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EU Task Force on Rail Infrastructure charging: summary findings on best practice in marginal cost pricing[1]

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[1] This paper draws on the contributions received from various Member States, particularly Sweden, Finland and Austria, on approaches to marginal cost pricing.

1 INTRODUCTION

An expert group on rail infrastructure charging ('the charging group') was set up by the European Commission with a remit to report on best practice in rail infrastructure charging, consistent with the charging requirements of Directive 2001/14/EC. The group consisted of members with practical experience in the application of differing charging frameworks throughout the EU and who represented rail network operators, government departments and regulators. The group reported its findings to the Commission in June 2002.

The main charging provisions of EU Directive 2001/14/EC are as follows:

- charges shall be set at the cost that is directly incurred as a result of operating the train service (that is, the marginal cost resulting from operating the service);
- a charge may be included which reflects the scarcity of capacity during periods of congestion;
- the infrastructure charge may be modified to take account of the cost of the environmental effects caused by the operation of the train. Charging of environmental costs which result in an increase in the overall revenue accruing to the infrastructure manager shall however be allowed only if such charging is applied at a comparable level to competing modes of transport; and
- charges may be averaged over a reasonable spread of train services and times.

Specific exceptions to the above principles are allowed as follows:

- in order to obtain full recovery of the costs incurred by the infrastructure manager a Member State may, if the market can bear this, levy mark-ups on the basis of efficient, transparent and non-discriminatory principles; and
- for specific investment projects, the infrastructure manager may set higher charges on the basis of the long-term costs of such projects if they increase efficiency and/or cost-effectiveness and could not otherwise be undertaken.

There are also provisions in the Directive related to discounts (generally allowed only where such discounts reflect actual cost savings to the infrastructure manager), reservation charges (to discourage capacity being requested and not used), and compensation schemes for unpaid environmental, accident and infrastructure costs of other modes.

This paper summarises the main findings of the group, reporting on examples of identified best practice in relation to the determination of marginal costs. No single country yet implements 'pure' marginal social cost pricing although there are examples of good practice in implementing individual components of marginal cost. These individual components consist of:

- the marginal cost of maintaining and renewing the infrastructure (wear and tear costs);
- marginal environmental and accident costs;
- marginal congestion costs; and
- scarcity costs.

The paper highlights areas of inconsistencies between countries (Finland, Sweden and Great Britain) in estimating wear and tear costs, even where marginal cost pricing is applied. The paper does not deal with the potential difficulties in implementing marginal cost pricing since these have been considered in papers presented at previous IMPRINT seminars.

The Member States who took part in the infrastructure charging working group were: Germany, France, Italy, Austria, Portugal, Finland, Sweden and the UK.[2] Existing charging policy only in these countries was considered.

The remainder of this paper is structured as follows. Section 2 discusses two alternative 'best practice' approaches to deriving marginal costs associated with maintenance and renewal of the infrastructure, including details of the modelling methods used. Section 3 provides a comparative analysis of the results of the approaches applied in different countries. Section 4 discusses best practice in relation to other components of marginal cost and Section 5 provides some brief conclusions.

2 MARGINAL COST PRICING – WEAR AND TEAR COSTS

A diversity of approaches exist in establishing and setting usage charges. Two alternative approaches, used by a number of Member States and considered to be best practice in terms of consistency with the provisions of Directive 2001/14, were discussed in detail by the charging group:

- an econometric approach which estimates a total cost function and then takes the first derivative of total cost with respect to gross tonne miles to derive the marginal cost (seen in Finland, Sweden and Austria); and
- an approach which allocates total variable costs across all the different vehicles running on the network, using detailed cost causation engineering relationships (used in Britain).

The econometric model

The econometric model is used in Finland, Sweden and Austria. This assesses marginal costs by examining engineering data and calculating detailed costs built up on an activity-by-activity basis. It examines the individual relationship between activities and costs and according to cost category and asset type.

Although the models used in Finland, Sweden and Austria are similar (there are some differences due to data availability, e.g. the Finnish dataset did not include bridges and tunnels), the results of the approach differ between countries, as shown below.

