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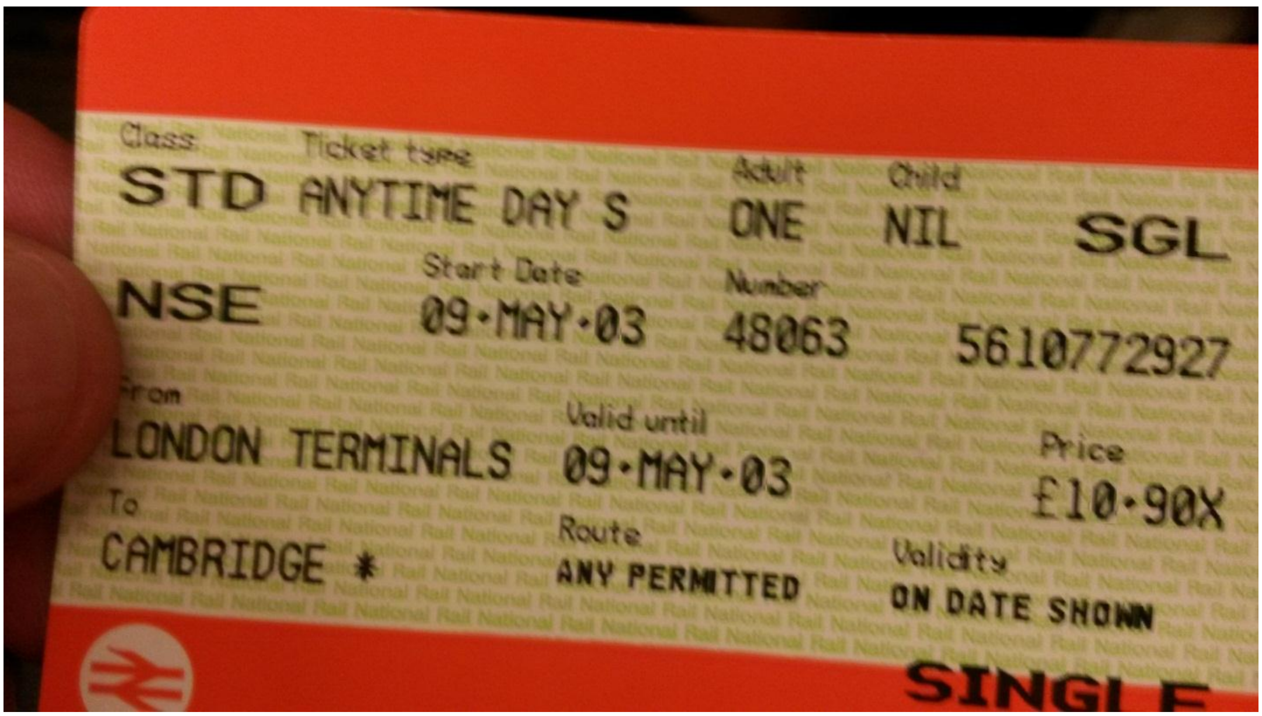
National Railcard Economic Research

Commissioned from The Railway Consultancy Ltd by Railfuture



Executive Summary

- Many British people find the cost of rail travel a barrier for this mode of transport. Other European countries have tried to address this problem with railcards offering discounted travel. This report examines this alternative for the British rail industry.
- The proposed National Railcard is a card offering discounted off-peak travel throughout the whole UK network, for passengers travelling alone who are not eligible for any other railcards. As such, it is designed to fill off-peak spare capacity. Consequently, the extra revenue from this additional demand should feed straight into train operators' profits.
- This product is a two-part tariff where a fixed cost is paid for the card and a discounted price is paid for subsequent rail trips. This pricing scheme is already being widely used to maximize profits (e.g. mobile

phones and sport clubs). It can also be shown that the theoretically optimal two-part tariff will maximize passenger numbers.

- The passenger facing the decision to buy the card or not must weigh up the cost of paying for the card with the benefits of the discounts to rail travel obtained from it. Passengers must consider their expected travel frequency in order to make this decision. However, once the card is bought, the perceived cost for rail travel is the discounted fare and the cost of the card plays no role whatsoever in the decision of how much rail travel to consume. As a consequence of the discount offered, trip frequencies are expected to be enhanced for those who buy the card.
- We used survey data on personal travel profiles such as trip frequencies and average trip lengths for the whole UK. We modelled the reaction of passengers facing these decisions using two alternative assumptions about their behaviour. A naïve behaviour assumption was contrasted with a more sophisticated one. However, results for both approaches were similar.
- We split our analysis into the **"**London and South East" and "Elsewhere" markets. We found the latter to have greater benefits from this product. In the former market, rail trips tend to be relatively more related to commuting and, for a card priced £20, offering a discount of one third on off-peak rail travel, our model predicts only some 500,000 cards to be sold. The equally priced, currently available Network Railcard only sells 360,000 each year, but this product is less attractive: it's geographically limited and is subject to a minimum fare.
- Under our most conservative forecasts, a card with such pricing will be bought by 2.7 million passengers each year across the UK. Passenger miles will increase by 11% and incremental profits for the industry will be in the order of £50 million. This could mean fewer subsidies paid and higher patronage. Consequently the subsidy/passenger miles ratio would fall by 5%.
- We studied the performance of the scheme over a range of plausible pricing structures. We found that profits are maximized when the card is priced at £30 and offers discounts of 50%. Under this scenario, we forecast 2.7 million cards to be sold, generating £70 million incremental profits and boosting off-peak passenger miles by 25%. Subsidy per passenger mile is minimized at this point, implying a reduction of 13% from actual levels.
- The value of the reduction in external costs from transport such as pollution and congestion was estimated at £2m. Other benefits of this scheme, albeit not quantified in this report, are social inclusion to the railways and the financial net impact for TOCs which will receive income before the service has been delivered.
- Our results show that a National Railcard can encourage more people to travel by rail off-peak, thus enhancing TOCs profits. However, they are heavily dependent on a series of assumptions, so profit figures may be overstated. Nevertheless, we believe there is indeed a positive case for a National Railcard. The importance of our preliminary results suggests it might be worthwhile to conduct further research in order to test these assumptions and to advance the detail of the scheme.

National Railcard Economic Research

The Railway Consultancy Ltd,
1st floor South Tower, Crystal Palace Station, London. SE19 2AZ.
Tel 020-8676-0395 Fax 020-8778-7439 e-mail info@railcons.com

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1 Introduction

1.1 Recent research shows that many British people find the cost of rail travel a barrier for this mode of transport. Dissatisfaction has been shown, both with regards to the general level of fares and the complexity of discounts for rail travel, where there are any. An attempt to tackle this problem has been made in many other European countries by offering discount travel cards (e.g. Bahn Card in Germany). Railfuture has therefore commissioned the Railway Consultancy Ltd. to undertake this economic research into a proposed National Railcard for UK.

1.2 This product has been envisaged as a card which offers off-peak discount travel. The only cost of it is an up-front payment in order to purchase the card. It is effectively an extension of the currently available cards (Young Person's Railcard, Senior Citizens Railcard and Network Railcard) which will become available across the whole UK rail network and for all customers.

1.3 This product has the potential of generating more passenger traffic for the railways both in terms of completely-new trips, and abstraction from other modes. It can then be a significant element towards achieving the Government's ambitious goals set in the recently published 10-Year Transport Plan, namely a 50% increase in rail patronage levels. Additionally, as it will be only available for off-peak travel, it has the appeal that it will be filling spare capacity on these trains.

1.4 However, it is not necessarily true that this important discount on rail travel will mean higher revenues for the rail industry. This is important since, the way the franchise contracts were set up, the SRA has to cover all losses that Train Operating Companies (referred as TOCs hereafter) incur due to increased regulation. A National Railcard will directly generate profits by the sales of the card (railcard revenues). The existence of the card will increase off-peak passenger numbers, but at the expense of a lower yield per passenger. The net effect on ticket revenues will depend ultimately on the responsiveness of passengers (their 'elasticity of demand') to this discount throughout the target markets. The interaction between railcard revenues and ticket revenues will render the scheme positive or negative in terms of rail finances.

1.5 To address this issue we have built a demand forecasting model based on personal data on off-peak patterns of travel, provided by the National Travel Survey (NTS). We therefore examine the impact on patronage and profits that this card will convey over different pricing ranges.

1.6 This report is organized as follows. In section 2 we present the general structure and further discuss the case for a National Railcard (NRC, hereafter). In section 3 we develop a theoretical framework to understand the economics of a National Railcard. In section 4 we present the underlying concepts and assumptions behind the structure of our demand forecasting model. In section 5 we discuss the way the data was processed to prepare it for use in the model. Section 6 presents and discusses our results. Finally, conclusions are set out in section 7.

2 The Structure of, and Case for, a National Railcard

2.1 The proposed National Railcard has been envisaged as a card offering discounted off-peak travel throughout the whole UK network, for those passengers travelling alone and who are not eligible for any other railcards. It then resembles a Young Persons or a Senior Railcard but it is aimed at the people aged 25-59, who may travel alone (unlike with the current Family Railcard). The National Railcard will be equivalent to a two-part tariff, with an up-front admission fee (the cost of the card), and a standard discount on the price of subsequent off-peak journeys. A fairly priced scheme of this type will be in essence offering a discount in off-peak travel, especially to those wishing to travel off-peak above a certain trip frequency. As such, it will encourage more off-peak trips to be made both from current rail users as well as from users of competing modes. It is possible that this kind of scheme can enhance TOCs profits and hence imply fewer subsidies to be paid by the taxpayer. However, as mentioned, the effect on profits will depend on the response of the market towards it.

2.2 As well as encouraging more people to use rail transport, a National Railcard scheme:

- Can be an effective tool for smoothing demand over different times of the day. This will have positive consequences in terms of alleviating overcrowding in the peak and making more efficient use of capacity.

- Can reduce the general level of transport-related externalities. As people transfer from car or air to rail, fuel consumption and noise pollution, traffic congestion and road accidents will all be reduced. Not only car users but society as a whole will benefit.

- Can promote social inclusion on the rail network, as people with lower incomes will be in a better position to afford travelling by rail.

- Can substitute a series of competing off-peak tickets, thus simplifying the current complexity of discounts to rail travel.

- Can be a very powerful source of customer information for management purposes (especially if smartcards are used). Personal and travelling profiles of those buying the card can be stored in a database which can be exploited by TOCs, regulators, researchers etc. This will create a positive feedback that will enable improvements in the design of the scheme.

2.3 Nevertheless, there are also some expected shortcomings of such a scheme. Its impact on rail finances is uncertain. Depending on the elasticities of demand, this product could either increase or decrease revenues for the industry. New passengers might bring new revenue. Alternatively, it might tempt “high yield” passengers into buying cheaper tickets, hence undermining TOCs market segmentation strategies, and consequently having a negative impact. Thirdly, the scheme might be costly to implement in terms of administration, marketing and staff training costs. If the railcard actually ends up reducing the profitability of TOCs, then the taxpayer will end up paying for this scheme via more subsidies. These complex responses require the construction of a model to try to forecast the profitability of this scheme, as set out in section 4.

The market for a National Railcard

2.4 The overall aim of the National Railcard is to stimulate the demand for rail travel. However, most of the passenger Train Operating Companies would not support such a move if it generated demand across the entire traffic day, because they are already at capacity in the peak periods. Moreover, because of the economics of peak rail operation (with assets which are only used for a couple of hours per day leading to a financial loss being incurred), increased peak demand would lead to an increased demand for subsidy, which would have direct implications on the funding of the industry by the Strategic Rail Authority. In the current funding climate, such a product is simply not realistic.

2.5 In the off-peak, however, with key assets such as rolling stock and traincrew not fully stretched, any additional fares revenue can feed straight through into profit. A railcard aimed solely at this market is potentially worthwhile.

2.6 The above arguments relate closely to suburban rail operation. On Inter-city routes, a similar phenomenon applies, except that peak revenues are driven by the application of higher fares, which are paid by business passengers. Off-peak revenues are from leisure passengers (although a very small number of book-ahead tickets may be available on peak trains too). As the demand from business passengers is inelastic (they generally continue to travel if the fares are increased, often because their business is paying), reducing fares in the peak would be counter-productive for Inter-city operators too. Off-peak passengers, however, are sensitive to rail fares, and more revenue can often be generated by lowering the fares – for instance, through discounts associated with a railcard.

2.7 The detailed aim of the national railcard, therefore, is to stimulate price-sensitive demand on off-peak trains, where the railway already has capacity, or can make it available at relatively low cost.

Different Off-Peak Time Bands

2.8 The 'off-peak' may be disaggregated into a number of different time-bands, in which different cost pressures and demand features apply. These time-bands include:

(i) inter-peak (1000-1600, Mon-Fri);
(ii) weekday evening (1900-2400, Mon-Fri);
(iii) Saturdays and Sunday mornings;
(iv) Sunday afternoons/evenings.

2.9 Although some generic comments can be made about the different time-bands, it should be remembered that there are seasonal variations in all of them. In general, the summer holiday months are busiest for all off-peak trips, although the extent to which this is the case varies across the country. In some of the urban areas, the effect may be negligible, whereas (for instance) on the Cornish branches, summer traffic levels may be ten times winter ones.

2.10 In the inter-peak, most railways have spare capacity which is easily-available for use. For instance, drivers contracted to drive trains in the morning peak period will have a break, but still be available for use at lunchtime. The train-crew cost of running additional services then can even be zero. However, on the demand side, a significant number of commuting trips (perhaps one-third) are made in the inter-peak, either from late starters, early finishers, or those on shift work. Stimulating demand for this journey purpose is not cost-effective, since such passengers are not normally responsive to changes in fares. Many inter-peak long-distance trips are made on business, and a similar problem arises – these trips do not need to be encouraged through the use of a railcard, but it will be very difficult to avoid business travellers taking advantage of such a railcard (unless they form part of a return journey where the other part takes place in the peak period, and will require a higher-priced ticket). The remaining trips are those genuinely of interest – leisure trips of which examples include short-distance shopping day out trips, and longer-distance trips by the retired going to Visit Friends & Relatives (the VFR market).

2.11 Because longer-distance travel by definition takes longer, trains may be relatively well-loaded throughout the day. However, fare reductions would be expected to have a significant impact here, since railways are now competing against low-price airlines as well as the private car. Overcrowding could indeed be a problem in this market if the National Railcard were successful and additional services might need to be run, since there are relatively few opportunities for lengthening inter-city trains.

2.12 The weekday evening market is a much smaller market, and is characterised by returning commuters who have gone out after work – be this to a professional meeting, or for a drink. This market is probably not very price-sensitive.

