# Maintenance Incentives under Different Infrastructure Regimes

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*Abstract*

An increasing issue in privatised infrastructure is the appropriate incentives needed to ensure adequate maintenance of the infrastructure as a public resource. This paper explores the implications of some of the insights from theories of regulation and contracts for optimal management of transport infrastructure maintenance with respect to the interests of different stakeholder groups: contractors, owners, regulators, governments (subsidy providers or guarantors) and users. Evidence is taken from two UK examples: the major road network and the rail network. The former is seen to be largely a successful involvement of private capital through PFI-style DBFO deals which has had positive impacts on service quality and cost to the public budget, though arguably less than could have been achieved. The rail network privatisation is seen as a failure in which maintenance was sacrificed in the interests of short-term profit. However, it can also be argued here that the real mistake was to underestimate the quality of the network inherited from British Rail. The paper concludes with some lessons and recommendations taken from the analysis of these two sets of cases.

*Keywords*: Infrastructure maintenance; regulation; asymmetric information

## *Introduction*

Much of the recent debate about infrastructure has concentrated on three main issues, the wider economic impacts of infrastructure development  which are difficult to capture in direct charges, the potential for infrastructure to be developed effectively by the private sector in the presence of risk and network effects and the scope for, and impact of, unbundling of infrastructure provision from the provision of services on that infrastructure. One further issue which has been less explored, but which has come more to the fore with experience of vertically separated, privately operated, infrastructure is that of maintenance. What defines the optimal level of maintenance for an infrastructure and what incentives exist to ensure that the infrastructure operator maintains the infrastructure in this optimal state? In this paper we explore some of the issues surrounding this question with particular reference to the experience of the use of the private sector in highways and railway infrastructure in the UK.

Private sector involvement in the two sectors has been different (see Vickerman, 2003, for a more detailed discussion of these arrangements). In the highways sector there have been two basic approaches. Major highways are the responsibility of the Highways Agency, an arms-length organisation responsible to the Department for Transport, which is charged with the development and maintenance of the motorways and other major trunk roads. Lengths of this network have been developed by private sector developers under DBFO schemes in return for which shadow tolls are paid. Major bridges have been developed through fixed term franchises or concessions under which the concessionaire develops the new infrastructure and receives real tolls for a fixed period, typically 20 years, after which the bridge reverts to the state. If the initial investment is amortised in a shorter period the asset reverts at that time. A similar arrangement applies to the UK first fully privately developed toll road, the M6 Toll, which opens for traffic in January 2004 to alleviate congestion on a parallel untolled motorway to the north of Birmingham. In these cases tolls are regulated by the government.

In rail, as part of the privatisation of British Rail, the core infrastructure was transferred to a privatised company Railtrack plc, which received revenue for track charges and was charged with the development of the rail network. Initially this was to be a purely commercial arrangement, subject to the regulation of charges, but subsequently a Strategic Rail Authority was created to prioritise and oversee the development of the network. This arrangement proved to be unviable and the assets were ultimately transferred to Network Rail, a not for profit company.

In both cases the maintenance, as well as the long-term development of the network, is a key issue in which the public sector has a series of key interests. Poor maintenance implies a poor quality network in which the user is unable to receive the proper value for the toll paid.

This arises either through the need to schedule excessive maintenance repairs on poorly constructed infrastructure which leads to congestion, or in some cases compete closure leading to lengthy diversions and time loss; or through potential damage to vehicles or rolling stock. More seriously poorly maintained infrastructure leads to safety problems, a higher risk of accident and hence additional costs of risk of injury or death. The public sector has a direct financial interest in many cases since it is responsible for direct payment of shadow tolls or of guaranteeing the payment of access charges where rail operators' revenues are reduced or costs increased due to maintenance problems. The public sector is also the ultimate regulator and has to establish standards relating to delays and minimum safety standards.

For the infrastructure provider there are two issues. The first is the appropriate construction standard to be employed in order to minimise lifetime construction and maintenance costs. Better initial construction implies higher initial costs, but lower maintenance costs, for a given forecast level of traffic. If traffic is greater than that forecast, or consists of a different composition, for example relatively more heavy freight traffic than expected, then the lifetime of the asset may be shorter and incur higher maintenance costs. The second is how to manage the maintenance. There may be potential benefits in devolving maintenance to a specialist. The Highways Agency has done this in two ways. One has been to transfer a larger part of the network to the DBFO company responsible for new investment so that it become responsible for the operation of a complete link of the network even where the new investment is only part of that link. The second is to let maintenance on an existing link of the network to a private sector company. The latter approach was widely used by Railtrack for the rail network. The problem is then what objectives to set such a specialist maintenance company.

