X-INEFFICIENCY IN BRITISH RAILWAY ENGINEERING

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ABSTRACT

Over the last decade, British railway engineering has come under increased scrutiny, with general perceptions of massive maintenance cost escalations and a general lack of control over these costs. Very little however has appeared in the academic literature on the subject. This paper examines these two issues through an examination of the infrastructure costs over the period 1980 to 2008. This period saw three different infrastructure management regimes in place - the nationalized British Rail (1980 – 1994), the privatized Railtrack (1996 to 1998) and the not for profit Network Rail (2002 to 2008).

Infrastructure costs are broken down into operating, signalling and management costs. The results show that in all categories costs have increased since privatisation, but in most cases these increases are considerably short of most of the figures reported in the press. Furthermore, some of these cost increases actually began under the nationalised structure. The one major exception however is management costs, which have rocketed. This is found as clear evidence of x-inefficiency in infrastructure provision, however rising operational costs are found to be due to imperfect competition in sub contractor markets driving up costs. The paper concludes that rail infrastructure provision may well now have the worst of both worlds, with the subsidy of the public sector sustaining imperfect competition in the private sector.

Keywords: rail infrastructure management, x-inefficiency, privatisation, imperfect competition

INTRODUCTION

Over the last decade, British railway engineering has come under increased scrutiny, with general perceptions of massive cost escalations and a general lack of control over these costs. Shaoul (2006) for example estimates that rail industry costs have more than doubled since privatisation, with the infrastructure provider being a major contributor to this increase. Very little however has appeared in the academic literature on the subject. This paper reviews costs over the period 1980 to 2008, a period which encompasses three different infrastructure management regimes - the nationalised British Rail (1980 – 1994), the privatised Railtrack (1996 to 1998) and the not for dividend Network Rail (2002 to 2008e).

This is then considered under the framework of Leibenstein's (1966) idea of X-inefficiency, through an examination of agent/principle and impactor/impactee relationships in rail infrastructure provision in an attempt to provide some form of explanation of cost increases.

One of the major problems with this research however has been in collecting data that actually allows some form of meaningful comparison of the three different ownership regimes to be made. The whole issue of data collection in the British rail industry however appears to be highly problematic. To give a simple if trite example, in the 2006 edition of the annual publication 'Transport Statistics Great Britain' (DfT, 2006), some 500 kilometres of the nation's rail infrastructure appears to have disappeared between 2003/4 and 2004/5 due to a break in the series caused by 'a change in methodology'. This begs the question of how many ways can there be to measure the distance covered by the rail network? It also raises the question that if such a simple measure can produce an almost 4% cut in the length of the network, then how are things likely to be with more complex issues? Furthermore, Shaoul (2006) also highlights the difficulty in obtaining relevant and consistent data from the train operating companies, the (then) SRA and from government statistics. Nevertheless, what is presented in this paper are comparisons that are, as far as possible, believed to be 'realistic', although some margin for error to allow for measurement differences should always be present in any such analysis.

PRIVATISATION OF BRITISH RAILWAY INFRASTRUCTURE

With firstly the White Paper, New Opportunities for the Railways (HMSO, 1992) and then the Railways Act 1993, the whole railway services sector within Great Britain was transferred to the private sector, including both assets and operations. As this whole process has been well documented elsewhere, this section only focuses on the position of the infrastructure in the privatised structure. Prior to privatisation, British Rail (BR) was divided into some 6 business sectors, three for passenger, two for freight and one for post. Train infrastructure costs were allocated on a prime user basis, where the prime user of a given route bore all the fixed and marginal costs of the infrastructure, with other users only paying their marginal costs. All maintenance and engineering works concerning the infrastructure were carried out by a separate division within BR, British Rail Infrastructure Services (BRIS). Consequently, all track and signalling costs were accounted on a national basis and shown separately in the BR accounts. In restructuring for privatisation, the entire rail infrastructure was transferred to a separate division, and infrastructure costs paid on the basis of a full cost access charge for all users. BRIS was split up into around fourteen infrastructure service companies (Infracos), eight for maintenance and six for renewals. The infrastructure division was then floated on the Stock Exchange in April 1996 and sold for £1.9bn and the Infracos sold to the private sector in private sales. The 'plan' was that Train and Freight Operating Companies would pay the full cost of infrastructure access, with the access charge being made up of an 'access' charge, i.e. a fixed access fee, and a variable charge dependent upon the distance travelled and rolling stock used. Railtrack would contract out all of its maintenance and renewals to the Infracos. Due to the monopoly position of Railtrack, access charges were regulated by the Office of the Rail Regulator on the basis of a fixed percentage of the value of the asset base (originally 8%). These were set over five year control periods, the first running from 1995 to 2001 and the second from 2001 to 2006.