2.13 The Saturday and Sunday morning market is characterised by days out (e.g. for shopping, or to football matches) and, in the summer, longer-distance trips to/from holiday destinations. These are journey types where price is a key factor in determining rail demand. However, there will be occasions when increases in such trips cause the railway significant additional costs. Whilst the railway may be society's preferred way of moving such large numbers of people (for instance, for environmental reasons to keep holiday areas relatively traffic-free), additional train services will need to be run. Although it is unlikely that the overall demands on assets will exceed those during the weekday peaks, this will occur in particular areas – for instance, in the West Country, where rail has a low peak commuting role but a high use for holiday traffic.

2.14 The Sunday afternoon market forms part of two separate journey purposes, which overlap. First are the returning day-out passengers. However, perhaps more important are the weekend-away passengers, typically leaving the major conurbations on Friday evenings and returning on Sunday afternoons (less commonly on Monday mornings). For some inter-city operators (e.g. GNER), Sunday afternoons are already their peak time of demand, since the 'window' of convenient trips is relatively small (e.g. 1400-1800). Earlier trips are not encouraged (in order to enable railway maintenance to take place unhindered), whilst later trips are less convenient for passengers. Any national railcard will inevitably stimulate further demand in this area, which may lead to a reduction in the quota of the cheapest (book-ahead) tickets available.

The Urban Areas

2.15 The major journey purposes of rail passengers in urban areas are for commuting (in the peaks) and shopping (off-peak). Only in London do significant numbers of trips occur for leisure purposes, as can be seen from trips to the major museums during school half-term holidays, and by tourists 'seeing the sights'.

2.16 The main potential difficulty in the key urban areas away from London (where services are specified by the PTEs) is that some 'off-peak' tickets may be valid in the evening peak. Increased numbers of passengers using these tickets may necessitate increased restrictions on ticket products such as Cheap Day Returns, but such restrictions can be difficult to police, since relatively few stations have ticket barriers where the appropriate checks can be made.

3 The Economics of a National Railcard

3.1 As mentioned earlier the National Railcard is a two-part tariff. It is already much used by companies who enjoy considerable market power in other sectors of the economy to maximize profits (e.g. mobile phone plans).

3.2 There are two very important aspects in the modelling of demand for such a product. The first one is to model the way in which passengers are going to decide whether to enter the scheme or not. The second is to model the decision of how much rail travel to consume, in those cases where the card has been bought. In this section we develop a simple explanation intended to represent the reasoning of the passenger towards buying or not the card. We will then derive a rule called *participation constraint*. This means trying to work out under which conditions passengers will be prepared to buy the card and under which they would not buy it. Next we will describe how people are going to decide their overall consumption of rail travel once the card has been bought. Finally we will look at the theoretical financial implications for the TOC under the assumption of it trying to maximize profits.

3.3 From the point of view of the passenger, the decision to buy a National Railcard or not will be one which trades off the advantages of discounted travel with the disadvantage of paying the up-front fee. Ignoring the discount rate (i.e. the fact that a given amount of money is more valuable today than it is tomorrow) we can set a simple explanation to replicate the decision whether to buy this product or not, as follows:

3.4 Let us consider a person planning to make T off-peak trips by rail this year, irrespectively of him buying the card or not. The cost is S per trip. Then we assume the cost of the card to be K and the discount offered to be D%. The annual cost of travelling if the person doesn't buy the card is simply:

$$\text{Total Cost (no card)} = S * T \qquad (1)$$

3.5 On the other hand, if the person buys the card which offers a discount of D %, but entails a payment of K, his total cost will be:

$$\text{Total Cost (with card)} = K + S*(1-D)*T \qquad (2)$$

3.6 This person will then buy the card whenever (1) exceeds (2) or algebraically,

$$S > \frac{K}{T} + S*(1-D) \quad \Rightarrow \quad S*T*D > K \quad (3)$$ [1]

[1] If we assume a monthly discount factor of δ, and we assume trips (T) are consumed across the year in equal installments of T/12, then condition (3) can be re written:

$$S*T*D*\left[\left(\frac{1}{\delta*12}\right)*\left(1-\frac{1}{(1+\delta)^{12}}\right)\right] > K \qquad (3^*)$$

This means that the present value of all the discounts must be greater than the up-front payment. Since the term in brackets in (3*) is less than 1 then we can see that incorporating the discount rate into the framework diminishes the probability of the individual fulfilling the participation constraint (buying the card). It follows that T*, the level of demand at which it starts making sense to buy the card, also increases.

3.7 Equation (3) shows the participation constraint for this individual. The expression on the left side shows that this person will buy the card every time the fare per trip is higher without the card than it would be when holding it. Another way of interpreting the participation constraint is as on the right hand side expression in (3): the person will buy the card every time the total amount of money gained through discounts exceeds the up-front fee payment. The total amount of discounts gained depends on the number of trips undertaken during the year T (also called trip frequency). From (3) we can derive the trip frequency T* at which the passenger is indifferent on buying or not the card:

$$T^* = \frac{K}{S * D} \qquad (4)$$

3.8 According to this, people travelling more than T* will wish to buy the card, and people travelling less will not. In our demand forecasting model we have used this participation constraint to estimate the demand for the NRC. However, this analysis is heavily dependent on the ability of people in forecasting their trip frequency beforehand. For simplicity, we have assumed that passengers will use their past history of trip frequencies as an estimate for the expected trip frequency for the following year.

3.9 Yet this explanation is quite naïve. It assumes that the person will choose to continue making the same number of trips, even though a discounted alternative is offered. However, economic theory suggests that any reduction in the price of a good will make people increase the quantities of it consumed.[2]

3.10 We can think of more sophisticated individuals who will recognize that, a result of the price reduction, their trip frequency will be enhanced when buying the card. If T_0 was the trip frequency last year, when the passenger didn't have a railcard, we can expect the trip frequency this year (with the NRC) to be T_1, with $T_1 > T_0$. These more sophisticated passengers will not take their decisions based on the principle underlying (3), because they recognize the fact that if they don't buy the card they will make fewer trips than if they do buy it. Instead, they evaluate both alternatives by trading off the utility (benefit) derived from each level of rail travel with its associated cost. They will buy the NRC if:

$$U(T_1) - K - T_1 * S * (1-d) > U(T_0) - T_0 * S \qquad (5)$$

i.e.

$$U(T_1) - U(T_0) > K + T_1 * S(1-d) - T_0 * S \qquad (6)$$

3.11 In (5) we can see that a passenger will buy the NRC if the overall utility of undertaking T_1 trips and buying the card is greater than the utility of not buying it and undertaking T_0 trips. In other words, expression (6) shows that (s)he will buy the card, every time the incremental utility for travelling T_1 instead of T_0 is greater than the incremental cost.[3] As a more sophisticated version of the participation constraint (3), we have derived in Annex B the participation constraint for these individuals who would make optimal decisions by maximizing their utility functions (see eqn. 9A).

Graph 3.1

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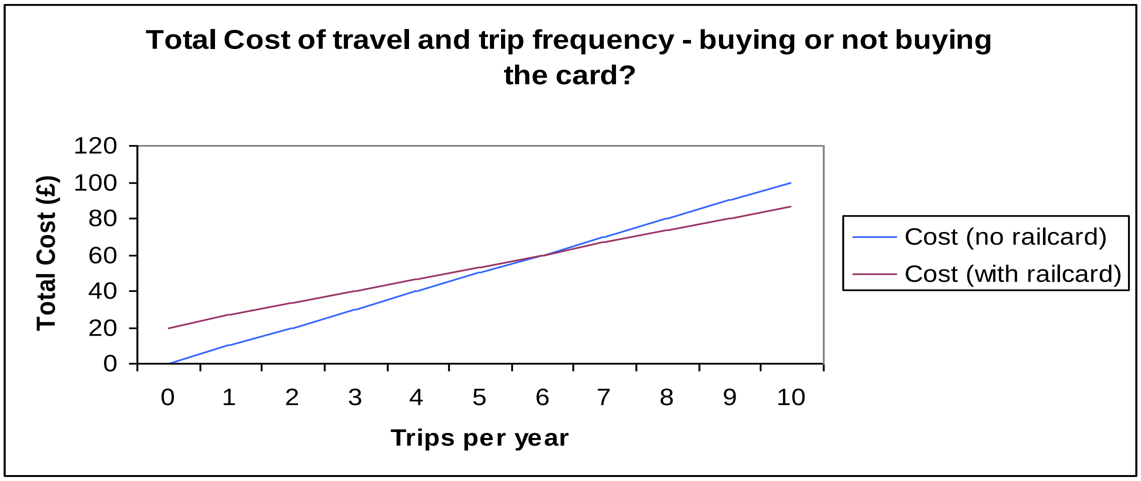
[2] This argument is specially true in the case of a *normal good.* We will assume that off-peak travel is a normal economic good - i.e. its demand increases when income increases. This assumption comes from the fact that off-peak travel can be characterized as a derived demand from leisure, which is in turn a normal good.

[3] We are assuming that money enters the utility function in an additive, linear way.



3.12 In Graph 3.1, we have calibrated our simple equations to show the total cost of travelling via each pricing scheme. We assumed a trip which costs £10, and a NRC priced £20 which offers one-third discount. As we can see, it doesn't make sense for a person with a low trip frequency to buy the card. Initial payments for the card are too high and are not compensated by enough discounts to rail travel. In the above case, the threshold number of trips T* that make the card worth buying is 6 trips per annum. A rather naïve individual - such as the one depicted by (3) - facing this situation will reason: "I travelled 5 times last year and so I will travel 5 times this year: It doesn't make sense to buy the card." Alternatively, a more sophisticated individual, taking into account the fact that the price of rail travel has gone down will reason: "I travelled 5 times last year, but If I buy the card I will travel (say) 7 times this year". After that he will look at the utility derived from making 7 trips, subtracting the cost of them (using the red line) and compare this with the utility derived from making 5 trips, again subtracting the cost of them (using the blue line).

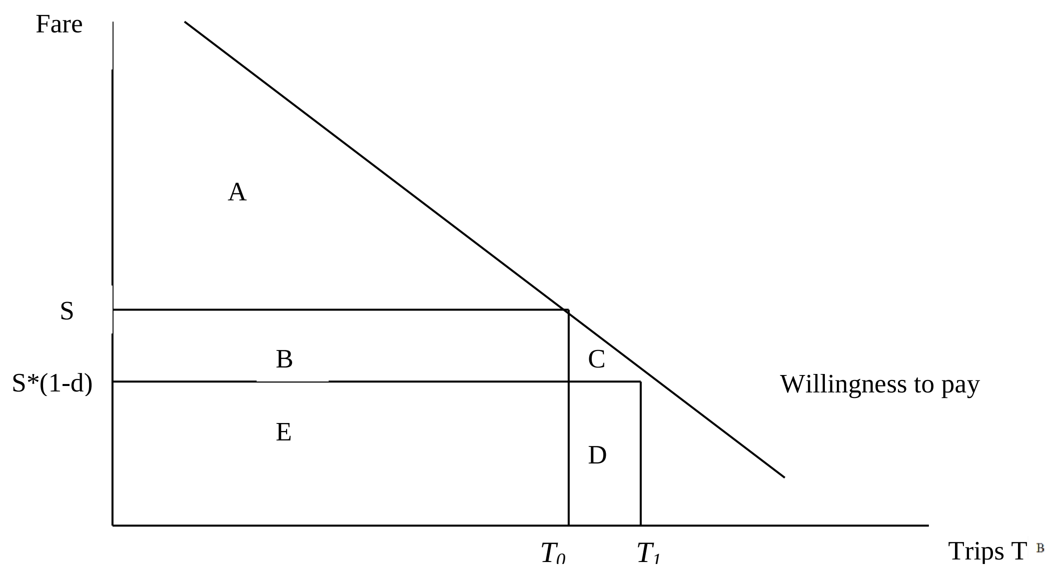
3.13 Once the decision whether to buy the card or not has been made, the individuals have yet to decide how much to travel. But how are travelling patterns of those buying the card going to change once the card has been bought? This is a very important issue to assess the overall profitability of the scheme as well as its capacity to foster the usage of rail.

3.14 As we argued earlier, the decision to buy the card or not is made before the service is used and consequently is based on expected travel frequencies. On the other hand, once the card has been bought, the decision on how much to travel will depend on the perceived marginal cost for off-peak rail travel (the additional cost for an extra journey). Any rational person will then consume rail travel until the marginal utility of travelling (the marginal benefit of an extra trip) equals the marginal cost of travelling, which equals the discounted fare (S*(1-D)).[4] Consequently once the card is bought, the cost of the card plays no role whatsoever in the decision of how much rail travel to consume.

3.15 We can see this in Graph 3.2. The downward sloping curve is the willingness to pay of a hypothetical passenger for each additional trip. This equals the marginal utility of rail travel, since no one could be expected to pay more for an extra trip than the utility derived from it.

[4] Ownership of a car can also be thought of as a two-part tariff. To buy the car, the cost of it is taken into account. However, once the car has been bought, the perceived marginal cost is perhaps only the cost of the petrol. Car owners don't take into account the initial cost of the car when making their everyday decisions as to how much to use it. Instead they look at the marginal cost of using it. Getting rail fares onto a similar perceptual footing as car travel is a key element of the railcard.

Graph 3.2: Introduction to two-part tariff pricing



3.16 Let's first assume the price for rail travel to be S. Trips will be demanded up to the point where the marginal utility (or willingness to pay) is equal to the price of travelling. Hence this passenger will make T_0 trips. Revenues for the TOC will be S* T_0 or graphically, the areas B + E. We can see that for every trip to the left of T_0, the passenger would be prepared to pay more than S. This phenomenon is called *consumer surplus*. It is the difference between what this hypothetical passenger would be prepared to pay for consuming T_0 trips and the amount he actually pays. Graphically, the consumer surplus on each trip consumed is equal to the difference between the willingness to pay curve and the price paid. In this case total consumer surplus equals the area A.

3.17 But how could the TOC increase its revenues? Let's suppose it charges the passenger a fixed up-front payment that would give him access to the rail network at a price of S per trip. The other alternative for the passenger is not to consume trips at all. How much is the maximum fee that the TOC could charge the passenger with him not withdrawing from the market? The maximum the consumer can bear paying is his consumer surplus, which is equal to the triangle A. If the TOC charges more, the consumer stops using rail, because his consumer surplus would be negative. If the TOC charges less, the passenger will pay the fee and consume T_0 trips, but will have some consumer surplus left which could be still captured by the TOC via a higher fee. Thus we can see how, when the price per trip is set at S, the TOC can maximize its revenues by changing the pricing structure for a two-part tariff consisting on a fixed fee of A and a variable charge of S. Revenues are maximized by extracting all the consumer surplus from the customer.

