QUALITY BUS PARTNERSHIPS AND MARKET STRUCTURE

(PPAD 9/84/21)

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1 INTRODUCTION

This is the final report of the project 'Quality Bus Partnerships and Market Structure' (PPAD 9/84/21) commissioned by the Department from the Institute for Transport Studies, University of Leeds and Transport Studies Unit, University of Oxford. The objectives of the study, as agreed at inception, were:

- to undertake a set of case studies on the effects of Quality Bus Partnerships. This was to be undertaken in collaboration with the TAS Partnership, who were awarded a companion project.

- to develop a simulation model of the bus market, at corridor level using real data on demand, revenue and cost, and driven by evidence-based elasticities

- to use the model to assess the economic benefit of quality partnerships and assess the impact of such agreements on market structure and performance

During our work, we have provided a number of interim reports including a literature review (Bristow and Shires, 2001) a model development report (Whelan, Shires, Toner and Preston, 2001) and a report on the case studies (ITS/TSU, 2000). In addition to this report, we are submitting at the same time the Quality Bus Model (QBM) User Manual (Whelan 2003). In addition, we have given a number of conference papers based on the work done for this project (Bristow et al 2001, Whelan et al 2001, Preston et al 2003).

2. CONTEXT

The purpose of this chapter is to describe the process and stages of the work from its inception to completion. This is necessary as a number of changes and developments occurred during the course of the project. Specifically, the decision by the Commission for Integrated Transport (CfIT) to investigate the value for money from bus subsidies influenced the course of the work, since the model we developed in 1999/2000 was taken up and used in the work for CfIT. It is also probably fair to say that the pace of creation of Quality Bus Partnerships, especially following the Transport Act 2000, did not proceed as expected at the inception of this study, and this too has meant that our work has been refocused in the light of external events.

2.1 Objectives

This project was commissioned in 1999 at a time when Quality Bus Partnerships were becoming recognised as a way of encouraging investment in bus service provision and improving the quality of the product offered. The 1998 White Paper (DETR, 1998) had recently appeared stating that:

"Quality partnerships work but they need to be more widespread and put on a firm footing. We will therefore introduce legislation to put these partnerships on a firm footing."

The objectives set in the project specification were:

(i) to provide a factual and theoretical analysis of any effects of Quality Partnerships to date on competitive behaviour and market structure.

(ii) to monitor any such effects during the course of the project, and

(iii) to discuss and hypothesise about any future effects, particularly with reference to legally backed Quality Partnerships.

A related project examining the administrative processes of Quality Partnerships and their relative performance in achieving patronage growth and mode shift was commissioned at the same time. Some synergy between the two projects was envisaged.

The proposal set out the following elements:

(i) Factual analysis: through case studies using a structured interview with participants and non-participants to gain an understanding of partnerships: why partnerships had developed in particular ways, experience of competition, problems experienced, changes in behaviour etc. This analysis was intended to give insights into operator behaviour and competitive response which might aid the design of the model. The proposal envisaged a high degree of cooperation in the case studies with the companion project. It was assumed that the companion project would provide operator data in a format suitable for use in a model of a quality corridor.

(ii) Theoretical analysis: the development of a micro-economic simulation model of bus operation and competition on a corridor. This to be developed in a similar way to the PRAISE model developed to assess on-track competition in the rail industry. Review work was required to establish suitable parameters and values for the model.

2.2 Phase 1: Case Studies

Initially the set of case studies was decided in cooperation with TAS who were awarded the companion study and the Department. The ITS methodology was piloted on the Leeds Scott Hall Road guided busway and then implemented at six locations: Nottinghamshire, West Midlands, Edinburgh, Leicestershire, Cheltenham and Brighton. This gave us examples of specific corridors in large and medium sized cities and the perspective from smaller towns and a more holistic approach. The key features of the partnerships are shown in Table 2.1 below:

Table 2.1 Features of the Case Study Quality Bus Partnerships

Quality Bus Partnership	ASSOCIATED FEATURES
Leeds Scott Hall Road	Segregated bus way; bus lanes; traffic priority measures; new low floor buses; route branding; increased service frequency; increased information and publicity; driver training.
Nottinghamshire Calverton Connection	Bus lanes; new buses; increased service frequency; driver training; route branding
West Midlands Line 33	Traffic priority measures; bus lanes; real time information; new low floor buses; new passenger infrastructure; route branding; increased passenger information and publicity; increased service frequency; driver training.
Bloxwich	Bus lanes; improved passenger infrastructure; new low floor buses; increased passenger information and publicity; driver training.
Primeline Coventry	Bus lanes; improved passenger infrastructure; new low floor buses; increased passenger information and publicity; driver training.
Edinburgh Greenways	Traffic priorities; bus lanes (greenways); increased passenger information and publicity; improved passenger infrastructure.
Cheltenham Route 2	Traffic priorities; bus lanes, new buses; improved passenger infrastructure – note not all of features are in place as yet
Brighton	Increased passenger information and publicity; improved passenger infrastructure; new vehicles (some low floor); driver training; increased frequencies; route branding.

Source: Bristow et al 2001

In-depth interviews were carried out with representatives of the local authorities and bus companies involved to explore issues covering the planning, implementation, impacts, competition and policy issues surrounding quality bus partnerships. Interviews took place in late 1999 and involved 28 interviewees in total, 15 from bus companies and 13 from Local Authorities. The case study work was reported in 2000 (Institute for Transport Studies/Transport Studies Unit).

Key points emerging from this stage of the work were:

- A clear preference for voluntary partnerships. Voluntary Quality Bus Partnerships were seen to have improved relationships and enhanced the understanding between local authorities and operators.
- Quality Bus Partnerships were setting new standards for the industry.
- Quality Bus Partnerships had encouraged bus operators to target their investment strategies and operators had contributed to infrastructure investment.
- Quality Bus Partnerships had led to patronage growth, usually in an otherwise declining market. However, identifying the reasons for this growth and particularly the degree of modal switch was difficult given a lack of detailed monitoring work.
- Leadership and effective project management were seen as critical to the success of Quality Bus Partnerships. The ability to bid for management resources within the Local Transport Plan would be welcomed.
- Marketing was seen as a key factor in achieving patronage growth.
- Quality Bus Partnerships occurred in conditions of mature competition, normally with one or two operators.
- Quality Bus Partnerships have been subject to limited, short-run competition in certain areas.
- There were widespread problems with enforcement of bus priorities. Although efforts had been made to include police forces in Quality Bus Partnerships, they were seen as a missing partner. Decriminalisation of parking offences was seen as only a partial solution while moving offences remained the exclusive domain of the police. It was felt that the police did not have any incentive to prioritise the enforcement of bus priorities.
- A constraint on the further development of Quality Bus Partnerships was the position of the Office of Fair Trading on competition in the bus industry. Further integration of services and ticketing would not occur while operators perceived the threat of legal action.

The case studies proved extremely useful in a number of respects. They gave an insight into the market impacts of a range of quality measures, the circumstances in which operators and authorities could combine to deliver partnerships, the key success factors and the remaining uncertainties about the regulatory environment. In the proposal, further case study work was planned to look at new partnerships formed during the course of the work, and particularly at the impact of new statutory partnerships.

However, after reporting on the case studies, the second phase of the work was refocused, after discussion with the Department, to concentrate on the development of the model. This was the outcome for a number of reasons:

- The case studies had revealed little experience of competition and further case studies were not expected to shed significant further light on this issue.

- The position of the Office of Fair Trading was perceived to place a constraint on the development of Quality Bus Partnerships. The Transport Bill had not yet been passed, so statutory partnerships could not be included in the study. Also there was some doubt as to whether the Act would bring forward statutory partnerships, given the evidence from the case studies. The period saw a slowing down in the number of partnerships formed.
- The basic model required refinement and validation. It had not proved possible to obtain operator data through the companion project, so this task fell to ITS.
- A review of parameters and values for the model was required.

In the light of the above the second phase was revised to focus on Model Development.

2.3 Phase 2: Model Development

The quality bus model is described in full in Chapter 3, and its features will be outlined only briefly here. The core features of the model are: -

- a <u>corridor</u> approach typically describing a simple radial route linking a city or town centre with the suburbs.
- a <u>demand</u> routine in which demand is sensitive to the generalised cost of bus travel (fare, time and quality). Demand is simulated and is represented at two levels. The higher level is the choice between bus, car, slow modes and not travel. The lower level is the choice of service (route departure time operator and ticket type), thus permitting analysis of various forms of competitive behaviour.
- a <u>supply</u> routine in which the operator costs of running bus service are represented in a conventional CIPFA-type form. These costs are supplemented by the infrastructure and operating costs associated with quality measures of various kinds.
- an <u>evaluation</u> routine capable of comparing the cost revenues and user benefits associated with various fares, service and quality initiatives and various forms of competitive interaction. Following discussions it was decided to add a capability for estimating the external benefits of better bus service in terms of the impacts on congestion and pollution. This work drew on the ITS/AEA research for the Department 'Surface Transport Costs and Charges' (Sansom et al, 2001) using the road and area typology in that work rather than case-specific data.

Elasticities and other Model Parameters

Having developed the model structure, it was necessary to populate the model with suitable parameters and values. This required us to:

- review the theoretical basis for the form of the demand relationships and the properties of the set of elasticities and cross-elasticities.
- review and collate the relevant information on appropriate parameter values for time, comfort, reliability, information and other parameters.

This element of the work was based on a review of the literature both published and unpublished and is reported in Bristow and Shires (2001).

Model Testing
In order to test the model, data on actual bus services had to be obtained. One of the case study areas generously offered us access to their data. We found the conversion of electronic ticket machine data into a form suitable for entry to the model a more difficult and time consuming process than we had anticipated. However, we were able to generate a data set with which to test the model albeit at a more aggregate level than originally intended. The development and testing of the model was reported to the Department in Whelan et al (2001).

Shortly after this, CfIT invited tenders for a study on achieving best value for money in the bus industry. ITS/TSU joined a bid led by LEK Consulting, which was successful. The role of ITS/TSU was two fold, in the inception phase to provide a review of issues and in the main phase to contribute through modelling of bus routes. The project officer agreed that ITS/TSU work on the CfIT project would complement the quality bus study and was likely to enhance the quality of the final product. It was therefore agreed that work on the quality bus project would be put on hold while the CfIT project was completed. The content of phase 3 would then be agreed with the Department in the light of the CfIT findings. The CfIT project ran during 2001 and was completed in February 2002.

The CfIT work was extremely useful to the model development in two main ways:

- The project gained access to operator data on seven 'representative route types' which enabled the model to be tested against a wide range of conditions.
- The project and feedback from the steering committee identified areas where the model could be improved.

2.4 Phase 3: Model Enhancement and Policy Tests

Following the completion of the CfIT work, it was agreed with the Department that Phase 3 of the work should concentrate on:

- enhancing the QBP model so as to take account of the limitations of the version of the model used in the CfIT work.
- running policy tests to assess the outcome under various forms of competitive behaviour.
- running policy tests to assess the impact of various forms of subsidy allocation, relating particularly to the CfIT recommendation that fuel duty rebate should be replaced by a per passenger or a per passenger mile subsidy regime. These possibilities were of interest in the context of the Government's Bus Subsidy Review.

2.4.1 Model development

When applying the QBP model to the case study routes for the CfIT work we noted that it would be beneficial to incorporate more flexibility in both the inputs and outputs of the model. In particular:

- the model should more easily accommodate the tastes and preferences of different market-segments particularly the difference between those with and without a car available, and
- the model should allow for a supply side response to changes in demand;

The issues and solutions are described below.

Market Segmentation

The market for travel is diverse with each individual traveller having their own set of needs, tastes and preferences. To simplify the model structure it was assumed that the market could adequately be modelled using average values for taste and preferences, represented by market elasticities, values of time, values of quality etc. It became apparent during the development of the CfIT case study runs that it would be beneficial to accommodate segmented tastes and preferences including: peak period traffic, off peak traffic, those with cars available and those without cars available. Whilst it would be feasible to accommodate this diversity by running a separate model for each segment in each time period it was noted that a unified model with the ability to allow for tastes to vary across the population would be beneficial. To this end a new model was to be developed which can be run for a key one hour period or for a full day, which allows individual travellers to have their own preferences. By specifying preferences at the level of the individual it is also possible to aggregate to market segments or to have average values for the market as a whole.

Operator Response to Increased Demand

The Quality Bus Model works by assigning simulated individuals to services throughout a given operating period. Where services are forecast to become overcrowded a 'flag' is raised in the output file reporting such an occurrence and the analyst must make a judgement whether or not to change the timetable. Rather than try to identify an optimum new timetable within the program, the model will be revised to make the assumption that sufficient duplicate services are run to accommodate the level of demand and reports the number of bus hours, kilometres and cost of these additional services.

2.4.2 Policy Tests

It was agreed with the Department that we would run the model using the data from two of the seven CfIT corridors, duplicating some of the policy tests to assess the impact of the above model changes. The model would also be run to reflect various competitive scenarios and to address specific policies.

As the model is able to handle market segmentations, it was necessary to obtain data that allows us to split the market in this way. Information on car available and non-car users was available from the CfIT study with respect to values of time and elasticities. Any allowance for variation between the peak and the off-peak was dependent on evidence from earlier studies. More detailed information was required on market shares, as this stage we had data on market share by distance. Disaggregations by area type (excluding London) car/non-car available, commuting trips/other trips and peak/off-peak were also required and were obtained from NTS. For each area type, the market was split as follows:

Car available peak trips
Non-car available peak trips
Car available off-peak trips
Non-car available off-peak trips.

In deciding which policy tests would be most helpful we considered the project objectives, the modifications made and the then current consultation paper “Review of Bus Subsidies” (DfT, 2002).

In order to explore the impacts of the increased segmentations and supply loops, a number of the key policy tests from the CfIT work were rerun. This step also acted as a testing stage for the changes to the model:

- 20% fares cut
- 20% frequency increase
- 5% journey time improvement
- Medium Quality enhancement.

The runs were for the large and medium radials as these are the types of route most likely to already have or develop a Quality Partnership. This should enable us to identify any key differences in results and their possible policy implications.

Most QBPs have experienced little or no direct competition. However, if the concept is to be adopted more widely it is possible that this will change. Two types of market entry were considered:

- entry by a quality competitor
- entry on price by a low quality operator.

This allowed an exploration of whether and under what conditions entry is sustainable.

In the light of the 2002 consultation document on bus subsidies, policy tests relating to subsidy were thought to be a useful addition to the modelling work. The options outlined in the consultation document are:

- Fuel Duty Rebate (FDR) retained with variable rates targeted at specific services or cleaner vehicles.
- FDR replaced by a per passenger subsidy
- FDR replaced by a per passenger kilometre subsidy
- FDR funds to go to Local Authorities for tendering
- FDR funds to rural and urban challenge
- Scrap challenge funding and divert to existing funding streams
- Extension of concessionary fares schemes.

The model was thought to be of use in exploring the implications of bullet point one, assuming the subsidy were targeted toward cleaner vehicles and bullet points two and three.

This programme of work for Phase 3 was agreed in late August 2002. The work was carried out and completed in early 2003 and is reported here. The final development of the model is discussed in Chapter 3 and the model tests in Chapter 5. Chapter 4 covers the derivation of the final model parameters. Chapter 6 contains our conclusions.

3. DEVELOPMENT AND TESTING OF THE QUALITY BUS MODEL

In this chapter the development and testing of the model is described. Section 3.1 first addresses key questions relating to the purpose, scope and functionality of the model. Section 3.2 reviews the possible modelling approaches available. Section 3.3 outlines the model structure. Section 3.4 develops the demand model, Section 3.5 the cost model and Section 3.6 the evaluation model. Section 3.7 contains an overview of competitive response and dynamics in the model. Section 3.8 covers model inputs and outputs. Section 3.9 outlines the model testing on data supplied by a case study operator. Section 3.10 provides a summary and conclusions.

3.1 Desirable Characteristics of a QBP Model

The properties needed in a QBP model depend upon answers to the following questions:

(a) What is the purpose of the model?

The purpose of the QBP model is to provide an insight into the likely outcomes of alternative regulatory and investment policies. In terms of the model outcomes, the Department were interested in a number of issues, which it was felt could be addressed by the following questions:

- is a QBP likely to generate benefits (for users, operators, other road users, society at large);
- is a QBP needlessly restrictive;
- will a QBP eliminate competition;
- will a good share of the benefits accrue to consumers;
- how necessary is quality passenger infrastructure to the success of QBPs?

(b) What is the scope of the model?

The long-term objective for modelling is to develop a framework that can be used to assess all reasonable regulatory and investment policies at corridor or area-wide level. In the short-term, however, we have worked on the assumption that there exist well-defined corridors that form the basis for operator strategies and which may be the subject of QBP arrangements. Although clearly not picking up all QBPs, this is a realistic description of many QBP arrangements.

The model must be capable of dealing both with symmetrical cases in which all operators benefit from the quality measures, and asymmetrical cases in which the quality operator has exclusive rights to certain facilities such as sections of busway. New statutory QBPs under the Transport Act 2000, may exclude operators who do not meet the agreed quality standards from using facilities provided under the agreement.

(c) What outputs are desirable?

Ideally, the model should generate output to form the basis of a social cost-benefit analysis. At an aggregate level this will involve information on operator demand, revenues, market share, operating costs, profitability, measures of consumer benefit (consumer surplus), together with estimates of financial implication from a change in externalities (environmental, decongestion, accidents). The outputs should be disaggregated to provide a view on where the costs and benefits accrue. This may be at route or service level.

(d) What inputs are available?

The parameters within the model must be set flexibly enough to be capable of dealing with various levels of spatial interaction and competition between routes. Model outcomes will be determined by

- the relevant values and elasticities on walk, wait, in-vehicle time, comfort, reliability, fare and other quality issues, some of which are known with more confidence than others;
- costs related to distance, time and peak vehicles required;
- cost differences between operators;
- the relevant fare and service strategies adopted by operators.

(e) How flexible should the model be?

The model should be capable of being updated and adapted when new research becomes available or when the model needs to be applied to a new set of circumstances. In general, the modelling process should be viewed as an ongoing process in which the model is continually improved over time.

3.2 Review of Public Transport Models

Before developing our own model, we examined a range of existing models of public transport, which could either be used directly or could be adapted. The review centres on work based in the UK.

3.2.1 Strategic and Semi-Strategic Models

Approaches based on adapting strategic integrated transport models such as START (MVA, 1992) were rejected for the following reasons:

- although these models are simplifications of the traditional land-use and transport study (LUTS) model the level of geographic detail is not appropriate for this study
- the feedback between demand and supply in these models is not usually explicit.

The use of area-wide simulation models such as GUTS (Game of Urban Transport Simulation; Willumsen and Ortuzar, 1985) and its successor PLUTO (Planning Land-Use and Transport Options; Bonsall, 1992) were rejected for similar reasons.

Commercial transport modelling software such as EMME/2, SATCHMO, TRIPS and VIPS all provide the facility to model public transport networks and their interaction with private cars in considerable detail, applying matrix-based demand models alongside public transport assignment models. There would clearly be benefit in "bolting on" a competition model to existing software if possible. In previous reviews in the context of competition between rail operators, none of these models was found to be appropriate (ITS and Gibb 1998). This conclusion holds also for the bus market. Modelling approaches that offer greater promise are discussed below.

3.2.2 Operational Models

Model for Evaluating Transport Subsidy (Glaister, 1987)

The Model for Evaluating Transport Subsidy (METS) traces the effects of changing public transport fares and services on the overall urban transport system. It was calibrated for Greater London plus the six English metropolitan counties. There is competition between modes but not within. The overall structure has demands, user costs, waiting times, travel times, traffic speeds and traffic volumes determined simultaneously; a feasible equilibrium is one which satisfies all the above relationships and, for feasible equilibria, revenues, costs, subsidy requirements, economic benefits and marginal net social benefits are computed. This outline has been adopted by others (as illustrated by recent reapplications of the model to London (Grayling and Glaister, 2000) and the metropolitan areas (Glaister, 2001)) and remains a realistic model shell, with the debate more about how to make use of advances in modelling particular relationships within and between modes rather than what to include. The model, however, omits accident and environmental impacts.

Economic Modelling Approach (Dodgson, Katsoulacos & Newton, 1993)

The Economic Modelling Approach (EMA) was born out of a desire to model anti-competitive behaviour in the bus industry. While that goes beyond what we need, the building of a model which predicts the non-cooperative Nash equilibrium is part of our requirement as is the need to predict cooperative equilibria.

The EMA uses operator-specific direct demand models with own and cross-price elasticities for each of the two operators included. Passengers' choice of bus is determined by a rooftops model modelled at an aggregate level, that is, allocating portions of the demand profile to particular services. In principle, it is possible to have the operators placed asymmetrically in terms of the elasticities, though in practice that was an added complication.

The EMA can demonstrate the situations in which either, both or neither of the incumbent and the entrant are able to make profits and hence yield a set of rational strategies. Our model will need to do the same, where an extra dimension to a potential entrant's strategy is the question of whether to match on "soft" quality and enter the QBP (with price and service level decisions determined appropriately), or whether to remain outside. The indicators used by Dodgson et al. (fares, bus miles, patronage and profits for all concerned) will be of critical importance in our model.

MUPPIT (Preston, Nash and Toner, 1993)

A micro economic partial equilibrium model of stylised urban transport operations within a given corridor, was based loosely on work done at ITS on the Nottingham-Mansfield corridor, is computer based and has been given the acronym MUPPIT (Model of Urban Pricing Policy in Transport). The approach adopted has some similarities with work undertaken by others (Beesley, Gist and Glaister, 1983; Glaister, 1987).