Under this structure, efficiency improvements in infrastructure maintenance and operation would be driven by a single (regulated) purchaser (Railtrack) of railway infrastructure maintenance/renewals contracting this work out. Eight and six companies respectively would bid for this work, hence ensuring that costs decreased and competition in infrastructure maintenance would ensure that costs remained at a low, i.e. cost efficient, level.

EFFCIENCY AND PRODUCTIVITY IN RAIL INFRASTRUCTURE

As may be imagined, research on the subject of the efficiency/productivity of rail infrastructure provision is very scarce and patchy due to the fact that there was little interest or indeed opportunities to study the topic prior to the Swedish (then highly radical) division of infrastructure from operations in 1988. The first study of note was the NERA report (2000) undertaken for the then UK Office of the Rail Regulator to examine efficiency in the provision of infrastructure. NERA examined five countries (America, Canada, Australia, Japan and Sweden) selected on the criteria that a significant proportion of services had been split from operations. Most of their analysis however concentrated on US Class 1 railroads. Whilst accepting that differences in both traffic mixes and densities could significantly affect the cost of infrastructure provision, they concluded that a productivity improvement of between 3.3% and 3.9% found from their analysis of US railroads was the ‘true’ value of long term productivity growth in infrastructure provision. Whilst unquestionably providing a benchmark figure, its transferability to a European context may be more problematic due to the relatively low tech and low density of US railroads. In the more technically advanced and heavily used rail systems found in Europe, the potential for such productivity growth may be less attainable as ‘simple’ productivity gains may be far more difficult to achieve.

The NERA report makes reference to an earlier study by LEK (1999) undertaken on behalf of EWS (the main UK heavy haul freight operator at the time). LEK compared Railtrack’s infrastructure charges to EWS with the five largest US Class I railroads, and also analysed changes in productivity since the American Staggers Act (i.e. de-regulation) in 1980. Based upon single ratio productivity measures, LEK found productivity improvements to be an average of 6.7% over the nineteen years reviewed. Nevertheless, this approach to productivity assessment was heavily criticised by NERA (2000) as failing to account for economies of density, which in this case arose from a combination of increasing traffic volumes and route rationalisations arising from company mergers, which would lead to an over exaggeration of the estimated productivity improvements. The estimated figure is also considerably above the findings of a desktop exercise on the impact of US deregulation on productivity carried out by Cowie (2010). He found the short term impacts of Staggers on productivity to be of the order of 6/7%, however most research reviewed suggested longer term productivity increases of around 3%.

Booz Allen and Hamilton Consultancy (2000) in a commissioned assessment of Railtrack’s own efficiency savings forecast of 1.5% (Railtrack 1999), undertook what they described as a 'bottom up' approach of examining spending needs by expenditure category (business segment). In a report very critical of Railtrack's asset management, BAH derived a target figure of between 4 and 5% for efficiency gains for Railtrack in the period 2001 – 2006. This would be achievable through a combination of 'catch up', i.e. the firm adapting to the practices of a private sector company, and long term improvements in the efficiency of infrastructure provision. The authors identified that the latter effect would arise from the four main areas of improved contractual relations, improved supply chain management, the introduction of new technology (both hard and soft) and finally through improved internal organisation.

More recently, Kennedy and Smith (2004) examined the efficiency of the privatised Railtrack through estimation of a distance function by comparing Railtrack's seven geographical zones over a period of seven years. In summary, the authors concluded that Railtrack achieved efficiency gains in the order of around 8% per annum over the period reviewed, although most of these cumulative savings were offset by post Hatfield unit cost increases. Nevertheless, through their internal benchmarking approach they suggest that an overall efficiency target of around 13% would not have been unreasonable for the Regulator to set Railtrack.

Summarising past studies of efficiency and productivity of rail infrastructure provision, these have found a very diverse range of estimates of actual and potential productivity gains. Whilst undoubtedly different traffic mixes and densities indicate that there is no one 'general' figure that may be applicable in all situations, estimates of 1.5% annual increases would appear to be on the low side, whilst estimates of around 13% on the high. What should be highlighted however is that estimates such as the NERA (2000) figure of around 3.5% productivity annual increase have been achieved in growing markets where productivity gains may be easier to achieve. For example, 3.5% cumulated over 13 years (the time period of the study) results in a total productivity increase for the whole period of just over 56%, a phenomenal improvement. The growth in traffic levels however over that same period was around 51%, thus what was the actual increase in the productivity of the infrastructure? The question only arises due to the administrative division between infrastructure and services, whilst in reality a rail network is a complete system i.e. one in which it is difficult to isolate the performance of the individual components. This highlights some of the issues and difficulties involved when undertaking this type of analysis on the productivity of rail infrastructure. Furthermore, when put in the context of a growth in traffic of 51%, a 56% productivity growth does not seem particularly notable. However, if a 56% improvement in productivity had been achieved with constant traffic levels, that would represent a remarkable productivity improvement. Thus productivity figures need to be viewed in the context, specifically the prevailing market conditions, in which such gains are achieved. This issue is further developed in Appendix 1.

