FINANCING NEW LOCAL RAIL SERVICES

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INTRODUCTION

This paper examines the case for a new rail service between Nottingham and the towns of Mansfield and Worksop in the East Midlands region of the United Kingdom (see Figure One - Mansfield is reputedly the largest free-standing town in the country without a regular rail service). Inevitably, this proposed service has become known as the Robin Hood line. In section two, the method that was used to forecast and validate demand for the new service is described. In section three, a series of evaluation tests are undertaken based on both financial and social criteria. In section four, a series of sensitivity tests are carried out which indicate that the combination of fares and output required to maximise social benefits are quite different from those that maximise commercial benefits. In section five, the policy implications of these findings are examined.

1. DEMAND FORECASTING

The conventional approach to forecasting the demand for rail services in Britain is an incremental one based on detailed information on fares and service elasticities. This approach is not, however, applicable to a new service where the base level of demand is zero. Instead an approach is required that measures total travel demand by rail and gives detailed output on the composition of that demand (in particular, what modes it is abstracted from) in order to perform adequate evaluation (Preston, 1991A).

This means that a mode-choice model is required and this will be most easily calibrated with disaggregate (i.e. individual) data. In areas where a comparable existing local rail service exists, this model can be calibrated using observations of actual choices i.e. using revealed preference data. However, in the case of the Robin Hood line, there is no comparable existing local rail service. In this case, reliance has to be placed on hypothetical questioning techniques.

The approach that was adopted was initially developed to determine the demand for a new rail service between Leicester and Burton-on-Trent (the Ivanhoe line) and is described in detail by Fowkes and Preston (1991). The approach involves two stages. In the first stage 58,000 travel questionnaires were distributed to households served by the proposed Robin Hood rail scheme. Over 10,000 were returned, representing a response rate of 17%. This survey included a stated intentions question which asked respondents to state their intentions of using the new service for specific journeys. Despite checks to ensure that respondents were representative of the total population, it was known that this information would be strategically biased in that some respondents are likely to overstate their intentions of using the new service in order to get the service introduced. This is often referred to as policy response bias.

In the second stage around one in four respondents were invited to take part in a stated preference experiment. Over 1,000 questionnaires were returned, representing a response rate of 51%. Models of the choice between car and train and between bus and train, based on binary logit and segmented by area, were calibrated. These statistical models were then used to predict whether individuals would switch to rail and this was compared with whether they said they would switch to rail in the stated intentions survey. Overall, it was found, as expected, that the stated intentions forecasts were 54% higher than the stated preference forecasts. The forecasts were therefore adjusted, so that the initial set of forecasts indicated 7,200 trips by rail per weekday (Preston, 1989).

The forecasts were validated in two ways. Firstly, the forecasts were converted into trips per head and compared with similar trip rates for services that had recently been opened (Preston, 1991B). Secondly, the forecast trip rates were compared with actual trip rates for a small number of existing stations in the East Midlands area, whilst the whole forecasting procedure underwent an independent audit (Scott Wilson Kirkpatrick, 1991). The initial forecasts were generally given a clean bill of health except that it was found that the corridor population had been over-estimated. It was also recommended that, given the response of bus operators (see next section), rail fares should be 25% higher than existing bus fares in the peak and 10% higher in the off-peak. The revised demand forecast was then 6,100 trips per weekday.

2. EVALUATION TESTS

The likely costs and benefits of the proposed rail service is given by Table One. The capital costs of the scheme, involving upgrading the track and signalling of existing freight lines, excavating a tunnel and installing a short length of new track, 11 new stations and the purchase of four car two-train sets, was estimated to be in excess of £10 million. The operation of a half-hourly service between Nottingham and Mansfield and an hourly service beyond to Worksop was costed at over £1 million per annum.

The rail service was estimated as attracting revenue of over £1.7 million per annum. However, 46% of this revenue was predicted to be abstracted from bus. The net revenue to public transport was estimated to be less than £1 million per annum.

Measures of consumer surplus can be derived directly from the binary logit using the path integral formula (see, for example, Neuberger, 1971). From this, rail users were estimated to benefit by an amount, net of tax, equivalent to over £1 million per annum.

