondent planned to catch before they arrived at the station. The exception to this is for trips between Southend and London where the choice between train types involves a choice between different stations. However, it is quite permissible that the respondent plans to catch whichever train arrives first and such behaviour must be examined separately. The routes where surveys were conducted are listed in Appendix 1.
The key questions contained in the questionnaire related to:

- origin and destination
- journey purpose
- actual use of different types of rolling stock
- intended choice of train
- journey time by each train
- egress time by each train
- cost by each train
- service interval of each train
- ratings of crowding and reliability of each train
- ratings of different rolling stock attributes of each train

Additionally, travellers from Southend to London were asked about the access times and costs to the two stations in Southend.

### *4.2.3 Stated Preference 1*

The first SP exercise is a direct equivalent of the RP exercise. It aims to estimate the overall values of different rolling stock types and offered nine trade-offs between rolling stock, travel time and cost. The two types of rolling stock offered to any individual were based on those operating on the route, and hence the routes again had to be judiciously chosen. There was also careful customisation of the journey times and costs around the respondent's actual journey and this was facilitated by undertaking a computerised survey of train travellers.

Journey time and cost were included not only because this allows a value of time to be derived which permits an assessment of the quality of the SP responses in terms of a well established parameter about which much evidence is available, but also because the value of rolling stock may well depend on the amount of time spent in it whilst the inclusion of cost allows a money value of rolling stock to be estimated without having to import a value of time from elsewhere.

The SP approach has a number of attractions due to its experimental nature. Firstly, it can control for extraneous influences and therefore ensure that the results are not distorted by the impact of other variable, such as reliability and crowding, which can influence train choice. Respondents were told that factors other than time and cost were the same for each of the two train types being compared. Secondly, the ability of SP exercises to precisely control the situations that the respondent evaluates means that a more ideal set of trade-offs between trains can be modelled. The problem of unfamiliarity with different types of stock which can arise in studies of rolling stock was minimised through surveying on routes where there were two different stock types and restricting the SP exercise to present these two types of stock. Finally, more data can be collected per person and this improves the efficiency of the parameter estimates.

### *4.2.4 Stated Preference 2*

The second SP exercise was administered as part of the same computerised survey which presented the first SP exercise but it contrasts with the latter in that it examines rolling stock attributes in greater detail rather than simply estimating an overall valuation of one type of rolling stock relative to another. Given the range of attributes to be considered, two second stage SP exercises were used, denoted SP2A and SP2B, with random distribution of one of them to respondents. The variables considered in each exercise were:

SP2A: Journey time, crowding, seating layout, ride quality, ventilation

SP2B: Journey time, ambience, noise level, seating comfort

Journey time was included to enable the results from this more detailed analysis to be linked to the RP and SP1 models. Ambience was specified as the internal environment, decor and appeal whilst ventilation denoted whether there was an air conditioning system or not.

The SP exercise stated whether each rolling stock attribute took the level of the chosen or the alternative train type. For the two attributes of seating layout and ventilation, there was some additional wording stating the positioning of the seats and provision of tables and also whether air conditioning was provided. For all the attributes other than seating layout and ventilation, the respondent's rating of it for the appropriate alternative was presented.
The novel feature of this second SP exercise is that the rolling stock attributes took only two levels and were based on the levels associated with the chosen and alternative train types on the traveller's

route. The reasoning behind this is that a key problem with valuing rolling stock is one of unfamiliarity with the rolling stock attributes being considered. This is compounded by the difficulty in accurately and succinctly describing the attributes to respondents. These problems are minimised by the use of attributes of rolling stock with which the individual is familiar. However, the advantage of using attribute levels with which the respondent is familiar does come at a cost since we are restricted to the rolling stock differences that the respondent faces.

## 4.3 Data Collection

### *4.3.1 Revealed Preference Survey*

The data collection approach adopted for the RP survey was based on the use of self-completion questionnaires distributed at stations where passengers face a choice between different rolling stock types with differing characteristics. In particular, the survey focussed on routes where passengers can choose between a fast journey in poor stock and a slower journey in better stock.
The need to achieve the large sample for the RP model dictated that a self-complete rather than an interviewer-led questionnaire was conducted. On most routes, the choices in which we were interested were only available at a small number of stations, typically at the boundary between inner and outer suburban areas. Accordingly, blanket distribution of survey forms on trains would have resulted in a high proportion of irrelevant responses from passengers who do not have a choice of rolling stock available to them. It was therefore decided to distribute survey forms at appropriate stations for subsequent postal return.

Survey staff were stationed at entry points to stations with instructions to approach passengers and ask for their destination station to ensure that we contacted those who face a choice of train type. Those making relevant journeys were then asked to take a questionnaire together with a FREEPOST envelope to return it.

Pilot RP Survey

A relatively large scale pilot survey was undertaken between 07.00 and 12.00 on Tuesday 12th November 1996 at Colchester, Bromley South and Orpington stations. A previous document has reported on the results of this pilot survey and here we shall highlight only the main features. The objectives of the pilot were to:

- confirm that the approach of asking about actual rolling stock choices would produce sensible results, given that the qualitative phase of the work had raised some doubts about the way in which passengers consider rolling stock issues;
- check that the specific questions asked were understandable and unambiguous;
- identify the response rate that could be expected from the main survey.

In total 1200 survey forms were distributed during the pilot and 419 were returned, a response rate of 35%. Of these 371 were fully completed, as shown in Table 2 below. The response rate was considered satisfactory and implied that 14300 forms would need to be distributed in the main survey to achieve the required response of 5000 returns.

**Table 2: Details of Pilot Survey**

| Station | Forms | Forms | Percent | Returned | Fully | Percent |
|---|---|---|---|---|---|---|

| | Out | Returned | Returned | Incomplete | Complete | Complete |
|---|---|---|---|---|---|---|
| Bromley South | 400 | 156 | 39 | 17 | 139 | 35 |
| Colchester | 400 | 172 | 43 | 17 | 155 | 39 |
| Orpington | 400 | 91 | 23 | 14 | 77 | 19 |
| TOTAL | 1200 | 419 | 35 | 48 | 371 | 31 |

Analysis of the pilot data showed that respondents made choices in the manner implied by the questionnaire and realistic results were obtained. However, some modifications were made to the questionnaire to improve the wording of certain questions. In particular, the description of alternative rolling stock types was expanded to distinguish between slam door suburban and InterCity rolling stock and it was decided to use a 10 point rating scale rather than a semantic scale (very good, good etc.) to represent the less easily quantified factors, such as reliability and crowding, which can influence choices between train types. These changes meant that the pilot data and the main survey data were not entirely compatible and hence the pilot data is not contained in the models reported below.

Main RP Survey

The main survey took place at 35 stations on weekdays between Tuesday 28th January and Friday 7th February 1997 with the consent of the relevant train operators. Interviewing took place between 07.00 and 12.00, largely because this was when the largest number of travellers would be most effectively contacted, but it does mean that the RP sample is weighted towards commuting trips.

The survey was undertaken at all stations where a relevant and realistic choice was considered to exist. These were mainly in the South East, but passengers were also contacted at Preston and at stations in the West Midlands. A list of the survey locations is given in Appendix 1 together with the destinations of interest and the rolling stock types employed.

Special versions of the survey form were used at Preston and at Southend. At Preston travellers have a choice between a number of sliding door rolling stock types which have widely different quality attributes and the questionnaire was modified to incorporate this. Southend to London services operate with differing stock types from separate stations and it was necessary to produce a special version of the form which allowed for variations in access time and access cost.

In total 14210 survey forms were distributed and 4776 were returned, a response rate of 33%. A complete breakdown of the survey response by station is given in Table 3.