DATA SOURCES AND ISSUES

In order to consider costs under the three different regimes of British Rail, Railtrack and Network Rail, the data used in this research comes from a variety of sources. Beginning with data on the nationalised British Rail, this came from the BR Annual Reports from 1980 through to the final BR report of 1994. These present total operating costs broken down by activity, and included costs under the following main headings: operations - operation control, area management, control, signalling operations; infrastructure - track and associated structures, signalling, telecommunications. This division of costs allowed infrastructure costs to be isolated for the purposes of this analysis. The management costs of BR were also found in the Annual Reports and only refer to the (whole) Rail Group.

Costs relating to Railtrack proved far more problematic, as the Railtrack Annual Reports provided very little detail as regards specific costs. The main source therefore is the BAH Report (Booze, Allen and Hamilton, 1999) which was produced for the Rail Regulator. For the years 1996 to 1998 this included expenditure under the following headings: expenditure on operating, maintaining and renewing network. Management costs were also found in the BAH report, however signalling costs had to be estimated on the basis of signalling staff wages, as BAH (1999) highlight that staff costs dominate this expense.

Network Rail costs for 2002 to 2008 came from the Regulatory Financial Statements (see for example Network Rail, 2004) which include costs under the following headings for all years except the last three: maintenance, track, train control, electrification, other OPEX own costs, signalling staff cost, other staff costs, other production and management costs. The statements from 2006 onwards only contained two headings; total maintenance and operating expenditure, hence the series which broke down the staff costs was no longer continued, hence management and signalling costs could not be separately analysed.

The intervening years were estimated through simple extrapolation of the data, and are included for simple completeness; however none of the analysis is based upon these estimated figures.

Whilst undoubtedly different ownership regimes will have differences in the accounting practices used and hence the figures could never be used for highly detailed cost comparisons[1], they are believed to be of a nature to allow broad comparisons of the costs under the three different ownership regimes to be made.

RESULTS

The results of the analysis are presented below. Firstly, total operating cost of the infrastructure is analysed for the period 1980 to 2008, signalling costs are then briefly considered before management costs are examined. All evaluations are based upon standardising the data by three operating statistics related to the infrastructure – route kilometre, train kilometre and passenger kilometre, and then changes since 1980 (=100) are tracked through index numbers. As regards the three measures, train movements as measured by train kilometres are probably the main measure through which these costs should be standardised, although there are arguments for all three to be used hence all three are included.

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[1] Indeed this is no different from any other cost analysis contained in cross sectional or panel data, as this is no different from accounting variations between firms.

Figure 1 shows the changes in total infrastructure costs, both operating and maintenance, as standardised by route, train and passenger kilometre for the period 1980 to 2008.

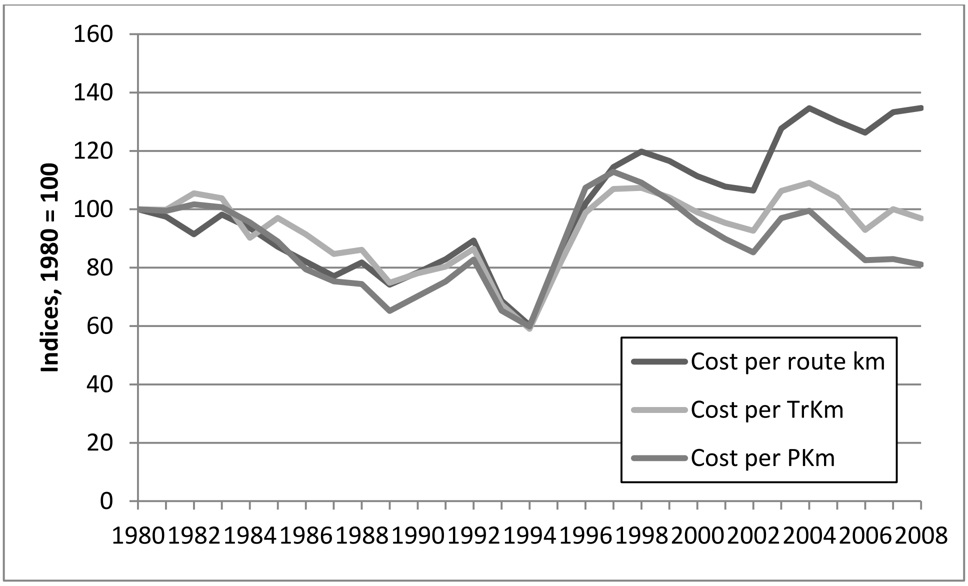

Figure 1: Change in total Infrastructure Costs by route, train and passenger kilometre

