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USING THE RAIL FARES INDEX TO ILLUSTRATE FURTHER DEVELOPMENTS IN QUALITY ADJUSTING SERVICE SECTOR PRICES

Craig Richardson
UK Office for National Statistics

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Using the value of time for quality adjustment – testing the concept for rail fares

Craig Richardson
Office for National Statistics

This article has two aims. Firstly, to develop a possible alternative method of quality adjustment to the ones commonly used by statistical offices, for example, hedonic indices. In particular, we aim to develop a method more applicable to a service sector price index, one that takes into account several aspects of service performance. Secondly, we aim to illustrate the proposed concepts with a test of concept index. Rail fares have been chosen for the test of concept as they give us several measurable and objective quality indicators,and the indicators chosen are all ones which can not be adjusted for by using conventional quality adjustment methods, such as hedonic indices or option costing.

Introduction

This article has two aims:

- to develop a possible alternative method of quality adjustment to the ones commonly used by statistical offices, for example, hedonic indices. In particular, we aim to develop a method more applicable to a service sector price index, one that takes into account several aspects of service performance
- to illustrate the proposed concepts with a test of concept index.

Rail has been chosen for the test of concept as it gives us several measurable and objective quality indicators, such as frequency, delays, expected duration, and so on. We acknowledge that this is far from a complete list of what matters to passengers, but crucially, the indicators chosen are all ones which can not be adjusted for by using conventional quality adjustment methods, such as hedonic indices or option costing.

The purpose of this work is to promote discussion regarding the quality adjustment of services. The Atkinson Report (Atkinson, 2005) highlights the need for quality adjustment in the provision of government services. However, this suggests that the Office for National Statistics (ONS) also needs to consider the need for quality adjustment of private sector services. Quality adjustment of services is a difficult issue. This article aims to show some of the innovative ideas being considered by ONS as part of its ongoing research and development programme.

To be able to test the concept of using the value of time we have had to make several strong assumptions regarding the nature of quality, and it should be stressed that ONS has no plans to introduce this methodology into any of its price indices. This workstream is not being continued, but research into service sector quality issues more generally will continue.

The conceptual basis of price indices and quality adjustment

A fixed basket

Central to the notion of a price index is the nature of the basket of goods and/or services priced over the period. Generally, price indices in ONS are known as fixed quantity price indices (or fixed baskets), and use a Laspeyres formula. This means that they measure the change in the price of a basket of fixed composition, quantity and quality. Key to this is the assumption that quality remains unchanged over the period in question. It follows that quality changes that occur in the sample must be separately identified and excluded from the index, to ensure that the movement in the index reflects only the underlying price change.

Option costing and hedonic quality adjustment of goods

The rapidly changing quality of certain goods (such as PCs and digital cameras) in the Consumer Prices Index (CPI) sample have led to a series of ONS projects to improve the quality adjustment techniques used for these goods. A milestone in this research programme was the introduction of hedonic quality adjustment for PCs in the CPI and Laptop PCs in the Producer Price Index (PPI) in January 2003.

Ball and Allen (2003) describe the problems facing statisticians dealing with changing quality in the goods they are trying to price. Before the introduction of hedonics, price statisticians in the UK generally used a technique known as option costing, where the retail cost associated with a change in specification is obtained from the cost of purchasing the change separately or as an added option. This is then used to adjust the price of the original model to give a price comparison that is independent of any changes in quality.

However, as Ball and Allen (2003) state, the application of option cost involves an element of judgement, for example, determining the appropriate proportion of the option cost that should be taken, and the identification of the relevant subset of options to price from the complete set of options available to producers and consumers. Also, in many instances, the options are not sold separately so an option cost is not available.

Hedonic methods allow us to remove some of the judgmental aspects of option costing and to impute a value to a characteristic even when it is not available as an option. By regressing the prices observed against a dataset of various quality attributes, we can attribute a (shadow) price to the attributes and then use this to predict the value of a given quality change using the regression coefficients. Key to the conceptual basis of the hedonic approach is the assumption that quality is effectively a range of choices which the consumer can make at the time of purchase, for example choosing between 256Mb or 512Mb memory when purchasing a PC.