## Table 3: Revealed Preference Survey Response

| Date | | Station | Handed Out | Total Returned | % Returned | Returned After Deadline | Returned Incomplete | Good Data | Actual and Alt Same | Usable Data | % Usable |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 14210 | 4776 | 34% | 120 | 1101 | 3555 | 657 | 2898 | 20% |
| Tuesday | 28-Jan | Egham | 450 | 166 | 37% | 2 | 72 | 92 | 29 | 63 | 14% |
| Tuesday | 28-Jan | Milton Keynes Central | 440 | 195 | 44% | 1 | 29 | 165 | 25 | 140 | 32% |
| Tuesday | 28-Jan | Staines | 450 | 88 | 20% | 1 | 34 | 53 | 6 | 47 | 10% |
| Tuesday | 28-Jan | Woking | 450 | 192 | 43% | 1 | 45 | 146 | 36 | 110 | 24% |
| Wednesday | 29-Jan | Walton-on-Thames | 450 | 190 | 42% | 8 | 25 | 157 | 16 | 141 | 31% |
| Wednesday | 29-Jan | West Byfleet | 450 | 199 | 44% | 2 | 36 | 161 | 20 | 141 | 31% |
| Wednesday | 29-Jan | Weybridge | 450 | 169 | 38% | 2 | 43 | 124 | 5 | 119 | 26% |
| Thursday | 30-Jan | Feltham | 450 | 151 | 34% | 0 | 42 | 109 | 14 | 95 | 21% |
| Thursday | 30-Jan | Richmond | 450 | 8 | 2% | 1 | 2 | 5 | 0 | 5 | 1% |
| Thursday | 30-Jan | Surbiton | 450 | 145 | 32% | 4 | 35 | 106 | 16 | 90 | 20% |
| Thursday | 30-Jan | Wolverhampton | 440 | 136 | 31% | 2 | 20 | 114 | 13 | 101 | 23% |
| Friday | 31-Jan | Birmingham Int'l | 147 | 45 | 31% | 0 | 17 | 28 | 2 | 26 | 18% |
| Friday | 31-Jan | Brighton | 450 | 170 | 38% | 2 | 62 | 106 | 24 | 82 | 18% |
| Friday | 31-Jan | Haywards Heath | 450 | 44 | 10% | 1 | 24 | 19 | 6 | 13 | 3% |
| Friday | 31-Jan | Preston | 120 | 28 | 23% | 1 | 27 | 0 | 0 | 0 | 0% |
| Friday | 31-Jan | Three Bridges | 450 | 154 | 34% | 0 | 49 | 105 | 19 | 86 | 19% |
| Monday | 03-Feb | Bedford | 601 | 272 | 45% | 4 | 48 | 220 | 31 | 189 | 31% |
| Monday | 03-Feb | Orpington | 440 | 118 | 27% | 3 | 39 | 76 | 44 | 32 | 7% |
| Monday | 03-Feb | Otford | 440 | 146 | 33% | 2 | 18 | 126 | 12 | 114 | 26% |
| Monday | 03-Feb | Sevenoaks | 440 | 213 | 48% | 5 | 38 | 170 | 58 | 112 | 25% |
| Tuesday | 04-Feb | Beckenham Junction | 440 | 155 | 35% | 3 | 39 | 113 | 39 | 74 | 17% |
| Tuesday | 04-Feb | Bromley South | 440 | 128 | 29% | 6 | 22 | 100 | 14 | 86 | 20% |
| Tuesday | 04-Feb | Leamington Spa | 294 | 95 | 32% | 1 | 20 | 74 | 11 | 63 | 21% |
| Wednesday | 05-Feb | Chatham | 440 | 161 | 37% | 5 | 36 | 120 | 43 | 77 | 18% |
| Wednesday | 05-Feb | Gillingham (Kent) | 440 | 177 | 40% | 9 | 33 | 135 | 62 | 73 | 17% |
| Wednesday | 05-Feb | Ipswich | 577 | 219 | 38% | 7 | 59 | 153 | 19 | 134 | 23% |
| Wednesday | 05-Feb | Rochester | 133 | 53 | 40% | 3 | 10 | 40 | 8 | 32 | 24% |
| Thursday | 06-Feb | Colchester | 576 | 239 | 41% | 12 | 19 | 208 | 5 | 203 | 35% |
| Thursday | 06-Feb | Shenfield | 440 | 125 | 28% | 4 | 25 | 96 | 16 | 80 | 18% |
| Thursday | 06-Feb | Southend Central | 231 | 52 | 23% | 1 | 0 | 51 | 0 | 51 | 22% |
| Thursday | 06-Feb | Southend Victoria | 235 | 62 | 26% | 3 | 0 | 59 | 0 | 59 | 25% |
| Friday | 07-Feb | Coventry | 419 | 94 | 22% | 4 | 23 | 67 | 8 | 59 | 14% |
| Friday | 07-Feb | Didcot Parkway | 407 | 136 | 33% | 8 | 51 | 77 | 14 | 63 | 15% |
| Friday | 07-Feb | Twickenham | 440 | 137 | 31% | 5 | 23 | 109 | 15 | 94 | 21% |
| Friday | 07-Feb | Virginia Water | 230 | 114 | 50% | 7 | 36 | 71 | 27 | 44 | 19% |

Table 3 shows that the response rate ranged between 20% and 50% at all but two stations where a response of 10% or less was obtained. No specific factors which contributed to the poor response at these stations were identified.

At the majority of stations, the surveys were undertaken without problems. Some stations were much busier than others resulting in complete distribution of the allocation of survey forms, while at others there were fewer passengers found making a trip of interest. At some stations, depending on the layout, it was less easy to identify in which direction travellers were bound, resulting in some forms being given out erroneously.

Unfortunately, major problems were experienced during the survey at Preston station on Friday 31st January. An incident on the line at Blackpool led to serious disruption of the service to Manchester. Four trains were cancelled completely. From previous experience, such an event causes great dissatisfaction amongst passengers, effectively biassing any data collected in such circumstances. Of those trains which ran on time, some were made up of carriages of different stock types as a result of the disruption, thus making the identification of the chosen and alternative train types impossible. For these reasons, the 28 questionnaires from Preston were not considered worth including.

As the data was returned, it was processed and checked. The majority had been well completed, with information being provided for both the actual journey and an equivalent journey by the alternative train type. Where data on the alternative train type was not provided, the record cannot be used in the RP model since the purpose of the exercise is to compare the train types and hence these records must be rejected.

Similarly, those who failed to identify which train was actual and which was alternative must also be rejected. Some respondents failed to understand the questions resulting in the alternative train questions being answered as for a completely different journey, most likely an alternative route. A small number of forms were returned where the journey described was not of interest, for example, the destination given was one to which a choice of trains did not exist. The total forms returned which were incomplete or irrelevant was 1101. A further 120 forms did not arrive in time to be included in the data processing. This left a total of 3555 forms containing complete data.

There were also 657 respondents who stated that their alternative train type was the same as their chosen train. Although such responses contain useful information, we did not collect the additional data needed to be able to extract the information from such responses by appropriate modelling and hence these records must be removed from the data set. It may be that for these travellers the alternative to the chosen train is not another train type but the same train type at some other time, although matters are complicated to the extent that some of these respondents might not perceive there to be an alternative train type on the route. We are then left with a maximum number of 2898 RP interviews.

Table 4 shows how we proceeded from the cleaned and checked data of 2898[1] observations reported in Table 2 to the 1694 observations upon which the RP models have been calibrated. From the sample of 2898 were removed 871 observations which could not be modelled. This included 823 respondents who stated that they intended to catch the first train to arrive whilst we also removed three cases where the rolling stock had an invalid code. A further 45 said that they did not

[1] This figure excluded the pilot survey data because of the incompatibility of some variables with the main survey data.

know which train they would catch and these might be people who actually make their decisions at the station after observing travel conditions.

**Table 4: Omitted RP Data**

| | |
|---|---|
| Clean Data | 2898 |
| Intended to catch first to arrive | 823 |
| Intended not known | 45 |
| Wrongly coded stock type | 3 |
| Omit Outliers | 161 |
| Omit Missing Ratings for Crowding and Reliability | 172 |
| Modelled Choices | 1694 |

We omitted 161 observations as outliers. These were cases where the time difference between alternatives exceeded 30 minutes, the cost difference exceeded £10 per trip, the frequency difference exceeded two hours, the access time difference exceeded one hour or the egress time difference exceeded one hour. The surveys were not conducted on routes where the two train types had such large differences and we believe that this category contains those who interpreted the alternative train to be one by another, more circuitous, route. Finally, we must remove 172 observations where ratings of crowding and reliability have not been provided for the two train types.

### *4.3.2 Stated Preference Surveys*

The SP surveys were carried out on weekdays between Wednesday 29th January and Friday 21st February 1997. The routes selected covered broadly the same areas as the RP surveys, although it was necessary to concentrate on the longer distance flows since the interview took up to 20 minutes to complete. Care was taken to ensure that the RP and SP surveys were not conducted in the same area in the same week in order to avoid irritation to rail travellers.

The SP survey was designed to be conducted on a train, on a face to face basis with the interviewer using a laptop computer. This method has the advantage that the data collected is self-checked and is therefore all usable. The program was designed such that once the route and the actual train being used were entered, the characteristics of that train and of all the alternatives available on that route were identified.

The information collected on the current journey was similar to that in the RP survey. However, we felt that the interview would have become too long had we included the full set of questions about the alternative train type so as to have sufficient data to include with the RP model. The alternative train which could be used was selected by the respondent by class number and characteristics which included door type, seating layout, table arrangement, ventilation provision and noise level. The respondent then gave ratings out of 10 for various characteristics of both train types. Two SP experiments were then conducted, and these were described in sections 4.2.3 and 4.2.4.

The main problems experienced in data collection related to South West Trains who were experiencing problems with driver shortages resulting in cancellations which caused disruption to our survey schedules as well as the timetable. Surveys were underway on the Woking/Weybridge lines on the day that South West Trains offered a day of free travel on their trains in compensation.

In total, 783 interviews were successfully conducted. As two SP exercises were completed by each respondent, a total of 1566 completed SP records were obtained. A list of the survey routes and the number of interviews obtained on each is given in Table 5.