Whilst popular discussion may concentrate on issues such as whether private sector infrastructure operators will put profits before safety, the basic questions to be answered are more complex than this. Putting profits before safety implies that there would be no revenue implications of operating an unsafe or under-maintained network, or at least that these implications would be smaller than any cost saving. Since most infrastructure has an expected life greater than the typical franchise granted to an operator there might be an incentive to depreciate the asset more rapidly if there is no penalty for the condition at the end of this period. This requires consideration of how long the operator has control of the network and the conditions imposed on the state of the network at the end of that period – most franchises refer rather vaguely to the infrastructure being transferred in good working order.

How is the state of an infrastructure network defined? This requires some measure of its performance in terms of delivering the service required, but those maintaining and operating networks will have better knowledge of their long-term potential to deliver a given level of service than those regulating that provision. Thus there is asymmetric information facing any regulator and contracts transferring a network between owners are likely to be incomplete. This occurs both ways in that there is just as great a question over how far Railtrack (and more particularly those investing in Railtrack plc) knew the true state of the network as did Network Rail as its successor. How does a government agency assess the state of an estuarial bridge or a road link on the completion of its franchise; how will the governments assess the condition of the Channel Tunnel at the end of a 99 year franchise?

These are the basic questions to be evaluated, in the following section we outline the theoretical considerations raised by these questions.

*Theoretical considerations*

A basic model of incentive structures in a regulated market has been set out by Laffont and Tirole (1993). The key elements of such a model are to identify the amount of effort which an agent will employ to fulfil the contract let by principal and, conversely, how the principal can formulate a regulatory structure to ensure that the agent will deploy the effort the principal wishes to see. In a world of perfect (and symmetric) information and no risk this would be a trivial problem. In a more realistic world there is risk and the effort which the agent employs is typically unobservable directly by the principal. Assuming the agent is risk averse the effort which the agent employs is likely to be less than that which is desired by the principal.

Assume a regulatory authority, the "principal", which regulates a service developed by an operator, the "agent". The outcome is measurable ex post in terms of profit $\pi$ and depends on the effort exercised by the agent, *e,* which cannot be observed, and a random effect $\varepsilon$ with zero mean and standard deviation $\sigma$:

$$\pi = e + \varepsilon$$

Effort *e* has a cost $C(e)$ which has positive first and second derivatives. The agent is risk averse, measured by the rate *r,* and requires a minimum utility *u* to operate.

Assume that the principal pays the agent in accordance with a linear function related to the realised ex post profit π:

$$s(\pi) = \delta + \gamma\pi$$

The principal's problem is to fix $\delta$ and $\gamma$? Note that the agent derives a mean utility from the operation given by:

$$E(U_A) = \delta + \gamma e - r\gamma^2\sigma^2 / 2 - C(e)$$

Effort can be fixed, thus:

$$C'(e) = \gamma$$

The principal assumes risk aversion as follows:

$$E(U_P) = E(\pi) - s(\pi) = e - \delta - \gamma e$$

The problem is to maximise the utility, taking account of two constraints:

$$C'(e) = \gamma$$
$$E(U_A) \geq u$$

This gives:

$$\gamma = \frac{1}{1 + r\sigma^2 C''(e)}$$
$$\delta = u + C(e) + \frac{r\sigma 2C'(e)}{2} - eC'(e)$$

It is interesting to compare these results with the global optimum, which involves maximizing:

$$E(U_A) + E(U_P) = e - C(e) - r\gamma^2\sigma^2 / 2$$

and leads to:

$$C'(e)=1$$

The results and their implications can be seen in the following table:

| Characteristics of the agent and the situation | No uncertainty ($\sigma$=0) or no aversion to risk ($r$=0) | Uncertainty and risk |
|---|---|---|
| $R\sigma$ | 0 | $\neq 0$ |
| $E(U_a)$ | U | $U$ |
| $\gamma$ | 1 | $0< \gamma<1$ |
| $e$ | effort optimal: $C'(e)=1$ | effort sub-optimal: $C'(e)$ |
| $\delta$ | $u+C(e)-e$ | $u+C(e)-e\ C'(e)+r\gamma^2\sigma^2/2$ |
| $E(U_P)$ | $e-C(e)-u$ | $e-C(e)-u-r\gamma^2\sigma^2/2$ |

The "participation in results", measured by $\gamma$ is complete ($\gamma$=1) in the absence of uncertainty or with risk neutrality, and it is that which ensures optimal effort. It is reduced in the presence of uncertainty or risk aversion, and hence leads to a reduced effort and increased costs for the principal.