Quality adjustment and services

Quality adjustment of services remains an issue that ONS is yet to explore in great detail, possibly because the conceptual issues surrounding it remain largely unresolved. For example, ONS's Corporate Services Price Index (CSPI) concentrates on trying to ensure that the quality of the services chosen is comparable over time. The CSPI quality adjustment guidance is currently the same as for the Producer Price Index, in that specification changes are categorised as one of the following;

- *'W' specification changes* – assumes that the change in price is due entirely to the change in specification, so the price relative is left unchanged at the time of the change in the model.
- *'X' specification changes* – assumes a notional price change is due partly due to a change in specification but is partly a genuine price change. For instance, the washing machine manufacturer may introduce a new model at the time of a general ten per cent price rise in its products. In such a case an 'X' specification change would say that ten per cent of the notional price rise in Model B compared with Model A was due to a price rise while the remainder was due to the change in specification.
- *'Z' specification change* – applied if the change is purely cosmetic, implying that the whole of the notional price change is passed through as a 'genuine' price increase.

Within the CSPI, effort is primarily being focused on expanding the coverage of the index, however, there are a number of reasons why there has been little work on formal quality adjustments for services in both the CSPI and RPI;

- Firstly, many service products have not experienced sustained quality change in a particular direction such has been the case in goods such as computers or cars.
- Secondly, while it is certain that the quality of a restaurant meal is changeable, the assumptions behind the matched-pair price index – that you collect the price of the same meal from the same restaurant each month – should, on average, be a good estimate of price change. (Although it should also be noted that this misses substitution between options, and so may miss quality changes),
- Thirdly, where quality differs between similar products, services typically price differently to reflect this. For example, tickets to the theatre differ depending on the view. Thus quality changes should be picked up during basket updates.

Quality changes in a number of services have, however, been sustained, and this is the motivation for this test of concept. In particular, the Atkinson Report (Reference, 2005) highlights the need for quality adjustment in the provision of government services. However, this suggests that ONS also needs to consider the need for quality adjustment of private sector services.

Assuming the quality is changing, initial research suggests that when considering quality adjustment of a service, the first question to be asked should be "is quality an objective or subjective issue?" Even this may not be as black and white as it may seem if we do not narrow the question down to the key elements of quality that matter to the consumer. Consider the purchase of a theatre ticket. Two theatregoers may have completely different views regarding the quality of the production (a subjective measure), but there may be more legroom for seats (a qualitative measure).

Where services can be treated like goods, hedonic methods may still be suitable (for example, for the rental of office machinery in the PPI the price depends largely on the quality of the PC being hired). However, most services are not this simple to deal with. Rail travel for example is not a tangible product; it is a change in the state of the individual (that is, transporting them from A to B). It is also an example of where, unlike PCs, quality is not a measure which the consumer has much choice over at the time of purchase, beyond that of choosing first or standard class tickets. But even first class tickets do not prevent delays. With PCs you pay more, knowing you will receive a higher quality product (more memory, larger hard disc etc), but with rail you pay

the same for a journey, regardless of the eventual quality. This effectively prevents us from using hedonic methods to quality adjust rail fares. (Although research in Japan suggests that the mark-up of first class tickets over standard class ones may be an indication of willingness to pay for a seat. And arguably delays are more bearable if you are sitting down.)

Developing the cost-of-time approach

In this article we propose a method for dealing with services which involve customers saving or using time. This is based on the cost of time. Valuations of the cost of time are used in transport policy cost-benefit analyses, for example to place a value on a new rail route or road, which can then be compared against the costs of providing the improvements.