**Table 5: SP Survey Routes and Interviews**

| Route | Number of Interviews |
|---|---|
| Wolverhampton - Coventry | 113 |
| Birmingham - London | 183 |
| Brighton - London | 56 |
| Southend - London | 59 |
| Ipswich - London | 71 |
| Woking / Weybridge - London | 111 |
| Preston - Manchester | 48 |
| Gillingham / Sevenoaks - London | 139 |
| Other | 3 |
| TOTAL | 783 |

# 5. QUANTITATIVE RESEARCH: EMPIRICAL RESULTS

## 5.1 Introduction

The quantitative research aspect of the study involved a major data collection exercise based around the actual possibilities of using different rolling stock types. A number of the models that have been developed are reported in this section. They are generally robust, with plausible and precise results, large sample sizes and generally very good explanations of choices. A number of plausible relationships with socio-economic factors have also been estimated.

## 5.2 Modelling Issues

Prior to presenting the results we will briefly outline a few modelling issues. The logit model is that most commonly used to explain choices between two travel alternatives. It expresses the probability of choosing an alternative as a function of the indirect utilities (U) of the two alternatives (1 and 2) as:

$$P_1 = \frac{1}{1 + e^{U_2 - U_1}} \qquad (1)$$

In turn, the utility terms are related to variables that influence the overall attractiveness of the alternatives. For example, the utility of alternative i ($U_i$) might be related to its journey time ($T_i$), cost ($C_i$) and headway ($H_i$) as:

$$U_i = \alpha_1 T_i + \alpha_2 C_i + \alpha_3 H_i \qquad (2)$$

The calibration of the model provides estimates of the α's which denote the importance of each variable on the utility of each alternative. In a linear additive utility function of the form of equation 2, the value of a variable in terms of another is simply derived as a ratio of their coefficient estimates; for example, the money value of time is estimated as the ratio of the time ($\alpha_1$) and the cost ($\alpha_2$) coefficients. This is the model form employed in this study.

The specification of the logit model's utility function follows similar principles to the specification of independent variables in regression models. Variables which are not of a continuous nature, such as rolling stock, can be represented by dummy variables. If we have n levels of such a variable, we can specify n-1 dummy variables whose coefficients are then interpreted in relation to the arbitrarily omitted category. Thus if we have three levels of rolling stock (1, 2 and 3), we could specify dummy variables to represent rolling stock type 1 ($d_1$) and rolling stock type 2 ($d_2$). If train journey time was the only other variable characterising the alternative, its utility function could be specified as:

$$U_i = \alpha T_i + \beta_1 d_{1i} + \beta_2 d_{2i} \qquad (3)$$

In this formulation, the impact of rolling stock is the same regardless of the train journey time. However, the benefits of rolling stock improvements can be expected to depend on the amount of time spent using it. From a modelling perspective, this requires the specification of interaction terms as the product of dummy variables denoting the rolling stock and the train journey time. A utility function with such features is:

$$U_i = \alpha T_i + \beta_1 d_{1i} T_i + \beta_2 d_{2i} T_i \qquad (4)$$

The effect of, say, the introduction of rolling stock type 2 would now be $\beta_2 T_i$, as opposed to $\beta_2$ in equation 3, and this would be greater for longer journeys. This formulation is entirely equivalent to the value of train time varying according to the type of rolling stock. For example, the value of time for the omitted stock type category would be $\alpha$ divided by the cost coefficient whereas it would be $\alpha + \beta_1$ divided by the cost coefficient for rolling stock type 1.

The groupings of the categories of stock type which have been surveyed were presented in Table 1 in section 4.1. These represent a wide range of stock types in terms of all the variables which have been included in the SP exercise.

The valuation of stock type may vary according to a number of socio-economic factors. The key variables typically used in such analysis of rail passengers are:

- journey purpose
- income level
- class of travel
- area

It turned out that 95% of the RP sample and 98% of the SP sample were standard class travellers. Hence segmentation by this variable would not be worthwhile. In addition, the RP sample was 90% commuters and thus segmentation of the RP model, or indeed segmentation within a joint RP-SP model of variables which are unique to the RP model, would again not be worthwhile. Income is expected to influence the sensitivity to cost variations and hence this segmentation can be undertaken in those models where cost is present. The key area distinction that can be made with the data we have collected is between London and the South East and elsewhere.

## 5.3 Revealed Preference

Table 6 reports an RP model based on the travellers' intended choice of train, with alternative one generally relating to the slam door or older stock type. It is based on what is for an RP model a large number of observations and it achieves a satisfactory goodness of fit.

**Table 6: Revealed Preference Model Results**

| Variable | Estimate (t Stat) |
|---|---|
| Train Time | -0.0754 (11.2) |
| Egress Time | -0.0805 (7.9) |
| Headway | -0.0263 (9.1) |
| Crowding | 0.1000 (5.4) |
| Reliability | 0.0675 (2.2) |
| C2 | 0.0048 (0.3) |
| C3 | 0.0060 (2.0) |
| C4 | 0.0017 (0.6) |
| C6 | 0.0032 (0.1) |
| C7 | -0.0071 (1.3) |
| C8 | 0.0106 (2.8) |
| Rho Squared | 0.158 |
| Observations | 1694 |

Train time, egress time and headway all have the correct sign, are highly statistically significant and seem to be plausible in relation to each other. We would expect egress time to be more highly valued than train time whilst the ratio of headway to train time is 0.35 which is reasonable and accords well with the p value of 0.4 traditionally used by the railways.

The cost coefficient was insignificant (t=0.9) and was therefore removed from the model. This finding is not surprising since in most cases the cost was the same by the two trains and most of the limited cost variation was attributable to small differences in egress costs where different destination stations would be used. Access time was also entered into a previous version of the model since the choice of train for Southend to London travellers involves a choice of station. However, this variable was far from significant (t=0.5) which is again unsurprising given that the access time differences between Southend Victoria and Southend Central were generally very minor and that there are only 53 Southend travellers in the model.

The crowding and reliability variables represent the ratings on a scale of 1 to 10 of the level of crowding on the train at the origin station and the level of reliability. Their purpose is to avoid confounding effects from these variables upon the estimated rolling stock valuations. Since 10 denotes very good, the coefficients have the correct positive sign and are both statistically significant. We are therefore confident that at least some of the difference between rolling stock types due to differences in reliability and crowding levels is being isolated. It proved important to do this since the removal of the crowding and reliability variables led to noticeable differences in the C3, C7, C8 and train time coefficients.

The rolling stock variables are represented by dummy variable terms which allow the value of a certain rolling stock type to depend on the time spent in that rolling stock. This is the specification represented by equation 4 above. We have used this specification since it achieved the same fit as the form of model which specifies the rolling stock effects to be independent of the level of journey time (equation 3) yet we feel that it is theoretically preferable.

The RP data does not contain any of the category C1 trains and C5 has been specified as the omitted category. The rolling stock coefficients are therefore interpreted in relation to C5 which represents the networker trains. Thus the time coefficient represents time spent in a networker. Time spent in some other train is equal to the sum of the train time coefficient and the relevant rolling stock coefficient; for example, the time coefficient for travelling on Mark II stock (C8) would be -0.0648. This is the largest variation in the time coefficient from its base due to rolling stock and involves a change of only 14%. All the other stock type coefficients would imply only minor changes in the time coefficient and all but one of them are statistically insignificant.

The low values of rolling stock contrast with most previous evidence derived from SP models and there are two things to note here. Firstly, even though the differences in the valuations of different rolling stock types are low, there could still be somewhat higher values associated with the individual rolling stock attributes. Secondly, it might be claimed that the values are low because of deficiencies in the RP approach and this is reflected in the low t ratios for the rolling stock variables. However, we would counter that the model is based on a large sample, achieves a reasonable fit, obtains plausible and highly significant coefficients for train time, egress time and headway and appears to be isolating the effects of reliability and crowding. Hence we would argue that we can be confident in the reliability of the model's results regarding the low values of rolling stock since it is robust in all other respects. In addition, the results from an equivalent model based on SP data will provide further evidence.

We have not segmented the RP model by income group because income is expected to influence the sensitivity to cost variations yet there is no cost variable in the RP model. Nor is there any segmentation by purpose, since 90% of the sample are commuters, whilst a segmentation by class of travel is not worthwhile since 95% are standard class.

The final RP model is one where we have replaced the dummy variables relating to stock type with the rating on a 10 point scale that the respondent provided for each train type. It has the advantage, as is apparent from Table 7, that only a single variable is entered into the model to represent stock type rather than the six dummy variables in the model reported in Table 6. The drawback is that we lose 54 observations where the respondent has not provided ratings of both train types.

The rolling stock coefficient (Stock) is highly significant and of the correct sign. Even though the crowding and reliability coefficients are smaller than in Table 6, the correlations between the estimated coefficients for stock and crowding and for stock and reliability are only -0.20 and -0.19 respectively. The model with the ratings also achieves a slightly better fit; for the same number of observations the RP model based on dummy variables achieved a Rho Squared of 0.155 which is less than the 0.161 achieved by the model based on ratings of the stock types. We can therefore be confident that the use of the rating scale variable is a satisfactory means of modelling stock type effects and does not seem to be the source of significant error in the model yet it has the convenience of a single variable and the advantage of precisely estimating stock type effects.