The results show a fairly ‘chunky’ type pattern, which in some ways is to be expected given that a large element of total operating costs is maintenance that can either be delayed or advanced given the prevailing financial climate. Nevertheless, several very clear patterns emerge. Over the first part of the period reviewed, 1980 to around 1989, total infrastructure operating costs fell to around 75% of their 1980 level in real terms. To that point, the general trend had been downwards, and this pretty closely matches the Organising for Quality (OfQ) restructuring process in BR at that time. After 1989 however, fairly significant cost increases emerge, with costs rising every year to around 85% of their 1980 level, before falling once more in the run up to privatisation. This restructuring period can be largely discounted in the overall pattern as they do not reflect a ‘steady state’ and hence no real trend implications can be implied. Railtrack ownership in 1996 represents a significant increase in costs, putting cost levels effectively back to their 1980 levels. Costs then further increased in the following two years. Interestingly however, whilst completely subjective, it could be argued that this increase in costs was simply an extension of the trend originally started during the latter days of BR ownership.

After 1998 the downward trend can be largely ignored, as this is simply based upon interpolated data. At the end of the whole period, total infrastructure operating costs, certainly when measured per route kilometre, appear to be significantly higher under Network Rail than either Railtrack or BR. By the end of the period reviewed, costs are some 30% higher than BR 1980 and 80% higher than BR 1989. When standardised by one of the other two ratios however, then by the end of the period they are around their 1980 level, although some 40% above BR 1989 under both measures. Furthermore, due to the large increases in train kilometres, some 26% higher than in 1989, this may actually underestimate the extent of cost increases due to economies of density, which are completely ignored in this analysis.

Research by Preston (1994) for example identifies such affects as being significant in railway operations.

A final point to note from Figure 1 is that cost increases appear to be associated with change, whether that be with the change from BR ownership to Railtrack, or Railtrack to Network Rail. Whilst some increases in costs are bound to be associated with restructuring, particularly with the first change, these appear to be more than simply that and are too long lasting to be simple restructuring costs. This may reflect change in aspirations as custody changes from one organisation to another and a lessening of downward pressure on costs, i.e. increased x-inefficiency.

The second component of operating the infrastructure is controlling traffic movements on it, and this is done through operation of the signalling system. These costs are again analysed over the three periods of BR, Railtrack and Network Rail ownership. Again this is done through expressing costs as a standardised unit in the form of route, train and passenger kilometre. In this case however, as with the final component examined in management costs, this series ends in 2005, because as highlighted beyond 2005 these costs were no longer shown separately in the regulatory financial statements.

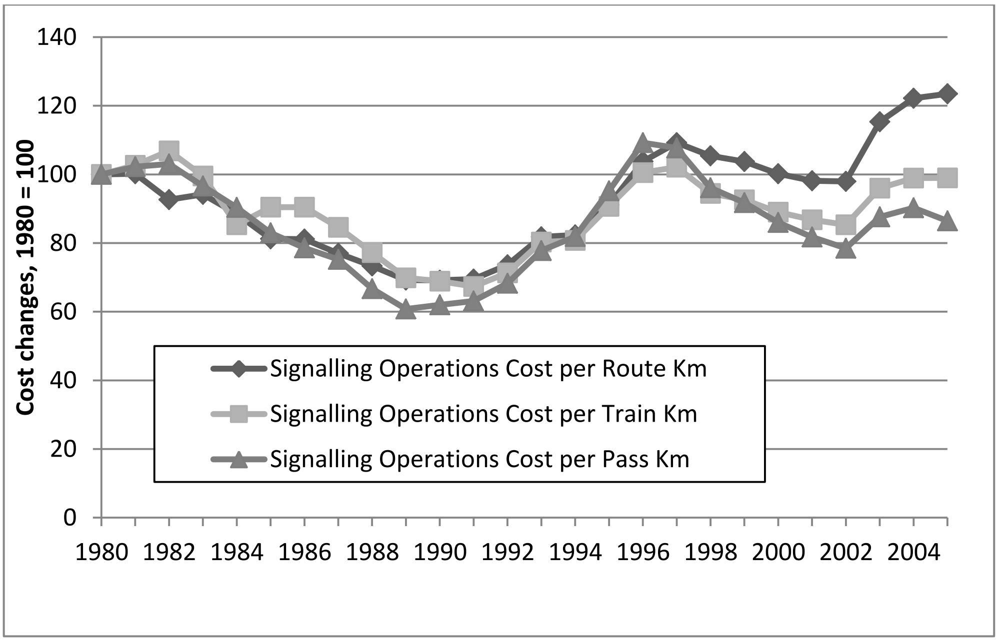

Figure 2: Change in signalling Operations Costs by route, train and passenger kilometre

Although not immediately obvious from Figure 2, the overall pattern is considerably ‘smoother’ than the figures relating to infrastructure operations and maintenance, which given the more ‘continuous’ nature of signalling operations is to be expected. This is also reflected in the continuous trend over the period of restructuring in 1993 and 1994. Beyond that however, there is actually very little in this figure to comment upon. The overall patterns are the same as before, with cost reductions under the period of BR during the OfQ initiative, costs rises in the latter period of BR ownership. Costs then rose significant under Railtrack, although not as high as for infrastructure operations, and finally the maintenance of high cost remains under Network Rail.