MUPPIT is corridor based and consists of three generation zones and one attraction zone. In the initial situation there are two modes (bus and car). A new mode (rail) is then introduced and its market share estimated using binary logit models.

The binary logit models were not thought to be appropriate once fares or services were altered, since they cannot allow for generation or suppression. Instead negative exponential demand models were developed based on empirical evidence on price elasticities, values of time and abstraction rates. Linear additive public transport cost models have been developed, with car cost based on a parabolic speed-flow curve

The demand elasticities used in the model were based on the best available evidence at the time for typical own-price elasticities (Toner, 1993, HFA et al., 1993). Evidence on cross-elasticities was less secure, and so these were derived by recourse to theoretical reasoning. A similar approach was used to obtain the various time elasticities required.

Although dealing with competition between car, rail and bus, MUPPIT treats bus operators as homogeneous, with their competitive response to a rail system change being either to change services or to change fares.

The evaluation measures are based on areas under (compensated) demand curves so that overall consumer surplus changes are accurate but their attribution to different modes (bus, car, rail) are arbitrary.

PRAISE (Preston, Whelan and Wardman. 1999) and MERLIN (Hood, 1997)

PRAISE (Privatisation of Rail Services) adopts a hierarchical structure to model the effects of fares competition on the railway system. The top nest determines the overall size of the market, the middle nest splits the traffic between first and standard class, and the bottom nest splits demand between services and ticket types. Novel features of the model include the treatment of outward and return legs of the journey, the analysis of advanced purchase tickets and the possibility of the rail market expanding or contracting consistently within the hierarchical structure. The cost model adopted was essentially an accounting-based approach in order to achieve fully allocated costs. There is separate identification of operating and capital costs and both types of cost are composed of both fixed and variable elements.

The outputs of PRAISE can be checked to see if the effects of changes in prices or services accord with external evidence. The competitive strategies which can be modelled include: cream-skimming; head-on competition with service matching; price wars; and product differentiation.

MERLIN (Model to Evaluate Revenue and Loadings for Intercity) has a similar demand structure to PRAISE but with the generation/suppression effects being incorporated by application of known market elasticities to changes in average fares and generalised times.

3.2.3 Conclusions

In terms of the modelling of competition, PRAISE seems to offer the most promising way forward in that a variety of responses can be modelled, including entry/exit decisions, service matching and fares competition. Adaptation of the ticket type module will also permit us to address the question of travelcards, both system-wide and operator specific. As far as the external environment is concerned, modelling abstraction/diversion from/to car and slow modes (bicycle, walk) can be satisfactorily accomplished using the same approach as adopted in MUPPIT.

3.3 Model Structure

Using a combination of past experience in developing competition models in the rail sector, information gleaned from our review of public transport models and bearing in mind the practicalities of modelling QBPs set out in Section 3.2, we have developed a bus operations model to forecast the outcome of different QBP situations. In particular, the model will provide information to be used to:

- determine demand and cost implications of QBPs,
- assess the likelihood of market entry and exit,
- evaluate pricing, service level and quality of service strategies, and
- undertake an economic evaluation.

The model has a degree of flexibility so that it can be applied to a range of possible QBP scenarios.

In the first instance, the spatial and temporal dimensions of the model are described. This is followed by an outline of the demand and cost models and finally the way in which the demand and cost models can be linked and dynamics added to the system is examined.

We have developed a model structure that is simple but flexible enough to deal with a variety of QBP arrangements. Working on the assumption that there exist well-defined corridors that form the basis for operator strategies the model consists of a series of n zones, with j parallel bus routes running through each zone. Demand for travel between any two zones in the network is then allocated to available individual services (e.g. the 0704 departure from zone 2 on route 1) according to the sensitivity of demand to the generalised cost of travel and the socio-economic characteristics of the travellers. A precise description of this process is given in Section 3.4.

Although clearly not capable of representing all QBPs, this network specification is a realistic description of many QBP arrangements and can be used to examine competition between QBP and non-QBP operators on the same or parallel routes.

The temporal aspects of the model are constrained, by and large, by the availability of base input data (see Section 3.5). The model has been set up to run either for a key hour period (e.g morning peak) or for a full day.

3.4 The Demand Model

The purpose of the demand model is firstly to determine the overall size of the bus market and secondly to divide the market between operators, ticket types and departure times. This information can then be combined with fare data to generate forecast revenues.

The individual is assumed to be the decision-making unit and all decisions are taken at "point of sale". Using decision rules based on utility maximisation, a given individual has to consider:

- whether or not to make the journey, and
- which mode to use.

If they choose to make a journey and travel by bus, the following additional considerations are of interest:

- which stop to board at and alight from (if available),
- which operator to travel with (if available),
- which service to use (time of departure), and
- which ticket type to use.

The interrelated choices set out above can be represented in a range of demand models, from models with complex hierarchical structures to relatively simple direct demand models. Our preferred approach makes the best use of documented evidence on bus passengers' valuations of journey attributes (e.g. in-vehicle time) and sensitivities to changes in costs (elasticities) and involves a two level choice model:

- Level 1 - Choice of service (route, departure-time, operator and ticket type)
- Level 2 - Choice of mode (including not travel)

This structure allows for the allocation of passengers between operators, ticket types and services and for the overall size of the bus market to expand or contract as service levels change.

3.4.1 Choice of Service (level 1)

For a given individual travelling between a given OD pair, the choice between available services is modelled as a function of the generalised cost of travel for each service and ticket combination(s). Here, generalised cost is represented by the fare paid plus a cost attribute vector, comprising in-vehicle time, adjustment time, ticket flexibility, and operator quality.

$$GC_s = Fare_s + \sum_{x=1}^{X} \alpha_x C_{sx} \quad (1)$$

Where fare is taken to be average fare per trip, C_x is the generalised cost attribute x (e.g. in-vehicle time), and α_x is its associated monetary value (e.g. value of time).

By making some assumptions about the distribution of bus user characteristics (defined by market segment) and their most desired departure times, we can derive the probability that the individual will choose a particular service and ticket type by way of a multinomial logit model:

$$P_s = \frac{\exp(-\theta_1 GC_s)}{\sum_{s=1}^{S} \exp(-\theta_1 GC_s)} \quad (2)$$

Where θ_1 is the spread parameter that governs the individual's sensitivity of choice to changes in generalised cost. As the value of θ_1 approaches zero, market share is split equally between all S options whereas as the value of θ_1 increases, the market share of the option with the lowest generalised cost tends to one. The value of θ_1 therefore determines the elasticity of demand for a given service conditional that bus is chosen:

$$\eta_s^{GC} = -\theta_1 GC_s (1 - P_s) \quad (3)$$

The market share for each service (route, departure-time, operator and ticket type) is taken as the average service probability over all simulated individuals.

3.4.2 Choice of Mode (level 2)

The upper level of the model is concerned with mode choice and therefore the overall size of the bus market. This decision is modelled by way of an incremental logit model and is based on the overall attractiveness of bus services relative to other modes and not travelling at all.

$$P_{bus} = \frac{\exp(\theta_2 EMU_{bus})}{\exp(\theta_2 EMU_{bus}) + \exp(\theta_2 EMU_{other})} \quad (4)$$

Where:

P_{bus} is the probability of choosing bus

$$EMU_{bus} = \text{Expected Maximum Utility} = \ln\left(\sum_{s=1}^{S} \exp(-\theta_1 GC_s)\right)$$

$$EMU_{other} = ASC_{other}$$

θ_2 is a structural coefficient ($0 < \theta_2 < 1$)

Here θ_2 governs the sensitivity of individuals to changes in the level of bus service offered and is determined by the elasticity of demand for bus travel:

$$\eta_{bus}^{EMU} = \theta_2 EMU(1 - P_{bus}) \quad (5)$$

The value of ASC_{other} is set so that the model correctly forecasts the base market share for bus. This model pivots around existing market shares as a function of changes in the overall level of service and fares in the bus market.

3.4.3 Demand Model Calibration

From the description of the demand model presented above, it is clear that there are three elements needed for model calibration. Firstly, evidence is needed on passenger's monetary valuation of bus journey attributes, for example, their value of time. Secondly, evidence is needed on the sensitivity of travellers to changes in generalised cost (or an element of generalised cost) between services. We therefore need information on cross elasticities between services to determine the θ_1 spread parameter. Finally, evidence on the overall sensitivity of the market with regard to changes in generalised cost (or elements of generalised costs) is needed to determine the θ_2 structural parameter. This information will come from well-documented evidence on fare elasticities.

The credibility of the model will in part depend upon the assumptions made about the input parameters. For this reason we have undertaken an in-depth review of published evidence on values of bus journey attributes and demand elasticities (Bristow and Shires, 2001).

It is important to note that whilst we have made a concerted effort to locate the best values for the model, the software is designed so that the analyst can change the assumptions to suit a specific local environment or when more up-to-date information becomes available, or simple to undertake sensitivity analysis.

Determining Generalised Cost.

Equation 1 describes a formula for the estimation of generalised cost for each service. To operationalise this function the analyst needs to make some assumptions on which variables to include within the cost attribute vector (C) and their associated monetary valuations. Service frequency is a key influence on costs and is discussed below, before considering the values to be used in the model.

Incorporating Service Frequency in the QBM

An increase in service frequency can be assumed to influence travellers' behaviour in three ways:

- There will be an increase in the choice of departure times and a potential reduction in the amount of 'schedule delay' experienced by travellers;
- There will be a potential reduction in the average wait time at the bus stop; and
- There will be an increase in service capacity and a reduction to potential problems with overcrowding.

The three aspects can be described as 'schedule delay time', 'schedule wait time' and 'excess wait time' and each is discussed below.

(a) *Schedule Delay Time*. This is the difference between when a passenger would most like to travel and the actual time of travel. The estimation of schedule delay time depends upon when passengers would ideally like to travel, the timetable and passengers' preferences for arriving early or late.

(b) *Scheduled Wait Time*. This is the time spent waiting at the stop and is usually taken to be a function of the service headway and service reliability. Where services are frequent and at regular intervals, passengers are assumed to arrive at the bus stop at random and are therefore assumed to wait on average a time equal to half the service headway. Where services are infrequent, it is assumed that passengers time their arrival at the bus stop to coincide with the arrival of the bus and therefore average wait time is less than half the headway.

(c) *Excess Wait Time.* This is additional time spent at stop when the passenger has been unable to board the first bus due to overcrowding. This component is largely beyond the control of the passenger and is a function of demand and the capacity of the service.

It is common practice in aggregate elasticity based demand models for service frequency to be represented either by attaching a penalty to service headway (measured in terms of equivalent in-vehicle time) or by estimating the likely wait time and a value of wait time. The drawback of this approach is that it is aggregate in nature and cannot assign passengers to specific services. It therefore has limited potential for dealing with issues associated with competition between different operators and overcrowding on individual services.

The approach adopted in the QBM is based on simulating the travel choices of individual passengers and assigning each passenger a probability that they will choose a given travel alternative based on the generalised cost of the alternative. Here, the relative attractiveness of each service is related to service frequency via 'schedule adjustment time'. The higher the service frequency, the lower the amount of schedule adjustment time and the higher the probability that services will be chosen. By aggregating the choice probabilities across all simulated individuals we are able to determine loadings (and hence overcrowding) on each service.

(i) Values of Time and Adjustment Time

The recommended values for in-vehicle time from our review are in set out in Table 3.1 and discussed in Chapter 4. While we have also found evidence of relationships between factors such as income and journey purpose and the value of time, it is not possible to make general recommendations on these aspects. Where appropriate local information should be used to adjust the recommended values. With regard to adjustment time valuation, there have been only a limited number of studies looking at this issue and these have been rail sector studies. The preferred value for adjustment time is therefore expressed relative to in-vehicle time using the same relativity between in-vehicle time and adjustment time as found in the rail sector.

Table 3.1 Recommended value of bus user time (pence per minute)

Category	***Value (1999 prices)***
Average in-vehicle time Peak in-vehicle time Off-peak in-vehicle time	2.5 3.3 2.3
Adjustment Time	0.6 times the value of in-vehicle time

Source: Bristow and Shires 2001

(ii) Determining a Monetary Value for Quality

We reviewed the small number of available studies that attempted to place a value on attributes of bus quality. We have distinguished between London values and those from elsewhere which appear to be substantially lower, all values are in 1994 prices.

Table 3.2 Values for Information Provision (1994 prices)

Information Type	***London Values***	***Non-London Values***
Real Time	8.5 pence per trip	4.5 pence per trip
Printed Timetable	8.0 pence per trip	4.0 pence per trip

Source Bristow and Shires 2001

Table 3.2 shows preferred values for information provision and we also considered a value of 2.5 pence per trip for the provision of pre-trip information (taking the value of standard timetables at home) for non-London based flows and 5 pence for London based flows to be the best available.

With regard to vehicle quality, we are largely distinguishing between a low floor vehicle and a non-low floor vehicle, values of a low floor vehicle of 2.5 pence for London based passengers and 1.5 pence for non-London based flows seem reasonable.

Evidence from one study suggests a total ceiling value to be placed on any package of measures of 26.1 pence for bus passengers in London, at this stage therefore we recommended the aggregation of quality attributes up to that value. Until further evidence is available a payment ceiling seems rational but adjusted for non-London passengers giving a total value of 13.5 pence.

The values reported here on the quality aspects of bus transport are based on a very limited number of studies and should therefore be treated with extreme caution.

Determining sensitivity of Demand

The spread parameter θ_1 governs the sensitivity of choice between services, whereas the structural θ_2 parameter represents the sensitivity to changes in the generalised cost of bus as a whole.

$$\theta_1 = \frac{\text{Fare Elasticity}}{\theta_2 \text{Fare}(1 - \text{Bus Market Share})} \qquad (6)$$

Where *Fare* is the fare for the option with the lowest generalised cost and θ_2 is determined via an iterative process to generate an appropriate "option" elasticity of demand. This is discussed in more detail below.

The model structure implies that the service elasticity is a function of:

- The value of adjustment time (pence per minute).
- The scale of service frequency change (changing from 1 to 2 services per hour will generate different service elasticities than moving from 3 to 4 services per hour because the former has a bigger impact on adjustment time)
- The fare elasticity which sets the overall scale of the model and determines the GC elasticity
- The fare, which helps determine the proportion of GC made up from adjustment time
- The impact of option values. This is the benefit of additional services even without a change in adjustment time.

The relationship between these influences can be expressed via the service elasticity:

$$\varepsilon_{\text{service}} = \varepsilon_{\text{adjust}} + \varepsilon_{\text{option}} \tag{7}$$

where:

$\varepsilon_{\text{adjust}}$ is the elasticity of demand with respect to adjustment time

$$\varepsilon_{\text{adjust}} = \varepsilon_{\text{fare}}\left(\frac{\text{v\_adjust} * \text{adjust}}{\text{fare}}\right) \tag{8}$$

$\varepsilon_{\text{option}}$ is the elasticity of demand with respect to option values. This value forms the lower bound of the service elasticity.

To be able to calibrate the model we need to specify a value for the elasticity of demand with respect to option values.

Table 3.3: Service Elasticity Spread

Service Change	***Value of Adjustment Time***	***Fare Elasticity***	***Option Elasticity***	***Service Elasticity***
1-2	5	-0.4	0.1	0.75
1-4	5	-0.4	0.1	0.50
4-10	5	-0.4	0.1	0.17
10-12	5	-0.4	0.1	0.13
1-2	10	-0.4	0.1	2.02
1-4	10	-0.4	0.1	1.19
4-10	10	-0.4	0.1	0.30
10-12	10	-0.4	0.1	0.19
1-2	5	-0.8	0.1	2.02
1-4	5	-0.8	0.1	1.19
4-10	5	-0.8	0.1	0.30
10-12	5	-0.8	0.1	0.19
1-2	10	-0.8	0.1	3.49
1-4	10	-0.8	0.1	2.05
4-10	10	-0.8	0.1	0.68
10-12	10	-0.8	0.1	0.41
1-2	5	-0.4	0.2	0.77
1-4	5	-0.4	0.2	0.53
4-10	5	-0.4	0.2	0.25
10-12	5	-0.4	0.2	0.22
1-2	10	-0.4	0.2	2.03
1-4	10	-0.4	0.2	1.20
4-10	10	-0.4	0.2	0.34
10-12	10	-0.4	0.2	0.26

Service Change	Value of Adjustment Time	Fare Elasticity	Option Elasticity	Service Elasticity
1-2	5	-0.8	0.2	2.03
1-4	5	-0.8	0.2	1.20
4-10	5	-0.8	0.2	0.34
10-12	5	-0.8	0.2	0.26
1-2	10	-0.8	0.2	3.49
1-4	10	-0.8	0.2	2.05
4-10	10	-0.8	0.2	0.69
10-12	10	-0.8	0.2	0.43
1-2	5	-0.4	0.3	0.81
1-4	5	-0.4	0.3	0.58
4-10	5	-0.4	0.3	0.33
10-12	5	-0.4	0.3	0.32
1-2	10	-0.4	0.3	2.04
1-4	10	-0.4	0.3	1.22
4-10	10	-0.4	0.3	0.41
10-12	10	-0.4	0.3	0.34
1-2	5	-0.8	0.3	2.04
1-4	5	-0.8	0.3	1.22
4-10	5	-0.8	0.3	0.41
10-12	5	-0.8	0.3	0.34
1-2	10	-0.8	0.3	3.49
1-4	10	-0.8	0.3	2.05
4-10	10	-0.8	0.3	0.71
10-12	10	-0.8	0.3	0.47

Table 3 demonstrates that for very small changes in adjustment time (service frequency from 10-12 per hour, with small values of adjustment time and low fares elasticity, the service elasticity approached the minimum value as denoted by the option elasticity. Increases in adjustment-time savings, value of adjustment-time and fares elasticity, all increase the service elasticity. Looking at the overall service elasticities, it is likely that a low option elasticity is appropriate and therefore θ_2 is set to generate an option elasticity of 0.1.

3.4.4 Application of the Model to Forecast Demand

The way in which the model is applied is outlined below:

1) For each OD pair on the network in a given operational period (e.g. a peak hour), we generate a sample of, say, 500 individuals with a given distribution of tastes (attribute values and elasticities), characteristics (market segment) and most preferred departure times.

2) For each individual, we estimate the generalised cost of each service and ticket type available and allocate each a probability by level 1 of the model.

3) The market shares for each service and ticket type (for a given OD pair in a given operational period) are then estimated by averaging the derived probabilities over all 500 individuals.

4) The overall size of the bus market (total number of passengers for a given OD pair in a given operational period) is then determined in Level 2 of the model and subsequently assigned to individual services using market share estimates.

On this basis, total demand and revenue estimates can be derived for each service and ticket type. Where services are estimated to reach capacity a "flag" is raised in the model output to alert the analyst. An assessment is then made of the additional resources (services) needed to provide for the extra capacity and these costs are reported in the output files.

3.5 The Cost Model

The literature on cost models identifies three broad approaches to modelling cost information. The first is an engineering approach which attempts to allocate costs according to engineering relationships for wear and tear. The second is an econometric approach which uses statistical techniques such as regression to estimate costs as a function of output and input prices or alternatively to estimate output (or production) as a function of inputs. The final approach is the accountancy approach that attempts to allocate all costs to physical measures of output. Despite numerous shortcomings, this approach has been the dominant approach in public transport cost studies. Ideally we would like to use a econometric model for bus costs but due to data availability we have had to rely on simpler accounting and average cost formulations.

3.5.1 Fully Allocated Costing Methods

Costs can be divided into three categories:

(a) Variable costs are costs that vary directly and immediately with output. For example, fuel costs vary directly with vehicle kms operated, crew costs may vary directly with vehicle hours etc.

(b) Semi-variable costs are costs that only vary partially with output. For example, vehicle maintenance is partly related to the extent that vehicles are utilised but there is some element of maintenance that will need to be undertaken irrespective of how intensely the vehicle is utilised. Similar arguments hold true for vehicle depreciation.

(c) Fixed costs are costs that do not vary immediately with output. That is, they cannot be varied in the short run. These costs include buildings and general administration.

The Chartered Institute of Public Finance and Accountancy (CIPFA) developed a fully allocated cost formula for the National Bus Company in 1974 (CIPFA, 1974). The formula attempts to allocate variable, semi-variable and fixed costs to measures of physical output, and identifies three measures of physical output to which costs can be allocated:

(i) Fuel, oil and tyre costs were allocated on the basis of distance operated, that is they were allocated according to vehicle kilometres (VKM);
(ii) Staff costs and vehicle maintenance costs were allocated on the basis of time operated, that is they were allocated according to vehicle hours (VH);
(iii) Vehicle depreciation and building costs were allocated according to peak vehicles (V).

An example of a fully allocated costing approach is given in Equation 9. As can be seen, total costs are a linear function of VH, VM and V, with average cost (in terms of vehicle miles) being inversely proportional to speed (VKM/VH) and vehicle utilisation (VKM/V) which is itself determined by the peakiness of the operation.

$$TC = aVH + bVKM + cV \tag{9}$$

Fully allocated costing methods have a number of drawbacks. Firstly, it is not always obvious what the appropriate physical measure is to which costs should be allocated. For example, in the bus industry vehicle maintenance was allocated to vehicle hours and vehicle depreciation to the number of vehicles operated, yet may be affected by the number of vehicle kilometres operated.