Estimates of benefits to remaining car users, in the form of reduced congestion were found by estimating the number of rail users abstracted from car for each origin-destination pair, disaggregated by time period. Traffic assignment models indicated which routes these trips were likely to be withdrawn from. The effect of the removal of this car traffic on congestion and accidents was only believed to be significant at saturated junctions and was estimated by Nottinghamshire County Council using the JIMVAL (Junction Improvement Evaluation) computer program. As a result, car users were estimated to benefit by around £1 million per annum. However, there is some concern that the amount of traffic attracted from car is forecast at a high level, accounting for up to one-half of central Nottingham bound rail traffic, compared to a maximum of one-third observed for new rail schemes elsewhere. In addition, we have taken no account of second round effects that are likely to lead to re-congestion and hence reduce the non-user benefits of a rail scheme. For example, assuming a car travel time elasticity of -0.5, Consultants HFA (1989) estimated the likely loss of non-user benefits as being 40%. Moreover, it may take a number of iterations before the new equilibrium is reached. Simulation work carried out by Preston and Wardman (1991) required ten iterations, but empirical evidence is required on the process of adjustment.

Determining the impact on bus users is similarly complex. Rail was estimated as abstracting £0.806 million revenue from bus services, but bus operators gained £0.172 million from existing services acting as feeders to rail stations. This left an overall shortfall to bus operators of £0.634. Bus operators were predicted as responding in two ways. Firstly, a small number of services would be withdrawn, reducing operating costs by £0.480 million but (assuming a service elasticity of 0.4) leading to revenue losses of £0.184 million. Secondly, fares were increased on competed routes by 15%, which, assuming a fares elasticity of -0.3, raised £0.450 million. The effect of increased fares and reduced services was estimated to lead to a loss in benefit to existing bus users equivalent to £0.8 million.

The costs and benefits presented in Table One are converted into present values in Table Two by dividing through by the discount factor $(1 + r)^n$, where r = interest rate, n = year of the project life and summating. In undertaking a **financial appraisal** we only examine the costs and benefits accruing to a single agency, in this case the rail operator. From row one of Table Two it can be seen that the Net Present Value (NPV) in this case is around -£5.0 million. This indicates that although the scheme covers its operating costs, it is not commercially viable as it fails to make a positive return on the capital invested.

If a **social cost-benefit analysis** is undertaken the costs and benefits accruing to all incidence groups are examined. Even if we assume that developmental and environment effects are neutral (in reality, they are likely to be small but positive), Table Two indicates that the new rail scheme has a strongly positive NPV of £8.4 million. We find that in this case a commercial and a social appraisal do not give the same policy signals, a result we have also found in earlier studies (Nash and Preston, 1991).

The above analysis suggests that, for the scheme to go ahead, a capital grant is required. Such a grant may be obtained under **section 56** of the 1968 Transport Act but for such an application to be successful, a particular form of evaluation, as specified by the Department of Transport (1989, 1991) has to be undertaken. This precludes analysis of user benefits on the basis that they can be captured via the fare box (assuming perfect price discrimination). In addition, contributions from the private sector are required to be sought. However, land ownership along the Robin Hood line is fragmented, there are no large gainers and there is an incentive for property owners to act as 'free riders'. Private sector contributions are likely to be limited to sponsoring station sites, although there may also be scope for private sector involvement through a design, build and operate contract. For the purpose of this paper we have assumed that private sector contributions are zero. In reality, there are likely to be modest contributions which are unlikely, however, to effect our overall conclusions. As a result of such a quasi-commercial, section 56 evaluation rows two, three and five are excluded from the evaluation. The NPV of the rail scheme becomes £6.1 million which although still positive, is considerably less than that achieved by social cost-benefit analysis. It is conceivable that, for more marginal schemes, a Section 56 and a social appraisal can also give conflicting policy signals (Nash and Preston, op cit).

3. SENSITIVITY ANALYSIS

A simple, semi-log model of demand for the new rail service was developed and took the following form:

$$Q = \alpha \, exp \, (\beta P + \gamma / M) \tag{1}$$

where Q = Thousand rail passenger miles per annum
P = Mean rail fare per passenger mile (pence)
M = Thousand train miles per annum
α, β and γ are parameters.

In this model the fare elasticity increases proportionately with the level of fare ($\eta_p = \beta P$), whilst the mileage elasticity decreases with the level of mileage ($\eta_M = -\gamma/M$). At the modelled level of P and M it was assumed that $\eta_P = -0.8$ and $\eta_M = 0.3$ (ie $\beta<0, \gamma<0$).