The final set of costs considered relate to management expenditure. Of all of the cost comparisons in this section, these are by far the least comparable, however this will be more fully outlined later. To begin, the change in total management costs per route, train and passenger kilometre are shown in Figure 3 below.

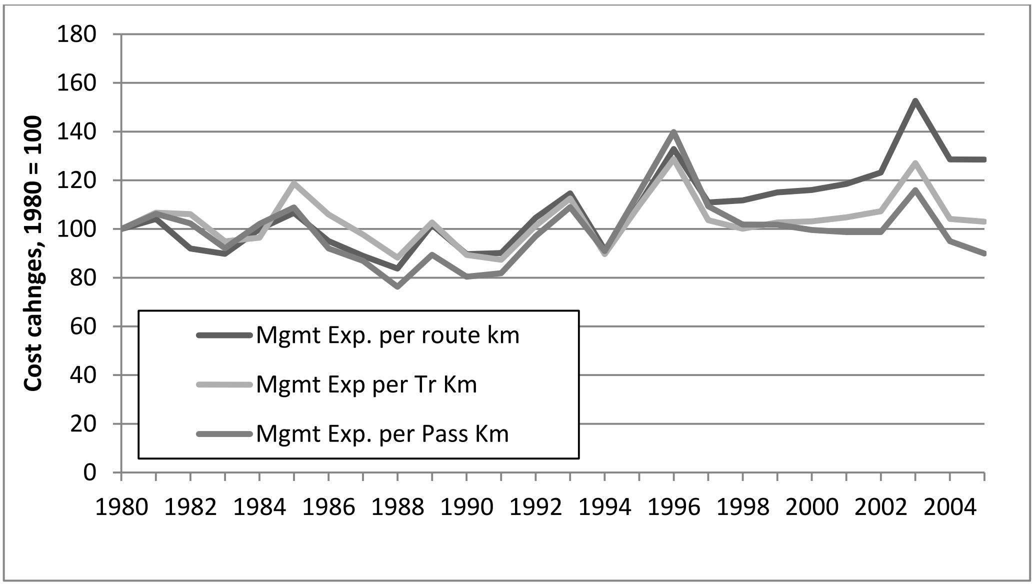

Figure 3: Change in Management Expenditure per route, train and passenger kilometres, 1980 to 2005.

Figure 3 does not initially paint too pessimistic a picture, with management costs per train kilometre at around about the same level at the end of the period under Network Rail as with BR at the beginning of the period. Cost increases during restructuring for privatisation and the Railtrack administration are also clearly shown on the graph. The problem however is that the BR management costs refer to the whole of BR, train services and operations, and not just the infrastructure. From 1995 onwards however, management costs under both Railtrack and Network Rail relate solely to the management of the infrastructure. In order to increase comparability therefore, BR management costs have been apportioned on the basis of staff numbers i.e. scaled on the basis of the percentage of staff employed in infrastructure and signalling operations. Dividing management costs in such a manner is undoubtedly an oversimplification of the problem and almost certainly will produce an underestimate of the costs involved as it completely ignores the concept of overhead[2], and this should be noted in the following analysis. Figure 4 provides these pro-rata comparisons.

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[2] Nevertheless this method actually apportions a significantly higher percentage of management costs onto infrastructure than the only other alternative that could have been used in this analysis, which is one based on the share of total operating costs accounted for by infrastructure and signalling operations.