Secondly, the approach implicitly assumes that costs are perfectly divisible. In practice, costs are likely to be lumpy, in other words indivisible. For example, in the regulated bus industry labour could only be obtained in units of around 8 hours. As the morning and evening peaks are separated by approximately 8 hours, this meant that at least two full shifts had to be employed with a consequent under utilisation of labour in off-peak periods. The up-shot of this was that in studies in the 1970s, such as the Bradford Bus Study (Travers Morgan, 1974), the cost per day of operating an additional bus in the peak was estimated to be around 3 times greater than the cost per day of operating an additional bus in the off-peak. In the bus industry, this problem has been reduced with the introduction of part-time workers and the reduction of peak-only services. Other British evidence prior to deregulation (McClenahan et al 1978) gave a peak to off-peak ratio of the cost of an additional bus of about 2.5; the figures now appear much smaller, between 1.1 and 2.

Thirdly, the method assumes that if there is a proportionate increase in VH, VKM and V, there will be an equi-proportionate increase in TC. This is tantamount to assuming constant returns to scale. We have no particular problem with this at the route level, although it may be that the “supergroups” benefit from some economies of scale.

Fourthly, the approach is largely aggregate in nature. Although it may give a reasonable approximation of the costs of individual routes, it does not give a good approximation of the additional costs of operating one more bus on a particular route or the avoidable costs of operating one less bus. This is because it will assume that fixed costs will increase/decrease in proportion to the change in vehicle hours and number of vehicles operated. In practice, at least in the short run, there is unlikely to be any change in these fixed costs. Allocated costs do not reflect very well the way costs change at a micro-level.

3.5.2 Developing the CIPFA formula

From DETR (2000a) we established the following information on the Great Britain local bus market in 1998/99:

Vehicle kilometres	2,643 million
Vehicles	79,300
Mean Vehicle Utilisation	33,329 kms per vehicle

Suppose a vehicle is used on average for 300 days per annum (allowing for down time etc.), then the average km run per vehicle per operating day is approximately 111. Given an average operating cost of £0.91 per vehicle km (see Table 3.4), this gives a total daily cost of £101.10.

Based on a CIPFA formula, 75% of these costs might be allocated to vehicle hours, 10% of costs to vehicle kilometres and 15% to vehicles. Based on reasonable assumptions, this gives the following parameters for the cost model shown in equation 9:

a = £16.41 per vehicle hour
b = £0.091 per vehicle km
c = £15.16 per vehicle.

It is important to note that this model is for an average vehicle. To more accurately reflect costs it will be sensible to develop the model to reflect different vehicle types (mini, midi, single deck, double deck, low floor), different local operating conditions and different levels of quality (QBP and non-QBP traffic). This point is illustrated in Table 3.3, which shows average operating costs per kilometre disaggregated at a regional level.

Table 3.3 Local Bus Services: Operating Costs per Vehicle Km (pence)

	Excluding Depreciation	***Including Depreciation***
Regions	*1998/99*	*1998/99*
London	146	155
English Met. Areas	87	90
English Shire Counties	75	79
England	90	94
Scotland	75	77
Wales	72	74
GB	87	91

Source: DETR (2000a)

3.5.3 Passenger Infrastructure Costs

Passenger infrastructure costs can vary considerably across QBP types, reflecting both the diversity of the road systems covered by QBP areas and the passenger infrastructure elements that are included in a QBP. Given this it is not possible to arrive at a universal average cost figure for QBPs, nor is it possible to report an average figure for similar types of QBPs (for example, those with high quality infrastructure), for example, the average kilometre cost of the Line 33 QBP in

Birmingham is around £150k, whilst in Edinburgh the cost per kilometre of Greenways is around £310k. What are therefore required are some detailed costs of specific attributes. At a QBP Conference organised by TAS (June, 2000), Clive Evans from CENTRO outlined some specific costs (2000 prices) associated with some QBPs:

- £8k to provide a Kassel kerb and paving at a bus stop;
- Driver training at £200 each;
- £6.2k for real time information at each bus stop; and
- £4.5 for a high specification QBP bus shelter.

Several issues can be raised about these costs the first of which is that, apart from driver training, they all fall on the local authority. This raises the question of whether to include them in the model since whilst they will not affect the bus operators costs they will impact upon the generalised cost of the passengers' trips via those passengers' valuation of quality attributes. The second issue that has to be determined is what the relative cost of passenger infrastructure provided for a QBP is compared with a non-QBP route. For example, would bus shelters be provided on non-QBP routes and if so how much less do they cost as compared with a high specification QBP bus shelter.

This issue also highlights the need to take into consideration the costs of any road infrastructure, such as bus lane and bus priority measures. Again none of these costs are allocated to the bus operators, yet the bus operators benefit via the quality of service bestowed upon their passengers. At the moment we would recommend that these costs be treated like passenger infrastructure costs, in that they be assessed in a cost benefit framework alongside the user benefits and revenues. To do this it is necessary that any additional road infrastructure costs that are attributable to a QBP be identified.

3.5.4 Cost Conclusions

As with any recommendations for inputs into models it is a useful exercise to first of all think through exactly what inputs are required. The QBP model will be attempting to model several competition scenarios, an extreme would be: a QBP operator (modern, low floor bus) versus a non-QBP operator (20 year old bus). From our discussions with operators we would expect that the operating costs (excluding depreciation) would be higher the older the bus but that when depreciation entered the equation, in the short run at least, that the older bus would be cheaper. Whilst this is a simplistic and tentative hypothesis to make, it would appear to be a sensible one. However, for the model what we propose at this stage is even simpler in that we would recommend that a new bus and an older bus (>10 years) be allocated the same variable operating costs (without depreciation) per kilometre function, but that the total operating cost function for a new bus also include depreciation.

We would like to point out that these cost figures should be seen as starting points and may be adjusted upwards or downwards depending upon the underlying cost conditions in the area being examined. For example, if a QBP was based in Oxford the scarcity of bus drivers would be expected to drive labour costs and therefore overall costs upwards. However, if we assume that the increase in costs is universal across all types of operators then the relative cost difference remains the same.

Within the simulation model, we have allowed for the user to specify costs based upon the CIPFA formula or simply on a pence per kilometre basis.

3.6 Evaluation Model

The evaluation model is based on the concept of economic welfare. In its simplest form this is taken as the unweighted sum of producer surplus and consumer surplus. Producer surplus (PS) is taken as revenue minus costs and consumer surplus (CS) is taken as the benefit individuals receive from consuming a good or service over and above its price. As such CS is taken to be a measure of user benefit and is defined by the shape of the demand curve and the price of the good or service in question.

Since its introduction in the London Transportation Study (phase III, Tressider et al, 1968) the rule of a half has been widely used to determine user benefits. This rule is a simple formula that assumes the demand curve approximates a straight line over the relevant area of change, with the result that consumer surplus can be measured by way of the formula shown in equation 10.

$$\Delta CS = \frac{1}{2}(GC_B - GC_A)(V_B + V_A) \qquad (10)$$

Where:
ΔCS = the change in consumer surplus
V = volume of travel
GC = generalised cost of travel
B = before situation
A = after situation

Following Williams (1977) it is possible to estimate consumer surplus by direct integration of the demand curve, and it is this approach which is adopted in the latest version of the model.

$$\Delta CS = \frac{1}{\theta_1 \theta_2} \Delta\left[\ln(\exp(EMU_{bus} + EMU_{other})\right] \qquad (11)$$

As yet, we have not taken into consideration other external benefits and costs in the evaluation framework. With regard to the environmental, decongestion and accident saving benefits that may arise from a mode switch from car to bus, we recommend that a lump sum benefit for each additional passenger should be derived using appropriate speed/flow curves and psu values. The National Transport Model road-type averages could be used as a default, and this was the approach taken in the work for CFIT (Bristow et al 2001).

3.7 Competitive response and dynamics

The model outlined above produces a 'snap shot' of company profits (revenue minus costs) under different operating assumptions. The model is run for key operating periods and then grossed-up to generate weekly or annual estimates. Three different ways of applying the model can be envisaged.

- Scenario Approach. The first approach is the most straightforward and involves the analyst specifying a number of likely scenarios and assessing the outcomes individually. The models will be iterated to generate pay-off matrices for the most likely competitive situations and game theory used to assess the outcomes. Typical scenarios might include:

  - a monopoly QBP operator;
  - two QBP operators matching frequencies;
  - two QBP operators with unequal frequencies;
  - a QBP and a non-QBP operator with unequal frequencies; and
  - fares competition.

- Optimisation. A different approach would be to define objectives for the operators and optimise the objectives subject to a set of constraints. Where competition is based on output, a Cournot or von Stackleberg equilibrium may arise (see Dodgson et al 1993 and Savage 1985 respectively); alternatively, where competition centres on price, a Bertrand equilibrium may arise (see James 1996).

- Generalisation. The third approach is a hybrid approach. It involves specifying, perhaps, 1000 scenarios and running the model in batch mode for each scenario. Simple regression models could then be estimated on the output. This would allow us to develop general demand, revenue and profit functions for each firm.

In each instance explicit behavioural response and decision rules should be used to assess where entry is feasible and sustainable.

3.8 Data inputs and model outputs - summary

To operationalise the model, four sets of inputs are required:

(a) Information is needed to define the existing bus network, including timetable and fares information for each origin-destination movement and distances between stops.

(b) Information is needed to define parameters for both the demand and cost models. Where local information is not available the default parameter estimates set out in Bristow and Shires (2001) and this document should be used.

(c) Information on existing base demand for each OD movement is needed. Whilst the model will generate market shares and identify growth or contraction in the bus market, base demand information is needed to help determine absolute numbers of passengers and hence operator revenues.

(d) The last piece of information required is a set of bus market share information varying by journey distance. This information is needed when applying the upper nest of the model to help determine how much the bus market can grow. Ideally this will vary by distance since for journey lengths under 0.5 km walk and cycle would tend to have the greatest market shares, whilst for journeys between 5-6 kms car and bus are the dominant modes. In the absence of more accurate local information, theses figure can be estimated from information contained in Table 3.3 of Transport Statistics Bulletin NTS: 1997/1999 Update

(DETR, 2000). The figures are subsequently adjusted to take account of non-travel and are reproduced in Table 3.4 below.

Table 3.4 Local Bus Market Share by Distance

Distance (miles)	<1	1-2	2-5	5-10	10-25
Bus Mode Share	0.55%	2.74%	8.22%	3.29%	1.37%

The outputs of the model consist of a number of key indicator groups that come under several headings, namely:

- Financial – patronage by ticket type and time period, total passenger revenues, total operating costs, average revenues, average operating cost etc;
- Operational – bus kms, bus hours, peak vehicle requirement; and
- Social economic appraisal – operator profitability, consumer surplus.

3.9 Model Validation

The model was initially developed on simulated data for a hypothetical bus route and then tested on real data. The next section of the report provides a description of the case study and this is followed by a description of a series of model runs for looking at the introduction of quality and subsequent entry into the market by a second operator. It is intended that this case study is viewed as a demonstration of some of the capabilities of the model, rather than an in-depth analysis of the potential for QBPs.

3.9.1 Description of the Route

Briefly, the route is 18.5km long incorporating 25 bus stops. The route is currently supplied by a single operator for most of its length, who operates a more or less uniform frequency of 4 buses per hour, between 6am and 6pm. The services are essentially inter-urban commuter services serving the outlying regions of a mid-sized British city. Within the city limits, the service faces on street competition. The data supplied shows the daily (6am to 6pm) demand for services from Monday to Friday in late July 1999 at approximately 1170 passengers. If all passengers pay full fare (i.e. assume that the difference between concessionary and full fares is made up by the local authority) and the average fare on the route is £1.09, the incumbent generates base daily revenue of £1280.40. There are a total of 1628 bus kilometres in the timetable and if each is costed at an average of £0.79, then we estimate total costs at £1286.12 and daily profits of £-6.20. For this time period, the incumbent is shown to more or less breakeven on this route, though we suspect that late July is not a typical operating period and that increased profits will be made at other times in the year. That said, we believe that this is a solid base to examine the impact of QBP.

3.9.2 Modelled Scenarios

We have chosen to look at the impacts of the introduction of a QBP using a scenario-based approach. In the first instance we look at the impact of a QBP on a monopoly supplier and assess whether the investment can be justified on increased revenues or whether a wider social cost benefit analysis in needed to justify investment. Following this, we use the model to look at the impact of new market entry and assess the likelihood of alternative competitive strategies based on fares, service levels and service quality.

3.9.3 How does a QBP impact on the monopoly supplier?

Table 3.5 shows the annual demand and revenue implications of an increase in service quality for a monopoly operator. Quality enhancements valued at 5 pence per trip (say the provision of real time information) leads to a 1.88% increase in demand and a corresponding increase in revenue of £7,092. Assuming that the QBP has no cost or capacity implications for the operator, profitability is set to rise by £7,092 annually. Not surprisingly, consumers benefit from the increase in quality, with their net gain valued at £17,712 annually. Combining both operator profitability and consumer surplus gives a measure of benefit to society as a whole - excluding the capital and operating costs of the QBP investment, this benefit is valued at £24,804 annually. Additional model runs have been made for more significant increases in quality and these results are shown in Table 3.5 also.

Table 3.5: Demand implications of a QBP for a monopolist

Quality	*Increased Demand*	*% Growth in Demand*	*Increase in Revenue*	*Increase in Profit*	*Change in CS*	*Change in Welfare*
5 pence per trip	6588	1.88%	7092	7092	17712	24804
10 pence per trip	13392	3.82%	14292	14292	35748	50040
15 pence per trip	20376	5.81%	21636	21636	54144	75744
20 pence per trip	27540	7.85%	29088	29088	72864	101952

Assumes 6am to 6pm operation for 300 days per year.

As well as improving bus quality, improvements to journey times and frequencies could also be assessed using this model together with complications such as second round effects on capacity requirement and demand levels. It is therefore quite easy to see how this model could be used to assess investment possibilities in a single operator case.

3.9.4 A Framework for Assessing Competition

If the increase in demand brought about through the introduction of a QBP is sufficient to trigger new entry into the market, then we need a methodological framework to be used to assess competition.

The most pragmatic way forward is to specify a series of plausible competitive scenarios rather than define a set of supply side algorithms that lead model convergence at an equilibrium. The competitive strategies available to each agent include those based on: pricing, quantity, service quality and cost reduction. The costs and benefits associated with each scenario are then compared with base statistics for: operator profitability, consumer surplus and overall economic welfare.

The following sections detail possible strategies available to the Entrant and Incumbent.

(a) Price Strategies

The main pricing strategies of interest are those that may be pursued by the Incumbent in response to entry. It is therefore assumed that the strategies of the Entrant remain unchanged.

In shorthand, the outcome of alternative price strategies is summarised as Price[Entrant, Incumbent], with price defined in relation to current fare levels as:

- **S**ame – unchanged P[S,S];
- **10**% **D**iscount for all ticket types P[S,D10];
- **20**% **D**iscount for all ticket types P[S,D20]; and
- **30**% **D**iscount for all ticket types P[S,D30].

(b) Frequency (Quantity) Scenarios

As in determining appropriate pricing strategies, the main frequency strategies of interest are those that may be pursued by the Entrant and the Incumbent. Frequency, or output, scenarios are denoted in a similar way to pricing strategies and can be assigned as:

- **S**ame - 4 buses per hour F[S,S];
- **L**ow **3** - 3 buses per hour F[L3,S];
- **L**ow **2** - 2 buses per hour F[L2,S]; and
- **L**ow **1** - 1 buses per hour F[L1,S].

The entrant may enter with a low frequency, perhaps to "test the market" or enter with a more frequent timetable to compete head on with the Incumbent. This strategy may compensate for a lack of quality if the entrant lies outside the QBP.

The Incumbent on the other hand is unlikely to wish to concede market share to the Entrant and will either maintain its existing service pattern or increase it in order to squeeze the Entrant's profitability. Indeed, the Incumbent may take pre-emptive action to try and deter entry by filling any gaps in the timetable.

(c) Quality (QBP)

All non-price, non-frequency attributes of operators can be summarised in terms of the Alternative Specific Constant (ASC). As these attributes are "unknown" we have made the decision to specify the ASC at five levels 0, 5, 10, 15 and 20 pence per trip. Quality attributes have been combined to show both operators participating in a QBP with various level of quality (the diagonal elements in Table 3.6) and to show asymmetric participation.

Table 3.6: Quality Competition Matrix

	Entrant					
	ASC	0	5	10	15	20
	0	Q[0,0]	Q[0,5]	Q[0,10]	Q[0,15]	Q[0,20]
Incumbent	5	Q[5,0]	Q[5,5]	Q[5,10]	Q[5,15]	Q[5,20]
	10	Q[10,0]	Q[10,5]	Q[10,10]	Q[10,15]	Q[10,20]
	15	Q[15,0]	Q[15,5]	Q[15,10]	Q[15,15]	Q[15,20]
	20	Q[20,0]	Q[20,5]	Q[20,10]	Q[20,15]	Q[20,20]

(d) Cost Strategies

An alternative competitive strategy would be for the entrant to enter at low cost, e.g. using old buses and low cost labour. Whilst we have not demonstrated this aspect of the model's capabilities in this analysis, it is perfectly feasible to allow the entrant to have different costs to the incumbent within the model.

(e) Combined Strategies

Although each competitive strategy can be pursued in isolation to each other, it is likely that operators will combine strategies to achieve the most favourable outcome.

The combination of the 4 pricing strategies, 4 frequency strategies, and 15 quality strategies yields a total of 400 scenarios to be analysed. The main findings are presented in Table 3.7, where Eng = Entrant and Inc = Incumbent.

Table 3.7: Combined Strategy Scenarios (hourly results)

	Ent. Fares	*Ent. Frncy*	*Ent. Qlty*	*Inc. Qlty*	*Demand*	*Profit*	*Inc. Profit*	*Ent. Profit*	*CS*	*Welf*
Max profit	Match	1	20	20	108.21	5.89	6.74	-0.85	30.52	13.46
Max profit Inc	Match	1	0	20	106.98	4.55	13.49	-8.94	27.15	8.75
Max profit Ent	-30%	1	20	0	106.48	-14.51	-32.26	17.75	29.87	-7.59
Max demand	-30%	4	20	20	124.02	-97.91	-69.72	-28.19	85.82	-35.04
Max welfare	-20%	1	20	20	110.26	-0.21	-7.15	6.94	37.91	14.75

The situation described assumes that both operators act independently of each other and that the cross elasticities of demand between services are high. In fact, if operators were to collude or the cross elasticities of demand are lower that assumed, the best strategy for each firm would be to price high and produce low. This strategy would be justified on the basis that the overall market elasticities on the route are low.

Unless the market can grow significantly, or the incumbent reduces output levels, this route is unlikely to support two operators and although consumers would benefit from competition, society as a whole would suffer welfare losses.

3.10 Summary and Conclusions

The overall objective at this stage of the study was to develop a computer-based simulation model of the local bus market that could be used to assess the implications of a wide range of QBP initiatives.

As our starting point, we identified the characteristics that we would ideally like in a QBP model. These characteristics were defined by: the nature of the study objective, the range of situations to which the model could be applied (corridor based or network based), the quantity and quality of available data to use as inputs and the degree of flexibility needed so that the model could be adapted and improved.

Before beginning work on model development, we felt it prudent to review existing public transport models to see if we could adapt an existing model to suit the task in hand. This review covered strategic and semi-strategic models as well as operational models. Whilst none of the existing models could be used directly, we concluded that many of the ideas contained in the PRAISE and MUPPIT models would be of use to this project.

The structure of our preferred model contains three core elements, comprising: a demand model, a cost model, and an evaluation model. The demand model works at the individual level and assigns simulated passengers to operators, services and ticket types and allows for the overall size of the bus market to expand or contract according to the overall level of service. The cost model assigns total costs to operators using a CIPFA-type fully allocated costing formula, and the evaluation model estimates overall operator profitability, consumer surplus and a measure of economic welfare.

The QBP model has been embedded in a computer program which can be adapted by the analyst to examine a range of scenarios on corridor based network, the size of which can also easily be changed.

The modelling framework described in this document includes significant improvements in functionality compared to the initial version of the model as set out in Whelan et al (2001). The improvements include:

- re-structuring the computer code to facilitate improvements in run times;
- re-organising the input files to make them more user friendly;
- allowing for different market segments with different tastes and preferences, and different access to tickets and services. For example we can now specify concessionary traffic with access to discounted/free travel at given times in the day;
- allowing for taste variation across the simulated population. Each simulated individual in the data set can have their own elasticity of demand and own attribute valuations;
- peak and off-peak ticketing restrictions;
- estimation of load factors at each stage of each journey; and
- estimation of additional costs if extra services are needed to accommodate overcrowding.

4. DERIVATION OF PARAMETERS FOR THE MODEL

In this chapter the source and derivation of model parameters and values is covered. We draw on two key sources:

- The review undertaken as part of the quality bus project (Bristow and Shires 2001) and later review work for CfIT (Bristow et al 2001)
- The work carried out by Accent Marketing and Research (2002) for CfIT. This was an important purpose built study that sought to elicit attributes across a wider range of quality attributes than had previously been attempted. The results are broadly credible though there are some problems with the absolute values, with a possible need for scaling, which is common with stated preference.

4.1 Best Estimates from the Literature

This section summarises the recommendations based on the literature review from Bristow and Shires (2001). The key studies identified with respect to bus user values of time (MVA et al, 1987; Preston and Wardman, 1991; WS Atkins and Polak, 1997 and Wardman, 1994, 1998, 1999, 2000 and 2001) were used to derive a set of recommended values. At 1999 prices, in-vehicle time values in pence per minute were: 3.3 peak, 2.3 off-peak and 2.5 overall. Walk and wait time and reliability were estimated as multiples of in-vehicle values, respectively 1.6 and 1.3.