Similarly, a simple operating cost model was developed, as incorporating a capacity constraint, as follows:

$$TC = \alpha' + \beta' \, [Q/\phi] + \gamma' C \tag{2}$$

where TC = Total Operating Costs per annum (£ thousand)
α' = Fixed costs per annum (excluding rolling stock)
Φ = Load Factor (if $Q/M \leq 50$, $\Phi = Q/M$, else $\Phi = 50$)
β' = Variable operating cost per train mile
C = Number of train units required
γ' = Fixed Cost per train unit (£ thousand).

Where there is no capacity constraint and hence no duplicate mileage is required this model simplifies to TC = $\alpha' + \beta'M + \gamma'C$ (4). With this function user benefit (consumer surplus) is proportional to Q i.e.

$$CS = \int_{P}^{\infty} \alpha \exp(\beta P + \gamma/M)\, dP = \frac{1}{\beta}(0-Q) = Q/|\beta| \quad \text{given } \beta < 0 \tag{5}$$

It is assumed that the loss of benefit to bus users and the gain in benefit to car users are also proportional to Q but the reduction in subsidy as a result of the withdrawal of tendered bus services is treated as a one-off windfall gain.

Given this model, the effects of different combinations of fare and frequency on social welfare are graphed out in Figure Two. The resultant function is well behaved over a broad range and illustrates the well-known result that, for a given financial return, there is a locus of fare and frequency combinations (Nash, 1982).

Detailed analysis indicated that the best financial result involved cutting mileage by around 40% and increasing fare by 25% compared to the base. Despite such measures, under our assumptions, the scheme still fails to make a return on the capital invested but the loss is reduced from around £5.0 million to £2.7 million (down £2.3 million). However, the social NPV has also been reduced by £2 million and the Section 56 by £1.2 million. A saving of £2.3 million in financial terms leads to a loss of £4.3 million in social benefits.

The best social result appeared to be to reduce fares by 7% (thereby reducing the premia over bus fares) and miles by 2% (although this is dependent on the definition of maximum load factor Φ_{max}). This leads to small increases in the social NPV (up to £0.3m) and the Section 56 NPV (up £0.2m) and a slight increase in the financial NPV (up £0.2m), suggesting a £0.2m increase in finance has led to a £0.5m increase in social benefits. This result suggests that the base level of fares and frequency is close to optimal, particularly given the wide confidence intervals we need to attach to our model's predictions.

In Table Four, the results in Table Three are re-produced, but, in line with earlier evidence, it is assumed that non-user benefits are reduced by 40% (in reality, this would also have an effect on revenue but we have been unable to quantify this). In this case, the best financial result out of the three options analysed is also the best Section 56 result; the commercial and the quasi-commercial evaluation results give the same operational policy results, but are in conflict with the operational policy favoured by a social cost-benefit analysis. However, the margins of difference are not large. Table Four suggests that a large number of fare/frequency combinations will give similar Section 56 evaluation results.

4. CONCLUSIONS AND POLICY IMPLICATIONS

In terms of methodology we have identified two areas that require attention.

Firstly, re-assignment of public transport trips given a new rail service and the subsequent reaction of commercial bus operators requires detailed modelling. Our modelling work suggests that the loss of benefit to captive bus users will cancel out most of the benefits to new rail users but more detailed work is required on the relationship of this benefit loss to changes in rail fare and frequency. Secondly, measurement of the extent of non-user benefits and the impact of re-congestion is required. Again more detailed work is required on the relationship of non-user benefits to changes in rail fare and frequency. Overall, our evaluation approach has been based on an aggregate model which incorporates a number of simplifying assumptions; in particular that user and non-user benefits are proportional to the level of rail demand. Ideally, a more disaggregate analysis should be undertaken in which the effect of rail fares and frequency on abstraction from bus, from car and on newly generated trips is assessed and the re-configuration of the bus and car markets taken into account.

In terms of policy, we would argue that on social grounds there is a strong case for the Robin Hood rail service, but there is not a financial case which once again indicates the policy divergence between financial appraisal and social cost-benefit analysis. The results also indicate that, on the basis of a Section 56 evaluation, the scheme should go-ahead, contrary to the expectations of some observers who believed that a positive Section 56 NPV was only likely to be accompanied by a positive financial NPV (Bates and Lowe, 1989 - but the Robin Hood line may be the exception rather than the rule here).

