FINNISH RAIL ADMINISTRATION

RHK • Strategy Unit

Publications of
the Finnish Rail Administration

A
12/2000

INTERNAL AND EXTERNAL COSTS OF RAILWAY ACCIDENTS

Juha Tervonen

Helsinki 2000

FINNISH
RAIL
ADMINISTRATION

Publications of
the Finnish Rail Administration A 12/2000

INTERNAL AND EXTERNAL COSTS OF RAILWAY ACCIDENTS

o Juha Tervonen

Helsinki 2000

RHK
FINNISH RAIL ADMINISTRATION
KAIVOKATU 6, P.O.Box 185
FIN-00101 HELSINKI

TEL. +358 9 5840 5111
FAX +358 9 5840 5100
E-MAIL: info@rhk.fi

ISBN 952-445-045-3
ISSN 1455-2604

Tervonen, Juha: Internal and external costs of railroad accidents. Finnish Rail Administration, Strategy Unit. Helsinki 2000. Publications of Finnish Rail Administration A 11/2000. 35 pages. ISBN 952-445-045-3, ISSN 1455-2604.

EXECUTIVE SUMMARY

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. The main applications are the levying of track user charges and socio-economic impact assessment of the rail transport mode.

Sweden and Norway are possibly the only countries that apply an established framework for assessing the internal and external costs of railway accidents. They mostly apply existing theory, but also make assumptions. The framework presented here is based on these models and existing theory.

Since the external cost is dependent on the nature of the accident, it is recommended that the cost be categorized by type and according to the severity of injury. Accident categories are:

a) Collision or derailing,
b) Level crossing accident (with and without warning device),
c) Falling from a platform or moving train, and
d) Accident on forbidden track line.

The key criteria in separating between the internal and external accident costs are the infliction and exposure of risk in different accident categories. In the case of collision, derailing or level crossing accident with warning device, 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 in level crossings without warning device, 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. In Finland, hospital costs, rehabilitation and compensations for lost income are effectively internalised through the insurance system applying the principles of strict liability.

When risk has been inflicted by the railway, the costs are allocated to the railway and visa versa. It should be clear that in accidents in level crossings with warning device the responsibility of accident costs is at the guilty party ignoring warning and entering tracks. It is recommended that the external costs of accidents in level crossings without warning device be shared between the rail and the 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.

In addition, the costs of delays caused by accidents should be considered, as well as environmental costs associated with accidents to transport of dangerous goods.

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

The proposed framework will not impact track user charges radically, although some increase is expected. Instead, it will introduce transparency by emphasizing situations of stronger cost responsibility of the rail mode, and on the other hand, releasing the rail mode of cost responsibility in other situations. A certain impact is the recognition of the costs of accidents at level crossings without warning device.

Tervonen, Juha: Rautatieonnettomuuksien sisäiset ja ulkoiset kustannukset. Ratahallintokeskus, Kehittämisyksikkö. Helsinki 2000. Ratahallintokeskuksen julkaisuja A 11/2000. 35 sivua. ISBN 952-445-045-3, ISSN 1455-2604.

TIIVISTELMÄ

Raportissa esitetään viitekehys eri tyyppisten rautatieonnettomuuksien sisäisten ja ulkoisten kustannusten luokittelemiseksi ja laskemiseksi. Tarkastelu keskittyy henkilövahinko-onnettomuuksiin. Lisäksi pohditaan kustannusten kohdentamista. Keskeiset sovelluskohteet ovat ratamaksun määrittäminen sekä rautatieliikenteen yhteiskuntataloudellinen tarkastelu.

Ruotsissa ja Norjassa on käytössä ainoat rautatieliikenteen sisäisten ja ulkoisten onnettomuuskustannusten tarkasteluun vakiintuneet mallit. Ne noudattavat pääpiirteissään teoriaa, mutta sisältävät myös omia ratkaisuja. Nyt esitetty kehikko on synteesi ko. malleista sekä teoriasta.

Onnettomuudet suositellaan kategorisoitavan tyypin ja henkilövahingon asteen mukaan, koska sisäisen ja ulkoisen kustannuksen jako riippuu onnettomuuden luonteesta. Onnettomuustyyppejä ovat:

a) suistuminen tai törmäys rautateillä
b) tasoristeysonnettomuus (varoituslaittein tai ilman varoituslaitetta)
c) laiturialueella tapahtuva henkilövahinko-onnettomuus tai putoaminen liikkuvasta junasta
d) muualla kielletyllä ratalinjalla tapahtuva henkilövahinko-onnettomuus