3.18 Now let's illustrate the situation of introducing a NRC which costs K and entitles the holder to a discount of d% on the full fare S. The original fare is S, and the discounted fare is S*(1-d). The passenger can now pay the up-front fee K and pay S*(1-d) for every trip he makes, or rather pay nothing and pay S for every one of his trips (not buying the card). What is the maximum amount K that can be charged for the card subject to the condition that the passenger buys it? The consumer surplus at a price of S*(1-d) is equal to A + B + C. As we have seen in our previous example, in the absence of the alternative of buying the full fare, the maximum that the TOC could charge is equal to this area.

3.19 However, when the alternative of paying full fares (and hence not buying the NRC) is still available, the answer is different. If the card costs A + B + C and the passenger buys the card, he will be left with no consumer surplus. In contrast, if he does not buy the card, he travels T_0 paying the full fare S and his consumer surplus is equal to the triangle A. He will then prefer not to buy the card, because if he buys it he ends up with zero consumer surplus, whereas if he doesn't buy it he would have a consumer surplus equal to A.

3.20 The other alternative is if the card price is B + C, then the customer is indifferent between buying the card and not buying it, because his consumer surplus under both scenarios is equal to A. This is a critical result. Consequently we have shown that when the option of buying full fares is still available, the maximum that can be charged for the card is slightly less than the area B + C. [5]

3.21 Finally let's use our graph to see how revenues (or profits (assuming no cost escalation due to the implementation of the NRC)) will change whenever the scheme is implemented. We have seen that if the price of the card is B + C, the NRC is bought and T_1 trips are consumed. The price paid for every trip goes down by d%. The TOC then loses the area B in terms of ticket revenue because every passenger pays less for each individual ticket. On the other hand, since the discounted ticket price encourages the passenger to travel more (albeit at a lower fare) the area labelled D is gained. Therefore, the change in ticket revenues is D – B. The extent on which D will be greater than B depends on the prevailing demand elasticity. If passenger demand is elastic (inelastic) D will be greater than (less than B). In addition to ticket revenues, the TOC now gets extra revenues from the cards sold. As we said earlier, this is equal to B + C. In overall, the net change in revenues for the TOC could be expressed as the addition of ticket revenues and railcard revenues D – B + B + C, equal to D + C. It is then clear than by choosing the profit-maximizing price for the card (B + C), revenues (and probably profits) are enhanced.

3.22 The picture shown so far would be the likely outcome only if a number of circumstances are met. First, the TOC needs to be able to charge B + C for the card (i.e. hence to maximize profits). In reality there are a number of constraints that would limit its ability to maximize profits this way. The TOC faces both political constraints (in the form of regulation) and in most cases strong competition from other modes.

3.23 Additionally, this analysis assumes that TOC faces only one type of passenger in the market. As we will see later this is not true. TOCs face a wide variety of markets each one with its travel patterns and frequencies, and elasticity of demand. Hence, it is not obvious that profits will be maximized with such a "one-size-fits-all" pricing scheme.

3.24 However, with a little more analysis it can be shown that the optimum two-part tariff entails a high fee K for the card and marginal cost pricing for each trip consumed (a high discount). The economic implication of this is that the outcome of perfect competition prevails and welfare for society is maximized, although the entire consumer surplus is gained by the TOC. In other words, society wins, even if individual passengers are not particularly happy.

[5] This argument is identical to the one made for the participation constraint (5). Consumer surplus can be interpreted as the total utility of consuming a given number of trips minus the monetary cost of making these. It can be seen that the area A on the context of Graph 3.2 equals the right hand side of (5).

4 Demand Forecasting model: Overview and Assumptions

4.1 The model is developed following the theoretical process displayed in the last section. It has been set up using processed data form the National Travel Survey (discussed in Annex A). Individuals were grouped in 7 categories depending on their off-peak rail trip frequencies. The average length for these trips was also noted. As we would expect, those with the higher trip frequencies and longer trips will be the ones most tempted to buy the NRC.

4.2 For each of these groups, we then calculated their participation constraints. This was done using the two types of participation constraints described in the previous section. In the case of the naïve participation constraint, we used equation (3*), the version which includes a discount factor (see footnote 1). The discount factor was added to account for the fact that trips planned to be made far in the future are naturally more uncertain than trips which are planned to be made in the near future. Therefore, passengers weigh less the benefits from discounts on travel to be obtained further in the future than those to be obtained in the nearer future. We assumed a yearly discount factor of 10%.

4.3 Each category could be thought as of representing an individual with certain off-peak travel profile. By deciding which of these 'individuals' would buy the card, the demand for the NRC can be derived. However, categories are not evenly sized. For example, one category might represent 10% of the population with the adjacent one representing only 2%. It will be seen that dealing with groups of individuals as if they were only one single individual will have the shortcoming of generating a discontinuous demand for Railcards.

4.4 We concentrated our analysis on the age group 25 – 59 and split the data for 'London and South East' and 'Elsewhere'. The assumption here is that young people and senior citizens will continue buying their specifically targeted products. There are a number of reasons why the geographical split is important. Not only is rail's competitive position much stronger because of road conditions, but a Network Railcard has been available in the South East for some years now.

4.5 The Network Railcard has already affected the off-peak trip distribution, and increased off-peak travel frequencies in the region, mainly because it provides discounted off-peak travel. Thus, if we carried our analysis for this region using the survey data, this would lead us to overestimate the number of National Railcards which are going to be sold. However, the National Railcard scheme is envisaged to overtake the Network Railcard scheme. A simplistic assumption would be to attribute the total number of Network Railcards sold in this area (approximately 360,000) to the more comprehensive National Railcard. Nevertheless, this assumption will overlook the fact that a National Railcard is an intrinsically different product from the Network Railcard because it offers a much wider possibility of destinations and it doesn't imply a minimum £10 fare. Another drawback of this assumption is that it would prevent us from performing demand comparative analysis for different pricing structures on this region. In light of this, we have provisionally decided to use the distribution for London and South East as it is, and to derive from it our conclusions, however noting that there might be a tendency towards overestimation.

4.6 Once the demand for the NRC has been calculated, we have still to assess the extent to which trip frequencies are going to be bolstered due to the availability of cheaper off-peak travel.[6] We did so by assuming passengers face the discounted price for off-peak travel as their perceived marginal

[6] Alternatively, people could react by increasing their average trip length and leaving their trip frequencies constant. Note that we have assumed constant trip lengths. The fact that all the adjustment is made via trip frequencies doesn't pose any methodological problems. Total expenditure on rail travel is ultimately derived by multiplying trip frequencies and average trip lengths so, whatever variable is chosen for the adjustment, the outcome will be the same.

cost of travelling. The responsiveness in each case will depend on the elasticity of demand assumed for each category or "market".

Interaction with other products

4.7 If no other similar product existed on the market, or if the National Railcard was envisaged to substitute all other alternative cards, the model as it stands would generate plausible forecasts. From the alternative products which are currently available, the National Railcard is envisaged to overtake the Network Railcard (as mentioned in paragraph 4.5) and some other minor regional railcards. As discussed in paragraph 4.4, Young Personas and Senior Citizens cards are assumed to co-exist with the NRC without significantly affecting its demand. However, there are other alternative products which will affect the demand for it.

4.8 In the first place, season tickets with no time restrictions are currently offered throughout the whole network. These are typically point to point season tickets or area based Travelcards in PTEs, which entitle the holder for unlimited travel upon a fixed up-front payment (they are in essence a special case of two-part tariff with a significant K and D=100%). Being sold for specific journeys, they typically serve trips made frequently, more specifically commuting. For example, 73% of journeys using Travelcard Seasons in the London Area are associated with "Work/Employers Business".[7] Yet, customers holding such cards can also benefit by making some free off-peak trips within the area of validity of their seasons card. For example, someone in London holding a 1 to 4 London Travelcard can travel free of charge to Highbury, Hampstead Heath and a variety of other leisure destinations. Hence, a regular season-ticket holder would not take into account, all these off-peak trips (or legs of trips) which could be undertaken free of charge, when calculating his participation constraint. This could be especially true for the most frequent travellers in our distribution (categories 6 and 7 in Annex A). Those who fall in category 7 (the "commuter brigade") make more than 104 trips per year. Consequently, they can be expected to be most inclined to hold season tickets. In order to account for this, we estimated the number of trips which are not eligible for the discount of the NRC and subtracted these from our base distribution, with emphasis on the most frequent travelling groups. It is important to note that season tickets are much more common in London & South East than in the 'Elsewhere' region.

4.9 Two factors were taken into consideration when making these deductions. First, the only way that some off-peak trips could be deliberately neglected in the consumers' participation constraints, is whenever season tickets are used on a regular basis. The unexpected consumption of season tickets (for example as a result of temping job in a particular place) can not be easily forecasted at the moment of making the decision to buy the NRC or not.[8] Second, not all off-peak trips planned ahead will match the validity area of the season ticket in all cases. Depending on the locations planned for off-peak travel, the season ticket may or may not act as a substitute for the NRC. Here, assumptions were made with regards to the "match factor" between planned off-peak trips and the validity area of the regularly-held season ticket.

4.10 The NRC as specified is available only for solo travel. In the model, each hypothetical passenger (represented by each one of the seven groups) "calculates" whether it makes sense to buy or not the NRC for *the holder* (i.e. from his/her personal point of view). But this doesn't allow for the possibility of opting for group discount travel. Family Railcards are currently available, offering convenient discounts only for group travel. As well as season tickets, the Family Railcard can be

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[7] Transport for London, London Travel Report, 2002.

[8] Here we could still assume that passengers facing their participation constraints calculate their expected demand for such products, based on probabilistic assumptions. However, this approach wouldn't be consistent with the level of rationality assumed in the naïve participation constraint (3).

thought of as a partial substitute for the NRC. Someone planning to make significant trips with their family (and not on his own) during the course of the year might prefer to buy the Family Railcard instead of the NRC. In many other cases NRCs and Family Railcards will be bought by the same individual.

4.11 Our base distribution doesn't allow us to recognize which trips were done with a group (thus are eligible for group discount) and which ones were made solo. To account for a proportion of trips done within a group, we used data from ATOC on the total number of Family Railcard holders (approximately 300,000) and we took into account the fact that the propensity to hold a family card must increase with the trip frequencies displayed in our distribution. We then made "educated guesses" to determine up to which extent this product will act as a substitute for the NRC and subtracted these trips from our base distribution.

Other assumptions

4.12 A key assumption of the model is that every person in the UK will go through the process of calculating the costs and benefits of buying the railcard, looking at their participation constraints. We are assuming perfect information or "perfect marketing" in the sense that everyone will know of the existence of this product and will be encouraged to consider it. This assumption is not exactly proven today with the available travel discount cards! However exigent this assumption might look, the results of our model will still hold if it is verified, at least, for the most frequent travellers (the upper categories in our distribution)[9]. Having made this point, the assumption seems quite more plausible. Those travelling more frequently by rail are more exposed to the different products available because they spend more time waiting at platforms where marketing posters are exhibited. Also, given their relatively high usage of rail transport, it is in their own interests to keep up to date with the latest products available. As it shall be seen later, in order to be consistent with this level of marketing effort assumed, we have also assumed considerable marketing expenditure to support the National Railcard (see section 6).

4.13 Another important assumption was that each of the categories studied acted as an individual with travel patterns equal to the average figures for each category. This gave for example, average trip lengths in the order of 20 to 70 miles. But we can expect a great deal of variability on trip lengths for each category, which leads to a problem with this approach. The problem is that there are some trips which are so long (and hence pricy) that passengers undertaking them would still buy the card irrespective of their annual travelling patterns. Take for example a trip on a saver from London to Aberdeen. It is priced at £96 (return). If the card costs £20 and it entitles for a 30% discount, then buying the card plus the ticket at a discount is automatically cheaper than buying the ticket only. It is sensible to expect that people making these long trips are going to buy the card, especially if they are made aware of the immediate benefits by the booking clerk. On the other hand, we can think of people who, according to our distribution, may have undertaken many short off-peak trips in the past. We can imagine some of these cases of frequent users of short distance rail travel failing to recognize the advantages of buying the card. The asymmetry between these two cases lies in the fact that the advantage to the infrequent London – Aberdeen traveller is instantaneous whereas for the one who travels seldom but short distance, the benefits of buying the card are subject to uncertainty. Unfortunately, at this stage of the research, analysis was undertaken at the average level. Nevertheless, with some additional work, an intra-category distribution by trip lengths should be possible to extract form the National Travel Survey Database.

[9] Indeed, those who make less than two rail trips per year account for 51% of those sampled in the South East and 73% of those in Elsewhere (National Travel Survey). It is by definition very difficult that these are going to participate in the NRC anyway.

4.14 Finally, another assumption which has been used in previous work by the authors of this report is that demand elasticities are constant irrespective of the level of fares. Demand elasticity figures from the Passenger Demand Forecasting Handbook (PDFH) are derived following this framework and so the assumption was used in our model in order to make consistent use of the data. It is generally acknowledged that these estimates are most accurate for forecasting the effect of small fare changes (typically 10%). As fares are decreased (as it is the case with the NRC), passengers start getting less responsive to subsequent fare changes. Our model uses constant elasticity measures to forecast changes in passenger miles for relatively important fare reductions (up to 50%). This necessarily introduces a tendency towards overestimation in our results, because it ignores the fact that passengers get less responsive as fares get lower.[10]

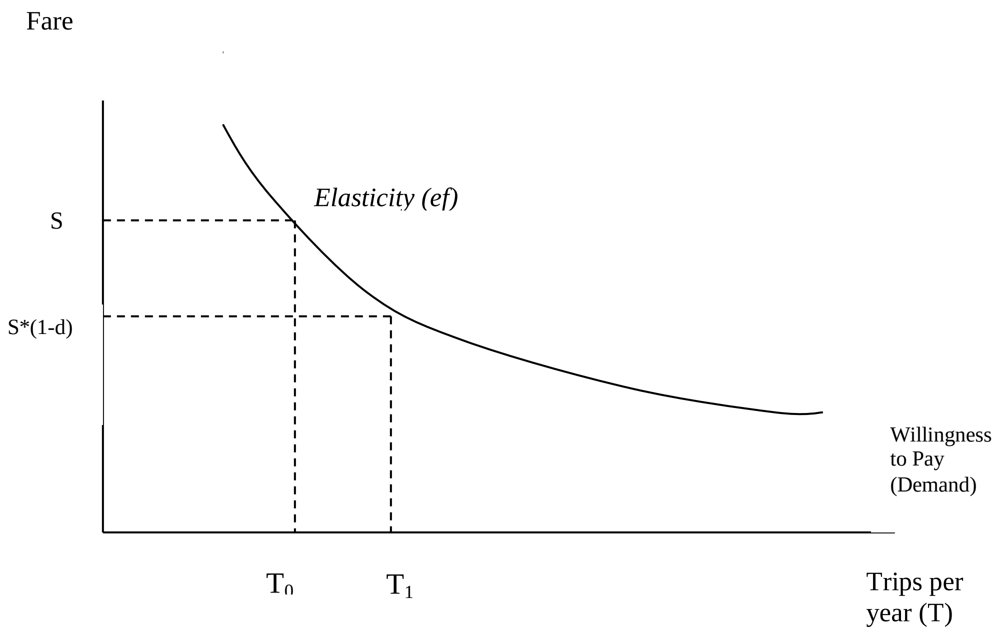
[10] Assuming a representative 30 miles rail trip, and a NRC awarding 50% discount, this over estimative bias would be 15%. The framework for this preliminary calculation was taken from: The Railway Consultancy, ltd. Fares Policy Research, 2002.