Evidence on bus fare elasticities was taken from two main sources, previous review papers (TRRL, 1980, Goodwin, 1992, Oum et al 1992 and Fowkes et al 1993) and from later empirical work (Selvanathan and Selvanathan, 1994; Fairhurst and Edwards, 1996; Clark 1997; White 1997; Preston 1998; Dargay and Hanley 1999; Grayling and Glaister 2000 and Wardman 2000). Our conclusions were that a fare elasticity of –0.4 was appropriate in representing short run responses. The patronage data suggests a peak/off-peak split of 40:60, which combined with a peak:off-peak elasticity ratio of 1.2 gives a peak elasticity of –0.25 and an off-peak elasticity of –0.5.

Estimates of short run service elasticities exhibit a wide range, +0.146 to +1.05. It is therefore difficult to conclude that any adjustment is necessary to the conventional assumption of +0.4.

Local evidence could where appropriate be used to adjust these values or to apply income or car ownership elasticities.

Evidence on the value of different aspects of quality was limited (Steer Davies Gleave, 1996; York and Balcombe, 1997; Balcombe and Vance, 1998; Prioni and Hensher 1998; Wardman et al, 2000). Any recommendations are therefore from a very limited base of evidence, especially as the studies are not directly comparable and even when valuing similar characteristics, use different definitions. Attempting to aggregate what information there is, a value for a quality package of 13.5 pence outside London and 26.1 pence in London seemed appropriate.

For bus operating costs we were dependent on published data.

4.2 CfIT Stated Preference Study

Accent Marketing and Research (2002) used stated preference techniques to explore modal shift in a number of different contexts as a part of the CfIT work on best value for subsidies to buses. Table 4.1 summarises the values obtained in this study.

Table 4.1 Base Values

Routes	*Value of Time (p/min)*		*Value of Adjustment Time (p/min)*[3]		*Price Elasticity*[4]	*Quality Package (pence)* [2]	
	Car[1]	*Bus*	*Car* [1]	*Bus*		*Car*[1]	*Bus*
Large Urban Radial	6.89	1.68	21.32	2.06	-0.322	227.0	24.2
Medium Urban Radial	7.59	4.14	10.06	3.10	-0.688	214.2	49.7
Small Urban Radial	7.45	1.87	NS	1.90	-1.056	153.2	17.3
Large Urban Orbital	4.75	2.01	NS	3.12	-0.481	407.6	29.8
Inter Urban	8.95	2.72[5] 1.19[6]	NS	4.76[5] 3.74[6]	-0.400	369.8	72.9[5] 45.2[6]
Small Market Town	11.63	0.92	24.00	1.0	-0.269	713.8	22.7
Park and Ride	9.40	2.18	NS	3.46	-0.803	421.8	38.3

NS Not significant.
[1]Based on switchers only
[2]Some quality attributes may already be provided – upper estimate
[3]Double the frequency value
[4]Base on a cost decrease of 10%. Factored up to 3.125 (1/0.32) for urban routes and 4.545 (1/0.22) for inter urban routes based on evidence from Vicario (1999) on the proportion of new bus users abstracted from car.
[5]Long route
[6]Short route

The intention was to use these values in the modelling work that formed part of the best value study. The values of time are largely consistent with existing evidence. The results that give cause for concern are those for the small market town in general, the large differential in price elasticity between the small urban radial and the small market town and the very high values of the quality package for car users.

The main concern are the values for the quality package, where the car use values appear extremely high. However, this is a common problem in naïve stated preference, which is well understood in the rail context. For example Pearmain (1992) found values of station improvements in the range of 11 to 115% of fare values. Cuthbertson et al (1993) recommend that simple willingness to pay or transfer price questions be used in conjunction with discrete modal choice SP experiments in order to get more realistic valuation. It is therefore useful to examine the results from the transfer price question in the Accent work, shown in Table 4.2. In the light of the values in Table 4.2 the Accent SP values for quality were adjusted downwards. The final values used in the CfIT work are shown in Table 4.3.

Table 4.2 Transfer Price Results

Routes	*TP – Quality Package Valuations (pence)*	
	Car	Bus
Large Urban Radial	35	26
Medium Urban Radial	28	25
Small Urban Radial	38	20
Large Urban Orbital	40	30
Inter Urban	62	94
Small Market Town	40	26
Park and Ride	36	32

Table 4.3 Revised Values Used in CfIT Modelling Work

Routes	*Value of Time (p/min)*		*Value of Adjustment Time (p/min)*		*Price Elasticity*	*Quality Package (pence)*	
	Car	*Bus*	*Car*	*Bus*		*Car*[6]	*Bus*[5]
Large Urban Radial	7	2	21	2	-0.3	60	20
Medium Urban Radial	8	4	10	4	-0.7	60	20
Small Urban Radial	8	2	9	2	-0.7	60	10
Large Urban Orbital	5	2	7	3	-0.5	40	20
Inter Urban	9	2[1] 1[2]	16	5[1] 4[2]	-0.4	160 220	50[1] 30[2]
Small Market Town	8	1	9	1	-0.7	80	10
Park and Ride	9	2	15	3	-0.8	50	10

[1] Short inter urban route
[2] Long inter urban route
[3] Assumes same ratio between value of adjustment time and value of time for car as for bus
[4] Based on elasticity for less than 100k radials
[5] Adjusted to take into account the existing level of bus quality
[6] Assumes same ratio between value of quality package and value of time for car as for bus

A more detailed explanation of the adjustments made to the original Accent values may be found in Appendix 1 of Bristow et al 2002a.

4.4 Cost Estimates

Cost estimates made for the CfIT work are reported here, as this is the best available source at present. For each route the base PVR, bus hours and bus vehicle kilometres are output by the model for the base case. Costs in each category can then be estimated using the CIPFA formula. LEK had obtained data as part of the best value study which provided a headline estimate for each route type.

Both the Peak Vehicle Requirement and bus hours are uplifted by 1.1 in order to allow for: rest periods, breakdowns, layover, setting up, training etc. This factor can be applied to the number of vehicles or hours or to the value.

Overhead items such as depot costs, administration, marketing etc are assumed to be a fixed proportion of the costs estimated above. The overhead figure varies by route and is taken from the LEK operator analysis. For the scenario tests we assume that the level of fixed costs does not vary.

Two quality scenarios are constructed a medium and a high quality package. For routes where a standard vehicle is in operation, it is assumed that these are replaced by new low floor vehicles and the difference in cost per year is the variable of interest which is £1200 or £23.08 per week.

We assume that journey time savings are achieved through investment in bus priority, namely bus lanes. In general we assume that a 5% journey time saving is achieved by a 2 kilometre stretch of bus lane while a 10% saving may be achieved if half the route has a bus lane along it. For certain routes, for example, the inter-urban route, the bus lane is confined to the urbanised sections. The amortised weekly costs of a kilometre of bus lane are £615.38.

We are probably overestimating the costs of journey time savings at the route level as bus lanes will in most cases be shared by different bus services, in which case the costs can be shared. Moreover, the length assumption may be excessive as treatment of specific junctions may be the key. On the other hand we are assuming the capacity exists to allow the introduction of bus lanes. In practical work, case specific costings would be required.

In the GOMMMS assessment we assume that all vehicle related costs fall on the operator and all infrastructure related costs fall on the Local Authority. While we recognise that in some circumstances operators will make a contribution to infrastructure costs, here we make a simple assumption for reasons of simplicity and transparency.

4.5 Summary

- Evidence in the literature is good on aggregate fare and service elasticities and the value of time.
- There is much less evidence on the value of individual aspects of quality and quality packages.
- The detailed stated preference work by Accent has shed light on values of quality and differentials between car and non-car available people and areas.
- Operator cost data is highly commercially sensitive and even with stringent confidentiality conditions is available only at an aggregate level.
- The Accent values were adjusted for use in the CfIT study.
- In the model runs reported in Chapter 5 the values were again adjusted and the reasoning for this is given in Chapter 5.

5 MODEL RESULTS

The enhanced Quality Bus Model was applied to two urban radial routes, which are two of the seven CfIT study corridors. As the new model is able to accommodate market segmentation and supply feedback, the results are different from those in the CfIT study. The model has been applied in four ways:

- Firstly to examine the impacts of changes to fares, frequency, quality and journey time, separately and in combinations.
- Secondly to examine competitive response by looking at entry by high and low quality operators offering a partial and a full service. The impacts on the whole route and each operator are examined.
- Thirdly to explore the impacts of different forms of subsidy as a replacement for the current FDR. These tests were run for both a monopolistic and a competitive market.
- Fourthly to examine the impact of changes to the fare elasticity and the values of the quality package. This process also tests the robustness of the model by making substantive changes to parameters
- Fifthly to examine a broader range of fare changes and quality enhancements so as to determine the nature of the response surface (in terms of welfare and profitability) to various bus policies.

5.1 Route Information, Assumptions and Policy Tests

The two corridors chosen for the modelling exercise are a large radial route and a medium radial route. Separate modelling work has been carried out for Monday to Friday, Saturday and Sunday to accommodate the different supply level and passenger characteristics. The results reported here, however, are the sum of modelling output from the three time periods. A conversion factor of 15 is used to gross up to each day of the week as the model is run on a representative hour. However, this does not fully capture the issue of peak overcrowding.

5.1.1 Values and assumptions used for the Large Radial Route

This route is a busy major radial route of approximately 12 kilometres in length in a large city. The services operates along a single route with the following frequencies in each direction:

10 buses an hour: Monday to Friday, peak and interpeak and Saturdays;
2 to 4 buses an hour: Monday to Friday evenings, Saturdays early and evenings, and Sundays.

Thus the service runs every 6 minutes during the main operating periods. The services are paralleled for part of the route near to the city centre.

Values and parameters have, as far as possible, been adapted from the Accent results for large urban radial routes. As the enhanced Quality Bus Model is able to model different market segments, different values have been estimated for each market segment. Four market segments are used: car available peak, car available off-peak, non-car available peak, non-car available off-peak.

Table 5.1 shows the values of time, value of adjustment time and value of medium quality package for car users and non-car users in this large radial route. The shares of bus users with and without a car are estimated from NTS data to be 26% and 74%. The weighted averages of Value of Time and Value of Adjustment Time for all bus users are 3.0 pence and 7.0 pence respectively. The medium quality package includes low floor bus, CCTV and good bus shelters. Based on the share split of car and non-car available passengers, the weighted average value of the medium quality package is 17 pence. In this case, the relative value of quality package is equivalent to 5 to 6 minutes of in-vehicle-time, which is consistent with the range of values in the literature (see for example the forthcoming Demand for Public Transport, TRL, 2003). In the sensitivity tests the value of the quality package is reduced to 8.5 pence, which brings its relative value down to equivalent to 2 to 3 minutes of in-vehicle-time.

Table 5.1 Value of time (£/min), adjustment time (£/min) and medium quality package (£)

	VoT	***VoAT***	***Medium Quality***
Car user	0.0689	0.2132	0.336
Non-car user	0.0168	0.0206	0.112
Weighted Average	0.0303	0.0705	0.17

Table 5.2 shows the price elasticity in the peak and off-peak hours. Evidence suggests that the off peak elasticity is around double the peak elasticity (TRL, 2003). The Accent work estimated an all day elasticity of –0.322, we therefore assume that the peak elasticity is 33.3% lower than the all day figure and the off-peak elasticity is 33.3% higher. For the sensitivity test, the all day elasticity is assumed to be –0.6, about double the value here.

Table 5.2 Price elasticity

	Peak	***Off-peak***	***All day***
Elasticity	-0.215	-0.429	-0.322

Bus operating costs have been estimated using the formula developed by CIPFA (Chartered Institute of Public Finance and Accountancy). Thus the costs are the sum of VKM related costs, vehicle-hours related costs, vehicle depreciation costs and overhead. In terms of quality costs, we have assumed that any vehicle related costs of quality packages fall on the operator, while any infrastructure related costs fall on the Local Authority. In the base scenario costs are estimated as £1.25 per vkm (operator only).

It is assumed that a two kilometre bus lane will deliver a 5% reduction in journey time. The weekly amortised costs of such a bus lane are estimated to be £1231. To provide a medium quality package, the authority would incur a weekly cost of £945 on CCTV at the 26 bus stops in this large urban radial route. For the operator, the cost for providing a medium quality package is the amortisation value of low floor bus and CCTV on the bus. In this study we have assumed that an older vehicle may be resold at the residual book value, thus the cost of new buses is the difference between this value and the cost of a new bus. It is recognised that this may underestimate the costs of providing new vehicles in a quality package. For the incumbent, this gives a weekly cost of £461 for the 17 vehicles required.

FDR is £0.137 per vehicle kilometre, which is calculated by dividing total FDR by total vehicle kilometres in the UK. This figure accounts for 80% of the fuel duty. In the policy tests values derived for the LEK study for CfIT are used, these are a per passenger subsidy of 10.4 pence and a per passenger kilometre subsidy of 1.2 pence. However LEK used a mean trip length of 9km which may include non-local bus services, so the per passenger kilometre figure may be a little on the low side.

5.1.2 Values and assumptions used for the Medium Radial Route

This route is a radial route of approximately 6 kilometres in length in a medium sized city. The service frequency is five buses an hour during the day on weekdays and four buses an hour on Saturday. There are one or two buses an hour in the evenings and on Sundays. The timetable is not equal interval as in reality more than one operator is involved. However, the data does not allow us to distinguish individual operators therefore in the base scenario the assumption is made that the service is provided by one operator.

The same four market segments are used here as for the large radial. The Accent report provided some estimates of parameter values for urban medium radial route. However, the values, in many cases, do not seem plausible, for example, the weighted average value of time is almost identical to the average value of adjustment time. As the values used for the large radial route are very close to those commonly found in the literature, it was decided to use the large radial values with minor adjustment.

Evidence suggests that in the case of bus commuters, the value of time increases with journey length (Wardman, 2001). Journeys on the medium radial are shorter than those on the large radial. In which case the value of time for the medium radial route should be close to but slightly lower than the large radial values. However, as the medium radial has a higher proportion of car available users (32%), this will act to increase the value of time. In the light of all this our final assumption is that the weighted averages of parameter values for the medium radial are equal to those for the large radial route and that the relative values for car and bus users are constant between the two urban radial routes.

Table 5.3 shows the values of time, value of adjustment time and value of medium quality package for car available and non-car available in this medium radial route. The shares of bus users with and without a car are estimated to be 32% and 68%, based on NTS data. The weighted averages of Value of Time and Value of Adjustment Time for all bus users are 3.03 pence and 7.05 pence respectively. The weighted average value of the medium quality package is 17 pence.

Table 5.3 Value of time (£/min), adjustment time (£/min) and medium quality package (£)

	VoT	***VoAT***	***Medium Quality***
Car user	0.0621	0.1816	0.3099
Non-car user	0.0151	0.0175	0.1033
Weighted average	0.0303	0.0705	0.17

Table 5.4 shows the price elasticity in the peak and off-peak hours. In this case the Accent estimate of an all day price elasticity of –0.7 is viewed as too high and the large radial values are applied.

Table 5.4 Price elasticity

	Peak	***Off-peak***	***All day***
Elasticity	-0.215	-0.429	-0.322

The base scenario operating costs are estimated as £1.63 per vehicle kilometre. The costs of providing a 5% journey time reduction are the same as for the large radial. In this case to provide a medium quality package, the authority would incur a weekly cost of £654 on CCTV at the 18 bus stops on this medium urban radial route. For the operator, the cost of providing a medium quality package is the amortisation value of low floor bus and CCTV on the bus. For the incumbent, the net weekly cost of seven new buses is £190.

The assumptions on FDR and other policy options are identical for both the large radial and medium radial route.

5.1.3 Tests to be run

Four sets of tests have been run. Firstly changes to the service and fare levels are made. The four basic comparative tests are:

- 20% fares cut
- 20% frequency increase
- 5% journey time improvement
- Medium Quality enhancement

These are also tested in combination.

The second set examines the competitive response of the operators. The scenarios under investigation include the following:

- Entry by a high quality operator;
- Entry by a low quality operator;

In all the competitive scenarios, the existing operator provides a medium quality package; it has the bus running 5% quicker but charges the same fare and provides the same service frequency as those in the base scenario. Certain assumptions have been made about the new entrant. Particularly, the low quality operator offers a 20% fare cut and has 10% lower costs than the quality operator. The low quality operator has a normal (longer) journey time.

When the new competitor enters the market, two possible modes of entry are considered. The new competitor could provide some additional service, e.g. 20% of supply level of the existing operators; alternatively, it could provide the service at the same supply level as the existing operators. These options correspond with niche market entry and full market entry respectively. Both alternatives are examined in the modelling.

The third set is the subsidy policy test, which examines the effect of reform on the FDR system. The following three policy options have been tested:

- FDR replaced by a per passenger subsidy
- FDR replaced by a per passenger kilometre subsidy
- Full FDR for quality operators

Firstly, we examine the impact of different subsidy policy on the monopoly operator. For each policy option, the tests include the four basic comparative tests on fare, frequency, journey time and quality. This gives us comparisons for a monopoly operator in order to identify which strategies look more or less profitable under different subsidy regimes.

Secondly, we examine the effect of different subsidy regimes under the competitive situation. The three above mentioned policy options have been tested, together with different assumptions about the behaviour and nature of the new entrant.

The results of these model runs for the large and medium radial routes are reported in Sections 5.2 and 5.3 respectively.

5.2 Model results for the Large Radial Route

The base scenario reflects the original market condition, where the incumbent offers no fare adjustment or attribute enhancement. The results are reported in table 5.5. Some features of the base case are worth noting. The service is very profitable with return on sales of 30.2%, probably representative of one of the top fifty routes in the country. The route is relatively long, and loads well, with an average load of around 20 passengers, around double the national average. The table shows costs before (gross cost) and after (net cost) FDR.

Table 5.5 Base Case Scenario (Base 1) (weekly data in £s)

No.	*Passengers*	*Passenger kilometres*	*Profits*	*Revenue*	*Net Cost*	*Gross cost*	*FDR*	*Vehicle Kilometres*
1	82,167	412,515	12,174	40,374	28,200	31,291	3,091	22,560

The results reported below contain a mix of financial and quantitative data and represent the *change* from the base, e.g. the change in profits after improving service frequency.

There are two bases used in reporting. For the monopoly operator scenarios, the base for comparison is the base case scenario in modelling (Base 1). For the competitive scenarios, the base for comparison is the scenario where the incumbent offers a medium quality package and 5% journey time reduction (Base 2). This is due to the fact that in all competitive scenarios, the incumbent is always a quality operator while the new entrant shows different characteristics. Moreover, to illustrate the relative position of both operators, the demand and profit *levels* of each operator are also reported.

5.2.1 *Service and Fare Level Changes*

In this section, the base for comparison is base 1, whose values are shown in Table 5.5. Results of these tests are shown in Table 5.6, all results are reported as changes from the base. Abbreviations used in this and future tables include:

- Freq (change in frequency)
- JT (change in journey time)
- MQP (medium quality package)
- CS (change in Consumers Surplus)
- VKMs (change in vehicle Kilometres)
- Pax (change in number of passengers)
- Pax kms (Change in passenger kilometres)
- LA cost (change in costs to the Local Authority)

Table 5.6 Fare and Service Level Results Change from the Base: £ per week (% in brackets)

N	*Test*	*VKMs*	*Pax*	*Pax kms*	*Revenue*	*Gross cost*[1]	*Net cost*[2]	*FDR*	*Profit*[3]	*CS*	*LA cost*	*Welf*[4]
2	Freq +20%	4583	3240 (3.9)	13354	1407	6356	5728	628	-4321 (-35.5)	4119	0	-830
3	JT –5%	0	1863 (2.3)	10300	903	-826	-826	0	1728 (14.2)	2511	1231	3008
5	Fare –20%	0	6168 (7.5)	31028	-5657	0	0	0	-5657 (-46.5)	8375	0	2717
9	MQP	0	13133 (16.0)	51447	5538	420	420	0	5118 (42.0)	15276	945	19449
6	Freq +20% Fare –20%	4583	9647 (11.9)	45334	-4450	6356	5728	628	-10179 (-83.6)	12785	0	1979
7	Fare –20% JT –5%	0	8172 (9.9)	42089	-4882	-826	-826	0	-4057 (-33.3)	11073	1231	5785
13	Fare –20% MQP	0	20313 (24.7)	86369	-891	420	420	0	-1311 (-10.8)	24800	945	22545

[1]Gross cost includes changes to operating costs and any capital investment by the operator
[2]Net cost = Gross cost – FDR
[3]Profit = Revenue – Net cost
[4]Welfare= Profit + CS - LA Cost - FDR

Of the four simple tests, the provision of the medium quality package leads to the biggest increase in passenger numbers and passenger kilometres. The implied fare elasticity is –0.32, and the implied service elasticity for journey time reduction and frequency increase are –0.39 and 0.21 respectively[1].

The quality improvement also leads to the biggest increase of profit, consumer surplus and welfare[2]. The only other scenario that leads to an increase in profits is the 5% journey time reduction, which also leads to an increase in welfare. Profits decrease in two scenarios: frequency improvement and fares reduction. In the case of 20% frequency increase, welfare has also been reduced as the reduction in profits outweighs the increase in consumer surplus.

[1] The elasticity is calculated as follows: E=(Ln(Q2)-Ln(Q1))/(Ln(X2)-Ln(X1)), where X1 and X2 are attribute variable and Q1 and Q2 are demand variable.
[2] ΔWelfare=ΔProfit+ΔCS-ΔSubsidy-ΔLA cost, where LA cost is the Infrastructure Cost to the Local Authority.

For the operator, the fare reduction leads to loss of revenue, while in other scenarios revenue increases as passenger numbers rise as a result of the enhancements offered. The frequency increase leads to substantial rise in operating costs; the fuel duty rebate received by the operator is also higher, reflecting the additional vehicle kilometres operated. The provision of the medium quality package also incurs additional costs, while the journey time reduction leads to the decrease of time-related labour costs.