Keskeinen sisäisen ja ulkoisen kustannuksen määrittäjä on riskin aiheuttaminen ja tiedostaminen kussakin onnettomuuskategoriassa. Kaikkien onnettomuustyyppien osalta matkustajat, junahenkilökunta sekä teillä liikkujat tiedostavat toimintaan liittyvän onnettomuusriskin. Tällöin henkilövahingon riskiarvo on sisäinen kustannus ja ulkoiseksi kustannukseksi jäävät viranomaiskustannukset sekä menetetty kansantalouden tuotanto. Kuitenkin varoituslaitteettomassa tasoristeyksessä, laiturialueella tai liikkuvassa junassa ihmisen varovaisuus ei välttämättä estä onnettomuutta. Tällöin myös henkilövahingon riskiarvot ovat ulkoisia kustannuksia. Suomessa sairaanhoidon, kuntoutuksen ja ansionmenetysten kustannukset on sisäistetty ankaran vastuun vakuutuskäytäntöjen kautta.

Silloin kun vastuu riskistä on rautateillä, on kustannusvastuukin rautateillä. Jos riskin ottaja on muu liikennemuoto, ei kustannusvastuu kohdistu rautateille. Ilman varoituslaitetta olevan tasoristeysonnettomuuden ulkoinen kustannus suositellaan jaettavaksi rautatie- ja tieliikenteen kesken. Onnettomuus matkustajalle tai saattajalle laiturialueella tailiikkuvasta junasta putoavalle matkustajalle kohdennetaan rautateille. Kielletyllä ratalinjalla tapahtuneet henkilövahingot eivät kohdennu rautateille, koska vahinko on seurausta tietoisesta riskinotosta.

Rautatieonnettomuudet aiheuttavat myös liikenteen viivästyksiä, sekä ympäristökustannuksia mikäli onnettomuus tapahtuu vaarallisten aineiden kuljetuksissa. Etenkin viivästysten tarkastelua suositellaan jatkossa.

Henkilövahinkojen arvottamisessa nojaudutaan vuonna 1999 määriteltyihin liikenneonnettomuuksien henkilövahinkojen yhteiskuntataloudellisiin yksikköarvoihin. Oikeaoppiset onnettomuuksien rajakustannukset voidaan määritellä suhteuttaen yksikköarvoja riskimalleilla liikkumisen määrään.

Ratamaksun tasoon esitetty kehikko ei vaikuttane radikaalisti. Kehikon tarkoitus onkin luoda läpinäkyvyyttä onnettomuuskustannusten tarkasteluun. Rautateiden kustannusvastuuta korostetaan toisissa tilanteissa, kun taas toisissa tilanteissa se joko rajataan pois tai se alenee. Merkittävämpi muutos seuraa henkilövahinkojen yksikköarvojen päivityksestä. Ohjausvaikutuksista voidaan sen verran että ilman varoituslaitetta oleviin tasoristeyksiin kiinnitetään nyt huomiota enemmän.

FOREWORD

The Finnish Railway Administration commissioned Electrowatt-Ekono Oy to prepare a framework on the internal and external costs of railway accidents in May 2000. The study was finalised by the end of October the same year.

The study is prepared by Juha Tervonen, M.Sc. (in Econ.), with the assistance and co-ordination of Tuomo Suvanto from the strategy unit of the Finnish Railroad Administration. A discussion on legal compensation issues was held with Mika Mäkilä from the technical unit. Nordic accident costing experts were also consulted in the course of the project.

The study is part of the on-going work in transport administration concerning the principles and application of marginal cost pricing. The most immediate impact of the framework suggested here is on the principles of levying track access charges on railways.

Helsinki, December 2000

Finnish Rail Administration
Strategy Unit

TABLE OF CONTENTS

1 INTRODUCTION

The new principles of transport pricing suggested by the European Commission aim at charging the costs of transport to the users of the network as they actually occur, by applying the principles of marginal cost pricing (European Commission, 1999a-c). According to economic theory, short-term marginal cost pricing adds efficiency to the use of transport networks, internalises the external costs caused by mobility, and influences the behaviour of operators and travellers. The core cost components (wear and tear of network, emissions and accidents) have been theoretically conceptualised for the purpose of levying network user charges, e.g. the track access charge on railways.

Railway accidents cause considerable socio-economic costs. Some of the accidents occur within the mode and some are collisions with the road transport mode in level crossings. In addition, people are hit or run over by trains in station areas and on other track lines. Also, accidents may happen to trains transporting dangerous goods. Some of the costs of these accidents are borne by the traveller as a victim or guilty party. Partly the costs are borne by the operator or infrastructure manager and partly by the society at large.

The marginal cost pricing of transport expects that accident costs would be assessed as internal and external cost elements, in other words, as costs, which are considered by the traveller or operator in the decision to travel or supply a service, and as costs, which are not considered. The costs not internalised into decision-making, and thus not covered, are pricing relevant external costs. This external element of accident costs should be known according to the relative risk caused by the volume of transport within the same mode and between different modes of transport.