This analysis is based on the situation of a single regulator and operator. The situation we need to explore is that where there is further vertical separation and the agent lets a maintenance contract. The regulator requires a minimum level of service from the infrastructure, which depends on the maintenance, but only has any direct control over the infrastructure operator, who faces uncertainty and whose effort cannot be observed directly by the regulator. The infrastructure operator now becomes the principal in a second principal-agent relationship. The operator's revenue depends on the quality of maintenance, but so do its costs. It lets a contract to a specialist contractor, setting a basic objective, but again there is uncertainty and the operator cannot observe the maintenance contractor's efforts directly. This can be explored using the hierarchical organisation model developed by Caillaud et al (1996).

Expressed simply there are now three parties, the regulator (*R*), the infrastructure operator (*O*) and the maintenance contractor (*C*). *R* derives social returns *T* and sets the basic parameters of the structure which involve a bonus payment of $\delta$ if *C* meets certain criteria, dependent on *C*'s effort *a*, which incurs a cost of $\frac{1}{2}a^2$. *O* pays *C* a fixed contractual amount *s* and derives social returns $S<T$. There are differential rewards to *O* depending on whether it meets the targets set by *R*, $B_f$ in case of failure and $B_s$ in case of success. *C* makes profits $\Pi=s+a\delta-\frac{1}{2}a^2$. Assuming the marginal cost of public funds to be $\lambda$ and for *R* to have to operate a balanced budget, three alternative situations can be analysed and compared with the first best position which produces a level of welfare to *R* of

$$V = aT - \frac{1+\lambda}{2}a^2 - \lambda\Pi$$

and involves an effort of $a=T/(1+\lambda)$ and $\Pi=0$.

The three cases are termed full centralisation, uncoordinated decentralisation and coordinated decentralisation (*cd*). With full centralisation, *R* determines all the payments and has full bargaining power over all decisions. Under uncoordinated decentralisation, *R* does not intervene in the relationship between *O* and *C*, who determine the appropriate level of $a$ and payment $s$. Under coordinated decentralisation, $R$ determines $\delta$, $B_f$ and $B_s$ but allows $O$ and $C$ to negotiate on $a$ and $s$. The outcome is that $a$ is always less than the first best situation in the case of full centralisation or coordinated decentralisation, but that coordinated decentralisation is preferable to full centralisation because typically $O$ will have better information than $R$ and this reduces the cost of incentives to $C$. $R$ can set the levels of $B$ appropriately to provide an incentive for $O$ to achieve success in $C$'s efforts. Here the policies of $R$ and $O$ are complementary. In the case of uncoordinated decentralisation there will again be underprovision of effort, and $C$ derives rent from bargaining, but whether it is better than full centralisation will depend on the size of this bargaining rent and the relationship between spillover benefits and cost of incentives. The table below summarises the outcome of the three cases:

| Case | Value $a$ (effort by $C$) | Value $V$ (welfare of $R$) |
|---|---|---|
| Full centralisation | $a = \dfrac{T}{1+2\lambda}$ | $V^{fc} = \dfrac{T^2}{2(1+2\lambda)}$ |
| Uncoordinated decentralisation | $a = \dfrac{S}{1+\lambda}$ | $V^{ud} = \dfrac{S(2T-(1+\sigma)S)}{2(1+\lambda)}$ |
| Coordinated decentralisation | $a = \dfrac{T}{1+\lambda+\gamma\lambda}$ where $\gamma = \dfrac{\sigma(1+\lambda)}{\lambda+\sigma(1+\lambda)}$ | $V > V^{fc}, V^{ud}$ |

Caillaud *et al* thus conclude that it is essential to introduce some coordination between the different levels of decision making in such a structure because there are strong complementarities. If we translate this to the cases we are considering here there is support for the view that unbundling the different aspects of infrastructure provision may improve outcomes relative to a fully centralised structure, because it provides incentives to get closer to the first best optimum. A fully centralised structure suffers from the lack of information at the different levels, but that if the decentralised structure is not sufficiently coordinated the potential benefits can be lost in bargaining rents to the contractor.