Table 5.6 also reports the results of three tests offering combinations of lower fares and other enhancements. All three scenarios have increased numbers of bus passengers and bus passenger kilometres. The fares reduction combined with quality enhancement is the most successful in increasing patronage and also leads to the smallest reduction in profits. All three scenarios lead to a reduction in profit, which reflects the low fare elasticity. However, in all cases the increases in consumer surplus are more substantial and the overall effect is a net welfare gain.

5.2.2 Competitive response

Although most QBPs have experienced little or no direct competition, in this section, the effect of entry by another operator, either with high or low quality, is examined. The base for comparison is the scenario where the incumbent offers a medium quality package and 5% journey time reduction (Base 2), whose values are presented in Table 5.7. Four competitive scenarios are reported in this section. The overall results are shown in Table 5.8 and the impact on individual operators in Table 5.9.

Table 5.7 Base for competitive scenarios comparison (Base 2) (weekly data in £s)

No.	*Pax*	*Pax Kms*	*Profits*	*Revenue*	*Net Cost*	*Gross cost*	*FDR*	*VKMs*	*LA Cost*
33	98,191	478,149	19,406	47,201	27,794	30,885	3,091	22,560	1,976

Table 5.8 Results for the Competitive Tests

N	*Test*	*VKMs*	*Pax*	*Pax kms*	*Revenue*	*Gross cost[1]*	*Net cost[2]*	*FDR*	*Profit[3]*	*CS*	*LA cost*	*Welf[4]*
34	Q Partial	4583	2563 (2.6)	11312	1158	6293	5666	628	-4507 (-23.2)	3406	0	-1729
35	Q Full	22560	11772 (12.0)	50665	5229	30885	27794	3091	-22565 (-116.3)	15219	0	-10437
36	LQ Partial	4583	675 (0.7)	5301	-499	5783	5155	628	-5655 (-29.1)	1543	0	-4739
37	LQ Full	22560	5896 (6.0)	30256	-825	28470	25380	3091	26205 (-135.0)	9179	0	-20117

Footnotes: See Table 5.6.

Table 5.9 Impact of Competition on Operators (weekly data in £s, percentages in brackets)

N	*Entry by*	*Passengers*		*Profit*		*Change in Pax*	*Change in Profit*
		Op1	Op2	Op1	Op2	Op1	Op1
34	Q partial	85923	14831	13357	1542	-12268 (-12.5)	-6049 (31.2)
35	Q full	54947	55016	-1602	-1557	-43244 (-44.0)	-21008 (-108.3)
36	LQ partial	89652	9213	15043	-1292	-8539 (-8.7)	-4363 (-22.5)
37	LQ full	66948	37139	3407	-10205	-31242 (-31.8)	-16000 (-82.4)

The results suggest that on this large urban radial route, increases in bus vehicle kilometres, resulting from competition, are not beneficial to society. Bus patronage and passenger kilometres have increased, which leads to an increase in consumer surplus. However, the additional operating cost and resulting profit reduction outweighs this such that overall welfare is reduced in all scenarios. Comparing the four scenarios, we can see that market entry by quality operator (scenarios 34 and 35) leads to a higher patronage rise and a lower profit reduction than for the equivalent scenarios where entry is by a low quality operator (scenarios 36 and 37). When the new competitor uses the full market entry strategy (scenario 35 and 37), the profit reduction is much bigger and the whole route is always loss making. In this large radial route, niche market entry by a quality operator (scenario 34) gives the best competitive result, however, welfare is reduced compared to the monopoly base.

From the individual operator's point of view, scenario 34 is also the only situation where the competition is sustainable. The incumbent, although suffering a 12.5% drop in patronage and a 31% drop in profits, still earns a profit margin of 32.5%. The new entrant also earns a healthy margin of 21.4%. When a low quality operator enters the market with partial service (scenario 36), the incumbent manages to keep the profit at a high level; while in scenario 35 and 37, it is either loss making or earns a low margin. The new competitor suffers loss in these three scenarios.

5.2.3 Policy tests

Policy options are considered in two contexts: firstly that of a monopoly operator and secondly a competitive scenario.

For the monopoly operator, the base for comparison is Base 1, as reported in table 5.5. Three subsidy policies are examined against the As Now (80% FDR), they are Per-passenger Subsidy (10.4 pence) and Per-passenger kilometre Subsidy (1.2 pence) and full FDR to a quality operator. For the first two policies, five scenarios with different operating strategies are examined: as now, 20% more frequent, 5% journey time reduction, 20% fare reduction and medium quality package. The modelling outputs for scenarios under the current subsidy regime are reported in Table 5.6 in the previous section and will not be repeated here. Effectively for each scenario the results are the same except for the change in subsidy and hence the change in operator profit. Table 5.10 shows the total subsidy and profit levels under the different policy polices. The final column shows the change in profit for each test scenario relative to the original Base 1. Overall the level of subsidy to this route increases and only two tests under the per passenger kilometre subsidy policy result in lower than current profit level.

Table 5.10 Subsidy Scenario Tests: £ per week

N	*Test*	*Subsidy*	*Profit*	*Change in profit*
FDR as now				
1	As now	3091	12174	0
2	Freq +20%	3719	7853	-4321
3	JT –5%	3091	13902	+1728
5	Fare –20%	3091	6517	-5657
9	MQP	3091	17292	+5118
Per passenger subsidy 10.4 pence				
22	As now	8546	17628	+5454
23	Freq +20%	8882	13016	+842
24	JT –5%	8739	19550	+7376
25	Fare –20%	9187	12613	+439
26	MQP	9911	24113	+11939
Per passenger kilometre subsidy 1.2 pence				
27	As now	4950	14033	+1859
28	Freq +20%	5111	9244	-2930
29	JT –5%	5074	15885	+3711
30	Fare –20%	5323	8748	-3426
31	MQP	5568	19769	+7595
Full FDR to quality operator				
9	MQP	3091	17292	+5118
32	MQP	3858	18059	+5885

The per passenger subsidy scenario results in the greatest increase in support and hence profit across the board.

The model has not considered any "second round" effects of subsidy reform. In a competitive environment to deter possible new entry attracted by the high rate of return, the incumbent can reinvest the additional subsidies. Scenario 22 shows that without a change in the operating strategy, the profit has increased by £5,454 under the new subsidy regime. Such an amount is comparable to the profit reduction caused by a 20% fare reduction or 20% frequency enhancement. As a result, the operator can adopt either of the strategies to boost patronage without jeopardizing its profitability. An operator is perhaps more likely to adopt an increase in service frequency as this is more likely to deter entry. Alternatively, fare reductions of 20% or a 20% frequency enhancement could be a condition of the funding. In this case fare reductions would increase welfare overall in the base yielding twice as large an increase in consumers surplus as a frequency change. In order to secure the best outcome from a welfare perspective a fare reduction could be made a condition of funding. However, the best offsetting change will vary between routes.

A switch to a per passenger kilometre subsidy, again increases subsidy and hence profits in the new scenarios compared to the existing regime. However, frequency enhancements and fare reductions lead to a fall in operator profits as the total increase in subsidy is much lower than under a per passenger subsidy regime. In this case if a Local Authority could also guarantee a reduction in journey times of around 5% then a 20% fare reduction could be achieved.

Finally, the policy option, which gives the quality operator full fuel duty rebate is examined, this results in a small increase in profit, increasing from £17,292 to £18,059 (up 4.4%).

For this route, a per passenger subsidy is the most attractive option for the operator. Such a subsidy would make quality enhancements more likely. Frequency increases and or fare reductions might also follow as the operator would need to beware of competition at the resulting profit levels. In non-competitive environments, or to secure such changes as a matter of policy, fare and/or service level changes could be made conditions of the subsidy regime. However, while this type of route would benefit others would lose and the operator might use these extra profits to cross-subsidise other services in order to maintain the network. This cross-subsidy would be lost if the “excess” profit were ear marked for service improvements.

The subsidy regimes are now examined under the competitive scenarios. The base for comparison is now therefore Base 2 which assumes the incumbent has adopted the medium quality package and has achieved a 5% reduction in journey times, as reported in table 5.7. The current subsidy policy (80% FDR) and three other policy options are examined. Under each policy regime, four possible scenarios of entry are reported.

For the current subsidy policy, the model outputs are reported in Table 5.8 and are not repeated here, again all values are the same as before save for the subsidy and profit. Table 5.11 shows the changes that would arise in Base 2 as a result of the different subsidy regimes, as a comparison with Table 5.12 which reports the results from the competitive scenarios. The changes in overall subsidy and profit are reported relative to the original Base 2. The actual profit levels for the two operators are reported in the final two columns.

Table 5.11 Base 2 under different subsidy regimes

Test	*Subsidy*	*Profit*
Base 2	3091	19406
Base 2 per passenger subsidy	10212	26527
Base 2 per passenger kilometre subsidy	5758	22073

Table 5.12 Subsidy Scenario under competition: £ per week

N	***Test***	***Change in Subsidy***	***Change in Profit***	***Profit Op1***	***Profit Op2***
FDR as now					
34	Q partial	628	-4507	13357	1542
35	Q full	3091	-22565	-1602	-1557
36	LQ partial	628	-5655	15043	-1292
37	LQ full	3091	-26205	3407	-10205
Per passenger subsidy					
40	Q partial	7388	2253	19203	2456
41	Q full	8345	-17310	1021	1075
42	LQ partial	7191	909	21276	-960
43	LQ full	7734	21561	7278	-9433
Per passenger kilometre subsidy					
44	Q partial	2783	-2352	15260	1794
45	Q full	3255	-22401	-1524	-1471
46	LQ partial	2711	-3572	17144	-1309
47	LQ full	3010	-26286	4057	-10,936

Table 5.12 shows that subsidy levels increase substantially under a per passenger subsidy scenario but less so under the per passenger kilometre regime, in fact where a low quality operator enters with a full service, subsidy levels would actually be slightly higher under the current FDR regime.

Both per passenger and per passenger kilometre subsidy regimes make partial entry by a quality operator more attractive to the entrant and less threatening to the incumbent.

A per passenger subsidy would make full entry by a quality operator profitable for the second operator, which it is not under the current regime. However, profit levels for both operators are too low to be sustainable in the longer run, suggesting that entry is unlikely.

5.2.4 Sensitivity tests

It is important to evaluate the extent to which the model results are influenced by the parameter values. A sensitivity test for the large radial route has been conducted based on alternative parameter values. In this case the key concerns are the fare elasticity which is on the low side, though it could be viewed as a realistic short run elasticity and the value of the quality package, where the empirical evidence is very limited. The tests are of an all day price elasticity of –0.6, which is about double the current value and a halving in the value of the quality package. As the value of the quality package serves to reduce the generalised costs, whose components also include travel time costs and adjustment time costs, it is sufficient to specify the alternative value of only one component the quality package. The relative value of the quality package is now lower moving from an equivalent of 5 to 6 minutes of in-vehicle-time (IVT) to 2 to 3 minutes of IVT. Table 5.13 shows the results obtained from running the simple single policy tests on these new parameters. The fare reduction of 20% results in almost double the number of extra passengers compared with the existing elasticity, which is as expected. However the response to the medium quality package is not significantly reduced. The fare reduction still leads to a significant reduction in profit levels. What this sensitivity test shows is that the increase in the absolute fares elasticity does not make fare reductions, on their own, commercially feasible, but does make them profit enhancing (compared to the base) in conjunction with a medium quality package.

Table 5.13 Sensitivity Tests for the Large Radial

N	*Test*	*VKM*	*Pax*	*Pax kms*	*Rev*	*Gross cost*[1]	*Net cost*[2]	*FDR*	*Profit*[3]	*CS*	*LA cost*	*Welf*[4]
2	Freq +20%	4583	7071	24034	2732	6356	5728	628	-2996	4171	0	547
3	JT –5%	0	5096	24710	2288	-826	-826	0	3114	3403	1231	5286
5	Fare –20%	0	11874	59720	-3421		0	0	-3421	8645	0	5224
9	MQP	0	12131	47650	5125	420	420	0	4705	7584	945	11544
6	Freq +20% Fare –20%	4583	19924	86949	-942	6356	5728	628	-6670	13398	0	6100
7	Fare –20% JT –5%	0	17696	87826	-1339	-826	-826	0	-513	12536	1231	10792
13	Fare –20% MQP	0	25804	114294	1275	420	420	0	855	17327	945	17438

Footnotes: See Table 5.6

5.3 Model Results for the Medium Radial Route

Table 5.14 shows the results for the base scenario (Base 1) reflecting the original market conditions. It shows that the service is slightly profitable, with a profit margin (return on sales) of 6.9%. The average load for this route is around 10-passengers, close to the national average.

Table 5.14 Base Case Scenario (Base 1) (weekly data in £s)

No.	*Pax*	*Pax kms*	*Profits*	*Revenue*	*Net Cost*	*Gross Cost*	*FDR*	*VKMs*
1	16,387	52,897	663	9,629	8,967	9,720	754	5,501

The results reported are a mix of financial and quantitative data and represent the *change* from the base, e.g. the change in profits after improving service frequency.

There are two bases used in reporting. For the monopoly operator scenarios, the base for comparison is Base 1. For the competitive scenarios, the base is Base 2. This is due to the fact that in all competitive scenarios, the incumbent is always a quality operator while the new entrant shows different characteristics. Moreover, to illustrate the relative position of both operators, the demand and profit *levels* of each operator are also reported.

5.3.1 Service and Fare Level Changes

In this section, the base for comparison is base 1, whose values are shown in Table 5.14,. The results of the tests are shown in Table 5.15

Table 5.15 Fare and Service Level Results Change from the Base: £ per week (% in brackets)

N	*Test*	*VKMs*	*Pax*	*Pax kms*	*Rev*	*Gross cost*[1]	*Net cost*[2]	*FDR*	*Profit*[3]	*CS*	*LA cost*	*Welf*[4]
2	Freq +20%	1283	2255 (+13.8)	5228	972	2268	2092	176	-1121	2974	0	1676
3	JT –5%	0	417 (+2.5)	1314	224	-274	-274	0	497	603	1231	-132
5	Fare –20%	0	1233 (+7.5)	3985	-1345	0	0	0	-1346	1998	0	652
9	MQP	0	2351 (+14.3)	6094	1139	189	189	0	950	3091	654	3387
6	Freq +20% Fare –20%	1283	3633 (+22.2)	9562	-516	2268	2092	176	-2609	5170	0	2386
7	Fare –20% JT –5%	0	1682 (+10.3)	5400	-1153	-274	-274	0	-880	2646	1231	535
13	Fare –20% MQP	0	3771 (+23.0)	10557	-363	189	189	0	-552	5325	654	4119

Footnotes: See Table 5.6

As the base profit level is low, the percentage changes are not reported in Table 5.15 as they are misleadingly high.

The implied fare elasticity is –0.32, and the implied service elasticities for journey time reduction and frequency increase are –0.42 and 0.61 respectively suggesting relatively high sensitivity to service quality features.

The quality package and the frequency enhancement both secure an increase in passenger numbers of over 10%. The quality improvement leads to the biggest increase in profit, consumer surplus and welfare. Operator profits increase when journey time is reduced or a medium quality package offered, these increases would make the route look more viable. Profits decrease in two scenarios: frequency improvement and fares reduction. As the profit reductions are quite substantial, these two options will not be commercially viable for this medium radial route. Consumer surplus has increased in all four scenarios, and generally, such increase is big enough to offset any profit reduction. As a result, the welfare is enhanced in all but one scenario, where the infrastructure costs required by journey time reduction outweigh the gain in both profit and consumer surplus.

Secondly, we consider the impacts of a combination of lower fares and other enhancements. The fares reduction combined with quality enhancement increases patronage by approximately 23% from the base; and is the only one of the three scenarios in which the operator is not loss making, given the very low initial profit level of 663.. All three scenarios lead to a reduction in profit reflecting the low fare elasticity. However, in all cases the increases in consumer surplus are more substantial and the overall effects are a net welfare gain.

5.3.2 Competitive response

In this section, the effect of entry by other competitors, either with high or low quality, is examined. The base for comparison is the scenario where the incumbent offers a medium quality package and a 5% journey time reduction (Base 2), whose values are presented in Table 5.16. Results from four competitive scenarios are reported in Table 5.17. Table 5.18 shows the impacts on the individual operators.

Table 5.16 Base for competitive scenarios comparison (Base 2) (weekly data in £s)

No.	*Pax*	*Pax Kms*	*Profits*	*Revenue*	*Net Cost*	*Gross Cost*	*FDR*	*VKMS*	*LA Cost*
33	19,274	60,577	2,157	11,039	8,882	9,635	754	5,501	1,747

Table 5.17 Results for the Competitive Tests

N	*Test*	*VKMs*	*Pax*	*Pax kms*	*Rev*	*Gross cost*[1]	*Net cost*[2]	*FDR*	*Profit*[3]	*CS*	*LA cost*	*Welf*[4]
34	Q Partial	1283	1697 (+8.8)	3988	730	2256	2080	176	-1350	2235	0	709
35	Q Full	5501	5210 (+27.0)	12534	2329	9635	8881	754	-6552	6663	0	-643
36	LQ Partial	1283	1080 (+5.6)	2692	175	2058	1883	176	-1708	1577	0	-306
37	LQ Full	5501	3650 +18.9)	9188	618	8823	8069	754	-7452	4980	0	-3226

Footnotes: See Table 5.6.

Table 5.18 Results of competition scenarios by operator (weekly data in £s)

N	*Entry by:*	*Passengers*		*Profits*		*Change in Pax*	*Change in profit*
		Op 1	Op 2	Op 1	Op 2	Op 1	Op 1
34	Q partial	17,458	3,512	936	-128	-1,816	-1,222
35	Q full	12,239	12,245	-2,222	-2,173	-7,035	-4,379
36	LQ partial	17,720	2,635	1,072	-623	-1,555	-1,085
37	LQ full	13,717	9,207	-1,582	-3,712	-5,557	-3,740

The results suggest that on this medium radial route, only niche market entry by a quality operator leads to net welfare gain. As a result, this is the preferable way of introducing competition as far as welfare is concerned. In other scenarios, further increases in bus vehicle kilometres, introduced by competition, is not beneficial to society. Bus patronage, passenger kilometres have increased, which leads to an increase in consumer surplus. However, the decrease of profit is bigger so the overall welfare has been reduced in three scenarios. Entry by a quality operator always leads to a greater increase in patronage and a lesser decline in profits when compared to entry by a low quality operator at the same level of frequency.

From an individual operator's point of view, none of the competition scenarios is sustainable. Although the incumbent earns a low margin when its competitor enters the niche market, it suffers substantial losses following a full market entry. The new entrant is always loss making, and the loss is particularly heavy in the case of full market entry. Entry on this route is not sustainable.

5.3.3 Policy test

Policy options are considered in two contexts: firstly that of a monopoly operator and secondly a competitive scenario.

For the monopoly operator, the base for comparison is the base case in modelling (Base 1), as reported in table 5.13. Three subsidy policies are examined against the As Now (80% FDR), they are Per-passenger Subsidy (10.4 pence) and Per-passenger kilometre Subsidy (1.2 pence) and full FDR to a quality operator. For the first two policies, five scenarios with different operating strategies are examined: as now, 20% more frequent, 5% journey time reduction, 20% fare reduction and medium quality package. The modelling outputs for scenarios under the current subsidy regime are reported in Table 5.14 in the previous section and will not be repeated here. Effectively for each scenario the results are the same except for the change in subsidy and hence the change in operator profit. Table 5.19 shows the total subsidy and profit levels under the different policy polices. The final column shows the change in profit for each test scenario is shown relative to the original Base 1.

Table 5.19 Subsidy Scenario Tests: £ per week

N	*Test*	*Subsidy*	*Profit*	*Change in profit*
FDR as now				
1	As now	754	663	
2	Freq +20%	930	-458	-1121
3	JT –5%	754	1160	+497
5	Fare –20%	754	-683	-1346
9	MQP	754	1613	+950
Per passenger subsidy 10.4 pence				
22	As now	1704	1613	+950
23	Freq +20%	1939	552	-111
24	JT –5%	1747	2154	+1491
25	Fare –20%	1832	396	-267
26	MQP	1949	2807	+2144
Per passenger kilometre subsidy 1.2 pence				
27	As now	635	544	-119
28	Freq +20%	698	-690	-1353
29	JT –5%	651	1057	+394
30	Fare –20%	689	-754	-1417
31	MQP	708	1566	+903
Full FDR to quality operator				
9	MQP	754	1613	+950
32	MQP	941	1800	+1137

It is interesting to note that for this route the existing FDR rebate is larger than the profit, suggesting that this route would become unviable in the absence of FDR. As with the large radial a per passenger subsidy is most attractive to the operator and in this case although fare reductions and frequency enhancements reduce profit levels, a small profit is still achieved. The increase in subsidy would be sufficient, approximately, to offset the losses to the operator incurred by a 14% fare reduction or a 17% frequency enhancement. Under this policy fare reductions or frequency enhancements could be made conditions of agreements to reduce journey time or establish quality packages. On this route, in contrast to the large radial frequency enhancement is more attractive from the perspective of both passenger and society as a whole.

However, the subsidy per passenger kilometre results in a smaller level of support for this route, rendering it marginal. The full FDR to the quality operator again results in a small profit increase.

The subsidy regimes are now examined under the competitive scenarios. The base for comparison is now therefore Base 2 which assumes the incumbent has adopted the medium quality package and has achieved a 5% reduction in journey times, as reported in Table 5.16. The current subsidy policy (80% FDR) and three other policy options are examined. Under each policy regime, four possible scenarios of entry are reported.