**Table 7: Revealed Preference Model with Ratings**

| Variable | Estimate (t stat) |
|---|---|
| Train Time | -0.0697 (11.4) |
| Egress Time | -0.0830 (8.2) |
| Headway | -0.0286 (10.2) |
| Crowding | 0.0617 (3.4) |
| Reliability | 0.0218 (0.7) |

| | |
|---|---|
| Stock | 0.1193 (5.6) |
| Rho Squared | 0.161 |
| Observations | 1640 |

The mean absolute difference in the rating between the preferred and alternative stock type faced by each individual is 2.18. The absolute difference provides an indication of how much two stock types are different without any cancelling effects due to different preferences across individuals amongst two stock types. Given the rolling stock coefficient, this mean absolute difference in ratings translates into an average difference in valuation between overall stock types of around 3.7 minutes. This forms 9% of the average journey time of around 43 minutes. We should note here that this figure does not correspond with rolling stock valuations of around 10% of the fare which are quite common and which in the literature review we concluded were too large. This is because the figure here denotes a maximum difference since it is based on a mean absolute difference in the ratings whilst we shall see that evidence from the SP model, where both time and cost are included, shows that the corresponding money value is a somewhat lower proportion of the mean fare paid than the time value is of the mean journey time.

## 5.4 Stated Preference 1

The SP1 model is reported in Table 8. It is based on a sample size of 7047, made up of 783 individuals each completing 9 pairwise comparisons of two train alternatives. The goodness of fit is amongst the highest that we have achieved in many studies involving binary choice logit models and the t statistics associated with time and cost are very high. These t ratios would remain very high if we corrected them to allow for the worst case of repeat measurements problem by dividing them by the square root of 9.

The base value of time is 6.40 pence per minute which is very plausible. Thus we have again obtained a very robust model in terms of the non rolling stock parameters and this provides a good foundation for analysis within this model of stock type effects.

**Table 8: Stated Preferece 1 Model Results**

| Variable | Estimate (t Stat) |
|---|---|
| Train Time | -0.1889 (35.8) |
| Train Cost | -0.0295 (35.1) |
| C1 | -0.0038 (1.6) |
| C2 | -0.0018 (0.6) |
| C3 | -0.0032 (2.7) |
| C4 | -0.0004 (0.3) |
| C6 | -0.0102 (1.7) |
| C7 | 0.0001 (0.1) |
| C8 | 0.0025 (2.4) |
| Rho Squared | 0.299 |
| Observations | 7047 |

The rolling stock variables are again specified as depending on journey time as in the RP model and represented by equation 4. Although there are some inconsistencies with the RP model, most notably with respect to C3 which is now negative and significant yet it was positive and significant in the RP model, we will see that the SP results are consistent with the RP results in implying relatively minor stock type effects. Indeed, it would not take a large adjustment in the light of any repeat observations problem to result in none of the stock type coefficient estimates being significantly different from zero at the usual 5% level.

Table 9 presents the implied values of time for each of the different rolling stock types, with C5 again representing the base, and it can be seen that there is little variation in the values of time across stock types.

**Table 9: Implied Values of Time by Stock Type**

| Stock | VoT | Stock | VoT |
|---|---|---|---|
| C1 | 6.53 | C5 | 6.40 |
| C2 | 6.46 | C6 | 6.75 |
| C3 | 6.51 | C7 | 6.40 |
| C4 | 6.42 | C8 | 6.32 |

There are some plausible features of the relative stock type valuations. Express Sprinters (C2) are preferred to Sprinters (C1) whilst the old slam door stock operating in the South East (C3) is regarded to be inferior to other stock types. The unexpected negative sign on the C6 coefficient (Wessex Electrics) may have resulted from the disruption experienced on South West Trains' services. Whilst the Mk2 stock (C8) is preferred to Mk3 (C7), we have not identified the cause of this although we ought not to be too worried because the RP model also found the Mk2 stock to be the most preferred of all the stock types and in any event the difference in the valuation is small. Indeed, if we ignore the C6 coefficient because of the service disruptions which were experienced, the largest variation in stock type valuation is between C8 and C1 and is only 12.6 pence for the average journey of 59 minutes. This is a minor valuation, forming only 1.4% of the average single fare of £9.13, and many of the other comparisons of stock type would have negligible values.

We have segmented the SP1 model by journey purpose, estimating separate models for commuting, leisure and business trips. This allows all the coefficients to vary across journey purpose. The segmented models are reported in Table 10.

The base value of time is, as expected, higher for business travel (13.03p/min) than commuting (6.24p/min) and leisure (5.79p/min). There is a reasonable degree of consistency with the results of a large scale review of the value of time recently conducted at ITS (Wardman, 1997). In that study, a model was developed on 444 value of time estimates to explain how they vary across studies according to key variables such as mode, purpose, distance, GDP and type of data. Hence the model can predict values of time on the basis of the collective experience of a very large amount of previous evidence. For GDP and prices at 1994 quarter 4 levels, and taking a distance of 50 miles, the model predicts values of time of 12.8 p/min, 9.1 p/min and 4.7 p/min respectively for business, commuting and leisure trips.

The results in Table 10 indicate that it would seem to be worthwhile pursuing segmentation of the time and cost coefficients by journey purpose in subsequent models. However, there are no outstanding differences in the incremental effects on the value of time from rolling stock across the three models. Given this, and that the rolling stock coefficients are mostly small with low t ratios, it does not seem worthwhile to further consider segmentation of the rolling stock dummy variables by purpose. Nonetheless, segmentation of the base time coefficient or the cost coefficient by purpose will lead to different absolute values of time on all stock types according to purpose but the incremental effect of stock type will not vary across journey purpose.

**Table 10: SP1 Model Segmented by Purpose**

| | Commuting | Leisure | Business |
|---|---|---|---|
| Variable | Estimate (t stat) | Estimate (t stat) | Estimate (t Stat) |
| Train Time | -0.1837 (20.6) | -0.1553 (21.5) | -0.3192 (19.3) |
| Train Cost | -0.0294 (20.7) | -0.0268 (26.0) | -0.0245 (4.7) |
| C1 | -0.0027 (0.7) | -0.0028 (0.9) | -0.0162 (1.2) |
| C2 | -0.0055 (1.0) | -0.0056 (1.4) | -0.0074 (0.5) |
| C3 | -0.0024 (1.1) | -0.0035 (2.2) | -0.0127 (3.7) |
| C4 | -0.0014 (0.6) | -0.0022 (1.4) | 0.0056 (2.0) |
| C6 | -0.0058 (0.6) | -0.0140 (1.7) | -0.0125 (0.7) |
| C7 | 0.0015 (0.4) | -0.0006 (0.2) | -0.0046 (0.7) |
| C8 | 0.0042 (1.7) | 0.0014 (1.0) | 0.0043 (1.8) |
| Rho Squared | 0.290 | 0.272 | 0.454 |
| Observations | 2466 | 3420 | 1161 |

Table 11 reports the SP1 model where the cost coefficients have been segmented by annual household income, that is, we have estimated separate cost coefficients according to the following income groups:

- Cost1 <£10,000
- Cost2 £10,000-£30,000
- Cost3 £30,000-£40,000
- Cost4 >£40,000

These four categories represent 7.6%, 38.7%, 16.5% and 11.5% of the sample respectively. The remaining 25.7% would not or could not provide details of their household income and CostX denotes the cost coefficient for this group.

We would expect that those with higher incomes are less sensitive to cost variations and hence have lower cost coefficients. This indeed turns out to be the case, with a monotonic relationship between the cost coefficients and income. The implied variation in the base value of time is quite large, varying from 5.25 pence per minute for those with household incomes of £10,000 or less to 11.12 pence per minute for those with incomes in excess of £40,000. The money values of stock type will vary in the same manner.

**Table 11: Stated Preference 1 Model with Income Segmentations**

| Variable | Estimate (t stat) |
|---|---|
| Train Time | -0.1902 (35.9) |
| Cost1 | -0.0362 (14.2) |
| Cost2 | -0.0319 (26.8) |
| Cost3 | -0.0253 (13.9) |
| Cost4 | -0.0171 (8.0) |
| CostX | -0.0313 (21.6) |
| C1 | -0.0035 (1.4) |
| C2 | -0.0023 (0.7) |
| C3 | -0.0033 (2.8) |
| C4 | -0.0003 (0.3) |
| C6 | -0.0098 (1.7) |
| C7 | 0.0001 (0.1) |
| C8 | 0.0025 (2.4) |
| Rho Squared | 0.302 |
| Observations | 7047 |

We have not segmented the SP1 model by class of travel since 98% of the respondents were travelling in standard class. We will, however, take forward the successful segmentations by income group and by journey purpose into a model which is based on all the different data sets combined.

The final SP1 models we consider are equivalent to the RP model reported in Table 7 in that they enter the ratings of the stock types rather than dummy variable terms. Two models are presented in Table 12. The first simply replaces the dummy variables with the rating coefficient and is otherwise identical to the SP model in Table 8. The other SP model segments the stock rating and time coefficients by purpose so that the results can be compared with the equivalent RP model which is based almost entirely on commuting trips.