Finland

The approach used in Finland to arrive at the wear and tear component of marginal costs is outlined below.

Forming a cost function

The first step is to define the cost elements which are relevant for short-run marginal costs. By specifying a cost function it is possible to estimate how costs vary with

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[2] The Netherlands also joined the working group for the final meeting.

explanatory variables (utilisation level, track length, track quality, etc.). All of these studies have used the type of cost function presented in P. Johansson and J. Nilsson's study [reference to be added]. The cost function for track unit i at time t is:

$$C_{it} = g(Y_{it}, U_{it}, z_{it}, \varepsilon_{it}) = g(x_{it}, \varepsilon_{it})$$

C_{it} is the independent variable (maintenance/renewal costs), Y_{it} is the track length, U_{it} is the utilisation level (measured in gross tons), zit is a vector of technical features (including for example the number of switches and crossings, average age of track, main line/secondary line, etc.), εit is a random error term and g is unknown functional form.

In studies which have used Swedish and Austrian cost data, the independent variable (Cit) includes only maintenance costs. In the Finnish study two kinds of cost function have been analysed: one which includes only maintenance costs and one which includes both maintenance and renewal costs. As one would expect and as illustrated below, this can lead to significant differences in the estimation of marginal cost.

Estimation of the cost function

The second step is to estimate the cost function. The estimation is done by regression analysis in order to detect functional relationships between costs, infrastructure characteristics and use of the infrastructure. Usually the cost function is specified in logarithmic form (and hence each of the coefficients can be interpreted as an elasticity).

Estimation results – coefficients for utilisation (gross tons)

Study	**Estimated coefficient for gross tons**
Johansson & Nilsson 1998, Sweden	0.13-0.28 (main lines)
Idström 2000, Finland	0.08-0.13 (all lines, only maintenance costs) 0.27-0.32 (all lines, maintenance + renewal)
Nilsson 2001, Sweden Finland	0.169 (all lines) 0.167 (all lines, only maintenance costs)
Stiassny et.al., 2001 Austria	0.105 (all lines)

In all of the studies the coefficient for gross tons is significantly below unity, which means that railway infrastructure maintenance is a decreasing cost activity (it exhibits economies of density). Based on the 2001 studies, the estimation results imply that if traffic levels (gross tons) increase by 10%, maintenance costs will increase by between 1% and 1.7%.

Determining marginal costs

The third step is to differentiate the estimated cost function, because marginal costs are the first derivative of the total cost function. The marginal costs are calculated in relation to thousand gross ton kilometers (kgtkm). By manipulation of the function a marginal cost, averaged over the whole network, can be derived as follows[3].

Marginal costs from different studies

Study	Marginal costs (in € cents)
Johansson & Nilsson 1998, Sweden	€0.32 / kgtkm
Idström 2000, Finland	€0.14 / kgtkm (maintenance only) €1.23 / kgtkm (maintenance + renewal)
Nilsson 2001, Sweden Finland	€0.13 / kgtkm (maintenance only) €0.24 / kgtkm (maintenance only)
Stiassny et.al., 2001 Austria	€0.55 / kgtkm (maintenance only)

The table above shows that in those studies where the cost function includes only maintenance costs, the marginal cost per kgtkm varies from €0.13 (Sweden) to €0.55 (Austria).

Only the Finnish study in 2000 included renewal costs in the cost function. In this case the average marginal cost is much higher than those derived from other studies. The Finnish study therefore shows that renewal costs have a significant effect on marginal costs. However this is the result of only one study and it is considered that more research and testing, using more and better data as it becomes available, would be desirable.

Some conclusions

The model created by Johansson and Nilsson operates well. By using this model, it is clear from the results shown above that marginal wear and tear costs of railway infrastructure can be estimated.

When the estimated cost function includes only maintenance costs, the estimation results (coefficients for track length, traffic volume, etc.) are very similar in different countries (Sweden, Finland and Austria). This means that a unit change in track length or traffic volume, for example, leads to a similar change in maintenance costs in all three countries.