5 Demand Forecasting Model: Data

5.1 The model which was set up to forecast demand for the NTC makes intensive use of data from multiple sources. As it has been mentioned, the main source of information is the National Travel Survey. Due to the complexity of this data and the various statistical procedures carried out to obtain it, it is described in Annex A.

5.2 As was described in the last section, demand for the NRC was derived solely by looking at participation constraints for each category in our sample. With regards to journeys stimulated by the NRC, Graph 5.1 illustrates the general framework to forecast the increase in demand for rail travel as a response to a reduction in fares. This graph summarizes all the necessary information to make this forecast.

Graph 5.1: Forecasting demand changes as a result of a fares change



5.3 In the case of an individual paying a fare of S and hence consuming T_0 trips a year, a reduction of the fare to S*(1-d) generates an increase in trip frequency to T_1. In order to perform this calculation the following information is needed: base level of trips (T_0), base level of fares (S), new level of fares (S*(1-d)) and elasticity of demand with respect to fares (e_f).

5.4 The base level of demand was obtained from the National Travel Survey. The base level of fares was obtained from data provided by ATOC on the number of passengers and revenue by flow and ticket type for the year 2001/2002. Specifically, we calculated the average fare from a combination of Saver, Supersaver and Cheap Day Return tickets. All these tickets are not available during the peaks. They are the alternative for those potentially interested in buying the NRC. An average off-peak trip length was calculated from the NTS data, and this was used to calculate the average fare per mile. Finally, the new fare per mile was calculated by applying the NRC discount over the original fare.

5.5 Data on demand elasticities was taken from the Passenger Demand Forecasting Handbook (PDFH, 1997, 2001). The focus was on elasticities for the leisure market, since one of the key assumptions is that this card will be primarily used for non-working purposes. However, these base elasticity measures had to be altered to capture differences in responsiveness across the different categories of individuals sampled in the NTS. It is well noted that when fares increase, the responsiveness of individuals to a given fares change also increases. The PDFH also suggests that more frequent travellers should be more sensitive to fares, other things being equal; since the income effect associated with a given price change is more important.[11] In order to capture the effect of differential fares per mile, empirical tables were constructed from fares manuals relating fare per mile with distance for selected TOCs. Fare per mile usually goes down with distance travelled; however, the effect of the taper is more pronounced over the longest distances. We used this data in conjunction with data from the NTS on average trip length, in order to assign a different average fare per mile to each category of passenger in our dataset. We then used the elasticity modifiers provided by the PDFH (2001) to modify the base elasticity for each category of passenger.

5.6 However, the limitations described in paragraph 4.13 were met here as well. As a result of working with average trip lengths for each category, there was little variation in the distance travelled between the different groups. In turn, the underlying variability in elasticities due to differences in travel patterns could not be fully replicated.

5.7 Elasticities for the leisure market are generally larger than for business/commuting market. In the latter, many times the employer pays the fare and in these cases the elasticity might be close to zero. In addition, these trips frequently cannot be avoided. Leisure travel, however, is generally more discretionary and is stimulated much more by cheaper fares. The elasticities that we used are generally higher for Elsewhere than for London & SE. This is probably because road congestion makes the car a less attractive alternative in London SE and hence rail faces less competition there.

5.8 Elasticities used for London SE in our model are typically between 0 and -1[12]. This means that a given fare reduction will generate a less than proportional increase in trips. Thus, any scheme reducing the level of fares will entail a loss at least in terms of ticket revenues for this market (B-D<0 in terms of Graph 3.2). However, this loss in revenues has still to be balanced with the net income from railcards sold.

5.9 Elasticities in the 'Elsewhere' region are typically slightly greater (i.e. more negative) than -1. However, the elasticity for group 7 (those making an average of 300 rail trips a year; 97 of these off-peak) had to be reduced to account for a time constraint.[13] Even if fares are considerably reduced, this group would not react vigorously, since they are already devoting much of their time to travel (off-peak) and so they have not got much more time left to travel more frequently. As a consequence, ticket revenue for Elsewhere will be positive for all these groups except for the last one. Once again, revenue from railcards sold has to be added to these numbers to find the incremental effect that this scheme is going to have over revenues.

[11] We didn't find any theoretical way of implementing this logic. As a consequence we left this out of our analysis.
[12] Additionally, for London and South East, Harris Research Centre (Reported in PDFH 2001) published elasticity figures obtained from surveys directed at Network Railcard holders. These are consistent with the figures used.
[13] Demand elasticity for the last group (most frequent travellers) in the South East was also reduced to account for time constraints.

6 Demand Forecasting Model: Results

6.1 In this section we present and discuss the results obtained from our model. Results will be shown under the two levels of rationality described in section 3. The first is a simple model based on the quite plausible, although naïve participation constraint (3). The alternative participation constraint is derived assuming more sophisticated individuals who recognize that if they bought the card they would travel more. Based on their assumed utility functions, they make the decision of how much to spend on off-peak rail travel and how much to spend on a basket of other goods and services (including peak rail travel). This consumption decision will be different depending if the card is bought or not. They finally compare the overall benefit (utility) when buying the card with the benefit when not buying it. Technically, this is done assuming individuals maximize a Cobb-Douglas utility function subject to a budget constraint (see Annex B)[14]. The explicit form of this participation constraint can be seen in (9B). As we argued in section 3, this participation constraint will be less stringent than the naïve version (3). As explained in Graph 3.1, there will be some cases where a naïve individual will choose not to buy the card whereas a more sophisticated one will. This will lead to higher numbers for railcard demand under the more rational hypothesis. Therefore we call our estimates based on (3) as "Low estimates" and those based on the approach in Annex B as "High estimates". However different in the magnitude of their forecasts, both approaches will predict an increase in NRC demand every time the cost of the card is reduced and/or more discounts are given.

6.2 With regards to the trip frequency enhancement due to the availability of the card, we also took different views for the two approaches. Our high estimate assumes unitary demand elasticity for each category.[15] The implication of this is that ticket revenues for each group will remain constant for different levels of fare discount.[16] On the other hand, Low estimates were calculated using the data on elasticities obtained from the PDFH as described in section 5. The approach followed was identical to the one shown in Graph 5.1.

6.3 We will first present some results for the London SE and Elsewhere regions separately. This will enable to show some differential aspects of these markets. Next, we will present our aggregate results for various combinations of pricing schemes (K, D), where K is the price of the card and D is the discount offered.

Regional results

6.4 As it will be seen, our results using the two different hypotheses on rationality generally will not differ greatly. For simplicity, we will present disaggregate regional results for the low estimate only.

<u>Graph 6.1</u>

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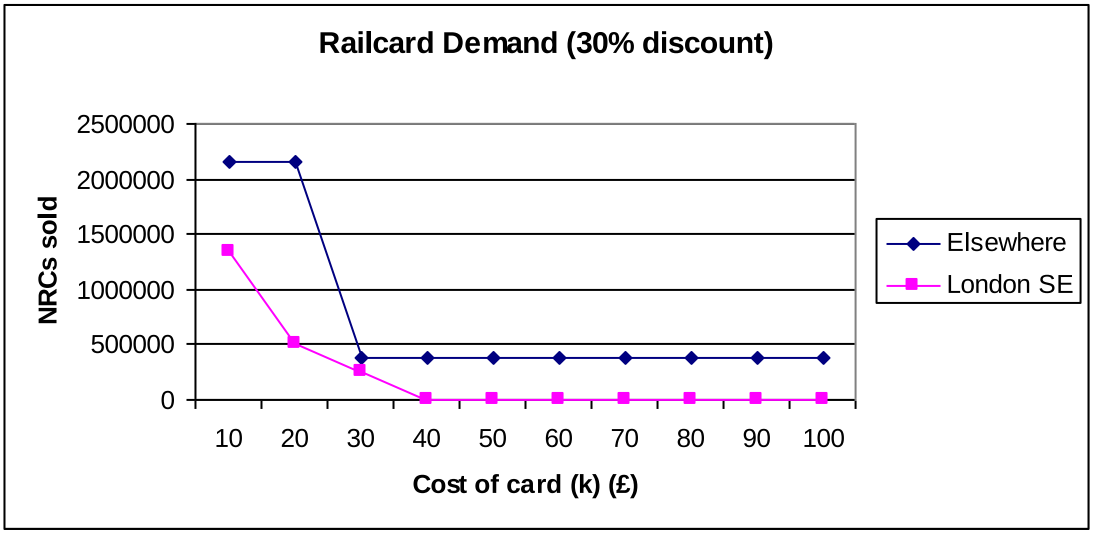
[14] This utility function is of widespread use in the economic literature. For example, see Varian, Intermediate Microeconomics: A Modern Approach, 2002.

[15] This assumption follows from the explicit utility function modeled.

[16] However, if the discount offered is lowered sufficiently, it is possible to make a hitherto participating group not to buy the NRC anymore. In this case, incremental ticket revenues for this group will drop to zero.



6.5 Graph 6.1 plots the level of demand for a card offering a 30% discount, as a function of the cost of the card (k). Naturally, both demands slope down – as the card gets more expensive, fewer individuals (as represented by our 7 categories) are forecast to buy one. The graph exhibits some lumpiness which is due to the fact that we worked with aggregate categories. The graph shows that the Elsewhere region is much more attractive as a market for the National Railcard than London SE. For example, for a card costing £20, demand is 2.2 M in Elsewhere but only 0.5 M in London and South East. This is due to a number of reasons.

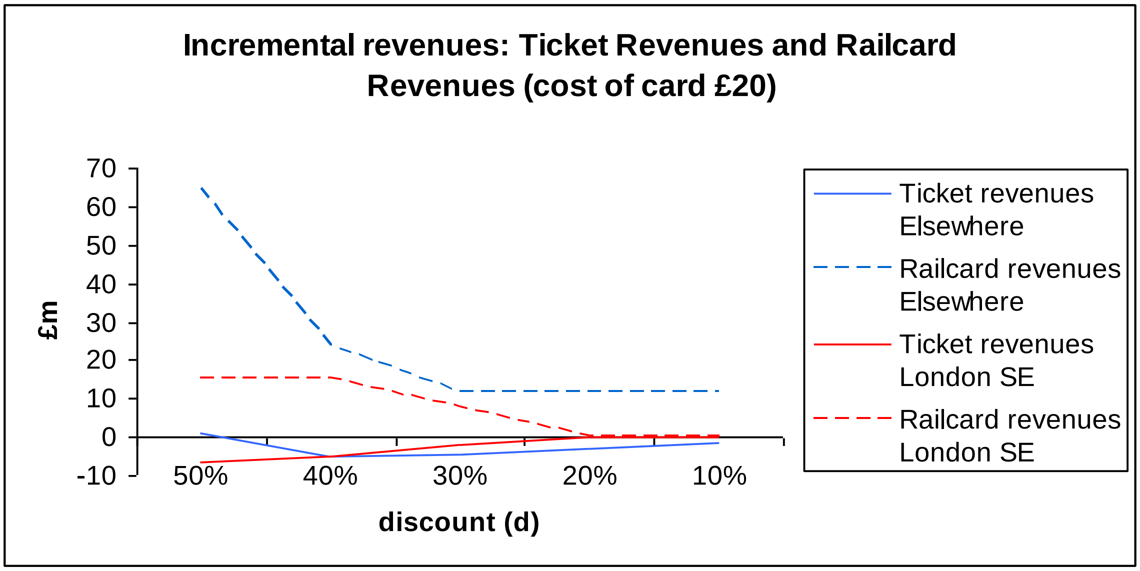
6.6 First, for any given price of card, the levels of demand are higher in the Elsewhere region than in London SE because the number of people in our target market is significantly bigger in Elsewhere. Secondly, we can see that when the price reaches £40, our model forecasts zero demand in the London SE region. For Elsewhere, the point of zero demand is reached when the card is priced at £120. This points out that passengers in the former market will be prepared to pay more for the card or, in terms of Graph 3.2, there is much more consumer surplus to extract from Elsewhere passengers. This has to do with the trip frequencies for the most frequent travellers in each region. In terms of our framework, the propensity to travel off-peak is higher for the Elsewhere region (see Annex A). This is due to a much higher proportion of commuting trips in the South East[17]. In addition, as described in paragraph 4.8, season tickets are much more popular in this region. This was taken into account when we deducted from our base distributions the trips assumed to be covered by season cards.

6.7 For every possible discount examined, the London SE market is priced off the NRC when its price reaches £50. However, we have assumed that one of the aims of this scheme is that the NRC is adopted throughout the country. Since the possibilities of price discrimination on a geographical place of residence basis are also limited, we have then ruled out card prices exceeding £50.

[17] NTS data shows that although the group of passengers making more than 104 rail trips per year is relatively higher in London SE, these people will make fewer off-peak rail trips. This could be explained as follows: Due to relatively high levels of road congestion during peak times of the day in London SE, many people might decide to use rail for commuting (hence the 104+ trips per year group is important). However, the preferred option for off-peak leisure trips (when the streets are less congested) is the car (this group of rail commuters consequently undertakes fewer off-peak trips).

6.8 In terms of model calibration, we can look at the demand forecasted by our model for a card priced at £20 offering a discount of 30% (cf. Network Railcard pricing). The model predicts that 500,000 NRCs would be sold in the London SE market[18]. This needs to be compared with current sales of Network Railcards of some 360,000. However, as we pointed out earlier, these are not identical products. The substitution of the Network Railcard for a NRC will necessarily generate more demand. The NRC has a much wider geographical scope where more expensive trips are eligible for discount and it doesn't require a £10 minimum fare.[19]

Graph 6.2



6.9 Graph 6.2 looks at the effect of changing discounts over the revenue structures for each geographical market. Incremental revenues sought to be delivered by this scheme are split in two: Incremental revenues due to railcards sold (railcard revenues) and the incremental revenues as a result of ticket sales (ticket revenues). It can be seen that for any discount, railcard revenues are considerably more important than ticket revenues (comparing them in absolute terms). The graph also shows the relative importance of railcard revenues in the Elsewhere region.