For the current subsidy policy, the model outputs are reported in Table 5.17 and are not repeated here, again all values are the same as before save for the subsidy and profit. Table 5.20 shows the changes that would arise in Base 2 as a result of the different subsidy regimes, as a comparison with Table 5.21 which reports the results from the competitive scenarios. The changes in overall subsidy and profit are reported relative to the original Base 2. The actual profit levels for the two operators are reported in the final two columns.

Table 5.20 Base 2 under different subsidy regimes

Test	*Subsidy*	*Profit*
Base 2	754	663
Base 2 per passenger subsidy	1704	1613
Base 2 per passenger kilometre subsidy	635	544

Table 5.21 Subsidy Scenarios under competition: £ per week

N	*Test*	*Change in Subsidy*	*Change in Profit*	*Profit Op1*	*Profit Op2*
FDR as now					
34	Q partial	176	-1350	936	-128
35	Q full	754	-6552	-2222	-2173
36	LQ partial	176	-1708	1072	-623
37	LQ full	754	-7452	-1582	-3712
Per passenger subsidy					
40	Q partial	1427	-99	1998	61
41	Q full	1793	-5513	-1702	-1654
42	LQ partial	1363	-521	2162	-525
43	LQ full	1631	-6574	-910	-3507
Per passenger kilometre subsidy					
44	Q partial	21	-1505	828	-175
45	Q full	124	-7182	-2538	-2487
46	LQ partial	6	-1878	973	-694
47	LQ full	84	-8121	-1857	-4107

The increase in subsidy of around £1,300 to £1,800 per week under the per passenger subsidy scenario alleviates the negative impact of competition on profits. However, none of the competitive scenarios are sustainable. A new quality operator earns a very low margin of 3% under partial entry, which might be sustainable, and is severely loss making in others. A low quality entrant is always loss making. The incumbent is profitable when faced with niche market entry but loss making faced full market entry.

The very marginal changes in subsidy under a per passenger kilometre regime suggest that no competitive scenario is likely to be viable in the long run.

5.4. Comparison of the large and medium radial route results

The results from large radial route and medium radial route are consistent. In this section, the scenarios that maximise consumer surplus, welfare and profit for the two radial routes are reported and compared. As there are two bases (base 1 and base 2) in reporting modelling output, the consumer surplus and welfare maximisation scenarios are presented in two settings: monopolistic and competitive. Also, only the scenarios within the current subsidy regime are reported, since subsidy is a transfer and thus has no impact on welfare.

The profit maximising scenarios refer to industry profit, regardless of the number of operators. However, to distinguish the effect of operating strategy and transfer (subsidy), two sets of scenarios are reported. First is the profit maximising scenario within the current subsidy regime; second is the one among all scenarios.

5.4.1 Monopolistic scenarios maximising consumer surplus and welfare

For both the large radial route and medium radial route, the scenario that maximises consumer surplus is unsurprisingly the same, being the one that offers frequency and quality enhancement as well as journey time and fare reduction. This scenario is sustainable on the large radial where profits fall by 31%, however, on the medium radial this scenario would result in a loss of £393 a week. Table 5.22 shows the full results.

Table 5.22 Large and Medium Radial Comparisons

	Test	*VKMs*	*Pax*	*Pax kms*	*Revenue*	*Gross cost*[1]	*Net cost*[2]	*FDR*	*Profit*[3]	*CS*	*LA cost*	*Welf*[4]
LR	All four	4583	26771	115288	1394	5783	5155	628	-3761	32858	1976	26645
MR	All four	1283	7407	19114	888	2119	1943	176	-1056	10068	1885	6951
LR	JT + Fare + MQP	0	22948	99598	68	-406	-406	0	474	28147	1976	26645
LR	JT + MQP	0	15587	63792	6657	-406	-406	0	7063	18391	1976	23478
MR	JT + MQP	0	2887	7679	1411	-85	-85	0	1495	3821	1885	3431

Footnotes: See Table 5.6

As the base profit level is low, the percentage changes are not reported as they are misleadingly high.

The routes differ when it comes to maximising welfare. On the medium radial it is the same as that for maximising consumer surplus while on the large radial the welfare maximising scenario excludes the frequency enhancement. This reflects the high service frequency already provided in this route.

5.4.2 Competitive scenarios maximising consumer surplus and welfare

The competitive scenarios that maximise consumer surplus are the ones in which a new quality operator offers full service. However, for both routes, this scenario is not commercially viable as the operators are loss making. Moreover, this scenario is not beneficial to society as a whole, as welfare falls.

The competitive scenarios with the highest levels of welfare are those in which a new quality operator offers 20% additional frequency. However, competition always leads to welfare loss for the large radial route. This again reflects the fact that this route already has high frequency so additional service introduced by competition is no longer welfare enhancing. Nevertheless, competition is commercially viable, as both operators still earn a good profit margin

The medium radial route shows another picture. Competition can be welfare enhancing. However, the new entrant is always loss making. Consequently, competition is not commercially viable for this medium radial route, at least under the current subsidy regime.

5.4.3 Scenarios maximising industry profits

The scenarios that maximise operating profits within the current subsidy regime are those with journey time reduction and quality enhancement. This is in part a consequence of our assumption that all infrastructure costs associated with quality packages and bus priority are borne by the Local Authority. In reality an operator contribution is likely which would reduce the associated profit level. As the fare elasticity is low, fare reductions do not lead to profit increases. Neither do the frequency enhancement, either provided by the incumbent or in the form of additional service by a new entrant. The subsidy regime that maximises profits to the operators is a per passenger subsidy.

5.5 Further Analysis of the Large Radial Route

The objective of this section is to provide a wider set of scenario tests so to identify the welfare and financial impact of different fares, service quality and service quantity combinations (see also Preston et al., 2003). This would allow a mapping of the response surface (in terms of welfare and producer surplus) of various bus policies. The scenario tests include:

- 15 different fare levels, ranging from 50% cheaper to 20% more expensive;
- 5 different levels of quality, including ‘as now’, ‘medium quality’, ‘high quality’, ‘high quality plus 5% journey time reduction’ and ‘high quality plus 10% journey time reduction’; and
- 2 levels of service quantity, ‘as now’ and ‘20% more frequent’

It should be noted that frequency enhancement could also be achieved by the introduction of competition (assuming the incumbent does not reduce service level). Two additional sets of tests have been run. The first refers to the situation where a new entrant provides service at 20% the frequency level of the incumbent, but has fares and quality level identical to the incumbent. The second refers to the situation where a new entrant provides 20% service level of the incumbent and competes with lower fares and lower quality. For the second set, there are also 5 quality scenarios: the new entrant provides no quality package, while the quality level of the incumbent varies from ‘as now’ to ‘high quality plus 10% journey time reduction’. There are only 11 fares scenarios: the incumbent charges the current fares, while the new entrant charge fares from ‘50% cheaper’ to ‘as now’. Consequently, the total number of scenarios in this set of tests is 55.

To reduce run times, this analysis was based on daily (average weekday) rather than weekly data, with the base case given by Table 5.23.

Table 5.23 Base Case Scenario in modelling (Daily data in £s)

Pax	Pax Km	Profits	Revenue	Vehicle Km
13,546	67,217	2,288	6,729	3,525

5.5.1 Scenarios with no frequency change

The first set of model run examines the effects of fares reduction and quality enhancement, holding the quantity of service at current levels. From Table 5.24, it is apparent that both quality enhancement and fares reduction have a very positive impact on welfare. A 50% fares reduction alone leads to a welfare gain of £949, which is 41.5% of the base scenario profit. Quality has a more dramatic effect on welfare, and the model suggests that a high quality package and 10% journey time reduction would lead to a welfare gain of £5,348, which is 233.7% of the base profit. When the fares reduction is combined with the best possible quality enhancement, the welfare increase is £6,093, which is the highest among all scenarios. Figure 5.1 in the Appendix gives a 3-D graphical illustration of the welfare impacts in all possible fares and quality scenarios. From the graph, one can see that the unconstrained welfare maximisation scenario lies at the top-right hand corner. This is a pattern that will be identified in almost all sets of test for all scenarios (the only exception is for competition by a low quality operator – see section 5.5.4).

Table 5.24 Change of welfare in different fares and quality scenarios at current frequency level (Daily data in £s)

	Fare Change							
	-50%	**-40%**	**-30%**	**-20%**	**-10%**	**As Now**	**+10%**	**+20%**
As Now	949	799	627	435	226	**0**	**-241**	**-496**
Medium Q	4261	4090	3896	3679	**3441**	**3185**	**2912**	**2623**
High Q	5380	5203	5001	4776	**4529**	**4263**	**3979**	**3679**
HQ/JT-5%	6093	5912	5706	**5476**	**5224**	**4952**	**4662**	**4355**
HQ/JT-10%	6549	6364	6153	**5919**	**5661**	**5384**	**5087**	**4774**

(Figures in bold in this table and all subsequent tables represent scenarios in which profits increase or remain unchanged.)

Table 5.25 shows that fare reductions and quality enhancements have opposite effects on profitability, which is in contrast to the welfare impact discussed above. By providing a high quality package and 10% journey time reduction, the operator's profits increase from £2,288 to £4,011, which is a 75% increase. On the other hand, a 50% fares reduction results in a loss of £437 suffered by the operator. Combining these two adjustments, the operator shows a profit of £673, which still represents a profit margin of 7.3%. Figure 5.2 in the Appendix is a 3-D graph illustrating the operator's financial results for all the scenarios. It should be noted that the profit maximisation scenario lies at the top left hand corner, which is in contrast to the welfare maximisation scenario, which reveals the opposite effects of fares reduction on welfare and operating profits.

Table 5.25 Operator's profit/loss in different fares and quality scenarios at current frequency level (Daily data in £s)

	Fare Change							
	-50%	-40%	-30%	-20%	-10%	As Now	+10%	+20%
As Now	-437	199	787	1329	1829	2288	2708	3092
Medium Q	24	743	1407	2020	2584	3101	3575	4008
High Q	183	929	1619	2255	2840	3378	3869	4319
HQ/JT-5%	464	1227	1933	2583	3182	3731	4234	4694
HQ/JT-10%	673	1452	2174	2838	3450	4011	4525	4994

If we assume that the government (local authority) aims to increase welfare but has no control over the fare level, the results on profits suggest that the authority might have some bargaining power to achieve fares reduction by operators. Within the quality bus partnership, when the local authority invests in the infrastructure required for the medium quality package, the operator would increase its profits by £266 even if the fares were reduced by 15% (not shown in the table). Similarly, when the authority invests to achieve a high quality package and 5% journey reduction, the profits of the operator would still increase by £295 after a 20% fare reduction. This scenario would capture 90% of the maximum welfare benefits we have modelled. Certainly, the financial situation will change if competition is induced by the higher profitability resulting from the QBP. On the other hand, one can argue that the incumbent might be more willing to cut fares as a device to pre-empt competition, although our modelling suggests service increases would be more likely.

The conflicting nature of welfare and profit maximisation and its implication on the policy of local authority can be more clearly demonstrated by Figure 5.3 in the Appendix, which was drawn using Matlab. The purpose of this graph is to illustrate the operator's choice of fares and quality combination at a given profit level (£2,000 in the example) and its impact on welfare. The "indifference curve" to the operator, Curve A, is identified by intersecting the "profit surface" (in red in the graph) with a reference plate (in grey). Curve A corresponds to a set of fares and quality combinations, whose projection on the "welfare surface" (in light blue) is Curve B. This graph shows that while these combinations could be indifferent to the operator as the profits are constant, the welfare impacts are quite different. Curve B suggests that by inducing the operator to enhance quality and to reduce fares, the welfare maximisation could be achieved without jeopardising profitability. Nevertheless, this policy option would require greater financial commitment from the local authority, which could be difficult to materialise, especially where the shadow price of public funds for local authorities is particularly high.

5.5.2 Scenarios with 20% frequency enhancement (Monopolistic Operator)

Table 5.26 shows that similar to the previous set of model runs, fare reductions and quality enhancement continue to lead to substantial increase of welfare even with a 20% frequency enhancement. However, in order to identify the welfare impact of frequency enhancement, it is necessary to compare the corresponding scenarios in

Table 5.26 and Table 5.24. It is interesting to note that frequency increase offers no welfare gains in this already densely served large radial route. For each combination of fares and quality adjustment, the welfare gain is always marginally lower if the frequency has been increased by 20%.

Table 5.26 Change of welfare in different fares and quality scenarios with 20% frequency enhancement (Daily data in £s)

	Fare Change							
	-50%	-40%	-30%	-20%	-10%	As Now	+10%	+20%
As Now	939	784	607	411	195	-38	-286	-548
Medium Q	4421	4245	4044	3821	3576	3312	3031	2733
High Q	5602	5419	5211	4979	4724	4450	4157	3847
HQ/JT-5%	6228	6042	5830	5593	5334	5054	4756	4440
HQ/JT-10%	6537	6348	6133	5893	5630	5347	5044	4723

The negative impacts of frequency enhancement on operator's profits are stronger than on welfare (Table 5.27). If the service is 20% more frequent, the operator will always suffer a loss with a 50% fare cut in all quality scenarios. Across all 75 scenarios, the frequency enhancement lowers the operator's profit by an average of £668, which is about 30% of the base scenario profit. This result suggests that frequency enhancement is an unlikely strategy for this large urban radial route, as neither the government nor the operator benefits from it.

Table 5.27 Operator's profit/loss in different fares and quality scenarios with 20% frequency enhancement (Daily data in £s)

	Fare Change							
	-50%	-40%	-30%	-20%	-10%	As Now	+10%	+20%
As Now	-1204	-549	58	617	1132	1605	2039	2435
Medium Q	-718	25	711	1344	1927	2462	2951	3399
High Q	-550	221	935	1592	2198	2753	3262	3727
HQ/JT-5%	-247	539	1265	1935	2552	3118	3636	4109
HQ/JT-10%	-48	750	1488	2167	2794	3368	3894	4375

5.5.3 Competitive scenarios with a quality niche market entrant

An increase in service quantity can be also be achieved by the introduction of competition. This is likely to happen when the frequency enhancement results in negative financial effects on the incumbent but the quality bus partnership promises better financial prospect for other bus operators. In this sub-section, a set of model runs is discussed, where the new entrant offers 20% additional service to the incumbent and matches the fares and quality level of the latter.

Table 5.28 shows the welfare impact of fares and quality combinations within this competitive market. Fare reductions and quality enhancements lead to substantial welfare gains. The scenario that maximises welfare lies at the corner, where the fare reduction and quality improvement are at their highest level. It is also interesting to compare Table 5.28 with Table 5.24. Following the introduction of competition (increase of service quantity), the average welfare gain across all 75 scenarios is lowered by £160, about 7% of the base scenario profit. It should be noted that timetables are not co-ordinated between the two competitors, which leads to lower welfare gain compared to the case of frequency enhancement by one monopolistic operator.

Table 5.28 Change of welfare in different fares and quality scenarios with competition from a same quality niche market entrant (Daily data in £s)

	Fare Change							
	-50%	-40%	-30%	-20%	-10%	As Now	+10%	+20%
As Now	715	560	386	188	-30	-260	-509	-774
Medium Q	4093	3918	3722	3496	3250	2988	2707	2405
High Q	5239	5057	4853	4618	4363	4091	3800	3485
HQ/JT-5%	6016	5831	5623	5382	5121	4844	4546	4224
HQ/JT-10%	6473	6283	6071	5826	5559	5277	4973	4644

Although the welfare impact caused by competition is not particularly significant, the financial impacts on the operators are more substantial (See Table 5.29). Comparing all corresponding scenarios between non-competition and competition, the incumbent's profits are lowered by an average of £891 as a result of competition. Overall, this route remains profitable in all but five scenarios, although lower profit levels reduce the average return on assets (RoA) by about a quarter. The profit margin remains high: without fare change, the return on sales is 24% with no quality package and 41% with the highest possible quality.

Table 5.29 Incumbent's profits in different fares and quality scenarios (Daily data in £s)

	Fare Change							
	-50%	-40%	-30%	-20%	-10%	As Now	+10%	+20%
As Now	-986	-424	87	569	1012	1411	1780	2120
Medium Q	-595	41	616	1163	1663	2113	2528	2913
High Q	-460	200	798	1366	1885	2352	2783	3183
HQ/JT-5%	-193	482	1093	1674	2205	2682	3123	3532
HQ/JT-10%	4	693	1318	1912	2454	2942	3393	3811

The new entrant also enjoys some financial success. It shows profit in 54 scenarios, out of a total of 75. With no quality package, market entry is possible even if the fares are cut by 15% of the current level. If the QBP is in place, with the high quality package and 10% journey time reduction, the new competitor can enter the market without loss even if the fares are cut by 40% (see Table 5.30). The profit margin is generally acceptable. Without change in fare level, its return on sales is 13.4% with no quality improvement and 31.9% with the highest quality level. Nevertheless, the new competitor is in a disadvantageous position if the incumbent launches a price war against it. With lower profit margin and possible financial loss in more scenarios, the new entrant could be driven out of business if it faces predatory pricing.

Table 5.30 Quality competitor's profits in different fares and quality scenarios (Daily data in £s)

	Fare Change							
	-50%	-40%	-30%	-20%	-10%	As Now	+10%	+20%
As Now	-282	-183	-94	-10	68	138	203	263
Medium Q	-219	-108	-7	89	176	255	328	395
High Q	-195	-79	25	125	215	297	373	443
HQ/JT-5%	-142	-23	84	186	279	363	440	512
HQ/JT-10%	-113	7	116	219	313	398	476	548

5.5.4 Competitive scenarios with low quality niche market entrant

It is possible that the new entrant does not participate in the quality bus partnership. This is most likely in one of the two following situations. First, the new entrant can undercut the incumbent by low fares and low quality while it is permitted to use the quality infrastructure provided by the local authority. Second, the local authority sets the standard of participation to such a high level that effectively only the incumbent can join in the QBP. Given the provisions of the Transport Act 2000, it is not envisaged that such competitive scenarios would become widespread in the future.

Nevertheless, staying out of the quality partnership remains a possibility for the operator, either voluntarily or involuntarily. This sub-section reports the welfare and financial impact when the new entrant does not participate in QBP and it is excluded from the use of quality infrastructure. For simplicity, it is assumed that the incumbent holds its fare level as present while its competitor offers various level of price discount; on the other hand, the incumbent provides quality package at various level while the new entrant remains the low quality operator.

From Table 5.31, one can see a slightly different pattern of welfare change in different scenarios (also see Figure 5.4 in the Appendix). There are a few points worth commenting on. First, the welfare impacts caused by the fare reductions offered by the new entrant are modest due to its small quantity of service. Second, unlike other competitive situations, fare reductions by the new entrant do not always lead to welfare gains, so the "corner solution" to welfare maximisation no longer holds. One possible explanation is that when the low quality competitor cuts price excessively, the investments in quality infrastructure are under-utilised so their potential benefits to the society cannot be fully realised. Third, for scenarios when the incumbent provides no quality package, 50% fares cut by the new entrant lead to much bigger welfare loss than other scenarios. This is because the significant increase of passenger numbers attracted by lower fares results in the problem of over-crowding for the new entrant. This model assumes the operator responds to this by providing more parallel service, which would incur some additional costs. This will also explain the low profit figure for that scenario presented below.

Table 5.31 Change of welfare in different fares[$] and quality[*] scenarios with competition from a low quality niche market entrant (Daily data in £s)

	Fare Change					
	-50%	-40%	-30%	-20%	-10%	As Now
As Now	-646	-194	-143	-126	-136	-169
Medium Q	2532	2617	2665	2684	2684	2670
High Q	3512	3590	3634	3651	3652	3641
HQ/JT-5%	4083	4165	4211	4233	4236	4228
HQ/JT-10%	4455	4533	4577	4597	4601	4594

Note:
$ Fares charged by the new competitor while holding the incumbent's fares constant;
* Quality package provided by the incumbent while the new entrant remaining a low quality operator.

Table 5.32 and 5.33 summarise the financial situation of both operators (Figure 5.5 and 5.6 in the Appendix give a visual illustration in 3-D graphs). The results show that the competition is not sustainable in any of scenarios examined, as the feasible set of the incumbent and that of the new competitor do not correspond. Although the incumbent's profits are reduced as a result of price cuts by its competitor, the introduction of a quality package quickly offsets such negative impacts. On the other hand, when the incumbent has quality enhancement, its low quality competitor is almost always loss-making. Thus, these results suggest that once the "free-rider" problem is tackled (the low quality operator is not allowed to use the quality infrastructure), entry by low fares and low quality is an unlikely option for any potential competitors.

Table 5.32 Incumbent's profits in different fares and quality scenarios (Daily data in £s)

	Fares					
	-50%	-40%	-30%	-20%	-10%	As Now
As Now	56	378	680	957	1204	1411
Medium Q	1657	1920	2143	2326	2480	2598
High Q	2123	2356	2550	2706	2837	2938
HQ/JT-5%	2511	2741	2930	3083	3208	3304
HQ/JT-10%	2835	3051	3228	3370	3486	3575

Table 5.33 Low quality competitor's profits in different fares and quality scenarios (Daily data in £s)

	Fares					
	-50%	-40%	-30%	-20%	-10%	As Now
As Now	180	572	536	456	347	230
Medium Q	38	17	-32	-95	-168	-238
High Q	-85	-107	-152	-207	-269	-329
HQ/JT-5%	-123	-148	-194	-250	-310	-367
HQ/JT-10%	-158	-180	-221	-270	-324	-376

5.5.5 Conclusions from the Further Analysis

This part of our work has clearly demonstrated the conflict between commercial and social objectives in bus policy. For the route we have examined, we have shown that the welfare maximising policy involves quality enhancements and fare reductions but not service increases. A profit maximising policy (at least for operators) would also involve increases in quality (albeit largely paid for by local authorities) but, in contrast, would involve fare increases and, in some competitive situations, service increases.