However the estimated marginal costs per kgtkm are different in each country. The differences can partly be explained by the different circumstances encountered in each country (e.g. differences in terrain). It is also important to recognise that countries have different systems of classification of costs. For example a cost that is classified as a renewal costs in Finland might be classified in other countries as a maintenance cost and vice versa. This is a common definitional problem. There is no clear distinction between what constitutes maintenance and renewal. This problem also extends to differentiating between renewals and enhancements. If a modern equivalent asset renewal approach is followed, it is possible that renewing the

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[3] Clearly, charges per kgtkm based on a constant marginal cost over the entire network is likely to lead to some types of traffic running over some parts of the network not covering the marginal costs imposed whilst other types of traffic on other parts of the network could face charges higher than the costs imposed.

infrastructure could lead to enhanced outputs (for example, renewed track may be able to accommodate heavier axle loads).

Only in one of the studies (Finland) were renewal costs included in the cost function[4]. In this case the estimated marginal costs were much higher, as would be expected.

Sweden

The Swedish charges account only for operating and maintenance costs and not the renewal costs of infrastructure, as discussed above. This is reflected in Sweden's relatively low charge for usage which is €0.32 per kgtkm, four times smaller than the Finnish charge. This charge is based on the 1998 Swedish study[5] of the relationship between maintenance costs and track use; this study was recently updated and led to the estimates for marginal wear and tear decreasing significantly to €0.13 per kgtkm (see table above).

Austria

The Austrian model is also based on the econometric approach developed by Johannson and Nielson, including only maintenance costs within the independent variable. An average value of marginal costs across the network of €0.55 per kgtkm was derived.

Dividing the network into core and supplementary lines gives a marginal cost of the core network of €0.48 and a marginal cost of the supplementary network of €3.09.

The study confirmed the anticipated result that marginal costs are below average costs. All the variables used in the model, except for the age of track, have parameters which indicate a significant influence on the marginal costs of maintenance.

Some observations on the econometric approach

The econometric approach to estimating marginal costs is very detailed and can lead to a highly differentiated charging structure providing appropriate price signals. The model developed by Johansson and Nilsson appears to be well specified and potentially transferable across countries, assuming adequate data is available. However, consistency of approach is important, particularly in relation to the inclusion of renewals costs in the independent variable.

One factor which the approach does not so far appear to have analysed (probably due to the lack of adequate knowledge) is the impact of different vehicle characteristics on damage to the infrastructure and hence on maintenance costs. Although factors such as weight (gross tons) and speed are taken into account, other factors such as suspension characteristics, are not. Initial research suggests that some types of track friendly suspensions cause significantly less damage to the infrastructure than other types of suspensions. Engineering knowledge on the exact relationship between suspension characteristics and asset degradation is somewhat limited at present but further research will improve our understanding significantly. It is described below

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[4] In Sweden, adequate data on renewals was not available.

[5] "An Economic Analysis of Track Maintenance Costs" by Per Johansson and Jan-Eric Nilsson. Published in 1998 and undated in 2001.

how Britain has introduced differential suspension factors into its charging framework in advance of this more detailed knowledge.

In practice, constant marginal costs are used across the network, differentiated in some circumstances between passenger and freight traffic. Although this weakens the behavioral impacts which the price signals are meant to promote, it is perceived to be necessary so as not to overly-complicate the charging structure.

The usage charging model used in Britain

At the last periodic review of Railtrack's access charges, there was considerable debate about the level of usage costs and how they should be estimated. Railtrack developed a detailed bottom-up engineering model to estimate marginal usage costs. This starts from detailed engineering relationships and adds up individual elements of cost caused by additional trains where they can be identified. Railtrack then "calibrated" the resulting sum of individual cost elements to the total expected cost derived from its Asset Maintenance Plans. These plans calculate the total level of costs for different types of asset using statistical methods.

The Regulator's consultants Booz Allen & Hamilton (BAH) developed an alternative top-down model[6] based on the engineering relationships used by Railtrack in its model. This model assesses the total costs to the infrastructure manager of operating, maintaining and renewing the network and estimates the variability of these costs by asset category. It then allocates the variable costs across all vehicles on the network by using engineering relationships describing the relative damage caused to the infrastructure for different vehicle characteristics. It is a network-wide model and therefore the costs produced by the model are not differentiated by type of track, etc.