The model which simply replaces the dummy variables with the ratings obtains a Rho Squared which is only slightly lower even though there are six fewer variables in the model. However, it does now produce a stock type coefficient which is not only of the correct sign but is also highly statistically significant. The value of time of 6.3 pence per minute is little different to the base value in the model containing dummy variable stock terms.

**Table 12: Stated Preference 1 Model with Ratings**

| Variable | Estimate (t stat) | Estimate (t Stat) |
|---|---|---|
| Time | -0.1877 (35.9) | |
| Time-Commute | | -0.1753 (22.9) |
| Time-Leisure | | -0.1576 (23.0) |
| Time-Business | | -0.3061 (20.7) |
| Cost | -0.0297 (35.4) | -0.0281 (33.9) |

| | | |
|---|---|---|
| Stock | 0.0727 (7.1) | |
| Stock-Commute | | 0.1048 (5.5) |
| Stock-Leisure | | 0.0703 (5.0) |
| Stock-Business | | 0.0449 (1.8) |
| Rho Squared | 0.298 | 0.309 |
| Observations | 7047 | |

The value of rolling stock is again seen to be low. The mean absolute difference in the rating of rolling stock types across respondents of 2.12 implies an average valuation of the difference in rolling stock of 5.18 pence per single trip. This is around 0.6% of the mean single fare of £9.13 for the respondents in the sample and is equivalent to 1.4% of the mean journey time of 59 minutes. The values obtained using the ratings approach are in line with the results obtained using the dummy variable approach. However, they are much lower than the results that have typically been obtained in previous empirical studies, although in some cases the physical differences between stock types will have been small.

The model segmented by purpose allows comparison with the equivalent RP model which is primarily based on commuting. There is no need to segment the cost coefficient since cost is not contained in the reported RP model.

The SP model's results for commuting indicate that a unit change in rating is equivalent to 0.6 minutes, which is around a third of the figure for the RP model. The mean absolute difference in ratings between the two train types for commuters of 1.86 corresponds to a time value of 1.11 minutes as opposed to the 3.73 minutes for the same calculation based on the RP model and data. Whilst there is a large proportionate difference in the time values of a unit rating difference, both models indicate low values of rolling stock improvement. It can also be seen that the specification of a single term for rolling stock instead of a series of dummy variables more readily supports segmentation by journey purpose.

It could be argued that the RP values are too high because it has excluded those with low values of rolling stock. For example, about 40% of the sample reported that they had the same train type for chosen and alternative or that they would catch the first train to arrive. However, these people do not necessarily have low values of stock type. For example, those reporting the same train type for chosen and alternative might be unaware of different train types, or else the best alternative to the current departure is the same train type but at a different time since the alternative train type is not satisfactory. The latter could imply a large value of rolling stock type. In addition, others may not perceive there to be a trade-off. Those who would catch the first train to arrive do not necessarily have low values; it could simply be that, in conditions which can vary considerably day by day, they wait until arrival at the station to observe crowding and reliability conditions prior to making any decisions. In any event, even if these individuals did have zero values this would not account for the large difference between the RP and SP values.
The SP values could be low because of problems with the Wessex electric (C6) valuation due to the service disruptions which occured. However, when we removed those with Wessex electrics in their choice set the rating, cost and time coefficients were barely different.

We have also used the ratings based model to examine area effects given that segmentation within this model form is more straightforward. We examined whether the rating coefficient varied between London and the South East and elsewhere. This is the key distinction that can be made with the data we have collected. Whilst the rating coefficient of 0.8 for London was higher than the 0.6 value for elsewhere, the difference was not statistically significant (t=1.6) and the difference became much smaller once income effects were included.

## 5.5 Stated Preference 2

We have combined the data for the two SP2 exercises into a single model and the results are given in Table 13. Each of the rolling stock attributes for both of the train types were rated on a 10 point scale by each respondent and, in addition to denoting whether the attribute level related to the chosen or alternative train type, the ratings were included in the SP presentation of each attribute except in the case of seating layout and ventilation where a verbal description was given.

**Table 13: SP2 Model Results**

| | With Mk2 | Without Mk2 |
|---|---|---|
| Crowd | 0.0358 (2.1) | 0.0663 (2.5) |
| Seat | -0.0929 (5.1) | 0.0341 (1.2) |
| Ride | 0.1231 (6.6) | 0.1794 (6.6) |
| Vent | 0.0351 (1.6) | 0.0380 (1.3) |
| Ambience | 0.1702 (9.0) | 0.1792 (9.1) |
| Noise | 0.0665 (3.5) | 0.0789 (4.0) |
| Comfort | 0.2860 (15.0) | 0.3059 (15.3) |
| Time | -0.2096 (39.0) | -0.2358 (34.7) |
| Obs | 6264 | 5080 |
| Rho Squared | 0.373 | 0.414 |

These ratings were used to represent the rolling stock attributes in the estimated SP model. There are three main reasons why we have adopted this approach to modelling the detailed rolling stock attributes as opposed to using a dummy variable specification:

i) Given that we have 8 stock type categories, the dummy variable approach would involve the specification of 7 dummy variables for seating comfort, noise, ride quality and ambience. This would lead to a large and unwieldy number of variables which would not contribute to the sufficiently precise estimation of what we would expect to be small effects.

ii) Results based on rating scales are more transferable since their application merely requires that we obtain ratings of the stock types being evaluated whereas the results from the dummy variable approach can only be applied to stock type comparisons contained in the model.

iii) It could be that some changes in stock type are not an unambiguous improvement, for example, some might like air conditioning and others might not. With the dummy variable approach, it is possible for positive and negative values to operate so that the estimated net effect is that the stock change has no apparent value. This therefore masks the fact that some do not like the change whilst others do yet such preferences would be apparent in the ratings of two alternatives.

Given that a higher rating is preferable, the coefficients relating to the stock type variables ought to be positive, with journey time having a negative coefficient. We experimented with interaction terms whereby the impact of a given rating difference between rolling stock attributes would have a larger effect for longer distance trips. However, the model form which entered the ratings without any interaction with journey time obtained the better fit. It could be that the ratings themselves are distance dependent; for example, a respondent would provide a larger rating difference between two rolling stock types for longer distance journeys than for shorter ones.

It emerged in some preliminary analysis that those who had Mk2 trains (C8) in their choice set were having an adverse influence on the results for seating layout to such an extent that, as can be seen for the data set based on all 6264 observations (783 individuals), the seating coefficient actually has the wrong sign and is statistically significant. Investigation of this issue has failed to reveal the precise cause of the problem but the removal of the 19% who had Mk2 trains in their choice set has quite clearly removed a source of error in the model. Not only does the seating layout variable then have the correct positive sign, albeit statistically insignificant at the usual 5% level, there has been a noticeable improvement in the goodness of fit statistic.

The results indicate that the most important aspect of rolling stock is the comfort of the seating and the available legroom, followed by the ride quality and the ambience. We feel that it is reasonable that these are the most important features of railway rolling stock. Indeed, we note that the literature review pointed to the importance of seating comfort amongst the detailed stock type attributes. Noise, ventilation and seat layout appear to be of minor importance.

We have segmented the SP2 model by journey purpose and the results are presented in Table 14. The purpose of business, commuting and leisure are denoted by B, C and L. Of the eight variables in the model, there was no statistically significant variation in the coefficients according to purpose for crowding, ride, ambiance, noise or time. For seating layout, business and leisure travellers had similar values but the coefficient for commuting was very low and statistically insignificant. In contrast, commuting and leisure had similar coefficients for ventilation but business travellers do not regard it as important. For seating comfort, which is the most important of the attributes, there is variation across the three purposes with leisure travellers regarding it to be of greatest importance and the least importance amongst business travellers.

**Table 14: SP2 Model Segmented by Purpose**

| | |
|---|---|
| Crowd | 0.0693 (2.6) |
| SeatBL | 0.0620 (2.0) |
| Ride | 0.1802 (6.7) |
| VentCL | 0.0464 (1.7) |
| Ambience | 0.1801 (9.1) |
| Noise | 0.0788 (3.9) |
| ComfortC | 0.2911 (8.2) |
| ComfortB | 0.2448 (7.1) |
| ComfortL | 0.3533 (12.3) |
| Time | -0.2367 (34.7) |
| Obs | 5080 |
| Rho Squared | 0.415 |

We have examined whether those travelling in a group had a different sensitivity to the seat layout variable but the coefficients estimated to alone and group travellers were not significantly different (t=0.44). However, we might expect the different preferences of group travellers towards particular layouts to be reflected in the rating itself and hence there is less reason to expect the coefficient to vary between group and solus travel than if a dummy variable approach had been used.

The crowding variable was included in the SP exercise even though it is not an inherent feature of rolling stock because it was felt that the response to seating layout might depend on the level of crowding. We examined whether the response to seating layout depended on the level of crowding. In a modified version of the model, we entered dummy variables to represent the three types of seating layout and allowed these coefficients to vary according to the degree of crowding as indicated by the ratings. No significant variations were observed, although this is perhaps unsurprising given that the seating coefficient in Table 13 is not estimated with a great deal of precision.