The concept of this article is that for a service such as rail journeys, quality factors such as delays, cancellations, changes in frequency and changes in the timetabled duration of a journey can all be expressed in terms of time, which can then be valued and used to quality adjust the fare. Valuing time is discussed in more detail later.

Planning the data collection

There are tens of thousands of routes available on the UK rail network. In order to carry out the data collection manually for this proof of concept, we have limited our sample to 50 routes. This represents a compromise between establishing the conceptual basis of the index and the practicalities of the data collection. We make no claim that this is an unbiased sample of journeys.

These routes were chosen using Strategic Rail Authority (SRA) data on the revenue per route for 2001, and represent the 50 highest revenue routes on the network. The revenue data for these 50 routes are also used to form the weights for the price index and these 50 routes represent approximately 15 per cent of total revenues in 2001.

For each of the 50 routes, an individual journey was chosen for the sample, for example the 08:29 from Chelmsford to Liverpool Street. We then collect the fare for this journey on a monthly basis, pricing a representative ticket type for that route. We also collect the quality data for these 50 journeys in real-time. While we accept that this is a small sample, it is approaching the limit of a manual data collection system.

The three guiding principles for choosing which quality measures to include were:

- they must be objective and measurable
- the data should be accessible in real-time
- they should matter to rail users.

On this basis, four quality measures were chosen:

- timetabled duration
- actual duration (and hence how early or delayed the service is)
- cancellations
- changes in frequency.

It is important to stress the need for multiple quality measures to account for the trade-offs that exist in the provision of this service. For example, it has been suggested that it is possible to reduce delays by reducing the frequency of service or by increasing the timetabled duration of the journey. If we only measure delays, these changes would show up as quality improvements, but this would not match the experience of rail passengers who have to wait longer for a train or spend longer on it. One key aspect of quality that we would like to include is over-crowding, but we have not been able to incorporate a measure into our current framework as no real time data is available.

It is also important to acknowledge that while it is accepted that sampling on one day a month is representative for prices, it is less than perfect for quality. For goods such as PCs quality is a long run trend towards improvement. For rail travel it seems likely that while there may be a long run trend, there is also likely to be substantial short run volatility, and this will be exaggerated by our assumption that one day per month is representative. However, this is an example of where our aim of testing the concept has been constrained by the practicalities of the manual data collection system.

Fares data

There are a number of established websites that offer the latest fares, although our choice is slightly restricted as not all offer the travelcard fares required.

For a number of routes, the representative ticket type is a season ticket. Currently we cannot price these direct from the web. Instead we price a standard day return ticket. Arguably this provides the same services as the season ticket for commuters on the day, but is priced on a single journey basis. While it may be argued that a sample of quality taken one day per month is unlikely to be representative of the quality actually experienced by the purchaser of a season ticket, this is the general principle of price collections such as the RPI, which assume one day to be representative of the month. But our treatment of season tickets does allow us to abstract away from the issue that season ticket prices often contain discounts for poor performance in previous periods (although this may have a slight downwards impact on the revenue weights for commuter routes).

Travelcards are almost exclusively a London phenomenon, and they represent a methodological difficulty. They are effectively combined rail and London Transport (LT) tickets. When calculating the revenue shares that we will use as weights in our price index, travel cards have been defined as origin to London terminals, since what we need is the rail part of the journey (and we are not interested in quality adjusting LT). However, no attempt has been made to adjust the revenue for the LT portion of the tickets. The product we are quality adjusting is the rail portion of the journey.

Timetable data

Data on the timetabled departure and arrival time, and the frequency of journey is taken from the National Rail website, as this should reflect the latest state of play for the network timetables.

Minor changes to timetables (for example, to the expected duration caused by planned engineering works) happen regularly enough to warrant us collecting expected duration and frequency on a monthly basis. However, National Rail timetables also have major changes twice a year (for example, introduction of summer timetables). Train services may be introduced or permanently cancelled, or, more usually, re-timed. In this case, the fixed basket approach requires that we aim to replace the missing service with the one that has the closest arrival time to our original journey (although not necessarily provided by the same operating company).