The Railtrack bottom-up approach had more detailed engineering accuracy, but this was spurious given the need for the Railtrack model to be calibrated to the asset lives produced by the asset maintenance plans. Further, some of the maintenance predictions from the model have required calibration to Railtrack's expectation of actual levels of activity. In terms of generating actual charges, the Regulator concluded that the detail of the bottom up model was not therefore warranted.

The structure of the model

The top down model starts with total anticipated maintenance and renewal expenditure, which are multiplied by percentage variabilities by infrastructure type. This gives an aggregate variable cost.

The model also uses basic operating statistics (vehicle miles by vehicle type and tare weight) to calculate an equivalent gross tonne mile (ETM). This is the gross tonne mileage by vehicle type adjusted to take account of the technical speed of the vehicle type and other factors. The parameters used to convert actual gross tonne miles by vehicle type to ETMs are derived from a regression equation of the results from the bottom up model developed by AEA Technology and used by Railtrack.

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[6] Booz Allen & Hamilton: "Railway infrastructure cost causation: a report to the Rail Regulator" November 1999. http://www.rail-reg.gov.uk/boozalle/cost_causation_cont.htm and "Usage costs: issues raised in the Regulator's consultation" October 2000. http://www.rail-reg.gov.uk/boozalle/bahusage.pdf

The equivalent gross tonne mile provides an estimate for the unit of damage for a particular vehicle type. The cost per ETM is then calculated by dividing the aggregate variable cost by the ETM measure for an individual vehicle type. This value is multiplied by an appropriate ration to convert it to the desired units (for example, pence per vehicle mile).

Inputs to the top down model

A. Total maintenance and renewal expenditure

The starting point for the top down model is the total maintenance and renewal expenditure, which derives from the total revenue requirement of the infrastructure manager. The expenditure figures used in the top-down model take account of efficiency gains which it is assumed Railtrack will achieve by the middle of the control period.

B. Variability of costs by asset type

The percentage variability of the maintenance and renewal costs (taken from the October 2000 BAH report mentioned above) for different asset types is reproduced in the table below.

Variability by asset type

	% variable
Track	
Maintenance	*30*
Renewals	
Rail	*95*
Sleepers	*25*
Ballast	*30*
Switches & Crossings	*25*
Structures	*10*
Signals	
Maintenance	*5*
Renewals	*0*
Electrification	
Maintenance	
AC	*10*
DC	*10*
Renewals	
AC	*35*
DC	*41*

Source: Booz Allen & Hamilton: "Usage costs: issues raised in the Regulator's consultation" October 2000

These variabilities were determined by BAH mainly through consideration of the AEA Technology work on usage costs and experience of other rail networks. The variability of track maintenance costs has been set at a level consistent with US experience at tonnages equivalent to those experienced by Britain's railway network.

C. Vehicle characteristics

The vehicle characteristics which are used as the determinants of infrastructure damage within the model are speed, axle-load and unsprung mass for both passenger and freight vehicles. In addition, suspension type and coal dust spillage are further determinants of cost for freight vehicles. Seven suspension type categories have been used, each of which has a different damage factor. These are not based on known engineering relationships but were considered important to introduce at this stage to incentivise freight operators to use more track-friendly equipment.

D. Parameters

The parameters (taken from the AEA Technology work) translate the different vehicle characteristics into damage factors. There are different parameters and hence different damage factors for track and structures.

The form of the charge

Railtrack proposed that usage charges be based on consist mile by different consist compositions (where a consist is the particular composition of a train) to increase the cost reflectivity of the charges. It would also substantially increase the complexity of usage charges. The Regulator's subjective evaluation was that Railtrack's proposed increase in cost reflectivity would be outweighed by the complexity that such disaggregation would introduce.

Railtrack also proposed geographical and asset type disaggregation. However, the Regulator believed that this would distort Railtrack's incentives in relation to track quality or design and could result in confusing and complex price signals to national train operators (freight operators in particular). As a result, the Regulator therefore believed that usage charges based on geography or asset type would not be appropriate. This would, however, be kept under review.