It can be seen that the disaggregate values are high and can be expected to exceed the maximum values that would be implied by the aggregate valuation. For example, in Table 13 a unit change in the seating comfort rating is equivalent to 1.29 minutes whilst the lowest value is 0.14 minutes for a unit change in the rating of seating layout. A unit change in the rating of the overall train type is 0.39 minutes from Table 12. Hence it will be necessary to rescale values to achieve consistency between the aggregate and disaggregate valuations.

## 5.6 Combined RP-SP Model

We now report what is termed a hybrid RP-SP model which is simultaneously estimated to all the data combined. Such a model allows for the fact that the different models have different scales, and hence scale factors (S1 and S2) are estimated so that all coefficients are estimated in the same scale as the RP model. This means that we could use the model to forecast choices between trains on a particular route in addition to using it to estimate money values.

Two RP-SP models are reported in Table 15. The first is based on the dummy variable specification for rolling stock, with the variables being allowed to interact with journey time along the lines of equation 4, and the detailed stock attributes are represented by their rating. The second model, termed the ratings model, specifies the overall rolling stock types using ratings rather than dummy variables in addition to the use of ratings to represent the detailed attributes

**Table 15: Joint RP-SP Models**

| Variable | Dummy Variable | Ratings |
|---|---|---|
| Egress Time | -0.0857 (8.3) | -0.0838 (8.2) |
| Headway | -0.0259 (9.6) | -0.0286 (10.3) |
| Train Time | -0.0676 (11.8) | -0.0646 (11.4) |
| Crowding | 0.0312 (3.9) | 0.0251 (3.3) |
| Reliability | 0.0679 (2.3) | 0.0237 (0.8) |
| Cost | -0.0129 (9.1) | -0.0127 (9.0) |
| Cost-B | 0.0043 (2.7) | 0.0041 (2.6) |
| Cost2 | 0.0014 (1.5) | 0.0017 (1.8) |
| Cost3 | 0.0039 (3.4) | 0.0039 (3.6) |
| Cost4 | 0.0064 (5.0) | 0.0064 (5.1) |
| CostX | 0.0017 (1.7) | 0.0020 (2.0) |
| C1 | -0.0012 (1.4) | |
| C2 | -0.0008 (0.7) | |
| C3-RP | 0.0022 (1.4) | |
| C3-SP | -0.0013 (2.9) | |
| C4 | -0.0002 (0.4) | |
| C6 | -0.0034 (1.6) | |
| C7 | -0.0003 (0.3) | |
| C8 | 0.0009 (2.5) | |
| StockRP | | 0.1284 (6.2) |
| StockSP-C | | 0.0366 (4.9) |
| StockSP-B | | 0.0191 (2.6) |
| StockSP-L | | 0.0217 (4.1) |
| Seat-BL | 0.0186 (2.0) | 0.0173 (2.0) |
| Ride | 0.0467 (5.7) | 0.0467 (5.9) |
| Vent-CL | 0.0155 (1.9) | 0.0138 (1.8) |
| Ambience | 0.0513 (7.2) | 0.0492 (7.1) |
| Noise | 0.0225 (3.8) | 0.0215 (3.8) |
| Comfort-C | 0.0832 (6.8) | 0.0795 (6.7) |
| Comfort-B | 0.0699 (6.1) | 0.0668 (6.0) |
| Comfort-L | 0.1010 (8.6) | 0.0965 (8.4) |
| S1 | 2.8120 (11.3) | 2.9330 (10.9) |
| S2 | 3.4930 (11.1) | 3.6610 (10.8) |
| Rho Squared | 0.324 | 0.327 |
| Observations | 13821 | 13767 |

We have carried forward the successful segmentations reported for the RP and SP models individually. However, they are interpreted a little differently now since the cost variable is segmented by purpose and income simultaneously. Cost is a base coefficient for all respondents. To this is added the Cost-B coefficient if the respondent is a business traveller. Given that business travellers are expected to be less sensitive to cost, Cost-B has the correct positive sign. The incremental cost coefficient for leisure was far from significant so the base represents both commuting and leisure travel.

As far as income groups are concerned, the four categories represent an additional effect on the cost coefficient of being in income group 2, 3, 4 or the unknown group. These are relative to income group 1. Given that we expect the sensitivity to cost to diminish as income increases, the incremental cost coefficients relating to income should be positive and be larger for larger incomes. This is indeed the case.

Given that the rolling stock rating valuation was somewhat different between the RP and SP models, and that almost all the RP data represents commuting, we have specified a separate rating coefficient for the RP data (Stock-RP) and three SP rating coefficients according to purpose. The stock type rating coefficient is highest for commuters, which presumably reflects the fact that they are frequent users, whilst it is lowest for business travellers although the latter is little different to the coefficient for leisure travel.

The relative scale of the RP and SP1 and the RP and SP2 models are denoted by S1 and S2. If these are greater than one then the RP model contains more residual deviation (error) than the SP models. This is precisely what we would expect since the SP exercises held all variables other than those characterising each alternative to be the same whereas the net effect of all those influences on actual choices which have not been explicitly included in the RP model's utility function will be discerned by its residual component.

Given that only a few variables enter into more than one of the data sets, with time entering all three and crowding entering two, the main advantage of combining the data is not to achieve more precise estimates, since we have to additionally estimate scale factors, but the placing of all the coefficients on a consistent basis so that valuations can be readily derived. In addition, the SP coefficients are rescaled to be consistent with actual behaviour and hence can be used, in conjunction with the other coefficients, to forecast choices between trains.

The overall fit of the model is good, as we would expect from the previous findings, and the t statistics are generally high. We will now use these models to examine the consistency between the aggregate and disaggregate values and also to evaluate a range of rolling stock improvements.

# 6. AGGREGATE AND DISAGGREGATE VALUES

## 6.1 Procedure

It is important to ensure that there is consistency between the disaggregate values and the aggregate values. However, we have already considered evidence which suggests that the disaggregate valuations in total will exceed the aggregate valuations we have obtained. This finding is not surprising since it is common in studies of this type to find that the sum of disaggregate valuations is greater than the corresponding estimated aggregate value (Jones, 1997). However, it is generally felt that the valuations of the disaggregate attributes in relation to each other remain unaffected.

We will assume that the disaggregate values obtained from the SP2 exercise provide an accurate account of the values of the various stock type attributes in relation to each other. It is then necessary to rescale their absolute values such that they are consistent with the aggregate valuations that we have estimated.

The procedure we have adopted is, across each individual in the SP data set, to regress the aggregate valuation obtained from the joint RP-SP model on the sum of the disaggregate values given the ratings that each individual supplied for the six rolling stock attributes. Given that the disaggregate values do not provide a comprehensive account of all the differences between two types of rolling stock, although we do believe that they account for the vast majority of the difference, the remainder of the effect can be discerned by the constant term. However, since this remainder effect may well vary across the two stock types which the respondent compared, it is necessary to specify a range of dummy variables rather than a single intercept. The sole purpose of these variables is to avoid any distorting effect from omitted factors on the scale factor which relates the aggregate and disaggregate values. Unlike the scale factor, the stock dummy variables have no subsequent use in the calculation of money values.

These dummy variables representing the stock type being compared are denoted Sxy where x and y denote the two train types being compared. The valuations are represented as the difference in generalised cost between x and y.

There are three comparisons of aggregate and disaggregate valuations that we can undertake:

Comp1: Aggregate valuations are derived from the RP-SP model based on dummy variables, with the SP coefficient used to represent the C3 stock type;

Comp2: Aggregate valuations are derived from the RP-SP model based on ratings of the stock types and using the RP stock type coefficient;

Comp3: Aggregate valuations are derived from the RP-SP model based on ratings of the stock types and using the SP stock type coefficients.

## 6.2 Comp1

The mean generalised cost difference between the two stock types the individual is faced with using the aggregate valuations from the RP-SP model based on dummy variables is 2.51 pence with a 95% confidence interval of ±0.63. The corresponding figure based on the sum of disaggregate valuations is 29.95 with a 95% confidence interval of ±4.87.

Table 16 contains the results of the regression of the aggregate value on the sum of the disaggregate values. A number of variables have been combined since their coefficients were very similar. In addition, coefficients with very low t ratios have been removed. These were S12, S13, S57, S45, S47, S23, S72 and S81.

**Table 16: Regression of Aggregate Dummy Variable Values on Disaggregate Values**

| | |
|---|---|
| Intercept | 1.184 (3.01) |
| S15&S24 | 3.113 (1.03) |
| S26 | -10.792 (3.37) |
| S34&S35 | 5.666 (10.01) |
| S36 | -9.944 (4.67) |
| S35 | 5.019 (6.51) |
| S38&S46 | 13.995 (3.57) |
| S48 | 7.162 (12.52) |
| S58 | 5.773 (7.97) |
| S68 | 12.670 (2.29) |
| S78 | 9.697 (7.33) |
| Scale | 0.024 (8.33) |
| Adj $R^2$ | 0.336 |
| Obs | 783 |

We have not here been able to estimate a strong relationship between the aggregate and disaggregate values and this is presumably because of the imprecision with which many of the stock type effects are estimated using the dummy variable approach. This is also likely to be the reason behind the very low estimated scale factor. Given these problems, we will not be using the dummy variable RP-SP model to calculate values. All values will be based on the RP-SP model based on ratings and we now turn to these models.