However, given that the service is given the go-ahead, there is another important policy question concerning the objective the operator should be set. If the operator is to maximise profits (and hence minimise the financial NPV loss), large fare increases and service reductions are required, reducing demand by around one-third of base levels (to 4,100 a day).. If the operator is to maximise social welfare then there will be modest fare decreases and service reductions, increasing demand by 5% to around 6,400 per day. The effect on operational policy if the operator is given a quasi-commercial objective (such as maximising Section 56 NPV) is not clear. In some instances (Table Three) the result will be the same as maximising welfare, in others, for example where non-user benefits are limited, it may be the same as maximising profits (Table Four). We would conclude that the existing mix of commercial objectives for bus and rail operators and quasi-commercial appraisal for specific grants for new rail services can be seriously distorting. A move to comprehensive social cost-benefit analysis, as practised in the United Kingdom for road investment (Department of Transport, 1981) and in some European countries for all transport investment (Nash, 1985), is required.

BIBLIOGRAPHY

Bates, J., and Lowe, S.. Criteria for Public Sector Support in Urban Public Transport. Brighton: PTRC Summer Annual Meeting, 1989.

Department of Transport.. The Role of Investment Appraisal in Road and Rail Transport. London: Department of Transport, 1991.

Department of Transport.. Section 56 Grant for Public Transport. Circular 3, 89, November. London: Department of Transport, 1989.

Department of Transport.. COBA9 Manual. London: Department of Transport, Policy and Methods Division, 1981.

Fowkes, T., and Preston, J.M.. Novel Approaches to Forecasting the Demand for New Local Rail Services. Transportation Research 25A. 1991. 4, 209-218.

Halcrow Fox and Associates.. Proposed Department of Transport Criteria for Section 56 Grants. Phase 1. Final Report. London: Passenger Transport Executive Group, 1991.

Nash, C.A.. Economics of Public Transport. London: Longman, 1982. 51.

Nash, C.A.. Policies towards Suburban Rail Services in Britain and the Federal Republic of Germany - A Comparison. Transport Reviews 5. 1985. 3, 269-282.

Nash, C.A., and Preston, J.M.. Appraisal of Rail Investment Projects: Recent British Experience. Transport Reviews 11. 1991. 4, 295-309.

Newberger, H.L.I.. User Benefit in the Evaluation of Transport and Land Use Plans. Journal of Transport Economics and Policy 5. 1971. 52-57.

Preston, J.M.. Nottingham - Mansfield - Worksop New Rail Service Project. Final Report. Unpublished report for Nottinghamshire County Council. January 1991.

Preston, J.M.. Demand Forecasting for New Local Rail Stations and Services. Journal of Transport Economics and Policy 25. 1991. 2, 183-202.

Preston, J.M.. A Note on the Traffic Generation of New Rail Services. Unpublished report for Nottinghamshire County Council. April 1991.

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

Scott Wilson Kirkpatrick.. Robin Hood Railway Line. Audit of Patronage Estimates. Unpublished report for Nottinghamshire County Council. April 1991.

Table 1
The Estimated Costs and Benefits of the Proposed Robin Hood Service
(£k, 1989 prices)

Incidence group	Cost		Benefit	
1 Rail operator	Capital Operating	10433 1086	[Rev from bus/ Rev from elsewhere	806] 946
2 Rail users			Reduced generalised cost net of tax [Tax saving	1024 143]
3 Bus users	Increased generalised cost	802		
4 Private transport users			Reduced generalised cost of travel and accident reductions	995
5 Bus operators	[Revenue lost to rail [Subsidy lost Revenue lost to other sources	806] 74] 222	Operating cost reductions Revenue as rail feeder Revenue from fare increases	480 172 450
6 Local Authority			[Reduced subsidy	74]
7 Central Government	[Tax loss	143]		

All figures per annum, except capital costs, and refer to equilibrium year 5. Figures in brackets [ ] indicate transfers.