The usage charges derived from the top-down model are therefore network-wide averages. They are disaggregated by type of vehicle.

Results of the model

The marginal cost per locomotive km (averaged across all locomotives) is €0.464; the marginal cost per coach km is an average of €0.096; the marginal cost per diesel motor unit km is an average of €0.099; and the marginal cost per electric motor unit km is an average of €0.100[7]. The average of these costs across all passenger traffic is €0.190. For freight wagons, the variable cost, averaged across all wagons, is €3.1 per kgtkm [check].

These charges incorporate expected efficiency savings. The variable charges for passenger services were set assuming savings equal to 3.1% per annum over the control period (5 years).

The Regulator believed that there was a compelling case for taking a longer-term view of efficiency in relation to most freight traffic. This is because long-term efficient charges would enable operators to plan their businesses with a reasonable degree of assurance and should help to achieve the UK government's growth targets for rail freight traffic. As a result, the Regulator concluded, apart from the exceptions discussed in the paragraph below, that for all freight services, freight access charges should assume ten years of efficiency improvement at 3% per annum.

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[7] These figures were calculated by taking the pence per vehicle mile quoted in the "Periodic review: final conclusions, Volume II"(in 1998/99 prices), converted into pence per vehicle kilometre and then converted into euros per vehicle kilometre at an exchange rate of €1=£0.61.

The longer-term view of efficiency does not apply to rail-freight traffic carrying coal for the electricity supply industry and iron ore. This is because these freight flows are not generally as price-sensitive as other freight flows since in both markets rail already enjoys a high market share with a clear competitive advantage over road. This means that such traffic would not be in danger of being priced off the network as a result of non-application of the long-run efficiency assumptions but also that there would exist limited opportunities for modal shift between road and rail.

Other marginal charges

There are two other charges applied in Britain, namely capacity (or congestion) charges and electric traction charges. These two, along with the usage charge, make up the total marginal charge to train operators.

Capacity charges are set to recover Railtrack's increased congestion costs of running an additional train on the network. These are the increase in Railtrack's expected costs through the contractual performance regimes from adding an additional train into the timetable, as reducing the gap between services makes it more difficult and costly for Railtrack to manage the knock on effects of an initial delay (known as reactionary delay). The capacity charges were determined using modelled relationships between delay and capacity utilisation across the network.

Where operators use traction electricity, they currently purchase this from Railtrack, who in turn purchases its aggregate requirements from competing electricity suppliers. The charges for traction electricity, by geographical area, are designed to be broadly cost reflective and to ensure that Railtrack is incentivised to procure electricity efficiently for the railway industry. There is a downward adjustment to traction electricity charges where operators use regenerative braking.

2 COMPARATIVE ANALYSIS BETWEEN BRITAIN, SWEDEN, FINLAND AND AUSTRIA

The Swedish (and hence Finnish and Austrian) approach and the British approach to the estimation of variable track access charges are similar in that they are both top-down estimates. In the Swedish case, the estimate is based on original econometric analysis whereas the British analysis is based on a literature search of econometric and engineering studies. Having established costs per gtkm, the British approach then goes further in distributing this cost across vehicle types on the basis of engineering studies.

There are substantial differences between the marginal cost estimates in the Swedish and British approaches. The most important factors causing these differences are noted below.

Scope

The Swedish study assesses maintenance costs alone, whereas the British study looks at both maintenance and renewal (re-investment) costs. The Finnish application of the Swedish model uses both maintenance and renewal and demonstrates that renewal costs are some 8 times higher than maintenance costs per gtkm.

Definitions

Britain's costs relate to infrastructure maintenance and renewal, not simply track. The Austrian application addresses the maintenance of electrification assets separately, but the status of other infrastructure maintenance activities (signalling, telecommunications, etc) is unclear.

As stated above, there is no universally agreed distinction between what constitutes 'maintenance' and what constitutes 'renewal'. Cross-country comparisons are therefore difficult at an aggregate level and require much more detailed work on cost classification.