Quality data

We collect the actual arrival time and a record of cancellations within our sample from the National Rail live online departure/arrival boards. These boards are provided by Thales Information Systems on behalf of the Association of Train Operating Companies (ATOC). The information on these departure boards is provided by an automated system which has limitations.

Where a train is cancelled we try to re-create the experience of someone on the platform. The arrival time recorded is the arrival time of the next available direct train between the origin and destination. The departure time remains that of the original train, and the extended delay is the key quality measure for cancellations that feeds into the index.

Valuing the cost of time

Principles

The principle underlying the majority of the research work on peoples' valuation of time is that time has an opportunity cost, that is, time spent travelling could have been used for other activities such as work or leisure. The question is whether we can measure this opportunity cost in monetary terms.

The Department for Transport (DfT) methodology (DETR, 2001) is based on 1998 prices, and identifies three types of travel time relevant for the current study:

- *working time*: journeys made in the course of work (commuting journeys are excluded)
- *non-working time*: all non-work journey purposes, including travel to and from work
- *waiting time*: time spent waiting to travel.

For working time, which refers to business trips, we use the value that is perceived by the employer, at factor cost (that is, net of indirect taxation). This takes into account gross wages and non-wage labour costs, and is expressed as a mark-up over wages. Using the 1992 Labour Cost Survey and the 1998 National Travel Survey, DfT estimate the mark up to be 24.1 per cent, giving a valuation of working time of £25.17 per hour (1998 prices) for rail users.

For non-working and waiting time we are interested in market prices (rather than factor costs), as this is what consumers pay. DfT use a single value for non-working time, regardless of mode of transport. The figure is based on the average income of travellers on the journey to work. At market prices the standard appraisal value is £4.52 per hour (1998 prices). In a review of the DfT valuation, Mackie *et al* (2003a, 2003b) comment that the valuation can be split into two categories; commuting and other. The values they suggest are £3.96 and £3.54 respectively.

Both DfT and Mackie *et al* only consider waiting time in the context of non-work travel. DfT suggest that waiting time should be valued at twice the value for non working time, while Mackie *et al* suggest using a ratio of 2.5.

Uprating

For working time, DfT assume the income elasticity is one, so we can uprate the working time simply by applying the growth in disposable income per head. DfT also believe that non-working time has a unitary elasticity of income, although Mackie *et al* suggest it is closer to 0.8.

For simplicity, we have assumed a unitary elasticity for both. Between 1998 and 2003, household gross disposable income per head grew by 29.7 per cent. This gives us the time valuations in Table 1.

Table 1
Time valuations

£

	1998	2003
Working time	25.17	32.66
Non-working time	4.52	5.87
Waiting time (DfT)	9.04	11.73

Options

We have two options for implementing the split between working and non-working time. We could use the DfT's calculations which show that on average over the whole week, six per cent of journeys are work related and 94 per cent are not. Or we could use the fact that between 10am and 4pm (which covers the majority of our sample), 11 per cent are work related, and 89 per cent are not. A third option may be to just take the non-working time value. This might be more appropriate if the index were to be used in the RPI, for example.

We have chosen to use the second option, in an attempt to be more representative of the week as a whole. These weights give us a valuation of £7.47 per hour for delays. For changes in frequency, and delays arising from cancellations, we use the waiting time value of £11.73 per hour.

For this piece of research we have kept the value of time fixed at the 2003 value throughout the sample. However, there is a case for allowing it to rise with household incomes as time progresses, so that both ticket fares and the value of time are in current prices.

The valuations presented here, and their application, remain provisional, and we would not argue that they present an objective assessment of the true value.

The key aim is to enable us to provide an illustration of what the quality adjusted index movements look like, but readers should be aware that the resulting index will be sensitive to the value of time used. If this method were to be used operationally, further research would be required to establish a valuation that is conceptually correct for the index it would be used in.