However, it should be noted that our model may over-estimate the welfare impact of fare reductions for at least three reasons. First, we have assumed that demand increases are spread evenly across the day and across the route and can be relatively easily accommodated given the spare capacity on the route. However, if demand increases were concentrated in time and/or space, this would have implications for peak vehicle requirements and hence operating costs. Although our model includes supply side effects, these are computed at a relatively aggregate level and may underestimate the impact at a more disaggregated scale. Second, we have not included a congestion impact of carrying more passengers in terms of increased boarding and alighting time. Third, we have not taken into account the shadow price of public funds. On the other had, our work assumes a relatively low (in absolute terms) fares elasticity.

This part of our work has shown that although Quality Partnerships might assist in moving towards more optimal levels of bus quality, they may fail to provide optimal fares and service levels, with there remaining a tendency for a too high fare/too high service regime (see also Evans, 1987). One possible solution might be to introduce an element of fare regulation into the Quality Partnership. For example, our modelling suggests that a high quality service with a 20% fare reduction, would increase operator's profits slightly whilst capturing 90% of the increased welfare that would be achieved by a much large (50%) fare reduction.

5.6 Conclusions

From the simulation results reported in this chapter, it appears that Quality Bus Partnerships are beneficial to the operator and society. For both the large and medium routes, the scenarios involving quality enhancement normally lead to the biggest increase in profit and welfare. There is no direct benefit to the local authority, which sees its investment in infrastructure turned into the profit of the operators. However, such schemes are expected to contribute to Local Authority objectives relating to congestion, environment and access. The lack of a direct financial benefit maybe one of the main reasons that quality bus partnerships, despite their obvious benefit, are being adopted slowly. This may be exacerbated by local authority resource constraints and physical and technical constraints which, for example, might limit the practical scope for bus priority measures. Other explanations might include that we have overstated the benefits of quality enhancements (and this is investigated to some extent in the sensitivity tests) and understated the capital and other costs of quality enhancements.

On the other hand, fare reductions and quality improvement are beneficial to society but are not always advantageous to operators. For the large radial route, the profit is reduced under this strategy, although the welfare gain is very substantial. In an unregulated bus market, a dominant operator would be reluctant to implement such a strategy.

It was postulated that the shift of the FDR to a per-passenger or per passenger km subsidy would contribute to the growth of the market by enabling more competition. However, the simulation results show the danger of such subsidy increase being appropriated by the incumbent as the change of subsidy regime only makes niche competition feasible for the large radial. Moreover, this competition does not appear to be beneficial from a societal point of view. This problem is more acute in more price sensitive and less quality sensitive markets. The sensitivity tests highlight the risk that changes to the subsidy regime could stimulate competition that is not beneficial to society, although such findings are contingent on the subsidy rates that we have used in this analysis.

Full FDR to the quality operator is also ineffective. The model results show that the quality operators already have competitive advantage against their low quality rivals, further subsidy to the former does not make competition any more likely.

To summarise, more incentives for local authorities to get involved in quality bus partnerships are needed. Furthermore, the danger that the benefits of quality bus partnerships are being captured by operators as monopoly rents should be considered. One possible solution to these two issues is the introduction of the quality contract. Under the quality contract, the local authority will have the power to grant exclusive operating rights on defined routes or within a defined area, on the basis of 'best value'. Once a quality contract had been let, other bus operators would not be allowed on those routes, or within the defined area, unless they were approved by the local authority. The expected benefits of a contracted bus network include stability of the network and services, local authority control over fares and the ability to specify the quality and quantity of services, and the connections with other buses. Disbenefits might include disruption during transitional arrangements and the risks of inefficient planning and non-competitive bidding. An alternative might be to develop quality partnerships that involve some kind of profit sharing arrangement between operators and the local authority of the kind that have been developed in Aberdeen and Greater Manchester.

Another explanation for the limited development of quality bus partnerships might be that there is a tendency for operators to undervalue quality. This may be because operators do not realise that those bus users (and non-bus users) with a car available have a much higher value of quality than those who do not have a car available. Understandably, bus operators have tended to concentrate on their captive market but our research suggests that the optional market might be substantial and might have values of quality that are three times higher than the captive market. This ought to be verified by other empirical studies. However, it ought to be noted that our estimates of passenger uplift as a result of the introduction of a medium quality package (up 16% for the large radial, up 14% for the medium radial) are consistent with recent work for the Demand for Public Transport: A Practical Guide (TRL, 2003). This suggests a mean passenger uplift as a result of bus quality enhancements of 25%, albeit with a large range (4% to 92%).

Appendix to Section 5.5 Graphical illustrations of the welfare and financial impacts of fare and quality adjustment

List of Figures

Figure 5.1 Change of Welfare (Large Radial; Monopolistic Operator; Current Frequency Level)

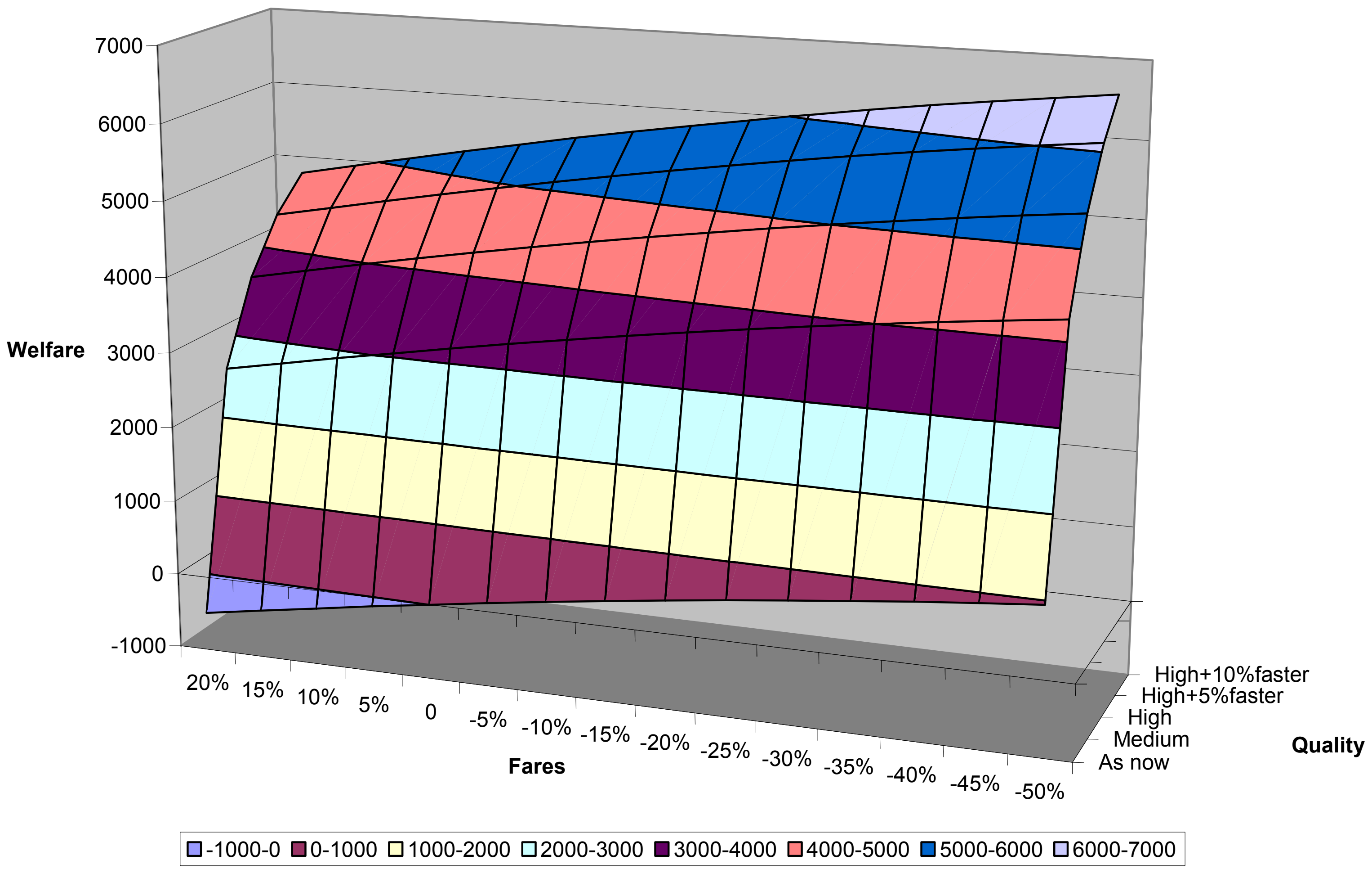


Figure 5.2 Operating Profit (Large Radial; Monopolistic Operator; Current Frequency Level)

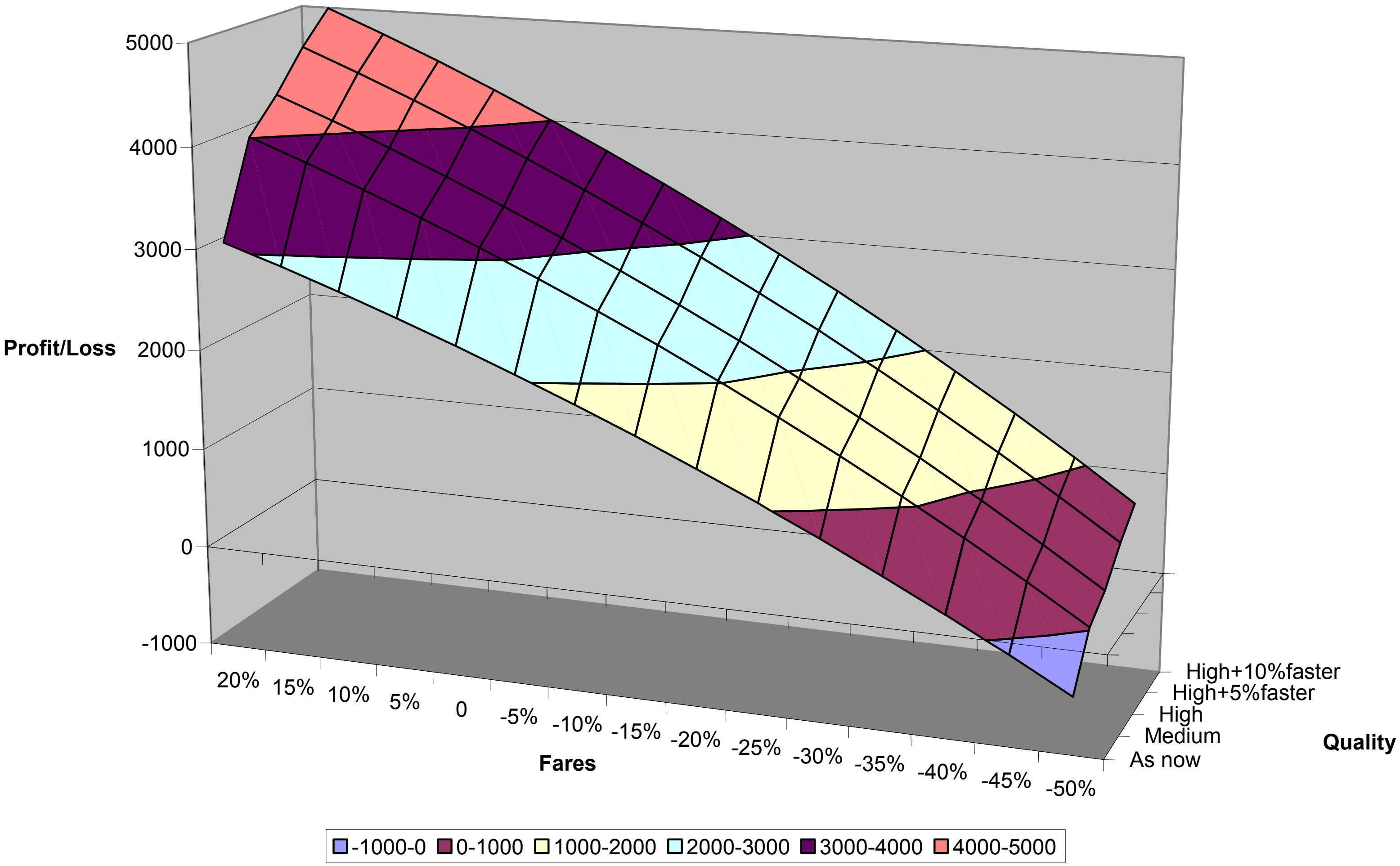


Figure 5.3 Welfare change/Profit (Large Radial; monopolistic operator; current frequency level)

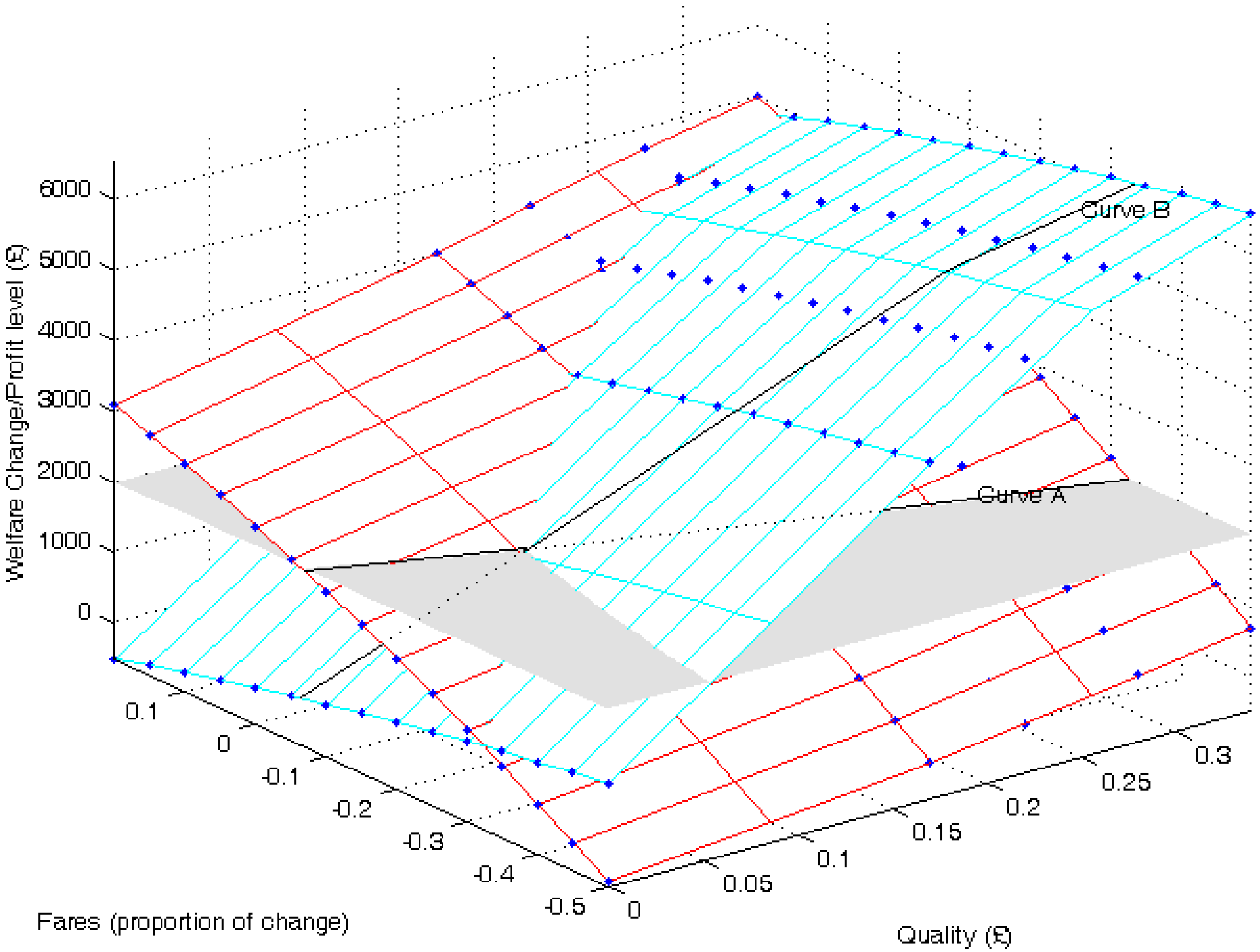


Figure 5.4 Change of Welfare (Large Radial; Competition by Low Quality Operator)

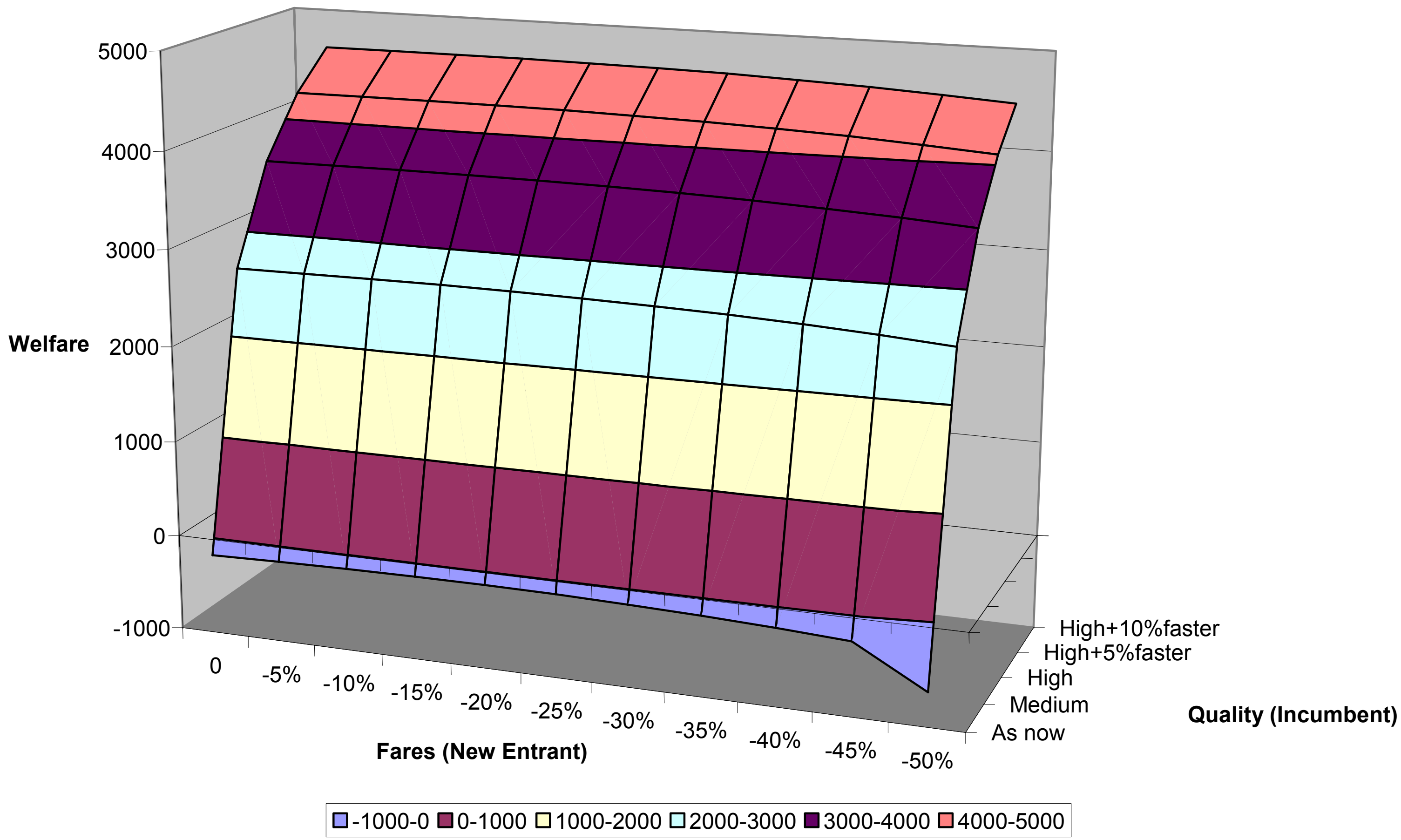


Figure 5.5 Operating Profit of the Incumbent (Large Radial; Competition by Low Quality Operator)