The difference between British and Finnish track renewals costs is some 35% whereas the difference between track maintenance costs is 830%. However, it is necessary to examine the maintenance strategies of each railway before drawing firm conclusions on these statistics – a policy of life extension of assets, for example, as recently pursued by the British infrastructure manager, would tend to increase maintenance costs and reduce renewals costs, both in aggregate and per gtkm. Overall, the combined maintenance and renewals cost difference is some 133% between Britain and Finland.

The British estimate of variability of track maintenance costs is rather higher than the Swedish (at an average of 30% rather than a range of 12-28%). This follows from the fact that the British estimate draws in particular from US experience (notably, the American Railways Engineering Association), which estimates variability across a range of traffic densities over time. This estimate will therefore include the effects of long term traffic growth on track quality, i.e. it will reflect the need to improve track quality and standards as traffic volumes grow – an important consideration in Britain as traffic volumes have been increasing rapidly. The Swedish estimate is essentially cross-sectional, on a traffic base which is not experiencing such high growth, and will therefore tend to exclude such factors.

Unit costs

Even if the activities undertaken in maintenance actions are identical between comparators, there may still be substantial differences in the cost of resources used to undertake those actions – both in terms of costs per man-hour, costs of materials and production technologies.

These can lead to significant differences even within the same network – on the British network, for example, there is a difference of 130% between the costs of re-railing in the south of the country compared to Scotland.

Across international boundaries, there will also be other differences relating to exchange rates and accounting policies, such as differences in the treatment of pensions costs, etc.

Composition of costs

A. Risk

British railway maintenance and renewal is wholly outsourced at the present time. The contracts are essentially output-based, with the contractor undertaking to provide whatever inputs are necessary to secure the contracted levels of track quality, etc. Maintenance costs in Britain will therefore include the costs of carrying this output risk. Although maintenance and renewal works are outsourced in Sweden, Finland and Austria, these tend to be focused more on inputs. In consequence, output risks are being taken by the infrastructure managers themselves and not necessarily monetised (or perhaps even recognised).

Of course, one of the benefits of output-based contracting is presumed to be a reduction in costs by allocating risk to those best able to manage it and therefore we would expect Britain's maintenance costs to be lower than those elsewhere – but only if the costs borne by the infrastructure managers themselves are appropriately valued and only if contracting in Britain is efficient. Neither of these is probably true at the present time. Therefore, the reported costs of maintenance may be higher in Britain than elsewhere, at least at present.

B. Internal charges

The privatisation process in Britain externalised a number of "contractual" relationships which were previously internal within the railway companies.

One example is the costs of engineering trains, both those carrying materials from factories/quarries to storage, those from storage to work sites and those carrying spoil (waste) from works sites. In Britain, the costs of these trains are equivalent to about 30% of total track renewals costs but were previously not recognised or properly captured.

Another example is the cost of taking engineering possessions, i.e. compensating train operators for taking sections of line out of service for maintenance/renewal activities. Historically, however, compensation has only been paid for disruptive possessions which have not been pre-booked and therefore the addition to cost from this factor is likely to be modest.

Derivation of Maintenance Budgets

Maintenance budgets for the Swedish, Finnish and Austrian rail infrastructure managers are drawn from Government. In such circumstances, there may be no close linkage between maintenance need and maintenance budgets. It is a common phenomenon in railway history, for example, for track maintenance to be reduced at a time of budgetary constraints. In Britain, there is a closer linkage as contractors are required to maintain track condition and quality.

However, it is not necessarily the case that, in practice, there are stronger incentives on the British infrastructure manager to be more efficient than its counterparts. As noted by Johansson and Nilsson, there is no evidence that professional railway engineers are any less incentivised in Sweden to be cost minimising. In fact, it could be argued that they are less incentivised in Britain because of the possibility of 'gaming' the regulatory settlement, i.e. deliberately over-estimating their requirements in the hope of securing a greater expenditure allowance from the Regulator.

Technical issues

There are a number of technical, engineering issues which need to be taken into account when comparing maintenance costs between railways. For example, existing track condition and the integrity of the original construction of the track have both been found to be important determinants of maintenance needs and therefore costs. Differences in traffic densities, track standards and safety requirements would also generate differences in expenditure requirements.