In a further contribution, Buehler *et al*.(2002) examine the effects of privatisation on infrastructure quality through impacts on investment. They conclude that the lack of vertical externality in vertically segregated industries can be expected to reduce investment incentives because of the problems in benefiting from the revenue increases associated with enhanced quality. They examine this under different institutional and market structures producing results which are consistent with those of Caillaud *et al*. suggesting that even under a decentralised structure, some coordination brings benefits.

From these theoretical perspectives we can expect that regulators and operators will seek to provide appropriate incentives which maximise contractors efforts and get contractors to reveal as much information as possible to reduce asymmetry. The likely incentive structure is one which encourages revelation by making contractors share in the risks associated with any renewals or maintenance.

*Evidence*

What sort of evidence can provide us with clues as to the relative performance of different modes of delivery of maintenance? There are two elements in this which we can term the quantity and quality of maintenance. Quantity is essentially an input measure which will tell us the amount of resources devoted to maintenance, typically this will be measured by the volume of maintenance expenditure. However, higher levels of maintenance expenditure may be indicative of less efficiency in maintenance: we would expect for example that the volume of maintenance expenditure would fall with privatisation and vertical separation because of the efficiency gains to be excepted from opening up the market to greater transparency and competition. Quality is essentially an output measure in which we would expect to associate better maintenance with better performance of the infrastructure, lower levels of disruption to service and lower accident rates. We look at measures of these separately for road and rail modes.

Road

The national road network (motorways and trunk roads) in the UK is managed by the Highways Agency, an arm's length authority responsible to the Department for Transport. Since the mid 1990s the Highways Agency has been promoting two forms of private involvement in the development and management of the network.

The most ambitious is a set of DBFO (design, build, finance and operate) contracts for the construction (or reconstruction) of new links. As part of the process, in addition to the investment in the new construction, the private sector assumes responsibility for the management and maintenance of a longer section of the route. The contractor receives a payment in the form of a shadow toll which is based on the level of usage and which incorporates an implicit congestion tax on the road operator where, for example, lane closures due to maintenance lead to delays. So far 8 of these contracts have been let with two pending (see Vickerman, 2003, for a more detailed discussion).

The alternative form of private involvement is the letting of a maintenance contract in which the private sector operator becomes responsible for the management and maintenance of an existing section of road. This is similar to the maintenance contracts used in the rail industry we discuss below.

The rationale for private sector involvement, and particularly through DBFO schemes, is that it enables investment in key sections of route to be brought forward whilst at the same time reducing costs through requiring the contractor to assume a share of the risks. The belief is that when the contractor becomes dependent on the service quality of the road the standard of construction will rise and hence the overall service quality of the network. This risk sharing approach is a means in effect of making the contractor reveal information to the Highways Agency as infrastructure operator.

In a substantial review of the Highways Agency's (HA) maintenance programme the UK National Audit Office (2003) has identified that, despite considerable increases in the unit cost of maintenance, better management has led to improved quality of maintenance. The HA has moved to a system where it employs an Agent for each area of the network responsible to the HA for identifying and managing maintenance in that sector and contractors on a term basis, such that there are longer term contracts. Routine maintenance has largely been moved to a lump sum basis so that contractors become responsible not for a specific element of maintenance, but for delivering a given quality for road network over the period of the contract. This therefore introduces a further stage in the hierarchy in which risk is appropriately shared by the HA, agent and contractor, each having an incentive to avoid cost overruns and poor quality by the level below. The specification is a form of coordinated decentralisation which should increase efficiency and improve the quality of the outcome. The NAO suggests that it might also encourage innovation.

The downside is that, in order to accept the risk, each of the lower levels of the hierarchy may be encouraged to overestimate costs, especially in long-term contracts where there is greater uncertainty. This may encourage over-tendering and imposes higher costs (or risks) on the higher levels in the hierarchy which need to devote resources to acquire the necessary information to control this.

The risk element was also identified in an earlier study of the DBFO programme by the NAO (1998). Here it was argued that because the bidding firm could note effectively manage the revenue risk from inaccurate traffic forecasts, there would be a tendency to overbid in the tendering process to provide a hedge against this, and the consequent benefits to the HA would be reduced.