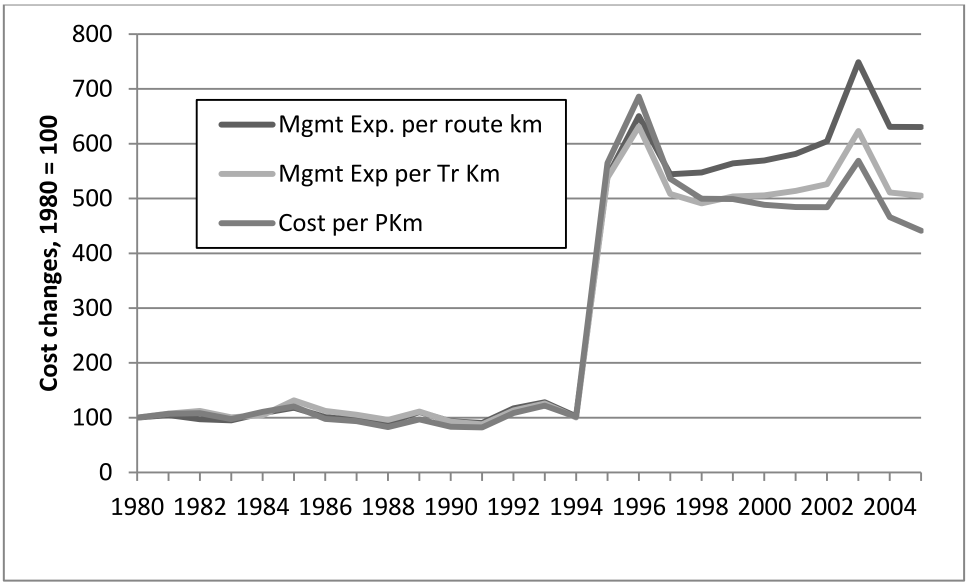

Figure 4: Change in Management Expenditure per route, train and passenger kilometres, 1980 to 2005, BR Mgmt cost apportioned on staff numbers.

Whilst the figures presented in Figure 4 should be considered as over-estimates of cost escalations under private ownership, they do nevertheless present a radically different picture from Figure 3. Figure 4 shows massive rises in management costs, increasing by over a factor of five and when measured by route kilometre (which has remained fairly consistent over the period reviewed), have continued to rise since privatisation to now stand at over six times higher than under BR. It is also interesting to contrast that while management costs appear to be the area where BR made the least ‘efficiency’ savings, it is the same area that has seen massive increases since privatisation.

Due to the incompatibility of the management costs over the three ownership periods however, all that can be clearly concluded from Figures 3 and 4 is that the cost of managing the infrastructure has risen by somewhere between 3% and 505% when measured per train kilometre. No other clear ‘evidence’ can be presented. However even assuming that the apportioned figures significantly understate BR’s infrastructure management costs, it is clear that there has been a massive rise in these costs. The Transport Select Committee (1995) for example estimated that total interface costs for the whole ‘new’ railway to be in the order of £700m a year, of which a large proportion of these will represent management expenditure on the infrastructure.

DISCUSSION

The results as presented show significant cost increases in rail infrastructure provision since the break-up of the state owned operator and the creation of a market in rail infrastructure maintenance services. Is this therefore evidence of x-inefficiency (Leibenstein, 1966) in rail infrastructure provision? X-efficiency theory highlights the importance of the environment impacting upon an individual’s work effort and hence under a certain set of circumstances an individual may fail to maximise effort. The classic example used to underline the concept is a large state owned monopolistic enterprise, ironically such as BR. Such a working environment is said to produce low rewards to management and the workforce, a loss of the sense of the individual and removes the threat of bankruptcy, hence leading to a reduced effort and the failure to adopt ‘best practice’. Leibenstein highlighted seven potential sources of x-inefficiency, two of which appear to be particularly relevant to this study – agent-principle relationships and impactor/impactee relations (Leibenstein, 1966).

Beginning with a review of management costs, if the rather bold assumption is made that the basic underlying cost of managing the infrastructure has not fundamentally changed[3], then all of the increase in management costs must have resulted from x-inefficiency introduced into the system through agent-principle relationships i.e. interface costs. The fragmentation of the rail industry has led to a vast increase in the number of agent-principle relationships within the sector and the infrastructure provider lies at the very centre of this increased complexity. Furthermore, the nature of impactor/impactee relations has also fundamentally changed. Whilst before there was one controlling body, the British Railways Board, that closely co-ordinated all of the various activities required to produce rail services, in simple terms these relations have now been externalised and divided. As a result, impactor/impactee relations have either become far less clearly defined or completely changed in nature and as a result have become far more costly to manage.

The counter argument of course would be that such management cost increases ‘should have been’[4] more than off-set through efficiency improvements in the actual maintenance of the railway. Consolidation of the Infracos however has resulted in a lack of competition to drive these costs down, and in fact the reverse appears to has occurred. Furthermore, the ‘transfer’ of the narrow knowledge base in the industry to the private sector, coupled with other practices such as the exclusive leasing of track maintenance rolling stock from the ROSCOs, has effectively created a mini-monopoly in rail infrastructure maintenance. Maintenance cost increases would therefore simply appear to be as a result of imperfect competition in the rail infrastructure industry rather than evidence of x-inefficiency.

CONCLUSION

This paper finds clear evidence of x-inefficiency in the management of the rail infrastructure, which has led to significant increases in management costs. With regard to actual maintenance and operating costs however, whilst costs have also significantly increased, there is less evidence that this is as a result of x-inefficiency but rather more as a consequence of imperfect competition in sub contractor markets. The privatisation of rail infrastructure has allowed market forces, which had previously lain dormant under public ownership, to come into play in the running of the rail infrastructure. What this has created is an imperfect market in rail infrastructure maintenance, and hence in simple terms cost ‘escalations’ are a result of the value of rail infrastructure maintenance now more accurately reflecting its true market value. The implication of course is that it had been considerably undervalued whilst in the public sector. However in an industry that is subsidised to the tune

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[3] In other words, the basic management cost involved of a train running on the infrastructure, which must still be present under the current structure.