## 6.3 Comp2

The mean generalised cost difference between the two stock types the individual is faced with using the aggregate valuations from the RP-SP model based on the RP ratings coefficient is 23.25 pence with a 95% confidence interval of ±3.65. This is similar to the sum of disaggregate valuations of 29.78 with a 95% confidence interval of ±4.82.

Table 17 presents the same results as Table 16 except that the dependent variable is now based on the aggregate valuations derived from the overall ratings and using the RP rating scale from Table 15.

**Table 17: Regression of Aggregate RP Rating Values on Disaggregate Values**

| | |
|---|---|
| Intercept | 0.505 (0.43) |
| S12 | -23.161 (3.18) |
| S15 | -9.714 (1.75) |
| S23 | -12.899 (1.15) |
| S24&S58 | 7.741 (2.66) |
| S48 | 4.705 (2.17) |
| S81 | 31.409 (1.26) |
| Scale | 0.668 (51.86) |
| Adj $R^2$ | 0.785 |
| Obs | 783 |

The coefficients which had low t ratios and which were removed from the model were S13, S26, S34, S35, S38, S45, S57, S68, S72, S78, S36, S46 and S47. This is encouraging since it implies that, as we would expect, the rolling stock attributes which make up the disaggregate values account for a large amount of the difference between rolling stock types.

It can be seen that a much better fit has been achieved than when the dummy variable estimates were used to form the dependent variable. The scale denotes that the sum of the disaggregate valuations requires to be reduced by a third to be consistent with the aggregate valuations from the RP rating.

## 6.4 Comp3

The mean generalised cost difference between the two stock types the individual is faced with using the aggregate valuations from the RP-SP model based on the SP ratings coefficient is 4.33 pence with a 95% confidence interval of ±0.66. The corresponding figure based on the sum of disaggregate valuations is 29.78 with a 95% confidence interval of ±4.82.

Table 18 presents the results of the regression of the aggregate values derived using the SP rating coefficients of the RP-SP model of Table 15. The coefficients which were removed because of low t ratios were S24, S26, S45, S46, S68, S72, S81, S47, S15, S13, S36, and S57.
A good fit has again been achieved but the scale factor is now much smaller. This is to be expected given that the previous results showed that the aggregate valuations derived from the SP data were much smaller than the aggregate valuations derived from the RP data.

**Table 18: Regression of Aggregate SP Rating Values on Disaggregate Values**

| | |
|---|---|
| Intercept | -0.238 (0.71) |
| S12 | -3.891 (2.80) |
| S23 | -3.096 (1.46) |
| S34 | 0.692 (1.45) |
| S35 | 1.473 (2.25) |
| S38&S48 | 1.096 (2.26) |
| S58 | 1.724 (2.81) |
| S78 | 2.259 (2.01) |
| Scale | 0.118 (47.07) |
| Adj $R^2$ | 0.767 |
| Obs | 783 |

# 7. VALUATIONS

## 7.1 Introduction

We consider here the monetary valuations of rolling stock implied by our models. This involves the application of the RP-SP model to the ratings supplied by respondents and with appropriate allowance for each individual's income level and journey purpose.

Our preferred RP-SP model is that based on the ratings since with the dummy variable approach many of the coefficients relating to the overall stock type are insignificant. Had we removed the statistically insignificant coefficients then most of the stock type valuations would be zero.

We will first consider the aggregate valuations and then present some disaggregate valuations. These valuations are based on the ratings both of the overall stock types and of the detailed rolling stock attributes that were supplied by the 783 individuals as part of the SP survey.

## 7.2 Aggregate Valuations

We have eight stock type categories in our data set as listed in Table 1. Table 19 presents the aggregate monetary valuations associated with the ratings of each stock type for both the RP and SP ratings coefficients. This involves the application of the RP-SP model to the ratings supplied by respondents and with appropriate allowance for each individual's income level and journey purpose. These valuations are based on the ratings of the overall stock types that were supplied by the 783 individuals as part of the SP survey.

The figures in Table 19 are calculated as the product of the mean rating for the stock type in question and the rating coefficient which is then divided by the appropriate cost coefficient to convert into monetary units.

**Table 19: Relative Monetary Valuations (pence) of Stock Type Ratings**

| Stock | RP | Rank | SP | Rank |
|---|---|---|---|---|
| C1 | 76.1 | 8 | 16.1 | 8 |
| C2 | 87.6 | 6 | 18.1 | 6 |
| C3 | 87.4 | 7 | 18.2 | 5 |
| C4 | 100.3 | 4 | 19.6 | 4 |
| C5 | 112.3 | 2 | 22.4 | 2 |
| C6 | 115.4 | 1 | 23.1 | 1 |
| C7 | 91.5 | 5 | 16.8 | 7 |
| C8 | 109.3 | 3 | 20.2 | 3 |

The higher the figure in Table 19 then the more highly the stock type is regarded. The money valuations in pence of the differences in stock type are taken as the differences in the figures in Table 19. For example, the Networker (C5) is regarded as being 24.9 pence per single trip better than the South East slam door stock (C3) using the RP values other things equal.

The rank ordering of the different stock types seems plausible. The Sprinters (C1) are regarded to be the least attractive of the stock types and all of the three types of South East sliding door stock (C4, C5 and C6) are regarded to be superior to the older slam door stock (C3). Within the sliding door South East stock, the newer stock (C5 and C6) is preferred to the non air conditioned and older sliding door stock (C4). There is little to choose between two newest types of South East rolling stock (C5 and C6) and this seems reasonable; the Wessex electrics are slightly superior and this might be at least partly attributable to the air conditioning. The air conditioned MkII stock is well regarded although it is not clear why the MkIII stock has not been rated more highly.

The differences in the RP valuations across different stock types are relatively small but we feel that they are plausible. However, the SP based values appear much too low.

## 7.3 Disaggregate Valuations

Table 20 provides the disaggregate values after application of the appropriate scale factor as estimated in section 6. We have here provided values solely on the basis of the RP results, that is, the disaggregate values scaled to be consistent with the RP aggregate valuations. These are based on the ratings of the detailed rolling stock attributes supplied by the 783 individuals as part of the SP survey.

**Table 20: Relative Disaggregate Valuations**

| Stock | Seat | Ride | Vent | Ambience | Noise | Comfort |
|---|---|---|---|---|---|---|
| C1 | 3.95 | 17.11 | 4.28 | 17.01 | 7.73 | 30.87 |
| C2 | 4.57 | 24.44 | 7.01 | 24.50 | 10.49 | 31.62 |
| C3 | 5.25 | 20.08 | 4.79 | 19.81 | 9.01 | 36.35 |
| C4 | 6.59 | 23.12 | 4.77 | 23.59 | 10.29 | 39.15 |
| C5 | 6.66 | 27.73 | 5.78 | 27.65 | 12.15 | 47.27 |
| C6 | 6.87 | 30.43 | 3.74 | 24.41 | 11.06 | 45.51 |
| C7 | 8.35 | 24.02 | 4.34 | 22.77 | 10.94 | 44.17 |
| C8 | 8.04 | 25.03 | 4.31 | 23.63 | 11.62 | 43.11 |

The results are to be interpreted in the same way as for Table 19, that is, the figures represent the aggregate monetary valuations associated with the ratings of each rolling stock attribute and the higher the figure the better the performance in terms of that attribute.

The valuation of a specific rolling stock attribute on one type of stock compared to another is the difference between the relevant figures in Table 20. For example, the ambience of an Express Sprinter (C2) is regarded to be better than that of a Sprinter (C1) to a value of 7.5 pence per single trip.

As would be expected from the previous discussion of the valuation of the rolling stock attributes, there is not a great deal of difference across the different stock types in the valuations associated with seating layout, ventilation and noise levels and the larger differences occur for the more highly valued attributes of seating comfort, ambience and ride quality.

With regard to ventilation, a noticeably high value is associated with Express Sprinters (C2) which has a good air conditioning system although the Networkers (C5) receive a high rating yet they are not air conditioned. The seating layout of the InterCity trains (C7 and C8), which includes a relatively large proportion of tables, is valued most highly whilst, as expected, the Sprinters (C1) and slam door South East stock (C3) perform least well in terms of noise.

With regard to seating comfort, the InterCity trains (C7 and C8) and the new South East stock (C5 and C6) are most liked with the seats on the Sprinters and Express Sprinters (C1 and C2) regarded to be least comfortable. The differences here can be quite large, with a 17 pence difference between Networkers and Sprinters attributable to seating comfort.

The Sprinters (C1) and old slam door stock (C3) perform least well in terms of ambience and this is hardly surprising. The Networker (C5), which is the newest of the trains considered here, is the most highly regarded in terms of ambience.