Rail

There is a popular view that for a long period under British Rail, but especially in the last decade or so of the nationalised system, the rail network was starved of investment in both infrastructure and rolling stock, but that the quality of operations, especially their safety, was maintained through an effective maintenance programme. The effect of privatisation, which was supposed to lead to a renewal of the rail system by introducing both more investment, but particularly more efficient operations, was in fact to highlight the long-standing deficiencies. New investment was paid for in part by reductions in both the quantity and quality of maintenance and this resulted in a series of serious accidents.

There have been several attempts to provide an objective assessment of the overall performance of the British rail system since privatisation. Glaister (2002) suggests that in some sense the privatised railway became a victim of its own success with investment and maintenance failing to match the rapid rise in traffic. However, he argues that the main problem which emerged was the government's reluctance to allow the railway to operate within the established structure and, in particular, the compromising of the role of the independent regulator as a guardian of the public interest since the government ignored the Regulator's advice when placing Railtrack in administration.

Using a social cost-benefit framework, Pollitt and Smith (2002) claim major efficiencies which have benefited consumers and the government whilst quality is assessed as being at least as good as pre-privatisation. They estimate that about 36% of rail industry costs are linked to infrastructure and that overall efficiency gains of about 2 per cent per year were achieved in the post-privatisation period compared to an estimated 1 per cent they estimate could have been delivered by BR in this period and an actual efficiency loss of around 1 per cent per annum in the period before 1992/93. They bring together evidence on a number of indicators on quality which support the view that the post-privatisation regime was more effective. Punctuality improved by 2.7 per cent in the initial period (to 1999/2000) against a background of an 11 per cent rise in train miles and a 28 per cent rise in passenger miles. Although delays began to rise after an initial sharp fall, this was due more to the train operating companies than to Railtrack as infrastructure operator.

Two key indicators of maintenance performance show conflicting trends. The number of signals passed at danger (SPADs) fell (although this was a major factor in at least one serious accident) (see Evans, 2001, for a more detailed analysis). The number of broken rails per train mile (the cause of other serious accidents, and the imposition of serous speed controls on much of the network) increased suggesting that maintenance levels may have been insufficient to cope with the pressure on the infrastructure resulting from increased traffic levels. The question posed is whether the level of maintenance should have been greater than it was in the post-privatisation period because of underinvestment in the previous period. Most seriously the Rail Regulator has indicated that the lack of an adequate asset register aggravated the situation and (importantly for our analysis) that the transfer of this information to maintenance contractors left the infrastructure operator Railtrack unable to act efficiently in response to the situation because they lacked the information on which to act. Thus a blanket speed limit was imposed after the Hatfield derailment because they did not know in sufficient detail where similar problems might arise, and the maintenance contractors would accede to this because of their risk aversion.

This issue was raised by the National Audit Office (2000) which noted that the Rail Regulator had had difficulties in establishing whether Railtrack had met their obligation to maintain and renew the rail network. This was partly because of the lack of an adequate asset register, but also because the original investment appraisal requirement for renewal set by the Rail Regulator had been ambiguous. This demonstrates that asymmetry of information is not one sided, it is also incumbent on a regulator to provide targets and incentives in manner which is transparent and easy to implement.

But is the suggestion that low levels of investment under BR led to under-maintenance in the privatised railway correct? Examination of the accounts of BR and Railtrack suggests that between 1975 and 1992/93 BR spent between just over £1 billion and £1.3 billion per year on maintenance and between £0.5 and £0.7 billion per year on renewals (see Gourvish, 2002, for a detailed account of the final years of British Rail and Ford, 2003, for a journalistic discussion). These figures show some cyclical behaviour but are remarkably steady. The change comes from 1993/94 with the preparations for privatisation. In 1993/94 maintenance fell to under £0.7 billion before rising again in subsequent years under Railtrack to between £0.75 and £0.9 billion. Renewals fell to £0.5 billion in 1995/96, the year before privatisation and then rose steadily to just under £1 billion by

2000/01. This analysis suggests that the problem was not particularly a hiatus in investment in the pre-privatisation period. It may be that rail investment over the long period, although fairly steady, was at too low a level, but international comparisons suggest that this is quite a difficult argument to sustain in terms of volume. What it does suggest is that some of the current problems of the railway may be associated with the substantial fall in maintenance expenditure which occurred after privatisation in the early years of Railtrack; this would be consistent with the argument developed in the previous section. Whilst higher renewal expenditure may be thought to lead to lower maintenance expenditures, there is also the problem that the more technically complex systems introduced require higher standards (and hence more expensive maintenance), thus returning us to the quality or quantity debate.