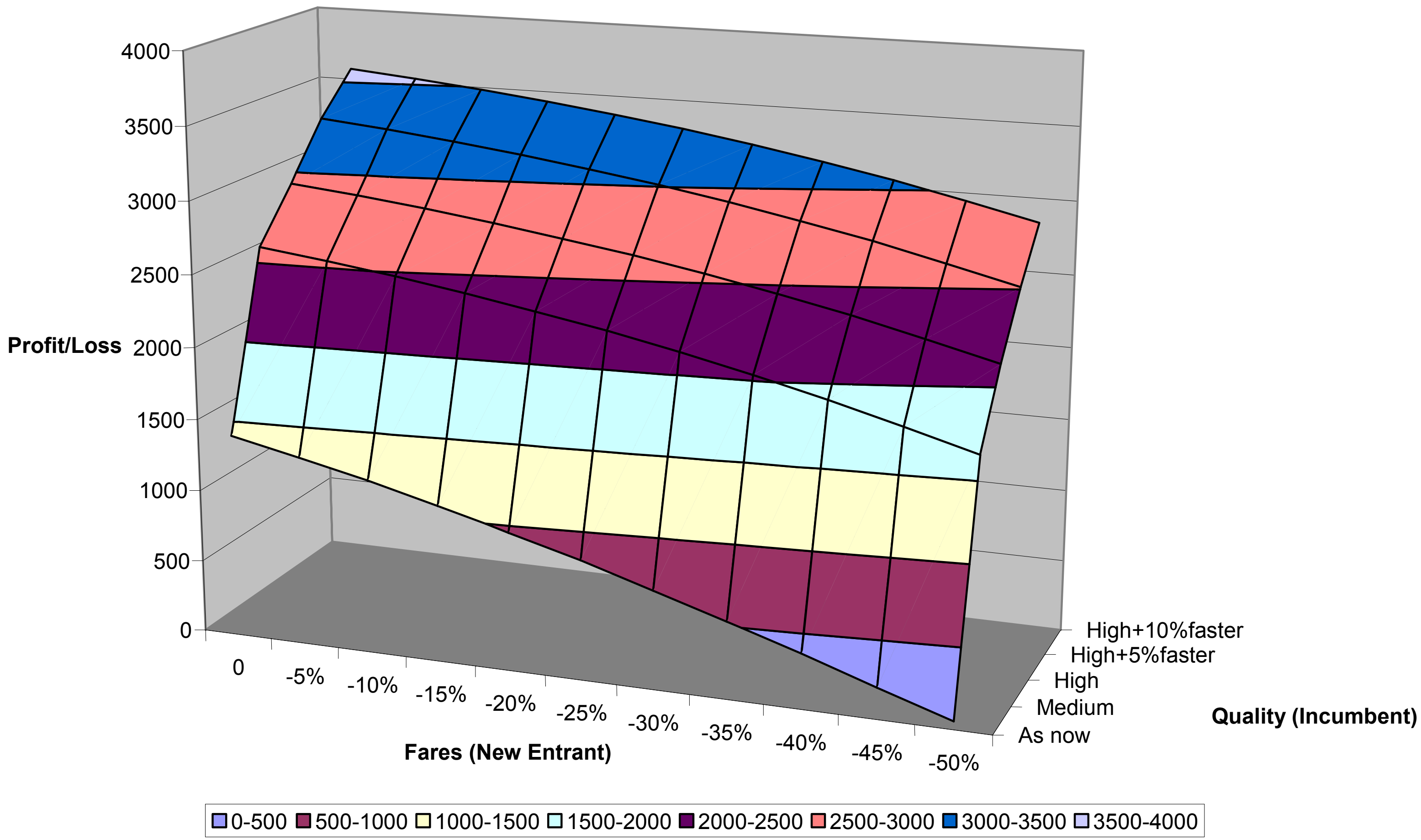
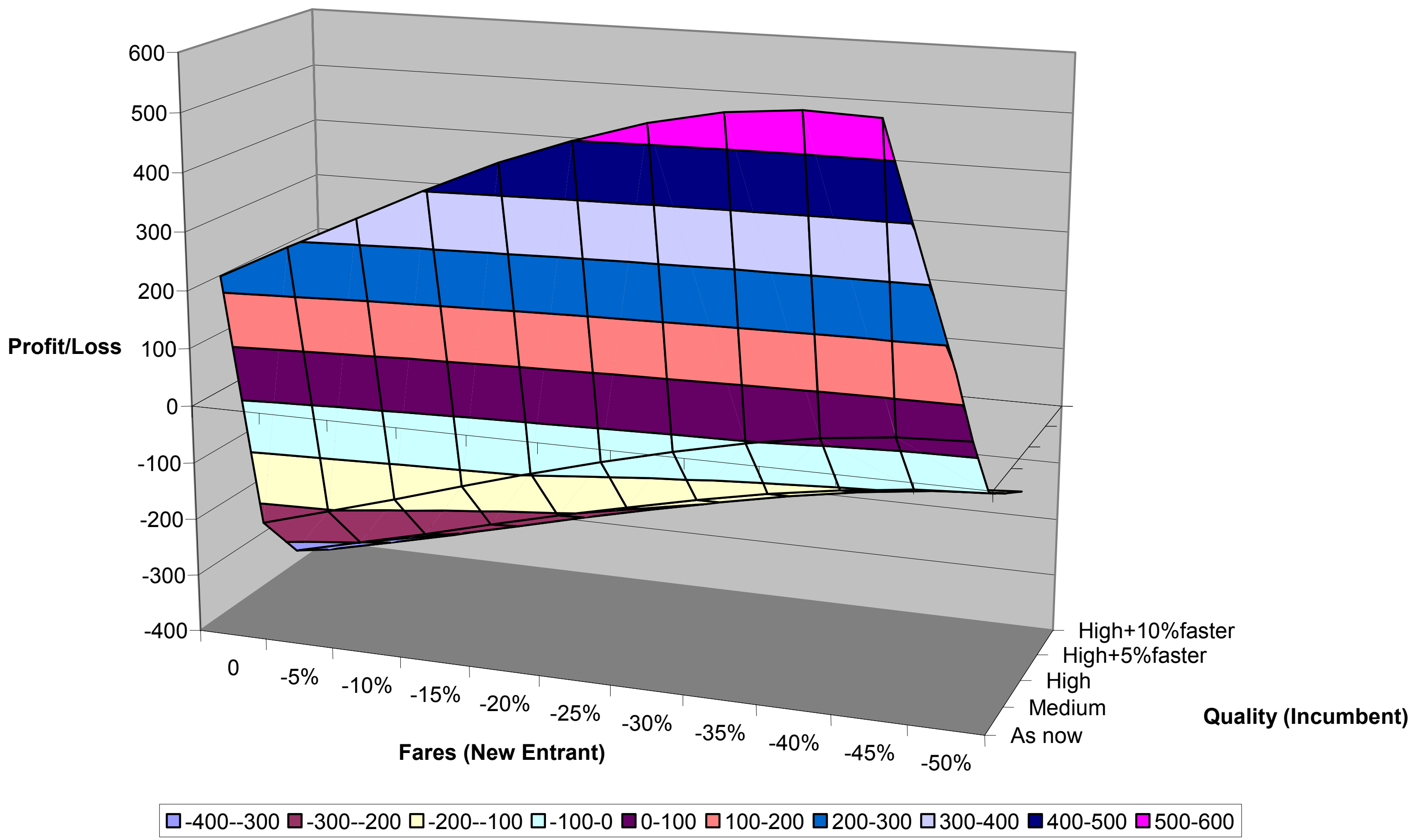


Figure 5.6 Operating Profit of the New Entrant (Large Radial; Competition by Low Quality Operator)



6. CONCLUSIONS

In this section, we attempt to pull together the strands of the work we have done for the Department and CfIT.

From the case study strand we draw three main conclusions.

1) Quality is an important dimension of bus service, and the evidence is that enhanced quality of vehicles and infrastructure can and does deliver patronage increases both absolute and relative to the market as a whole.

2) Since the provision of bus service is in the hands of commercial operators and the provision and management of the infrastructure they use is in the hands of the local authorities, development of successful quality initiatives requires some form of co-operation. The precise form it takes is secondary to the need to work together. Success depends on leadership, initiative, resources and political support. These are not always simultaneously forthcoming.

3) There is clearly resistance to "hard" forms of contract backed by statute as opposed to "soft" forms of agreement. This may be largely because softer forms of agreement are more flexible and adaptable to changes in market and local political circumstances. But also, there remains concern about the attitudes of the competition authorities and these doubts may favour a less structured form of agreement.

We were fortunate to be able to participate in the study for CfIT "Achieving best value" and in particular to be able to draw on the Accent work for that study on consumers' values of quality. From that work,

4) Quality is a multi-dimensional concept covering journey, time, reliability, information, quality of waiting facilities, safety and security, ease of boarding and in-vehicle ambience. Values of these attributes in packages are required. The absolute values of quality attributes from Accent SP work tended to be high relative to fares paid. Particularly high values are evinced by people who rarely or never use bus, and this gives rise to issues of appropriate market segmentation (car available/not). We have moderated the Accent values in the work reported below.

We have developed a simulation model of demand for bus services which we have applied at a corridor level in conjunction with a simple model of bus supply. We have investigated a wide range of quality measures and competition scenarios and in our most recent work examined the effects of various possible reforms of general bus subsidy support. From this,

5) Given the pattern of fare and frequency elasticities and quality values we have used, there is a significant payoff to higher quality. Indeed quality enhancement and fare reduction are both effective ways of increasing economic welfare relative to frequency enhancement for the relatively high frequency corridors tested.

6) Quality packages are beneficial to both the operators and to society as a whole given the elasticities, costs and traffic densities tested. However, without some form of revenue or capital contribution from operators, there is no direct benefit to

the local authority. This is a structural weakness in the incentives to create quality partnership arrangements. In some cases, as for the York Road busway in Leeds, operator contributions may be feasible; for other less ambitious schemes, some form of ring-fenced challenge fund might be the best way to kick start quality measures outside London.

7) In general, our work suggests that quality measures are unlikely to impact significantly on the competitive environment. Competition is not usually a sustainable outcome. In particular, high quality operators ought to be able to see off competition from low quality, low fare operators provided the operating cost differential is not too great, whilst even on the most densely trafficked routes the scope for competition between high quality operators is limited to relatively small scale entry. So, quality measures are unlikely to stimulate competition and it would be a mistake for the competition authorities to dictate a more competitive outcome as a requirement for approval of a quality partnership. Moreover, where quality enhancements do stimulate competition, such competition is likely to be in the service rather than the price dimension. Moreover, such service competition may not be beneficial in welfare terms.

8) However, the implication is that the natural outcome is some form of weak monopoly under which the gains from publicly funded quality measures are partially captured in enhanced monopoly rents to bus operators. Note that operators who are effectively maximising patronage subject to a minimum profit or margin constraint will be incentivised to pass at least some of the benefits on to consumers. This type of objective is consistent with public statements by bus operators about their objectives and with the less than unit fare elasticities observed in the market-place.

9) This does raise the question of pro-public interest regulation of the bus industry. Given what we say above about the unsustainability and undesirability of competition we can see only two options for dealing with any problem of excess profits. The first is through some form of price or margin regulation. However, practical considerations such as the basket of prices, equity across routes and areas, and incentive effects on operators probably rule this out, although fares regulation is widely deployed in the rail industry and our modelling work suggests it could be effective in the bus industry. The second would be the introduction of well-specified quality contracts under which a degree of regulation was accepted by operators in return for exclusivity on the basis of 'best value'. This could be a favourable environment for the creation of the next generation of quality measures.

REFERENCES

Project Outputs

Institute for Transport Studies/ Transport Studies Unit (2000) Quality Bus Partnerships and Market Structure: Phase 1 Report of a Study for the Department of the Environment Transport and the Regions. Draft. Version 0.4

Bristow, A. and Shires, J. (2001) "A review of the values of time, elasticities of demand and other parameter values for use in the Quality Bus Partnerships model", Report to the Department of the Environment, Transport and the Regions. February 2001.

Whelan G.A., Shires J.D., Toner J.P. and Preston J.M. (2001) Modelling Quality Bus Partnerships Draft Report March 2001.

Bristow A.L., Shires J.D. & Mackie P.J. (2001) Quality Bus Partnerships: New Evidence on Performance, World Conference on Transport Research, Seoul, Korea, July 2001.

Whelan G.A., Toner J.P., Mackie P.J. and Preston J.M. (2001) Modelling Quality Bus Partnerships, paper to the World Conference on Transport Research, Seoul, Korea, July 2001.

Preston J.M., Huang B. and Whelan G.A. (2003) Determining Optimal Bus Service provision: the Role of Quality in the Service Mix, paper to The 8th International Conference on Competition and Ownership in Land Passenger Transport (THREDBO 8), Rio de Janeiro September 2003.

Whelan G.A. (2003) Quality Bus Model (QBM) User Manual

References

Accent Marketing and Research (2002) UK Bus Priorities Modal Shift: Final Report. 7 January 2002.
http://www.CfIT.gov.uk/research/psbi/lek/pdf/appendix6.pdf

Balcombe, R.J. and Vance, C.E. (1998) Information for Bus Passengers: A Study of Needs and Priorities. TRL Reports 330.

Beesley M., Gist P., and Glaister S. (1983). Cost Benefit Analysis and London's Transport Policies. Progress in Planning, vol. 19 (3). Pergamon, Oxford.

Bonsall, P. (1992) Planning Land-Use and Transport Options.

Bristow A.L., Mackie P.J., Preston. J.M., Whelan G.A, Huang B. & Shires J.D. (2002a) Achieving Best Value for Public Support of the Bus Industry: Part 1 Summary Report on the Modelling and Assessment of Seven Corridors. Report to CfIT
http://www.CfIT.gov.uk/research/psbi/lek/pdf/appendix9.pdf

Bristow A.L., Hodgson F.C., Mackie P.J., Shires J.D., Preston J.M., Raje F. & Horvald T. (2001) Achieving best value for Public Support in the Bus Industry: Review for Inception Phase. Report to CfIT
http://www.CfIT.gov.uk/research/psbi/lek/pdf/appendix3.pdf

Chartered Institute of Public Finance and Accountancy (1974) Passenger Transport Operations London.

Clark S.D. (1997) National Multi-Modal Travel Forecasts: Aggregate Elasticities from Published Great Britain Transport Statistics. Working Paper 510, Institute for Transport Studies, University of Leeds.

Cuthbertson, T., McGrath, F. and Preston, J. (1993) Assessing the Commercial Benefits of Improving Station Facilities and Information Provision. PTRC Summer Annual Meeting.

Dargay J.M. & Hanly M. (1999) Bus Fare Elasticities: Report to the Department of the Environment, Transport and the Regions. ESRC Transport Studies Unit, ref 1999/26, UCL.

Department of the Environment, Transport and the Regions (1998) A New Deal for Transport: Better for Everyone. TSO.
http://www.dft.gov.uk/itwp/paper/index.htm

DETR (1999a) Focus on Public Transport. The Stationery Office, London. Annex B. Tables 2, 15, 22 and 27.

DETR (1999b) Transport Statistics Great Britain. 1999 Edition. The Stationery Office London. Table 4.13.

DETR (2000a) Transport Statistics Great Britain. 2000 Edition. The Stationery Office London.

DETR (2000b) Transport Statistics Bulletin NTS 1997/99 Update.

Department for Transport (2002) Review of Bus Subsidies

Department of Transport, Local Government and the Regions (2001) Transport Statistics Great Britain 2001

Dodgson, J.S., Katsoulacos, Y. and Newton, C.R. (1993) An Application of the Economic Modeling Approach to the Investigation of Predation. Journal of Transport Economics and Policy 27 (2), 153-170.

Evans, A, (1987) A Theoretical Comparison of Competition with Other Economic Regimes for Bus Services. Journal of Transport Economics and Policy, 21 (1), 7-36.

Fairhurst M. & Edwards D. (1996) Bus Travel Trends in the UK. Transport Reviews, Vol16, N2, pp157-167.

Fowkes A.S., Sherwood N. & Nash C.A. (1993) Segmentation of the Travel market in London: Estimates of Elasticities and Values of Travel Time, Working Paper 345, Institute for Transport Studies, University of Leeds.

Glaister, S. (Ed) (1987) Can the Value of Transport Subsidy Be Measured, Transport UK, Policy Journals.

Glaister S. (2001) The economic assessment of transport subsidies in large cities, in Grayling T. (ed) Any More fares? delivering better bus services. IPPR Chapter 5 pp55-76

Goodwin P.B. (1992) A Review of New Demand Elasticities with Special Reference to Short and Long Run Effects of Price Changes. Journal of Transport Economics and Policy, Vol26, n2, pp155-169.

Grayling T. & Glaister S. (2000) A New Fares Contract for London. Institute for Public Policy Research.

HFA and ITS 1993. Road Pricing in London: Review and Specification of Model Elasticities. Report to the Department of Transport.

Hood, I. (1997) MERLIN: Model to Evaluate Revenue and Loadings for Intercity. PTRC, Summer Annual Meeting, Proceedings of Seminar H, Brunel University.

ITS and Gibb Transport Planning (1998) Working Paper 1: Theoretical Approach to Fares Competition Modelling Consultancy report to Office of the Rail Regulator and the Office of Passenger rail Franchising.

James, T. (1996) Competition Over Service Frequency and the Ease of Entry on Bus Routes. UTSG Annual Conference, University of Huddersfield.

McClenahan, J.W., Nichols, D., Elms, M. and Bly, P.H. (1978) Two Methods for Estimating the Crew Costs of Bus Services. TRRL SR364.

MVA (1992) Strategic and Regional Transport Model, The MVA Consultancy. Woking, Surrey.

MVA Consultants, Institute for Transport Studies, University of Leeds and Transport Studies Unit, University of Oxford, The Value of Travel Time Savings, Policy Journals, Newbury, UK, 1987.

Oum T.H., Waters W.G. & Yong J-S (1992) Concepts of Price Elasticities of Transport Demand and Recent Empirical Estimates: An Interpretative Study. Journal of Transport Economics and Policy, Vol 26, n2, pp139-154.

OPRAF (1999) Planning Criteria – A guide to the Appraisal of Support for Passenger Rail Services, Office of Passenger Rail Franchising 1999.

Pearmain, D. (1992) The Measurement of User's Willingness to Pay for Improved Rail Facilities. PTRC Summer Annual Meeting.

Preston, J., Nash, C.A. and Toner, J. (1993) MUPPIT: Urban Transport Market Theoretical Analysis. ITS Working Paper 412.

Preston J.M. (1998) Public Transport Elasticities: Time for a Re-think? paper presented to the Universities Transport Studies Group Conference, Dublin, January, 1998.

Preston J. & Wardman M. (1991) Forecasting Motorists Long Term Behaviour in the Greater Nottingham Area. Working Paper 322, Institute for Transport Studies, University of Leeds.

Preston, J., Whelan, G.A. and Wardman, M. (1999) An Analysis of the Potential for On-track Competition in the British Passenger Rail Industry. Journal of Transport Economics and Policy, 33: 77-94, Part 1.

Prioni, P. and Hensher, D.A. (1999) Measuring Service Quality and Evaluating its Influence on the Cost of Service Provision. Paper Presented at the 6th International Conference on Competition and Ownership of Land Passenger Transoprt, Cape Town, 19-23 September.

Sansom T., Nash C., Mackie P., Shires J. & Watkiss P. (2001) Surface Transport Costs and Charges: Great Britain, 1998. Study by the Institute for Transport Studies, University of Leeds in association with AEA Technology Environment, commissioned by the Department of the Environment, Transport and the Regions. University of Leeds.
http://www.its.leeds.ac.uk/research/index.html then click on surface transport costs and

Savage, I.P. (1985) The Deregulation of Bus Services. Gower, Aldershot.

Selvanathan E.A. & Selvanathan S. (1994) The Demand for Transport and Communication in the United Kingdom and Australia. Transportation Research B. Vol28B N1, pp1-9.

Steer Davies Gleave (1996) Bus Passenger Preferences. A Report Prepared for London Transport Buses.

Transport and Road Research Laboratory (1980) The Demand for Public Transport: Report of the International Collaborative Study of the Factors Affecting Public Transport Patronage. TRRL, Crowthorne, UK.

Transport Research Laboratory (2003, forthcoming) The Demand for Public Transport: A Practical Guide.

Travers Morgan , R. and Partners (1974) Costing of Bus Operations – Final Report of the Bradford Bus Study.

Tressider, J.O, Meyers, D.A. Burrell, J.E and Powell, T.J. (1968) The London Transport Study: Methods and Techniques. Proceedings of the Institute of Civil Engineers, Vol 39, pp433-465.

Vicario, A.J.B. (1999) Diversion Factors and Cross Elasticities. MA Transport Economics Dissertation, Institute for Transport Studies, University of Leeds.

Wardman M. (2001) A Review of British Evidence on Time and Service Quality Valuations. Transportation Research E. Vol37 pp107-128

Wardman M. (2000) Using Existing Stated Preference Data to Analyse Bus Preferences, Working Paper 555, Institute for Transport Studies, University of Leeds.

Wardman M. (1998) A Review of British Evidence on the Valuations of Time and Service Quality. Working Paper 525, Institute for Transport Studies, University of Leeds.

Wardman M. (1997) Disaggregate Urban Mode Choice Models: A Review of British Evidence with Special Reference to Cross Elasticities. Working Paper 505, Institute for Transport Studies, University of Leeds.

Wardman M. (1997) A Review of Evidence on the Value of Travel Time in Great Britain. Working Paper 495, Institute for Transport Studies, University of Leeds.

Wardman 1994 and 1999 are these the 1997s above???

Wardman M., Hine J. & Stradling S. (2000) Interchange and Travel Choice, report to the Scottish Executive.

White P. (2001) Local Bus Industry Profitability and the Role of Longer-distance services, in Grayling T. (ed) Any More fares? delivering better bus services. IPPR

White, P.R. and Turner, R. (1989) Costing and Productivity for Different Vehicle Types – An Analytical Framework. Presented to International Conference on Competition and Ownership of Bus and Coach Services. Thredbo, Australia. (May also have been published in a special issue of Transport Planning and Technology).

White P.R. (1997) What Conclusions can be drawn about bus deregulation in Britain? Transport Reviews, Vol17, N1, pp1-16

Williams, H.C.W.L., (1977) On the formation of travel demand models and economic evaluation measures of user benefit, Environment and Planning, Vol9.

Willumsen, L and Ortuzar , J de D (1985) Intuition and Models in Transport Management Transportation Research 19A(1) 51-8.

WS Atkins Planning Consultants & J. Polak (1997) Bus Reliability Study – Stated Preference Research. Draft Final Report to the Department of Transport.

York, I. and Balcombe, R.J. (1997) Evaluation of Low-Floor Bus Trials in London and North Tyneside. TRL Report 271.