Results

We have collected fare, timetable and quality data for August 2003 through to January 2005. A summary of key results is presented in Table 2. We then apply the valuations to the data. Changes to timetabled duration, delays and cancellations are relatively simple to value as they are measured in minutes. Changes in timetabled duration are relative to the chosen base month. For changes in frequency we measure the numbers of trains on the route between 7am and 9am. We then assume that trains arrive at regular intervals over the two hours measured, and assume that rail users arrive at random points throughout the two hours. This allows us to calculate an expected waiting time. Changes to this waiting time relative to the base month are valued and added to the index. This methodology rests on a number of assumptions, in particular that rail users arrive at random times and that trains arrive at constant intervals of the period. However, it has the advantage of being easy to implement.

Once we have these valuations we simply add them to the underlying fare for each journey to obtain the quality adjusted fare. The adjusted and unadjusted fares are then weighted together using the revenue weights.

Table 2
Key quality movements

(Base month in **bold**)

	Total exected duration (mins)	Cancellations	Total frequency of services	Total delay (mins)	Averaage delay (mins, weighted)
Aug–03	3,322	2	518	656	12.1
Sep–03	3,320	1	519	321	6.9
Oct–03	3,321	0	517	97	1.6
Nov–03	3,321	0	517	339	7
Dec–03	3,321	0	518	119	2.9
Jan–04	**3,314**	**0**	**521**	**159**	**3**
Feb–04	3,314	0	521	97	2
Mar–04	3,314	1	519	128	2.2
Apr–04	3,314	0	518	112	2.1
May–04	3,314	0	518	108	2.2
Jun–04	3,435	0	506	56	1.2
Jul–04	3,336	0	516	48	1.2
Aug–04	3,440	0	508	137	3.3
Sep–04	3,556	1	503	65	1.3
Oct–04	3,253	0	522	185	4
Nov–04	3,245	1	541	183	4.1
Dec–04	3,245	1	541	214	5.4
Jan–05	3,274	0	558	121	2.9

Table 3 presents the quality-adjusted index, taking into account delays, timetable changes, cancellations and changes in frequency. The difference between the two indices reflects a composite measure of changes in the different facets of performance. The results are also illustrated in Figure 1, which highlights some of the events underlying the key movements in the quality-adjusted series.

A key feature of Figure 1 is that there is little evidence of a long run change in quality. In the case of PCs for example, there is a consistent and continuing improvement in quality, and an absence of quality adjustment would imply a bias to the index.

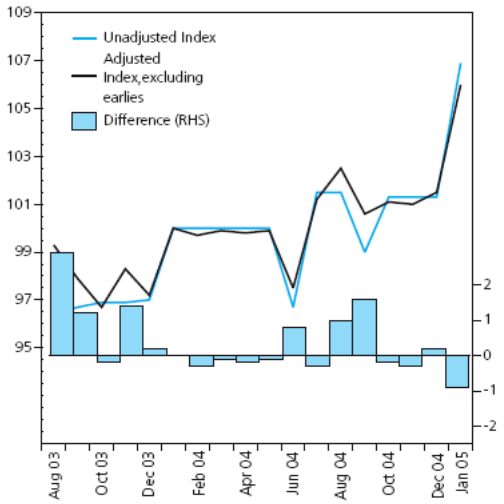
Table 3
Adjusted and unadjusted price indices

(Base month in **bold**) Jan 04=100

	Adjusted	Unadjusted
Aug–03	99.3	96.4
Sep–03	97.9	96.7
Oct–03	96.7	96.9
Nov–03	98.3	96.9
Dec–03	97.2	97
Jan–04	**100**	**100**
Feb–04	99.7	100
Mar–04	99.9	100
Apr–04	99.8	100
May–04	99.9	100
Jun–04	97.5	96.7
Jul–04	101.2	101.5
Aug–04	102.5	101.5
Sep–04	100.6	99
Oct–04	101.1	101.3
Nov–04	101	101.3
Dec–04	101.5	101.3
Jan–05	106	106.9

Figure 1
Adjusted and unadjusted indices

index, Jan 04 = 100



On the basis of Figure 1 there is less evidence of a potential bias in rail fares. However, it should be stressed that this is a short sample; several of the short lived quality decreases shown in Figure 1 in fact reflect engineering works that may be expected to enable a higher quality service in future. Another issue previously described is that it may be impossible to distinguish long run trends from short run volatility due to the constraints of our data collection system; namely the assumption that the performance on one day is representative of the month as a whole.