Data issues

Conclusions should be drawn with an understanding of the inherent deficiencies of the input data used in the various models, a point also made by Johansson and Nilsson. Research into this area in the context of separated infrastructure managers and train operators is relatively recent. Whilst the results of the various studies raise a number of interesting issues, these should form the basis for on-going research. The validity of the preliminary results, and their use in a policy context, need to be confirmed by logic, engineering judgement and experience.

3 OTHER ELEMENTS OF MARGINAL SOCIAL COST

Charging for environmental externalities

The working group concluded that environmental charges should only be introduced once similar charges are introduced for other modes of transport. Having said that, the working group believed that the introduction of charges (for all modes) to account for environmental externalities is desirable and would provide appropriate incentives both within the rail industry and across different modes. The current ‘best practice’ for estimating and implementing environmental charges are the approaches adopted in Sweden and Finland. Nevertheless, only a few components of environmental costs are incorporated. Accident costs and charges are also included in this section.

Sweden

Emission costs and charges

Sweden has an environmental charge based on Nitrogen Oxide emissions from diesel traction, differentiated by locomotive. The current level of charges represents a small proportion of the total external costs. The environmental impact of rail transport includes noise and vibrations, land take, air pollution and climate impacts.

The environmental impacts of electric traction (not quantified) depend on the level of renewable sources of electricity generation.

Accident costs and charges

The original Swedish accident charge, introduced in 1988, was based on a total cost allocation principle. The total external accident costs of railway accidents were allocated to the total number of train kilometres. No pure marginal cost analysis has been carried out.

In 1998, when the latest charging scheme was introduced, the accident charge was differentiated between passenger and freight. The charge, which is based on an average variable cost, included only non-level crossing accidents.

Since then there has been more work on level crossing accidents in the UNITE project[8]. The project considered road/rail level crossing accidents and costs related to personal injuries, with the aim of understanding the relationship between rail traffic volume and accident cost.

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[8] Lindberg, G; Deliverable 9: Accident Cost Case Studies, Case Study 8c/2: The marginal cost of non-level-crossing accidents on Swedish railways. (UNIfication of accounts and marginal costs for Transport Efficiency) Deliverable 9. Funded by 5th Framework RTD Programme. ITS, University of Leeds.

Finland

Emission costs and charges

Finland has an emission charge, derived from a study undertaken in 1998. The objective of the study was to determine, measure and value the environmental costs caused by rail traffic emissions. The review covered VR Ltd's (the Finnish railway operator) diesel and electric traction traffic in 1996. The environmental impact of diesel trains was assessed separately for urban centres (with concentrated centres of population) and rural areas. The environmental cost of electric trains was estimated based on the source of electricity supply (renewable sources or otherwise).

The valuation method used was the Impact Pathway Method, which consists of four steps: emission inventory; dispersion calculations; quantification of impacts; and their monetary valuation. The impacts studied included health effects (mortality and morbidity), materials damage, ecological effects (forest and crop damage) and climate change.

The results of this study revealed higher costs than those derived from comparable international studies, but were of the same order of magnitude, both for electric and diesel traction.

The marginal emission charges in Finland are €0.098 per kgtkm for passenger traffic, €0.39 per kgtkm for diesel-powered freight trains, and €c0.197 per kgtkm for electric-powered freight trains. The unit values of these charges are updated every three years.

Accident costs and charges

The accident charging framework in Finland is based on a study by Tervonen and Juha[9]

This report suggests a framework for categorizing and assessing the internal and external costs of railway accidents. The focus is on personal injuries and allocation of cost responsibility.

Since the external cost is dependent on the nature of the accident, the cost is categorized by type of accident and according to the severity of injury. The accident categories are: collision or derailing; level crossing accident (with and without warning device); falling from a platform or moving train, and accidents from trespassing.

The key criterion in distinguishing between internal and external accident costs is the exposure of risk in different accident categories. In the case of collision, derailing or level crossing accidents with warning devices, the passengers, train personnel and motorists are aware of their personal risks. Therefore, risk values are internalised for their part in all accidents. The remaining external costs are the costs to authorities and lost national product. However, in the case of accidents at level crossings without warning devices, or falling onto tracks from platforms or from moving trains, the risk costs are considered externalities, since careful behaviour may have not prevented the incident.