6.10 Ticket revenues for London SE are always negative. Demand is inelastic for every category of passengers in this market; consequently, discounting the price of the railcard generates a less than proportional increase in patronage. Then, the greater the discount offered, the more money is lost through the fare box. However as more discounts are offered, the number of railcards sold rises. The addition of these two effects determines total incremental revenues.

6.11 In contrast, in the Elsewhere region, all the categories except the most frequent travellers, exhibit elastic demands.[20] In those categories with elastic demand it makes sense to offer more discount – the increase in patronage is proportionately greater than the discount offered so ticket revenues increase; additionally more cards are sold (generating more railcard revenues). However, as the last group exhibits a rather unresponsive demand, offering more discounts

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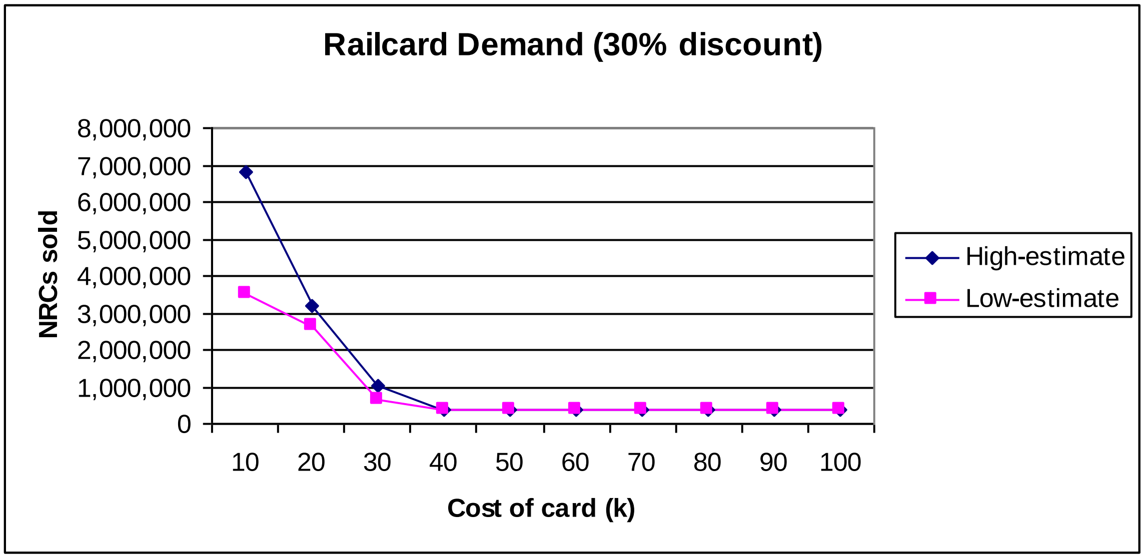
[18] This prediction arises from the Low estimates. High estimates predict a much higher one million NRCs to be sold.
[19] Specifically, trips which will give an automatic advantage and hence lead to more demand, such as London – Aberdeen (see paragraph 4.13) are less likely to happen on the geographically limited scope of the Network Card.
[20] An elastic demand will respond to a 1% fare change by a variation of more than 1% in the quantities demanded. Conversely, an inelastic demand is one in which quantity varies less than 1% as a result of a fares change of this magnitude.

generates incremental losses from this group. In this case, the decision to offer more discount is subject to a trade off – offering more discount boosts revenues for the 6 least frequent travel categories, albeit increasing the loss for the most frequent travellers' group. Not by chance, positive incremental ticket revenues are only achieved at 50% discount, where many categories exhibiting elastic demand participate in the scheme, counteracting the negative financial outcome for the most frequent group of travellers.

Estimated demand for the National Railcard

Graph 6.3



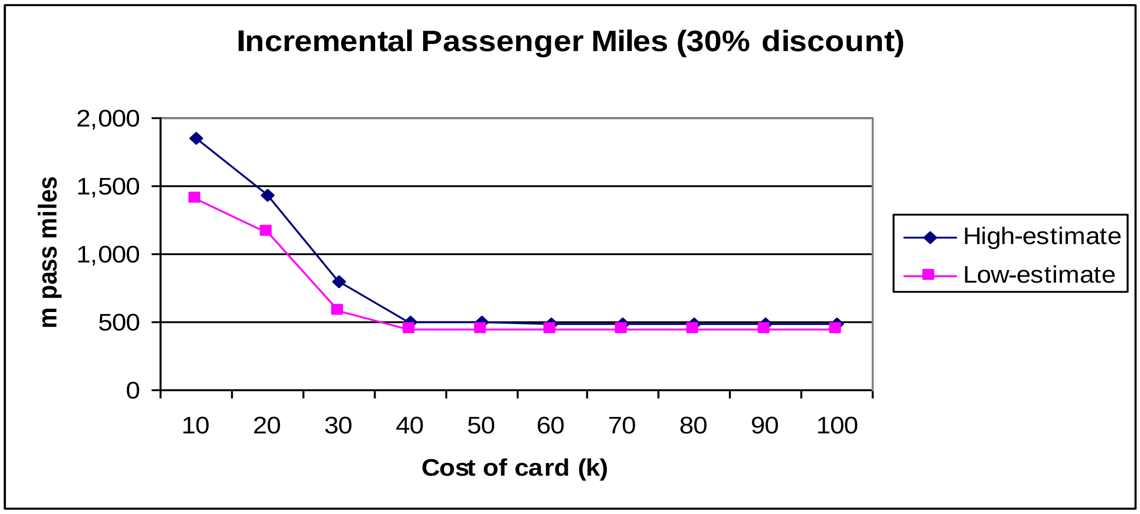
6.12 In Graph 6.3 we forecast the total level of NRC demand, as a function of the cost of the card (k). As the cost of the card increases, categories from our sample start dropping out from the scheme, generating the exhibited declining demand schedule. The participation constraint for the high estimate is less stringent and so for low levels of k more passengers 'participate' under this assumption. When the card costs £40, the levels of demand under the two different scenarios converge. At this point, the London SE passengers were already crowded out of the scheme by the large price charged for the card and the only ones participating are those most frequent travellers from the Elsewhere distribution.

6.13 A key question is: How much up-front fee payment (k) is needed to make these regular rail users to drop out of the scheme? In the case of the high estimate set of assumptions this threshold is £140 and in the low estimate case is £120 (railcard demand in Graph 6.3 would be equal to zero at these points respectively). These numbers relate to the areas B + C in Graph 3.2. As we shall see later, revenues will consistently increase over the price range £40 - £140 (see Graph 6.6). While the price charged for the NRC increases, both the level of NRC demand and off-peak tickets demand is (relatively) unaffected.

6.14 As an order of magnitude, Graph 6.3 also shows that if the proposed NRC is priced at £20 and offers a 30% discount, it is likely to be bought by approximately 3 million passengers.

Potential increased levels of usage

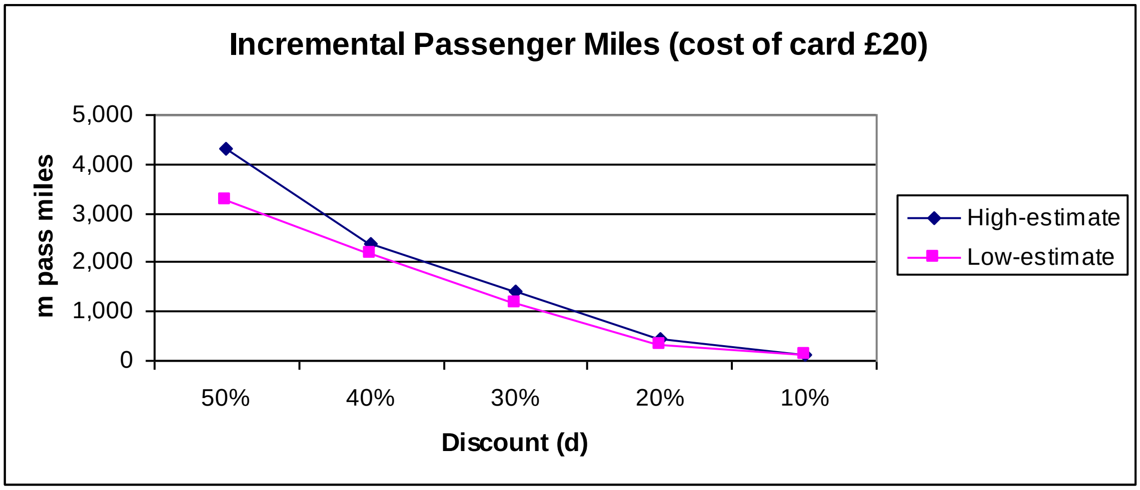
Graph 6.4



6.15 Graph 6.4 shows the incremental passenger miles that the scheme will produce for different card prices and for a 30% discount. This resembles Graph 6.3. Following the argument on paragraph 3.14, putting up the cost of the card is unlikely to have an effect on the trip frequencies of those who have decided to buy the card. The only effect the cost of the card has over incremental passenger miles is an indirect effect through the participation constraints. In Graph 6.3, we can see that when the cost of the card goes up from £20 to £30, the number of NRCs sold falls. Incremental passenger miles for this scheme are a result of passengers buying the card and subsequently enhancing their travelling frequencies due to the availability of discounted travel (if no one bought the card, incremental passenger miles would be zero!) Consequently, although people do not consider the cost of the card in the decision of how much rail travel to consume (direct effect); increasing the cost of the card reduces demand for the NRC and this reduces the number of passengers with access to discounts. As a result, the number of passengers who enhance their trip frequency is reduced and incremental passenger miles fall (indirect effect).

6.16 We forecast an increase of 1.4 to 1.1 billion passenger miles due to the implementation of this scheme at the standard (Network Railcard alike) regime (K=£20, D = 30%). This would of course predominantly be off-peak passenger miles. Using data from ATOC and National Rail Trends we estimated that some 10 billion off-peak passenger miles are currently undertaken annually on the British Network. Our results then suggest an increase of 11% to 14% on off-peak railway demand.

Graph 6.5



6.17 Graph 6.5 examines the effect of different discounts on a card priced at £20. As opposed to Graph 6.4, this one exhibits less lumpiness. In this case, both indirect and direct effects operate every time discounts are reduced. First, in the same way that with the cost of the card, reducing the discount makes the NRC less attractive and reduces demand by crowding out groups from the scheme (indirect effect). Second, even if no category in our sample is crowded out, a reduction in the discount offered makes travelling more expensive and reduces the incremental miles travelled by those who bought the card. A comparison of the two previous graphs reveals that incremental passenger miles are influenced only indirectly by the cost of the card but both directly and indirectly by the discount offered. Both elements of the pricing structure act upon the participation constraint but only the discount determines the extent to which passengers will increase the miles they travel once the card is bought.

Profits

6.18 The model as it has been presented aims to calculate the incremental revenue brought up by this scheme, conceptually following the ideas shown on Graph 3.2. Two adjustments are necessary for incremental revenues to be translated to incremental profits.

6.19 First, any cost increases that could be incurred under the different pricing scenarios must be taken into account. As mentioned earlier, the objective of this card is to fill off-peak spare capacity. If off-peak capacity is not overcrowded because of the implementation of this scheme, then extra revenues will translate directly into profits. However, if this capacity is exceeded and extra trains need to be run, a number of extra costs will have to be incurred (access rights, rolling stock leasing, staff, etc.). After some indicative analysis of average off-peak train loadings, we have made the assumption that, on average, passenger miles can be increased up to 50% from the actual levels, before significant extra costs arise. Since across all the scenarios studied, the maximum increase in passenger miles was roughly 40%, then we have not needed to make this adjustment. In reality, however, there are a number of trains where this assumption is not likely to be correct (particularly Sunday afternoon, and Summer Saturdays); further work is needed to examine the impact of these costs on the overall profitability of the railcard. Unfortunately, this is particularly complicated, as the extra resources required might then also be used at other (peak) times.

6.20 Another cost push factor which was taken into account was the incremental expenses that the implementation of the NRC implies in terms of marketing, management and administrative costs. Other costs such as printing costs and staff training costs were also taken into account.

Average data on these expenditures (per railcard sold) for the currently available railcards, was provided by ATOC. These figures were increased by 100% to reflect the fact that our forecasts assume a bigger marketing effort than the one undertaken for the current railcards. These figures of cost per card were then extrapolated to the number of cards sold for every pricing scenario studied and these costs were deducted from our revenue figures.

6.21 The revenues forecasted by our model as it is only refer to the off-peak travel segment. This is generally related to those passengers using off-peak tickets (savers, supersavers and cheap day returns). This approach doesn't take into account the likely negative impacts that this scheme will have over other rail markets (e.g. business passengers). The availability of this discount might tempt higher yield passengers who decide to purchase the card, to change their travelling patterns and substitute off-peak travel for morning travel (for example by changing the times of meetings etc.). In this respect, both estimates developed adopted an assumption of zero cross elasticity of demand. [21] This assumption will, other things being equal, tend to overestimate our results.

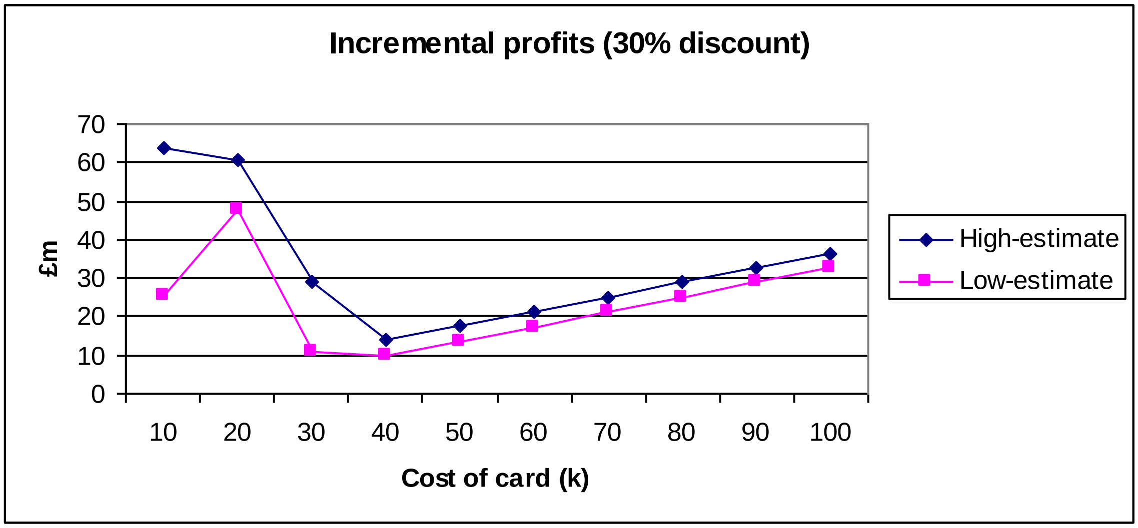
6.22 These negative financial impacts (also called leakages) will be exacerbated if the NRC is eligible for discount on single tickets. One of the alleged reasons why the £10 minimum charge was imposed on the Network Railcard was to prevent commuters travelling on open singles during the morning but returning home on singles bought with the card. At this stage of the NRC research project, this level of implementation detail has not been decided yet, but this issue should be addressed in further research. Not knowing the applicability of the NRC to singles, we have decided to ignore the analysis of these potential leakage effects on the yield per passenger of the business/commuter market. Therefore we have assumed single tickets to be not eligible for the discount offered by the NRC; passengers travelling on them would, in any event, tend to exhibit less elastic behaviour.