Given the potential volatility caused by the small sample, we do not propose to explore the movements in great detail. However, there are some movements which raise interesting conceptual issues.

In August 2003 a large proportion of delays were caused by the unusually hot weather, which led Network Rail to introduce speed restrictions, causing substantial delays. If we consider safety to be an aspect of quality then it is unclear whether these delays should be included in the index as deterioration in quality. In practice we are unable to determine which services were delayed by the speed restrictions, and which were caused other factors.

While the unadjusted index remained relatively flat into November 2003, the adjusted index rose sharply, and then fell back in December. Network Rail attributed the additional delays to a combination of poor weather and leaves on the line resulting in poor rail conditions. Given a larger sample, this is the sort of seasonal movement that we would expect to fall out in the annual comparisons.

June 2004 saw substantial engineering work being carried out on a major line. This forced passengers to use alternative routes which, while they took longer, cost less (The RPI itself saw a small downward effect from changes in the cost of passenger transport by railway). The quality adjusted index fell less sharply than the unadjusted index, reflecting the deterioration in quality. The quality change would have been more evident if not for the fact that the month saw very low delays on other routes. Finally, it should also be noted that whilst engineering work causes disruption in the short-term, its longer-term pay-off should be reduced disruption and improved services.

Usually if two train operators provide services on the same route, they charge the same fare. However, there are exceptions to this. A large portion of the fall in the index in September 2004 is due to the representative journey switching from one train operator to another with lower fares as a result of engineering works. This is a clear example of a movement which would not be so dramatic in a much larger sample.

The first six annual growth rates are shown in Table 4. These should remove some of the seasonal effects of the sample. We see that the adjusted index has generally grown slightly slower than the unadjusted index, suggesting that quality has marginally increased.

Table 4
Annual growth rates of price indices

Per cent

	Adjusted	Unadjusted
Aug-04	*3.2*	*5.2*
Sep-04	*2.7*	*2.4*
Oct-04	*4.5*	*4.5*
Nov-04	*2.8*	*4.5*
Dec-04	*4.4*	*4.5*
Jan-05	*6.0*	*6.9*

Conclusion

At present ONS is concentrating on expanding the coverage of the CSPI and improving the measurement of the government sector. However, this article represents early stages of a potentially large work programme into the wider quality adjustment of services. We would be extremely interested to hear users' opinions on this work. It is possible to draw some conclusions from this limited initial study:

- Hedonics may be suitable for some services (such as software or equipment hire). However, for those areas where it is not suitable, the valuation of time may be an option to explore.
- It seems likely that data collection for service sector quality will be more time intensive than for goods. We can not simply assume that the quality as measured on one day is representative of the month as a whole.
- However, this could be mitigated if the data could be collected automatically from administrative or regulatory datasets. For example, access to the performance data held by the Office of Rail Regulation would enable a much larger and more representative sample to be monitored, making the quality measure more accurate.
- Using the value of time for quality adjustment is technically possible but further work is required to establish the valuation to be used and the sensitivity of the final results to the valuation.
- It is important to remember that there are often several aspects of quality in services, as in goods. The quality adjustment needs to be able to take into account possible trade-offs between these factors.
- While the value of time is a relatively flexible methodology, there are areas where alternative methodologies need to be considered. For example, one important facet of quality missing from this study is over-crowding. One option may be to study the willingness of rail users to pay for a seat.

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