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[9] *Internal and external costs of railroad accidents*, Finnish Rail Administration, Strategy Unit, Helsinki, 2000.

The external costs of accidents at level crossings without warning device are allocated between rail and road transport modes. The costs of accidents on platforms and accidents to passengers falling from moving trains are allocated to the railways. The costs of accidents to pedestrians crossing the forbidden track line are not considered the responsibility of the railways.

Cost assignment is based on a recent updating of the socio-economic unit costs of personal injuries. Marginal external costs of accidents are estimated by applying these unit costs with accident risk models currently available, at least for level crossing accidents.

The marginal accident charges in Finland are €0.92/kgtkm for passenger traffic, €0.064/kgtkm for electric powered freight traffic and €0.1764/gtkm for diesel powered freight traffic.

Other findings

It has been suggested that, from an incentive viewpoint, differentiation of charges to reflect environmental externalities within the rail mode is desirable even in the absence of environmental charges faced by other modes. Charges for relatively environmentally friendly locomotives and rolling stock could be reduced from the base level of charges, whilst charges for more environmentally damaging locomotives and rolling stock could be increased above the base level, ensuring that the expected revenue to the infrastructure manager is held constant. However, if such differentiation of charges had the desirable behavioural effect, this would lead to the infrastructure manager under-recovering its costs.

Summary of environmental charges

Much research has been conducted in recent years in establishing methods for assessing the environmental impacts of transport and in quantifying these impacts. The application of emissions and accident charges in Finland and Sweden illustrate that implementation at a practical level is possible. However, both Finland and Sweden felt that the area of marginal environmental costs (including costs not yet captured in their charging frameworks) would benefit from further research. Consistency of approach across Member States would also be desirable.

Scarcity pricing

The charging group determined that there is curently no ‘best practice’ in scarcity pricing. It is important to stress that the use of pure scarcity pricing to equate supply and demand without complementary administrative rules, regulations and procedures is unlikely to be implemented in many countries. Examples might include:

- member states wanting to ensure that some capacity is reserved for rail freight operations which might otherwise be priced off the network;
- member states wishing to regulate certain fares or freight tariffs in the public interest. Demand for train paths is a derived demand and therefore fare regulation in the downstream market could impact upon the effectiveness of scarcity pricing to allocate capacity efficiently in the upstream market.

The charging group pointed out that there is a trade-off between managing demand through scarcity pricing and increasing supply (providing additional capacity) through enhancements to the network. This trade-off is clearly illustrated in network industries where investment is lumpy and capital costs are large. For example, if demand only exceeds capacity by a small amount at the prevailing marginal cost, it may be appropriate to introduce scarcity pricing in the short-term rather than increase supply through costly investment, such that charges exceed short-run marginal cost and demand and supply are brought back into line. As demand continues to grow relative to the fixed supply, scarcity prices will have to increase to maintain equilibrium. A point will be reached when the socially optimal level of infrastructure will increase and capacity enhancement will be justified in economic terms.

The working group concluded that scarcity charging is one of the most complex issues to deal with in the rail industry. It recommended that there needs to be more research into scarcity pricing and auctioning of capacity in the rail industry before it can be effectively implemented. In particular, there needs to be more emphasis on overcoming practical difficulties in the implementation of scarcity charging.

4 CONCLUSIONS

This paper has presented a summary of the findings of the working group on best practice in marginal cost pricing. It was agreed that the two approaches to determining marginal wear and tear costs discussed above, i.e. the econometric approach used in Sweden, Finland and Austria and the approach used in Britain, could be considered as best practice and could be followed by other Member States when implementing the charging principles laid out in Directive 2001/14. There is limited application of environmental charges and as yet, no instances of pure scarcity pricing, although Britain does include congestion charges in its framework. Scarcity pricing, in particular, is an area where further research is needed.

Focusing on the charging principles, there remains an inconsistency of approaches, even between countries which use the same modelling framework. This inconsistency arises, in particular, in the inclusion or otherwise of renewals costs which has a significant effect on the level of marginal costs.