6.23 Another key assumption of our analysis was that the market for this product is the leisure market. However, there are actually people travelling for business purposes on Savers (e.g. going to meetings during off-peak periods). We have not taken into account the fact that some of the passengers in our distribution might also be making some trips during off-peak times, but for business purposes. In those cases when the card is bought, these trips would be eligible for discount. Since much business travel is paid for by employers, then it is quite difficult to see how these trips are going to be encouraged by the existence of the NRC. Consequently, the discount on Saver tickets bought for business purposes will be, in many cases, revenue that is lost.

6.24 As these business trips are paid for by the employer, it would be more sensible not to include them within the "participation constraint" of the individual. In other words, when calculating whether to buy the card or not the passenger may not take these into account because he is not saving any money with them (his employer is instead). We have therefore made the assumption that all this revenue is lost for good. We then subtracted this from the primary revenues obtained from our different versions of the model. This assumption is quite pessimistic, because it is not true than in absolutely all cases the employer pays for these trips and hence they are not going to be stimulated. However, we can expect this bias partially to cancel out with the opposing one arising from the zero cross elasticity assumption.

[21] However, this assumption could be removed in further research. It is possible to include positive cross elasticities within both approaches. High estimates could be produced using a different utility function whereas low estimates could be enriched by using cross elasticity estimates from the 2002 PDFH (although this only refers to the to/from London market).

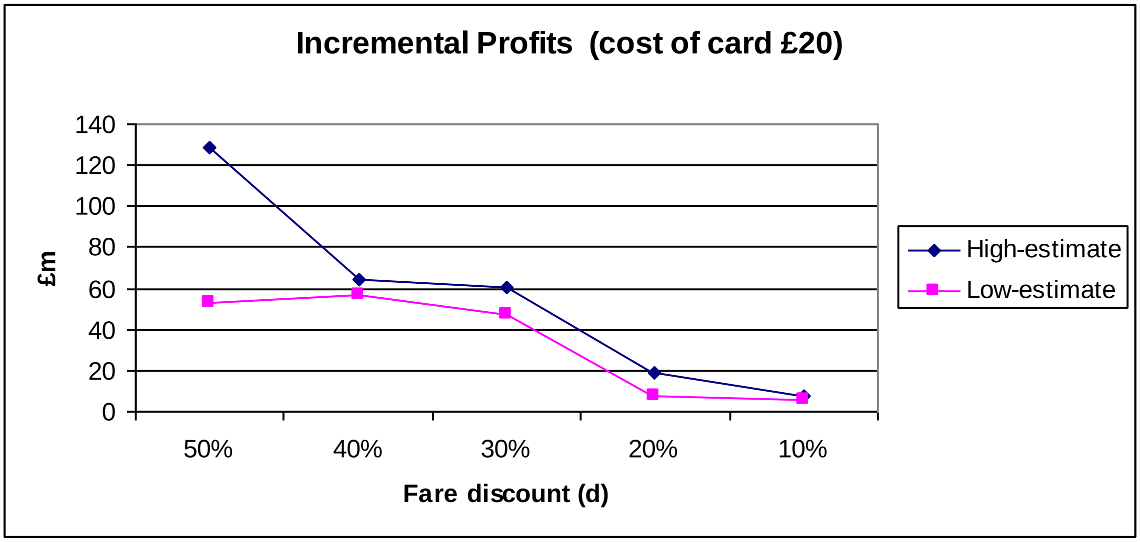
Graph 6.6



6.25 In Graph 6.6, we show our base revenue forecasts amended to account for leakages and incremental costs, and hence we infer the dynamic for incremental profits for this scheme. When the card is priced cheaply (e.g. £10) almost every category participates in the scheme and the profits come from selling lots of railcards at a low price. When the price of the card increases, more and more additional categories or markets start withdrawing from the NRC. The trade off is between charging a higher fixed payment (k) to a less numerous pool of NRC holders or charging a low (k) to a large number of NRC holders. In the low estimate there is a local maximum profit at £20, because when the card price goes up from £10 to £20, few passengers withdraw from the scheme. Conversely, when it goes further up to £30 a lot of them do (see Graph 6.3). Quite amazingly, this profit maximization point is coincident with the Network Railcard current pricing, but it is not clear whether the Network Railcard is underpinned by research similar to this.

6.26 In contrast, under the High estimate, the number of NRC holders drops considerably when the price of the card increases from £10 to £20; as a result, profits follow suit. At £40, only the last category of the Elsewhere region takes part in the scheme. As at this point this is the only group of passengers that the TOC faces, the optimum policy for the TOC is to increase the cost of the card until these passengers are left indifferent between entering and not entering the scheme (when all consumer surplus is extracted). However, as argued earlier, we have not considered prices above £50 in order not to prevent London SE passengers taking advantage of the scheme.

Graph 6.7



6.27 Graph 6.7 shows incremental profits for a card priced £20. As the discount gets bigger, more people enter the scheme (so railcard revenues increase). However, there is an impact on ticket revenues which depends on the profile of demand elasticities. In the case of the High estimate, unitary demand elasticity was assumed. This means that when discounts go up, ticket revenue stays constant whilst railcard revenues increase. This generates a profit function which increases with the discount offered. The low estimate approach exhibits a local maximum at 40%. At larger discounts, it is still true that more passengers will enter the scheme. However, the general demand inelasticity exhibited in London SE and in the last category of the Elsewhere region impacts negatively on ticket revenues, thus hindering total profits. Another reason for this is that at higher discounts, the leakage effect which we deducted from revenues is enhanced. The discount gained for every business passenger on Savers is greater and additionally the number of NRC holders increases.

6.28 As mentioned in paragraph 4.14, when fares decrease, the elasticity of demand is generally reduced. This will mean that always increasing discounts will generate diminishing returns in terms of revenues. This is why the conclusion suggested by our high estimate, namely that revenues will increase indefinitely as the discount offered is increased, seems rather implausible here.

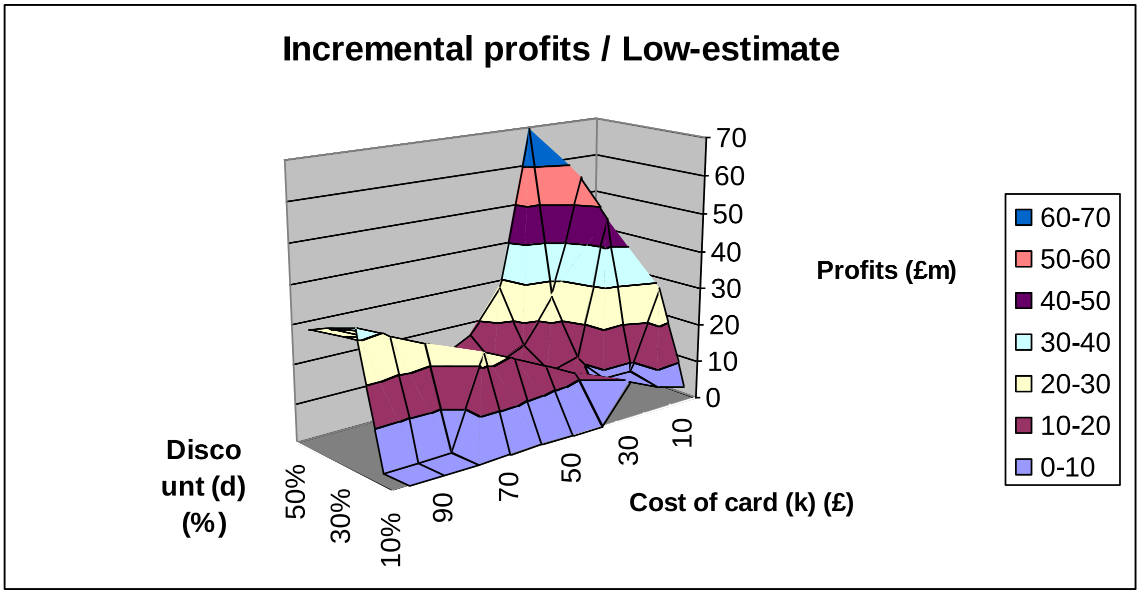
Pricing issues

6.29 The draft brief which triggered this research included the following as a specific point: "Fair price for the NRC, for the industry and passengers alike". In economics, it is generally difficult to talk about fair prices. It is easier to think in terms of which set of prices will maximize welfare for each of the interested parties.

6.30 First, we should consider passengers. Their welfare could be maximized by issuing a very cheap card offering a large discount. However, given that passengers are also largely taxpayers, if this pricing scheme means losses for TOCs, then this would need compensation via more subsidies and the argument wouldn't be so clear-cut. As we shall show later, all the plausible pricing combinations forecasted imply the delivery of incremental profits for TOCs. In this case, welfare from a passengers' point of view is indeed maximized for very cheap cards offering big discounts.

6.31 A second point of view is that of the TOCs. We are assuming that they are interested in maximizing profits (even though much of these could be compensated with a reduction in the subsidies received). In the following graph we examine incremental profits from this scheme under a variety of pricing structures, derived using our Low-estimate approach.

Graph 6.8



6.32 Graph 6.8 shows all possible combinations of pricing schemes involving card prices (k) and discounts (d). The profit maximizing point within the range of prices studied is (£30, 50%). At this point the low estimate predicts some £73m incremental profits. Some 2.7 million of NRCs would be sold and off-peak passenger miles would be increased by 26%. This point is the one which strikes the best balance between participation (railcard revenues) and pricing (ticket revenues).[22]

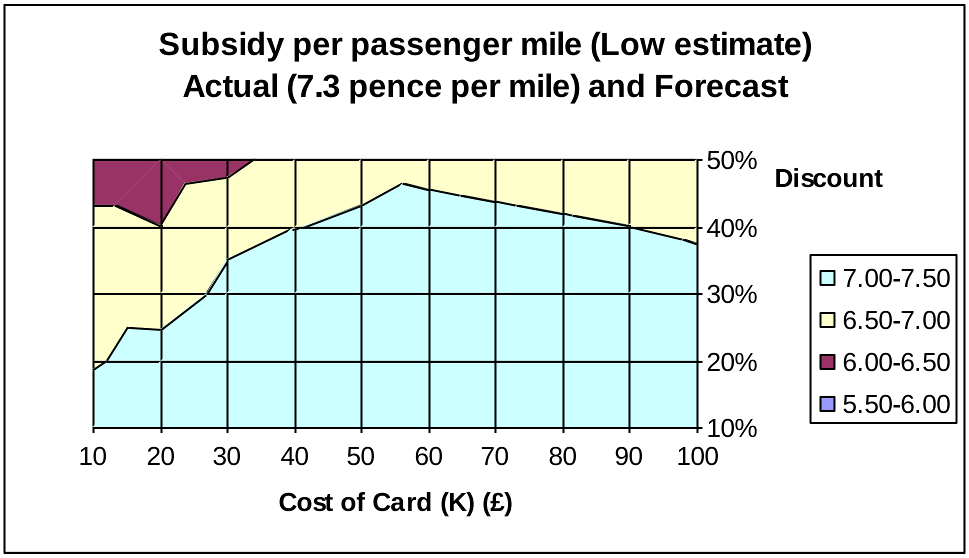
6.33 Nevertheless, if we allow the discount to exceed 50%, our model predicts even bigger profits for a card priced £30. As mentioned earlier, the fact that we have used a constant elasticity of demand framework, generates an over estimative bias in our results. This bias is greater the bigger the discount proposed. For this reason, we have decided to limit our study to 50% ticket discounts.

6.34 The preceding graph also shows that for all the discussed combinations, the scheme is likely to produce profits. Only when the card is priced too highly and the discount offered is too low (e.g. K=£90, D=10%) are all passengers crowded out of the scheme and profits are zero.

6.35 A third point of view could be the one of the Strategic Rail Authority. It can also be re-interpreted as the point of view of the government. In addition to wanting to maximise TOC profits, it might also be interested in the objective of minimizing the subsidy per passenger ratio. This objective of the SRA can be thought in terms of 'subsidy efficiency'. This is to generate the most passenger miles from a given level of subsidies or, alternatively, to minimize the subsidies paid for a given level of patronage.

Graph 6.9

[22] Remarkably, the High estimate approach indicates a very similar combination (£20, 50%) as the profit maximizing point.



6.36 The actual level of subsidies per journey is currently 7.3 pence per mile for the entire rail industry.[23] As this scheme generates both profits and passenger miles it will then have an impact on reducing the national level of subsidy per passenger mile (and, of course, per passenger too).

6.37 Graph 6.9 shows that although this scheme will make this ratio decline irrespective of the pricing adopted, the greatest reductions will be achieved for Railcards priced relatively cheaply (£10 to £30) and offering important discounts (e.g. 50%) (these conditions generate the red area in the top left of the graph, where subsidy is around 1p per passenger mile less than at present). As discounts get larger, more passengers enter this scheme. Additionally, passengers who already bought the card travel more, because the perceived marginal cost of travelling is reduced. This enhances both profits (hence reducing subsidies) and passenger miles.

Externalities

6.38 The final and most important view is that one of society. This should consider the point of view of passengers, the point of view of TOCs and the existence of negative externalities in transport. Every time a passenger is transferred from road to rail society gains because of the relatively lower level of negative externalities (e.g. accidents, pollution, congestion, etc) associated with rail transport. By looking to rail incremental passenger miles generated by the scheme, and making an assumption of which proportion of these miles would be newly generated trips and which proportion will be abstraction from other modes (e.g. car), these benefits can be quantified.