[4] A very loose reference to ‘efficiency improvements’ referred to in the Government’s White Paper “New Opportunities for the Railways” (HMSO, 1992).

of around £4bn a year, it does raise the issue of what actually constitutes the ‘true’ economic value as opposed to the current market value. It may well be that the provision of rail infrastructure now has the worst of both worlds, the subsidy of the public sector sustaining imperfect competition in the private sector.

APPENDIX ONE – PRODUCTIVITY IN BRITISH RAIL INFRASTRUCTURE PROVISION, 1976 TO 1991.

The literature review identified that all studies on rail infrastructure provision had been based on assessments of productivity where the market had been growing, thus in some ways it is difficult to determine the extent to which gains result from the efforts of management or through increases in output. Note however that this discussion was not based on any returns to scale argument, but rather that in very simply terms inputs tend to be sticky downwards but far more flexible upwards. Productivity performance may therefore be expected to improve in an expanding market as opposed to a declining one. As a result, this appendix examines this issue further through an estimation of BR productivity in infrastructure provision over the period 1976 to 1991.

Productivity measures were derived through the calculation of DEA efficiencies over the whole period of the study. It is not proposed in this brief appendix to outline the method used, as this can be gained through a number of books (see for example Charnes et al 1995 or Coelli et al 1996) or other academic papers (see for example Golany and Roll 1998). Put briefly, DEA is an iterative set of linear programming problems in which the efficiency of the unit under consideration, referred to as a Decision Making Unit (DMU - which in this case of course will refer to an individual year), is maximised. This is subject to the constraint that no other DMU in the dataset exceeds 100% efficiency when the same weights are applied to the output/inputs ratio. The method has been extensively used to estimate efficiencies and productivities in the transport industries (see for example Cowie 2002). In this example however, as only one firm is under investigation, it makes little sense to talk about 'efficiencies'. Furthermore, as a constant technological frontier is assumed, what the DEA efficiency 'scores' actually represent are total factor productivity (TFP) indices, and what is calculated are Malmquist productivity indices (Coelli et al, 1996).

Two outputs in the DEA model were specified to assess productivity changes over the period – Train kilometres and Track (as opposed to Route) kilometres. The basic logic behind including these two outputs in the assessment are that firstly the final output of a rail infrastructure system is the production of train services, and hence the level of train kilometres is a measure of the technical efficiency of the network. Secondly, in simple terms a more extensive network in terms of track kilometres would require a higher level of maintenance, and hence adjustments need to be made for variations in track kilometre. As outside of the first few years the length of the network varies very little, the 'primary' output (i.e. the one that is most responsible for variations in productivity) will be train kilometres. The inputs specified were the total number of BR staff employed on permanent way and signal telecommunications operations and the total cost of the track and signalling railway activity. Both input variables may be considered to be proxy variables for what would be ideal measures of the inputs of railway infrastructure provision, namely labour hours and other maintenance activities. The main problems with the inputs used are that firstly they do not relate exclusively to the maintenance of the permanent way but also include signalling, and secondly there will be a degree of correlation between the two as staff costs will be included in the maintenance costs. The signalling system however is an important part of infrastructure provision, as it controls train movements throughout the network and as such is an important component of infrastructure productivity. Furthermore, what is important in this analysis are the overall trends, hence as long as there is a high degree of consistency over the period analysed then any problems with using these proxy inputs variables should be minimised.

Using these two outputs and two inputs produces the following TFP profile of infrastructure provision in the nationalised British network from 1966 to 1991:

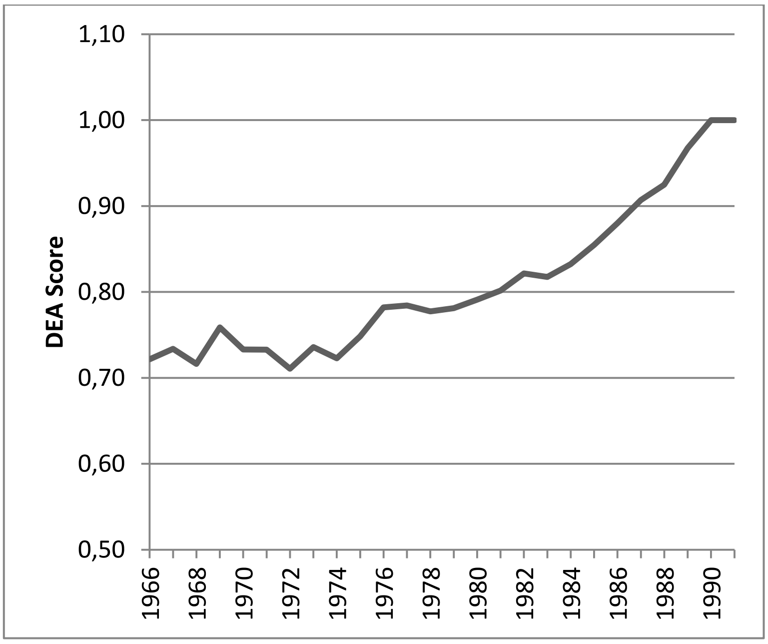

Figure 5: British Rail Infrastructure Total Factor Productivity, 1966 to 1991

When calculated over the whole period shown, productivity of the infrastructure increases each year on average by around 1.3% per year. What Figure 5 also shows however is a fairly 'lumpy' profile for the early period up to around 1978, but thereafter very strong and fairly consistent gains in productivity are achieved, particularly from 1984 onwards. This was the beginning of the 'Organising for Quality' era in BR, or more explicitly when a more market focused approach was taken. It is also true however that 1984 represents an albeit arbitrary division of the whole period into two – the first of railway 'decline' (pre 1984) and the second one of 'recovery' (post 1984). This is evidenced by the fact that 1984 was the lowest level of train kilometres outside of the 1982 strike year. By splitting the time period into these two intervals at 1984, productivity increases during the early period of 'decline' are in the order of 0.8% p.a., whilst from 1984 onwards productivity improvements are considerably higher, with an average annual improvement in the order of 2.4%. Growth therefore was particularly stronger during the period of recovery. This also matches the period of the 'Lawson Boom', which was a period of high unsustainable economic growth boosted by the then Chancellor, Nigel Lawson, which led to increased passenger numbers on the railway and significant reductions in the levels of subsidy paid to BR. The Intercity sector for example was entirely unsubsidised and there was talk of setting zero subsidy targets for Network South East.

In order to highlight the individual years further, Figure 6 presents a year-by-year breakdown of annual productivity improvements using a 3 point moving average in order to smooth out the major fluctuations in productivity growth.

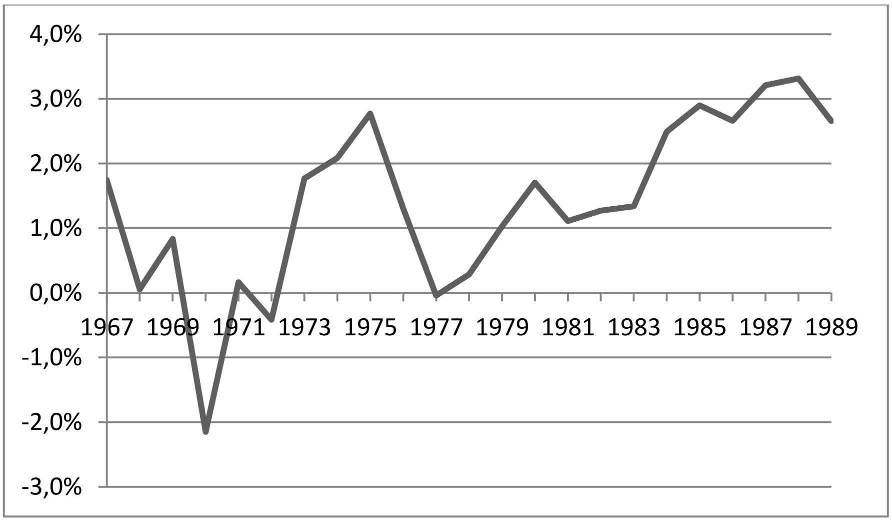

Figure 6: British Rail Infrastructure Provision, Year-on-Year Productivity Improvements

This graph simply underlines the discussion above. The early part of the period is characterised by some 'downsizing' in the British rail network as the Beeching era drew to a close, and rail infrastructure productivity improvements in this declining market are very low. Once the major closures had been completed by the mid to late 1970s, there is some strong growth, although again in the late 70s to mid 80s productivity decreases. This period was characterised by major economic/industrial problems in the late 1970s, including the winter of discontent in 1978, and a severe economic recession in the early 1980s. The mid to late 1980s then sees very strong growth in productivity, with annual figures of between 2 to 3 %.

To conclude this brief appendix, in the period of 'decline' the results relating to British Rail infrastructure provision suggest that productivity gains of around an average of 0.5% p.a. were achieved. In the latter period of expansion, productivity improvements averaged at around 2.4% p.a. Both of these estimates are considerably under what has been identified in the literature as long term productivity improvement targets in studies based upon American Class I railroads. This would suggest that the more technically sophisticated and densely used rail infrastructure networks of the primarily passenger orientated European railways simply cannot sustain such high levels of productivity growth in the long run. Targets of around 2 to 3% in an expanding market would appear to be more realistic, whilst in a declining market targets would be expected to be significantly lower, around 0.5 to 1%.

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