Table 2
Estimated Present Value of Costs and Benefits of Robin Hood Service
(£k, 1989 prices, 8% rate of return, 30 year project life)

	Costs		Benefit		Net
1 Rail operator	Capital operating	10433 12642	Revenue	18125	-4951
2 Rail users			Reduced gen cost Tax saving	10594 1480	12074
3 Bus users	Increased gen cost	8297			-8297
4 Private transport users			Reduced gen cost	10294	10294
5 Bus operators	Lost revenue	11400	Cost reduction Revenue gain	5029 6845 6371	0
6 Local Authority			Subsidy saving	764	764
7 Central Government	Tax saving	1480			-1480
TOTAL		44252		52657	8404

NB. Subject to rounding error.

Table 3
Base Result and Best Financial and Social Results (£k, 1989)

Fare	Miles	Fin. NPV	Social NPV	S56 NPV
Base	Base	-4951	8404	6107
+25%	-40%	-2742	6462	4922
- 7%	-2%	-5245	8754	6340

Table 4
Revised Base and Best Financial and Social Results
(£k, 1989 - assumes 40% reduction in non-user benefit)

	Financial NPV	Social NPV	Sect 56 NPV
Base	-4951	4286	1988
'Best' Financial	-2742	3701	2162
'Best' Social	-5245	4426	2012

Figure One
Location of Robin Hood Line (Nottingham-Mansfield-Worksop and Ivanhoe Line (Leicester-Burton)

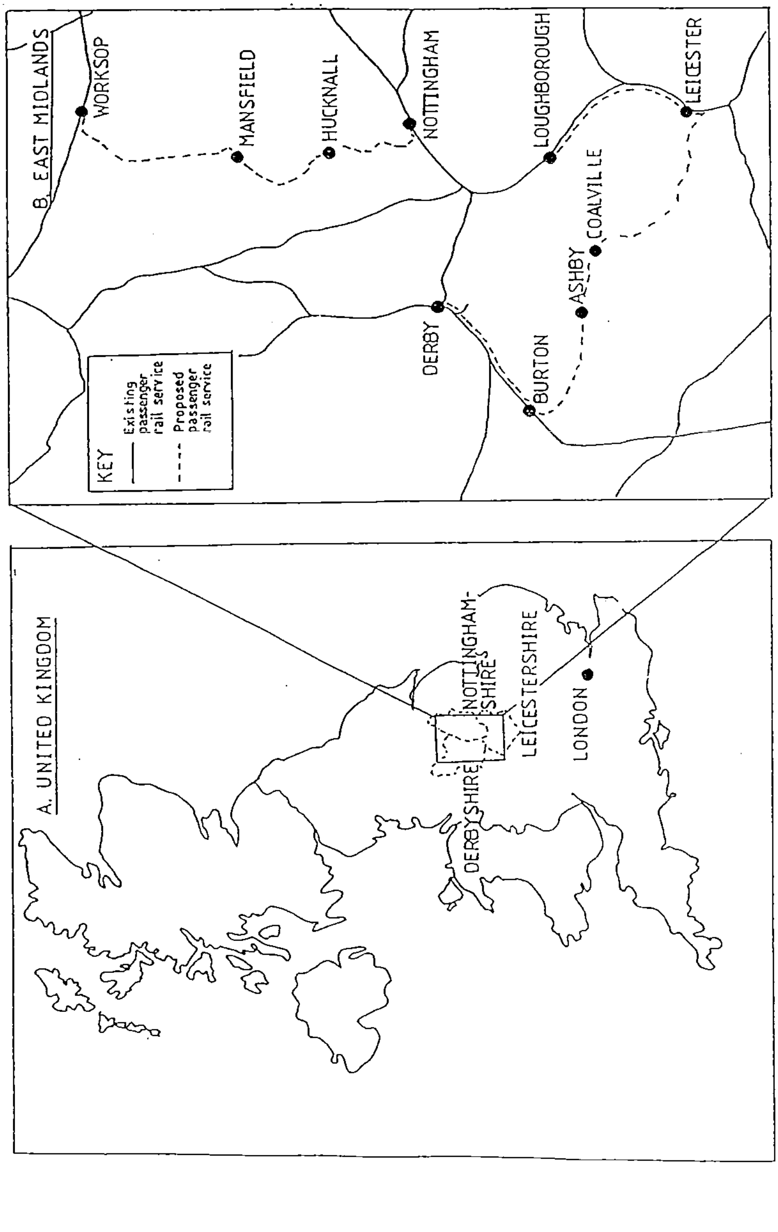

Figure 2:
Effect of Different Rail Fare and Frequency Combinations on Financial and Social Net Present Values