6.39 For this purpose we used data on the monetary value of external costs per passenger mile on road and rail[24]. We also assumed that 15% of incremental passenger miles would be generated and that 85% would represent abstraction from other modes. Within this 85% of abstraction from other modes, we assumed 15% to be former car trips and the rest to be abstraction from the rest of the modes available (bus, air, etc.).[25] We then calculated the net positive externalities due to abstraction from car and subtracted the negative externalities due to rail trip generation (those trips that would only take place if the NRC is implemented). We made the assumption that all

[23] National Travel Trends, 2002-2003.

[24] Oxera Environmental, The Wider Impact of Rail and Road Investment, March 2000. Table 2.4 (central values used).

[25] These assumptions refer to typical results in previous studies.

trips abstracted other than from car would not generate any net positive impact in terms of externalities. This is a negative assumption since it equates the level of external costs for travel on other modes to those on rail travel. Consequently, our results underestimate the monetary value of reductions in negative externalities.

6.40 Results show that the monetary value in terms of lessening of negative externalities would be in the order of a couple million pounds. Although they are considerably less than profits gained by TOCs, these figures are not insignificant. Using our lower estimate, a card priced (£20, 30%) will mean benefits analogous to £1m per year in terms of less congestion, less accidents and less pollution. For a card priced (£30, 50%), these benefits are £2m. Using our high estimates, these benefits are £1m for a card priced (£20, 30%) and £3m for one priced (£30, 50%). These gains to society are an increasing function of passenger miles generated by this scheme. We would therefore expect the highest figures for environmental benefits to be obtained for cards priced relatively low.

Discussion of results and assumptions revisited

Table 6.1: Selected results

	High Estimate					Low Estimate				
PRICING SCHEME (K, D%)	Railcards Sold (M)	Incremental Passenger Miles (%)	Subsidy per passenger mile (reduction, pence)	Incremental Profits (£M)	Value of reduction of externatlities (£M)	Railcards Sold (M)	Incremental Passenger Miles (%)	Subsidy per passenger mile (reduction pence)	Incremental Profits (£M)	Value of reduction of externatlities (£M)
(30, 50%)	3.5	35%	1.25	102	3	2.7	26%	0.96	73	2
(20, 30%)	3.2	14%	0.62	62	1	2.7	11%	0.50	49	1

6.41 Table 6.1 summarizes our results for two pricing combinations: A card costing £20 and giving 30% discount (Network Railcard pricing) and a card costing £30 and giving a discount of 50% (profit maximizing pricing). As discussed throughout the document, our results are always more optimistic for our high estimates. Other things being equal, this approach will tend to produce more railcard demand, incremental passenger miles and profits (hence fewer subsidies); also a bigger value of environmental gains.

6.42 Our analysis shows that the profit maximizing pricing scheme (£30, 50%), happens to lie in the region where subsidies per passenger mile are at the minimum (Graph 6.9). Under the low estimate this means some 2.7 million cards sold, generating 26% increase in off-peak passenger miles. Incremental profits are £73 million and environmental gains to society are valued at £2 million. This would reduce the national subsidy per passenger mile ratio by 0.96 pence. On the other hand, the high estimate predicts some 3.5 million cards to be sold and an increase of 35% in off-peak passenger miles. Incremental profits would be £102 million and environmental gains to society would be valued in £3m. Under this assumption the subsidy per passenger mile rate would fall by 1.25 pence.

6.43 When looking at the standard pricing (20, 30%), our model forecasts (depending on the estimate chosen) some 2.7 to 3.2 million cards sold every year on the whole network. Off-peak passenger miles are forecasted to increase from 11% to 14% per year. Profits for the industry would be fostered by some £49m–£62m, and the value in terms of reduction of externalities would be £1 - £2 million per year. Under this scheme, subsidy per passenger mile on the whole industry would be reduced by 0.50 to 0.62 pence.

6.44 The comparison of these two pricing schemes generally shows more railcard demand for a card priced higher (£30) but offering more discounts (£50%). However, our analysis did not take into account that people on very low incomes might find it difficult to pay the up-front fee (even if following discounts exceed this amount). These restrictions should be modelled in further research to address the issue of social inclusion. Taking this into account will probably tend to favour cards will lower prices.

6.45 Although our results seem optimistic, they are dependent on a number of assumptions which we believe to be realistic. These have been explained throughout the document and are summarized in Annex C. However, a few comments on their implications are needed at this stage.

6.46 Demand for the National Railcard is derived from two different participation constraints based on different levels of rationality (see eq. (3) and (9A)). An important assumption here is that the market is going to be fully aware of the existence of this product and will be encouraged to make this kind of calculations. Furthermore, we are assuming that people are able to calculate their expected travel frequencies for the following year, at least based on their past years off-peak travelling frequencies. This might not be particularly true in every case, since there is some degree of uncertainty linked to, for example trips to be made in 6 months time from today. Although we have tried to account for this uncertainty by adding a temporal discount factor to our participation constraint (see (3*)), the yearly 10% discount factor may underestimate the uncertainty underlying such choice.

6.47 We also assumed that passengers are rational in the sense that their perceived cost of additional rail travel once the card has been bought is the discounted fare. This is similar to the common assumptions made in the case of car travel. Here, the fixed payment made to buy the car falls out of the day to day decision of how much to use the car. We have tried to model an irrational participation constraint – one where passengers never forget the cost of the card and hence look at the average rather than at the marginal cost of travel. We have ruled out this alternative because, even though it is possible that some passengers will reason like this, in the aggregate we expect the rational outcome to prevail.

6.48 Our forecast of Railcard demand could be improved by augmenting the disaggregation of the data from NTS. The fact that we have worked with only 7 different categories of passengers generates the lumpiness exhibited in many graphs. Based on the fulfilment or not of the participation constraints of the different categories studied, our forecasts experience a discrete "jump" every time a group is crowded out of the market. In reality, we would expect a more continuous demand, where individuals with the least trip frequency within one category will be crowded out first, eventually to be followed by others in the same group with higher trip frequencies. This could possibly be accommodated by applying a logit variable to our results. However, to make this procedure resemble reality, we would need data on travelling profiles of those currently using analogous products (e.g. Network Card).

6.49 We have worked with average figures for each category. As it was discussed, within each category, there exists an implicit distribution for the different trips made according to length. If this data was available, we could make the participation constraint more likely to be fulfilled whenever especially long trips are present. This data should be available by NTS, although it might take more time to be developed.

6.50 Notwithstanding all these arguments, we are more confident in our NRC demand forecasts than in our incremental passenger miles and in our profit ones. These two latter not only suffer from the limitations mentioned (because they depend on the number of NRCs sold) but also suffer from limitations on their own.

6.51 The most important additional limitations are the estimates for demand elasticities. Although these represent the best estimates available, they haven't been specifically disaggregated in favour of our analysis. We have computed base leisure elasticities for each market and then altered these depending on average trip lengths for every category, using empirical tables of fares/distance. Here too, it would have been beneficial to know the distribution of trip lengths for each category. As the taper mechanism in the fares structure acts more pronouncedly over longer distances, this could have accounted for a higher variation in elasticities between categories. The PDFH also acknowledges that passengers with higher trip rates should exhibit more elastic demand patterns, due to a higher income effect. However, no methodological approach to support this is suggested. Instead, it might be possible in future work to use the sample of representative households from the National Travel Survey (or a sub-sample of them) to conduct stated preference analysis, in order to determine the demand responsiveness for each of these groups.

6.52 Our profit estimates are bound to have a further source of bias, due to the way we explicitly modelled the leakage effects from higher yield passengers. Further research on this topic must address the issue of the ticket coverage of this card in order to explore sensible ways to improve the modelling of these effects. The assumption of zero cross elasticity should be also removed in further research. This could be done by using PDFH data on cross elasticities between ticket types and by changing the utility function in Appendix B to one exhibiting non-zero cross elasticity of demand.

6.53 A series of incremental costs in terms of management, marketing and administration of the card were modelled. Current expenditure on railcards were doubled and extrapolated linearly to the number of Railcards sold under each scenario. The assumption of doubling these costs seems consistent with the level of marketing effort assumed. However, there might be economies of scale (in terms of management and admin, for example) and diseconomies of scale (due to a much wider geographical coverage) and these must be studied.

6.54 For the reasons discussed above, we place a differential amount of certainty on our results. The most certainty is reserved for our Railcard demand figures, followed by our passenger miles figures and finally by our profit figures. This is not a matter of choice. We tried to address all the economic issues linked with the application of a National Railcard. However, due to our tight budget both in terms of time and money, those estimates which were less complicated to model, required less assumptions to be made and/or were less data intensive, are the ones which we are ultimately most confident with.

7 Conclusions

7.1 Throughout this document we have studied many aspects of the economic appraisal of a potential National Railcard.

7.2 We started our analysis by identifying this product as a two-part tariff. This is a common technique used by companies which enjoy considerable market power to maximize their profits. Profit maximization following this theory would predicate a high cost for the card and marginal cost pricing (i.e. a high discount on off-peak travel).

7.3 This card has been envisaged as a means to fill off-peak spare capacity, by inducing passengers to travel more off-peak. The extent to which this is achievable depends on the attractiveness of the card and on the responsiveness of passengers' travelling patterns to the discount it offers.

7.4 We modelled these two decisions separately. First, we considered the individual trying to decide whether it would make sense or not to buy the NRC. This decision necessarily has to be considered on the grounds of expected travel frequencies. We then modelled the decision as to how much rail travel to demand, once the card has been bought. We argued that individuals will make this decision looking to the marginal cost of travelling, the discounted fare. The price paid to buy the card plays no role whatsoever in deciding how much to travel as much like the cost of buying a car doesn't influence decisions on how often to use it.

7.5 We have modelled this approach using two different levels of rationality. As it was shown, they tend to produce similar results. At a geographically disaggregated level, these show the relative importance of the Elsewhere region over the London and South East one. Not only the customer base is larger in the former market but passengers seem to travel more off-peak and thus would tolerate higher priced cards.

7.6 For a card priced with our standard assumptions (£20, 30% discount) these results forecast a demand of around 3 million Railcards generating an increment of 1.2 billion passenger miles. This would mean incremental profits of around £57 million and a reduction of 0.55 pence per mile on the national subsidy per passenger mile ratio.

7.7 We also evaluated different pricing schemes from various points of views. We found the optimum NRC to be priced (£30, 50%). This pricing implies around 3.1 million cards sold, generating some 3 billion incremental passenger miles as a result of this scheme. Incremental profits are forecasted to be in the order of £90 million per year and the national subsidy per passenger is forecasted to reduce by 1.1 pence per mile.

7.8 Finally, we calculated the value gained by society in terms of less congestion, pollution and accidents due to this scheme. This shown to be in the order of 1-3m, but it could be higher since these figures are probably underestimates. The comparison of both cards renders the profit maximizing one superior under all views. However, the lower priced (20, 30%) card might be better at promoting social inclusion, since it implies a cheaper up-front disbursement.

7.9 So far, this is the outcome with a one-size fits-all strategy as a National Railcard. At least theoretically, profits could be further boosted by implementing a menu consisting of more than one two-part tariff, each tailored to act upon a different group of the ones identified.[26]

[26] See Wilson R., Non-linear pricing, Oxford University Press, 1997.

7.10 Additionally, the profit figures on this report neglect the positive financial impact for TOCs that would receive railcard revenues before the services have been provided. Although these profits refer to the whole industry, it is still possible that some particular TOCs would not benefit from the scheme. Even in this case, a compensatory system to cross subsidize these TOCs could be implemented, consequently spreading evenly the profits from the NRC.

7.11 Our results are particularly optimistic. They show that a scheme like this one can foster usage of the railways during off-peak periods, making a more efficient use of the capacity available, yet generating profits. This outcome is linked to the pricing system which encourages the customer to make an "investment" in order to have the future option of discounted fares. Once this investment has been made, travelling decisions are based on the discounted fare available to this customer. In essence this is analogous to reducing the fares by the same as the discount offered, only that in this case an extra fee equal to the cost of the card adds up to the positive part of the profits equation. The reason for that a TOC can charge this extra fee and yet not expect the customer to stop travelling is because this customer always has some consumer surplus, for any given level of fares.

7.12 However, our analysis was subject to important data limitations which might have diminished the accuracy of our forecasts. In particular, the data from the NTS was set out in 7 discrete categories of passengers, each represented by its average travel profiles. As we argued, this level of disagregation is not sufficient to fully understand the incentives of each group towards buying the card. Moreover, we pointed out the fact that the distribution used for London SE might be spuriously augmented by the fact that an analogous card was available when it was produced. If this is the case, this would bias our results upwards.

7.13 Data on demand elasticity for each group studied in the National Travel Survey had to be estimated from base levels found on the 1997 PDFH. Furthermore these elasticities were derived assuming a constant elasticity demand function. It is acknowledged that as fares are reduced, passengers become less responsive to an additional fares change. The fact that we have been using these elasticities to forecast changes of up to 50% on the fare will generally imply an overestimation on passenger miles and revenues. Our results have also shown the relative significance of railcard revenues vis. a vis. ticket revenues. This would tend to make the commented overestimations less relevant. However, the relative insignificance of ticket revenues was also a consequence of the assumptions made, specifically elasticity figures used.

7.14 A number of recommendations may be suitable for further studies. Data on the distribution of trips by length for each category of trip frequency should be available by the National Travel Survey. This could be used to refine our findings on Railcard demand. The National Travel Survey also generates data on season card ownership and this could enable us to shed some more light into the interaction of these products with other semi-substitute ones. The data on demand elasticities should be at least rationalized or, if possible, some research effort should be directed to finding the different elasticities associated with the different groups studied. Non-zero cross elasticities should be assumed for further research. Finally, some implementation decisions, for example the eligibility of various tickets for discount should be addressed in more depth. As we pointed out, the issue of leakages of high yield passengers from other markets are highly dependent upon these decisions.

7.15 Due to a limited financial and time budget we were not able to address a number of these issues and refine the model to its maximum. This constrained the academic purity of some parts of the research. As a result we place more confidence in our estimates for Railcard demand followed by those on Passenger Miles and finally those on Profits. The two latter depend not only on the same assumptions that the former, but also on the quality of our demand elasticities and on the zero cross elasticity assumption.

7.16 Nevertheless, this report illustrated the main issues of the economics of a National Railcard. It has pointed out the various tradeoffs between ticket revenues and railcard revenues, as well as those between a higher customer base and a highly priced card. Moreover, it has established the presence of a market of 3 million customers and has given plausible estimates of the increase in passenger miles that this would imply. Forecasted profits are high and even though some of the recognized biases could render them lower, we think they would always be positive. Even if negative, they could still generate decreasing subsidy passenger ratios, as most probably the increase in passenger miles would outperform losses.