The ride quality of the Sprinters (C1) is somewhat worse than most of the other stock types, although to some extent there will be an interaction with infrastructure here. The best ride quality is attributed to the Wessex electrics (C6) and this is valued at 13 pence per single trip superior to the Sprinters. The old slam door stock (C3) is relatively poor in terms of ride quality but there is little difference across the other stock types.

# 8. CONCLUSIONS

This study has conducted a detailed investigation into the valuation that rail travellers place upon different types of rolling stock. It has involved a thorough literature review, an extensive piece of qualitative research and a large scale pilot survey which all contributed to the approach adopted in the major data collection exercise that was undertaken as part of the quantitative analysis.

The data collection was based on both RP and SP methods and focussed on the alternative types of rolling stock which travellers are currently faced with and hence which are familiar to them. The RP approach obtained values of the overall differences in stock type as did the first of the SP exercises. The second SP exercise examined the specific rolling stock attributes of:

- seating layout
- ride quality
- ventilation
- ambience
- noise level
- seating comfort

The models we have estimated have a number of desirable features. They tend to achieve a good explanation of the data and to obtain results which are plausible both in relation to each other and in absolute. The results are consistent with previous findings in key areas such as the values of time and headway and it has been possible to discern strong effects of the expected type from income levels and journey purpose. However, the results do differ from those of previous research in one principal respect; the values of rolling stock tend to be low. This finding is consistent with the results of the qualitative research which was undertaken whilst we had expressed concerns in the literature review that the values of rolling stock improvement obtained from SP methods were often what seemed to us to be too high. The various data sets have been combined to form a single RP-SP model although separate RP and SP stock rating coefficients are estimated within this.

Two different model forms have been specified. One is based on the ratings of rolling stock supplied by respondents and the other uses dummy variables to represent different stock types. We have preferred the approach based on ratings primarily because it obtains a much more precise estimate of stock type effects and because the results are more transferable to stock types not covered in the study.

We have obtained aggregate valuations using both RP and SP data, and we have also estimated scale factors to make the sum of the disaggregate valuations consistent with the aggregate valuations derived from the RP or SP data.

We prefer the results based on the RP data for three main reasons:

i) When faced with a choice between RP and SP models, there is a preference for models based on actual choices expressed in the market place provided that the RP model is robust. We have seen that this is the case since the RP model obtains plausible and precise results based on an acceptable sample size and it achieves a good fit.

ii) The RP aggregate values seem more plausible than the SP aggregate values since the latter tend to be very small indeed.

iii) The aggregate RP values are much more consistent with the disaggregate SP values than are the aggregate SP values. The scale factor in the former case is 0.67 whereas it is 0.12 in the latter case. We find it hard to believe that the aggregate SP values should be so much less than the sum of the disaggregate SP values.

It could be argued that the RP values are too high because it has excluded those with low values of rolling stock. For example, about 40% of the sample reported that they had the same train type for chosen and alternative or that they would catch the first train to arrive. However, these people do not necessarily have low values of stock type. For example, those reporting the same train type for chosen and alternative might be unaware of different train types, or else the best alternative to the current departure is the same train type but at a different time since the alternative train type is not satisfactory. The latter could imply a large value of rolling stock type. In addition, others may not perceive there to be a trade-off. Those who would catch the first train to arrive do not necessarily have low values; it could simply be that, in conditions which can vary considerably day by day, they wait until arrival at the station to observe crowding and reliability conditions prior to making any decisions. In any event, even if these individuals did have zero values this would not account for the large difference between the RP and SP values.

The RP monetary valuations of the aggregate stock types are relatively low but nonetheless plausible. The valuations of the different stock types in relation to each other also exhibit a high degree of reasonableness. For example, the Sprinters are regarded to be the least attractive of the stock types and all of the three types of South East sliding door stock are regarded to be superior to the older slam door stock. Within the sliding door South East stock, the newer and air conditioned stock are preferred to the non air conditioned and older sliding door stock.

The maximum valuation of a difference in overall stock type is equal to 39.3 pence per single trip which is equivalent to 4.3% of the average fare. This is for the comparison of Wessex electrics and Sprinters. The ranking of the stock types seems plausible. The fourth ranked stock type of the older South East sliding door stock is valued at 24.2 pence (2.6%) better than the Sprinters whilst the Express Sprinters, ranked as sixth best out of the eight, are valued at 11.5 pence per single trip (1.3%) better than the Sprinters.

Although there are some difficulties comparing valuations across studies because of the different stock type comparisons involved, we have examined a large range of stock types and the valuations are much lower than valuations of around 10% of the fare paid which are common in the literature.

The most important of the rolling stock attributes were seating comfort, ambience and ride quality. Indeed, our qualitative research and the review of the literature had pointed to the importance of this amongst the rolling stock attributes. MVA (1991) state, "..... it is evident that the major priorities for investment are generally related to ride quality and seating. However, for season ticket holders, there is also a strong priority for improvement to the (internal) appearance."

Given that our values are lower than most that have been obtained previously, the question naturally arises about the confidence that can be placed in the results obtained here. At the outset, we can claim a large number of plausible relationships and there is consistency with previous results in many areas other than rolling stock. Whilst the rolling stock valuations are lower, we believe that our results are more consistent with analysis of stock type changes on the demand for rail travel. If stock type values are of the order of 10% of the rail fare then demand impact models based on time series ticket sales data ought to be able to detect stock type effects, particularly since the effect of fare and journey times variations with much lower equivalent values are routinely discerned in such models. In addition, a novel feature of our results is that they are based on RP data relating to travellers' actual choices, and if anything these values might be too high. The SP exercises took particular care to offer scenarios which were familiar to respondents and this is an advantage over many previous studies. We have taken care to isolate related effects, such as crowding and reliability, whilst our results are consistent with the qualitative research which was undertaken. Moreover, the results are more general and are not tied to a specific investment case.

The research was warranted on the grounds that the previous research, and certainly that upon which Passenger Demand Forecasting Handbook recommendations are based, is now somewhat dated whilst we have covered a wide range of stock types in contrast to previous research where there has been an emphasis on InterCity stock.

The model can be applied to stock types which have not been covered in this study. This requires that ratings of different stock types are obtained and these ratings are entered into the joint RP-SP model. The model can also be used to forecast choices between different train types on a particular route.

As far as transferability to different market segments is concerned, the RP values essentially relate to commuting journeys. This was a key requirement of the study since it is here where fares are controlled. However, we also have information on how values vary with journey purpose from the SP study and amendments could be made to allow for different purpose mixes. However, we would caution against the use of the results for very long distance journeys since the results are based on mean journey times of 43 minutes in the RP data set and 59 minutes in the SP data set.

There are now numerous instances where the impact of changes in rolling stock on rail demand can be observed. Moreover, rail ticket sales data is now considerably more reliable than it was at the time of the first such studies. We recommend that the results of this study be validated against a large data set of actual changes in rail demand in response to rolling stock changes.

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# APPENDIX 1: RP AND SP ORIGIN AND DESTINATION STATIONS AND ROLLING STOCK

| STATION | DESTINATION | ROLLING STOCK |
|---|---|---|
| Ipswich | London | Mk2, 321, 312 |
| Colchester | London | Mk2, 321, 312 |
| Shenfield | London | 312, 321, 315 |
| Southend Central | London | 302,310,312 |
| Southend Victoria | London | 312,321 |
| Gillingham (Kent) | London | 411, 421, 423, 465 |
| Chatham | London | 411, 421, 423, 465 |
| Rochester | London | 411, 421, 423, 465 |
| Sevenoaks | London | 411, 421, 423, 465 |
| Orpington | London | 411, 421, 423, 465 |
| Bromley South | London | 411, 421, 423, 465 |
| Otford | London | 411, 421, 423, 465 |
| Swanley | London | 411, 421, 423, 465 |
| Beckenham Junction | London | 411, 421, 423, 465 |
| Brighton | London | 411, 421, 319 |
| Haywards Heath | London | 411, 421, 319 |
| Three Bridges | London | 411, 421, 319 |
| Woking | London | 411, 421, 159, 442, 455 |
| West Byfleet | London | 411, 421, 455 |
| Weybridge | London | 411, 421, 455 |
| Walton-on-Thames | London | 411, 421, 455 |
| Surbiton | London | 411, 421, 455 |
| Staines | London | 411, 421, 455 |
| Feltham | London | 411, 421, 455 |
| Twickenham | London | 411, 421, 455 |
| Richmond | London | 411, 421, 455 |
| Virginia Water | London | 411, 421, 455 |
| Egham | London | 411, 421, 455 |
| Didcot Parkway | London | HST, 165 |
| Milton Keynes Central | London | Mk2/3, 321 |
| Bedford B.R. | London | HST, 319 |
| Coventry | Birmingham | Mk2, 323, 321 |
| Wolverhampton | Birmingham | Mk2, 323, HST/Mk2, 158 |
| Birmingham International | Birmingham | Mk2, 323, 321 |
| Leamington Spa | Birmingham | HST/Mk2, 165, 150 |
| Preston | Manchester | 158, 156, 150 |