Following the collapse of Railtrack the government vested the rail infrastructure in a not-for-profit company, Network Rail, which was faced with restoring confidence in the quality of the infrastructure network as well as carrying forward an inherited investment programme. What appears to have occurred is that Network Rail's response was essentially to try and buy itself out of a problem. Both renewals and maintenance expenditure have been forecast to grow dramatically in the period from 2002/03 with renewals peaking at around £4 billion in 2006/07 and maintenance rising back to around £1.3 billion in 2003/04, before falling back to under £1 billion by 2008/09. This was a 37% increase in the figure allowed by the Rail Regulator in 2000 (ORR, 2000; SRA, 2003). In physical terms this would imply an increase of over 200% in the amount of rail renewal in five years.

Some of this increase (as in the road sector), is caused by the increase in the unit cost of maintenance. The costs of plain track renewal is estimated to have increased by 25% in real terms since 1999 (almost identical to the increase in the unit cost of road capital maintenance). At least some of this increase is due to the pressure on the industry's capacity, but some may also be due to risk hedging by contractors, and potentially due to poor management of maintenance contracts by the infrastructure operator.

This enormous increase in the volume of renewals and maintenance presents a particular problem for the Regulator. The Regulator is responsible for regulating track access charges, the main source of revenue through which the rail infrastructure operator finances its operations (although it also receives direct subsidy for some of its activities). In setting charges the Regulator has to have regard to the public interest, both in terms of the fare paying rail traveller and the tax payer. The Regulator thus has a direct interest in the level of expenditure by the infrastructure operator and to support his decisions on charges conducts a periodic analysis of this expenditure. Having conducted a detailed review in 2000 (ORR, 2000) the explosion in planned expenditure by Network Rail since that date led to a further Interim Review in 2003 which is currently under consultation (ORR, 2003). The Interim Review has concluded that planned expenditure is too great. This is not just a question of the volume of expenditure which is sustainable, but also the efficiency of maintenance. The Regulator has suggested that both maintenance and renewals and new investment could be secured more cheaply if some of the contracts were delayed and renegotiated. This implies that the Regulator is concerned that the response by the infrastructure operator to perceived lack of confidence in the standard of maintenance and renewal by the travelling public in terms of increasing the volume of such expenditure enables contractors to exploit the situation by raising prices. There is a further concern, that the management capacity of the infrastructure operator is insufficient to cope with such a rate of increase in expenditure and hence the quality of work carried out by contractors cannot be effectively monitored. Network Rail as infrastructure operator is proceeding in many areas to reintegrate the maintenance function as a direct operation thus removing the final stage of the operation as a separate bargaining contract.

The response by Network Rail (2003) confirms that some of the difficulties arise from managing the volume of maintenance with between 60 and 80 per cent being undertaken by contractors. In fact the problem is more complicated since there are seven major contractors, who themselves employ sub-contractors for considerable parts of the work. This is again similar to the road situation, but the failure appears to have been the lack of control over the decentralised process which the HA and its Agents have been able to impose in the roads case. A major problem is the lack of sufficient advanced planning for work which is thought to have led to costs being 25 per cent higher in some 20 per cent of cases than if the work had been properly identified and scheduled in advance. Network Rail claim to be able to identify cost savings of around 16 per cent on the estimated 2006/07 estimate of £1.3 billion, with a potential further 4 percent achievable.

*Some lessons*

The key issue which emerges from these examples is that it is not so much the volume of investment or maintenance which is important, it is the quality of that investment and maintenance. Quality here seems to depend critically on the ability of the infrastructure operator to identify, schedule and plan capital work, whether routine maintenance or renewals, and then manage its implementation effectively. In both the BR period and the subsequent privatised railway, this had been seriously lacking. In the roads case, where there was no problematic inheritance and the HA is an executive agency of government rather than a privatised company, this transition seems to have been managed more effectively.

These findings are consistent with the theoretical insights discussed above. The magnitude of the costs (and potential savings from better managed maintenance) are huge. Network Rail estimates it can save £266 million from more effective maintenance arrangements, the Rail Regulator believes that there are even greater savings to be found, without compromising the safety and quality of the network. But it must be remembered that these savings are on a figure which itself represented a four-fold increase from the levels of expenditure in the early days of the privatised railway. A move to a competitive market in infrastructure management may bring some benefits from the allocation of capacity, but seems to bring even greater costs in the maintenance of the quality of that capacity.

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