7.17 The railway industry has embraced price discrimination with the peak:off-peak markets with generally positive results. A two-part tariff (or a menu of them) is just another, yet more sophisticated, mechanism for price discrimination. Many industries including the telephone, airline, energy and food industry currently use these approaches, so it is suitable for the railway industry to examine its case. This is particularly true for all interested parties when, at least theoretically, it can deliver high profits and still boost passenger numbers.

Appendix A – Explaining the data from the National Travel Survey

The National Travel Survey is a continuous survey which monitors personal travel behaviour over time. It is based on a random sample of private households drawn from the postcode address file. The sample is carried by interviewers who extend to the surveyed four different questionnaires to fill in.

In order to carry this study we needed the distribution of off-peak travel for the age group 25-59 (the market for the card). Ideally we wanted this distribution to be split by deciles by trip frequency and for each of these we needed the average distance travelled (off-peak).

In preparing the data for this study we used the information collected through the main questionnaire at the individual level and the weekly individual travel diaries. The first of these documents is a general questionnaire asking about general travel patterns. The second, is a diary where the surveyed must fill in each trip made during the course of one week, detailing travel purpose, time of the day, mode and distance travelled.

Theoretically, we could have used the diaries to distinguish off-peak trips (via some definition for off-peak) and then construct our distribution. However, most people often fill in 0, 2 or 4 individual off-peak trips during the week (0, 1 or 2 return trips). This is then multiplied by 52 (weeks in a year) to get the overall yearly trip rate. This would have not helped us very much because we would have ended up with a distribution where people made either 0, 104, 208 and so on trips per year. This is not very representative. It is sensible to expect a less discrete distribution. The discreteness on this distribution would have been spuriously manufactured by the relatively short span of time which the diaries cover.

Another difficulty had to be overcome in order to make use of the data in the diaries: an appropriate definition for off-peak was needed. Two approaches were studied. The first one was to split trips by time of the day. However accurate this method might look, it had the technical shortcoming that many return trips undertaken with open return tickets could be made at times other than the evening peak, and hence would be noted as off-peak when they form part of a peak return trip (and were thus ineligible for the discount of a NTC). The second approach was to split trips by purpose. It is generally recognized that the majority of trips during the peak are related to business / commuting / education. On the other hand, the vast majority of off-peak trips are generally a result of leisure or personal business. We then proceeded to characterize those trips related to non-business purposes as off-peak.

The individual questionnaires have a number of questions which were relevant to this research. More specifically questions regarding age and location of residence could be used to split and disaggregate the data to our convenience. Moreover, the questionnaires contained a question regarding yearly trip frequency by surface rail. The questionnaire gave 7 possible "boxes" for answers, each one representing a range of travel frequencies as follows.

Trips per year by surface rail

0-1	1-2	2-12	12-24	24-52	52-104	104 +

However, the information on this question refers to overall trip frequencies and we were interested only in off-peak travel frequencies. Furthermore, we also needed information on average off-peak distances which were not gathered in this questionnaire.

The only approach viable to tackle our data needs was then to merge both sources of information. This was done through careful examination of the structure of the survey, with help from analysts at the National Travel Survey.

First, individuals where split by trip frequencies into the 7 mentioned categories. Only the ones aged 25-59 were selected and the data was split for those living in London & South East and Elsewhere.

The data from the weekly diaries was then used in the following way: For each of the seven categories the number of rail journeys declared on their weekly diaries was counted. Next, for each category the sub group within these declared trips which were made on journey purposes classified as "off-peak" was identified and counted. Dividing the number of trips declared as undertaken off-peak by the total number of trips declared, we then obtained the average propensity to travel off-peak. We then applied these figures of propensity to travel off-peak, over the mid arithmetic point of every one of these categories.[27] For example, if the average propensity to travel off-peak is 30% for the first group, we would multiply 0.5 (the midpoint between 0 and 1) times 30% to get 0.15. Our method then shows that the first group of the sample travels in average 0.15 times by off-peak rail every year. The main assumption needed to derive this method is that within each of these categories, overall trip frequency is perfectly correlated with off-peak trip frequency. Another assumption is that the mid point of each group is coincident with the average trip frequency (unobserved) for each group.

In addition to this, for each of the categories under study, average off-peak trip distance was measured from the information on the weekly travel diaries.

The final outcome from National Travel Survey was a chart looking like the following[28]:

Category	1	2	3	4	5	6	7
% of people in the sample							
Average propensity to travel off-peak							
Average off-peak trip distance							

Note: This data is not published here since permission from NTS was not granted.

This chart was re-converted into a proper distribution for off-peak travel, using the simple calculations explained earlier in this annex. From here, various conclusions were obtained and the results at the sample level were then extrapolated to the population of UK represented by the sample.

[27] If the sample within each category were uniformly distributed, then we could expect this value to be coincident with the median and average for each category.

[28] In the case of London & South East, a split in the last group had to be estimated since it comprised 10% of the sample.

Appendix B – NRC demand: a microeconomic approach

In this appendix, we derive the demand for the proposed NRC from the microeconomic perspective of an individual consuming leisure trips (T) and a basket of other goods (C). The key assumption throughout this derivation is that off-peak trips are normal goods. This stands from the fact that off-peak travel can be characterized as a derived demand from leisure activities, which in turn are normal goods.

We are going to derive the decision from the point of view of an individual maximizing a Cobb-Douglas utility function subject to a budget constraint.[29] We will confront this individual with the decision to buy or not to buy the NRC and we will then find out under which circumstances he will buy the card (participation constraint).

If the individual doesn't buy the card, his utility maximization problem can be written:

$$Max_{C,T} U(C,T) = C^{\alpha} T^{1-\alpha} \qquad (1B)$$

$$s.t. \quad p*C + f*T = Y \qquad (2B)$$

Basically, the individual wants to maximize his utility which is increasing in the amount of general consumption (C) and off-peak trips (T), subject to his budget constraint. The α parameter in (1B) measures the relative preference for consumption of C for the individual. The higher this parameter, the higher the weight given to C and the lower the weight given to T in the utility function. P is the average price for the basket of other goods and f the fare (let's assume saver). The budget constraint (2B) implies that his overall spending in these two "goods" must be equal to his income (Y).

Solving this problem, we obtain the optimum demand for C and T, which we call C* and T*.

$$C^* = \frac{Y\alpha}{p} \qquad (3B)$$

$$T^* = \frac{Y(1-\alpha)}{f} \qquad (4B)$$

As we can see, demand functions depend positively on each goods preference parameter and income. Demand for each good depends negatively on its price.

Now let's assume that the individual buys the NRC. The problem now looks as follows:

$$Max_{C,T} U(C,T) = C^{\alpha} T^{1-\alpha} \qquad (5B)$$

$$s.t. \quad p*C + K + f(1-d)*T = Y \qquad (6B)$$

The only difference is in the budget constraint (6B) is that he pays K for buying the railcard and receives a discount d on the fare.

The demand functions are now:

[29] This type of utility function is of widespread use in economic literature. It assumes constant demand elasticity and zero cross elasticity of demand.

$$C_{NRC}^{*} = \frac{(Y-K)*\alpha}{p} \qquad (7B)$$

$$T_{NRC}^{*} = \frac{(Y-K)*(1-\alpha)}{f*(1-d)} \qquad (8B)$$

The sub indexes NRC refer to the fact that these demands are conditional to buying the NRC. Notice that rail consumption will be higher the higher the discount (d) or the cheaper the card (K).

The individual will buy the card if his utility when buying the card is greater than when not buying it, hence:

$$U(C_{NRC}^{*}, T_{NRC}^{*}) > U(C^{*}, T^{*})$$

$$\left(\frac{(Y-K)*\alpha}{p}\right)^{\alpha} * \left(\frac{(Y-K)*(1-\alpha)}{f*(1-d)}\right)^{1-\alpha} > \left(\frac{Y\alpha}{p}\right)^{\alpha} * \left(\frac{Y(1-\alpha)}{f}\right)^{1-\alpha}$$

With some algebra we can work out the participation constraint for this individual.

$$Y*(1-(1-d)^{1-\alpha}) > K \qquad (9B)$$

This individual will buy the card if condition (9B) is satisfied. This condition can be explained more intuitively. First note that the second term inside the brackets in the left part of the equation is always less than 1. This condition shows that, other things equal, the higher K, the price of the card, or the lower the discount offered (d), the less probable is that condition (9B) is met. Therefore the less probable that the individual buys the card. The impact of trip frequency can also be extrapolated from (9B). The higher the relative value attached to rail travel (the lower α) the more probable he will buy the railcard. We can relate this to the naïve participation constraint (3) because the larger his preference for off-peak rail travel, the more often he will travel by rail off-peak. Therefore it will be more convenient to buy the card (these would represent the persons grouped in the top categories of the distribution). What happens if incomes rise? Since both goods are normal goods (the ones people tend to consume more when their income grows) then this individual consumes more of both goods. Consequently his demand for off-peak rail travel rises and, by the same argument he is more probable to find the NRC scheme convenient.

We used this framework to generate a set of forecasts which are presented in section 6 as "High estimates". Data on incomes (Y) for each category in the National Travel Survey was provided. Using these data, in conjunction with other variables from our base distribution, we could then estimate values for α, the preference parameter.

We have done this by assuming that the current demand function behind the actual travel patterns is equation 4B. We used data on current trip frequencies T*, the average price of trips f and incomes Y, to find out the underlying preference parameter α as follows:

$$\alpha^{e} = 1 - \frac{f*T^{*}}{Y} \qquad (10B)$$

The supraindex on the parameter α means that it is an estimation. This parameter is equal to the proportion spent in other consumptions. In turn (1- α) equals the proportion of income spent on rail travel. Given an income level, a fare and a number of trips consumed when the NRC was not available, we can extrapolate the parameter of preference for off-peak rail travel. This parameter (1- α) is equal to the proportion of total expenditure in off-peak rail travel as a proportion of income.

Once this parameter has been estimated from each of the sample groups we proceeded to make our forecast making use of equations (9B) and (8B).

It is important to mention that the Cobb-Douglas utility function has some special properties. Specifically it exhibits unitary constant demand elasticity for each product and it assumes zero cross elasticity with respect to other products (e.g. peak rail travel).

Appendix C – List of Assumptions

The following list includes all the assumptions underpinning our analysis. Each assumption is briefly described but cross references to the paragraph (or Annex) of the document where they are discussed is provided.

Structure of the National Railcard
The proposed National Railcard is assumed to be a card offering discounted off-peak travel throughout the UK network, for solo passengers. **[2.1]**
Assumptions

- Tickets eligible for discount are savers, supersavers and cheap day returns. **[5.4]**
- National Railcard overtakes Network Card. **[4.5]**
- National Railcard co-exists with Young Persons Railcard, Senior Citizen Railcard, Family Railcard and Season Tickets. **[4.7 - 4.8 - 4.10]**
- Young and Senior persons will continue buying their specific targeted products **[4.4].** No interaction of demand between the NRC and Young Persons and/or Senior Citizens Railcards. **[4.7]**
- Season tickets and Family Railcards are partial substitutes for the NRC. Interaction of demands with these products.**[4.8 – 4.10]**

Representative ness of the sample
Individuals surveyed in the NTS aged 25-59 were grouped into 7 categories according to off-peak travelling frequencies. The analysis was split into two separate regions. **[4.1 and 4.4]**
Assumptions

- The distribution is a fair representation of the target population. **[4.3]**
- Young and Senior persons will continue buying their specific targeted products .**[4.4]**
- Every group represents a market of homogenous passengers characterized by the average trip frequency and average trip length from the sample. **[4.13]**
- The mid-point in the NTS multiple choice question regarding trip frequency, represents the average trip frequency for that group. **[Appendix A]**
- The estimated disaggregation of category 7 of London SE is representative of the underlying population. **[Appendix A- footnote 28]**

Participation constraints
Participation in the NRC scheme for each of these categories or markets was decided using different participation constraints. **[4.2]**
Assumptions:

- Using the naïve participation constraint (3), customers forecast their trip frequency for the year to come by looking to last year's trip frequency. Customers calculate their total expenditure when buying and when not buying the card. They assign less value to future and uncertain trips than to those trips planned to be undertaken in the near future (see 3*). **[3.7]**
    - Yearly discount factor is 10%. **[4.2]**
- Using the more sophisticated participation constraint (9B) customers acknowledge the fact that if they bought the card then they would travel more than during last year. Consequently, they compare their utility when buying the card and making more trips with their utility when not buying the card and making fewer trips. **[3.10]**

Response of passengers to discounted travel
Those passengers forecasted to buy the card will enjoy a discount on rail travel which will incline them to enhance their off-peak travelling patterns.
<u>Assumptions:</u>

- Once the card is bought, the customer decides how much to travel by looking at the price of making one extra trip (the discounted fare). The cost of the card is a sunk cost and plays no role whatsoever in this decision. **[3.14]**
- Customers demand more rail travel by increasing their trip frequency and leaving their average trip length unaltered. [4.6 – footnote 6]
- In low estimates, passengers react accordingly to leisure elasticities reported in the 1997 PDFH. **[5.5 , 6.2]**
    - Other things being equal, passengers with higher average trip lengths exhibit lower elasticity of demand. **[5.5]**
    - Other things being equal, the group of most frequent passengers in each region exhibits a lower elasticity of demand. Their demand for off-peak travel is supposed to be time constrained. **[5.9]**
- In high estimates passengers exhibit unitary elasticity of demand. **[6.2]**
- For all our estimates elasticity is constant irrespective of the magnitude of the fares change. **[4.14]**
- In all estimates customers exhibit zero cross elasticity of demand with regards to other ticket types. **[6.21]**

Profits
<u>Assumptions</u>

- Current network infrastructure is able to accommodate an increase of up to 50% in off-peak passenger miles with no significant additional costs. **[6.19]**
- General costs of admin, marketing and management per card are doubled with respect of current costs for existing cards. **[6.20]**
- Open single tickets will not be eligible for card discount. **[6.22]**
- Passengers currently travelling off-peak for business purposes will exhibit zero elasticity of demand. **[6.23]**

Externalities
<u>Assumptions</u>
- Incremental passenger miles are 15% generated (new) trips and 85% trips abstracted from other modes. **[6.39]**
- Trips abstracted from other modes are 15% from car and 85% from the rest of available modes. **[6.39]**
- Value of negative externalities produced by other modes than car is equal to value of negative externalities produced by rail. **[6.39]**

Appendix D – Bibliography

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