The aim of this study is to define the theoretically correct internal and external accident cost elements, so that they will serve the levying of track access charges and the assessing of the socio-economic costs of railway transport in general. The examination covers accidents internal to the rail mode, accidents with other modes, and accidents to pedestrians hit by trains on the track line. The main emphasis is on personal injuries, but material damages and accidents in transport of dangerous goods are also included.

The actual external costs are not defined, but a framework of principles is presented. Due to some deficiency in existing theory and differences in the existing practices, grey areas are solved through reasoning based on general principles.

The socio-economic costs of road traffic accidents were first assessed in Finland by LTT (1990) and latest in 1999 in projects funded by the Ministry of Transport and Communications, Finnish Railway Administration and Finnish National Road Administration (Tervonen, 1999a-b). The costing concepts and practices are explained in these reports.

Section 2 of this report presents the theory of accident costing. Section 3 describes costing models currently applied. Section 4 reviews the safety of the Finnish railway network. In Section 5 a framework is suggested for costing railway accidents in Finland, and Section 6 discusses the impacts of the framework on track access charges. Section 7 concludes the report.

2 ACCIDENT COSTS ACCORDING TO ECONOMIC THEORY

2.1 The principles of marginal cost pricing

The High Level Group on Infrastructure Charging of the European Commission has presented a set of working reports on developing the marginal cost accounting and pricing of socio-economic costs of transport (European Commission, 1999a-c). The marginal costing theory of accidents mainly refers to road traffic, not the railways. Nevertheless, the same general principles should apply to all modes alike.

Theory and methods of costing the socio-economic consequences of accidents are established in decision-making particularly in road transport in many countries (Vägverket, 1997; UK DETR, 1997; US DOT, 1997; SIKA, 1999). In turn, the theory and methodology concerning marginal accident costs is still under development (Jansson, 1994; Elvik, 1994). Some interpretations do exist for the rail mode, which are also applied in determining track access charges, for example, in Sweden and Norway (Hansson, 1997; Hagen, 1997, Eriksen *et al*, 1999). On the other hand, for example, UIC (1999) considers the theory too complex for practical application.

The marginal costs of transport are socio-economic costs directly caused by the users of the network. Marginal costs can be linked with the movement of an individual vehicle and traveller. Such costs are accidents, emissions and noise. These cost categories account for the largest share of the socio-economic costs caused by transport.

Socio-economic marginal costs are external if they are not reflected and covered in the charges (e.g. ticket price, price of fuel, direct user charge, insurance premiums) levied on the users of transport networks. Depending on the circumstance, an external accident cost may consist of emergency costs, administrative costs, traffic delays, treatment costs of personal injuries, lost production and loss of human well-being. Material costs are usually internalised by traffic insurance. The same applies to treatment costs and compensations covered by liability or traffic insurances in Finland.[1]

The main influencing features of accident costs are the statistical risk of an accident and the severity of the outcome. Thus, accident costing should be performed as a function of accident risk and the costs, particularly for the pricing relevant mass of external accident cost.

The costs are in practice accounted by an inventory of actual costs, which eventually reflect averaged costs in defined sub-categories of total cost. By applying risk factors to these averaged unit cost categories, a proxy estimate of marginal accident costs is produced. By applying these principles to individual vehicles or travellers, the essential elements of the marginal accident costing theory are fulfilled.

The internalisation of external costs consists of designing such prices to the users of the network, which both fulfil cost coverage and clearly signal for the particular cost item. It is assumed that with an incentive provided, the travellers and operators alter their behaviour towards lower socio-economic costs, in this case accident risks. Charging should take place at

[1] Raideliikennevastuulaki N:o 113/1999 sekä Liikennevakuutuslaki N:o 279/1959.

individual traveller or operator level, varying according to risk behaviour and distance travelled.

According to theory, the charges should apply the liability principle, i.e. the risk imposer will pay the cost. The above principles are best put into operation within the traffic or liability insurance systems, but ticket prices and user charges can also be applied. These principles do not aim at replacing normative approaches to traffic safety, but instead, offer supplementing tools for providing incentives for safer traffic behaviour. A bonus/malus system applied at the individual traveller and operator level allows structuring efficient behavioural signals.

2.2 The cost structure of a traffic accident

The division of accident costs into internal and external elements requires first defining and assessing these costs. The unit cost of each cost element is assessed by an inventory of the real economic losses defined and by the willingness-to-pay approach for lost well-being. Figure 2.1 presents the generalised cost structure of a personal injury.

The socio-economic unit costs have originally been defined for the purpose of investment analysis (see e.g. Tielaitos, 1995). The same unit costs can also be used for pricing purposes, as the basis of providing a value for the cost elements is exactly the same. The difference is that investment analysis uses the total unit cost irrespective of the party covering the cost, whereas pricing is interested only in the external share of costs.

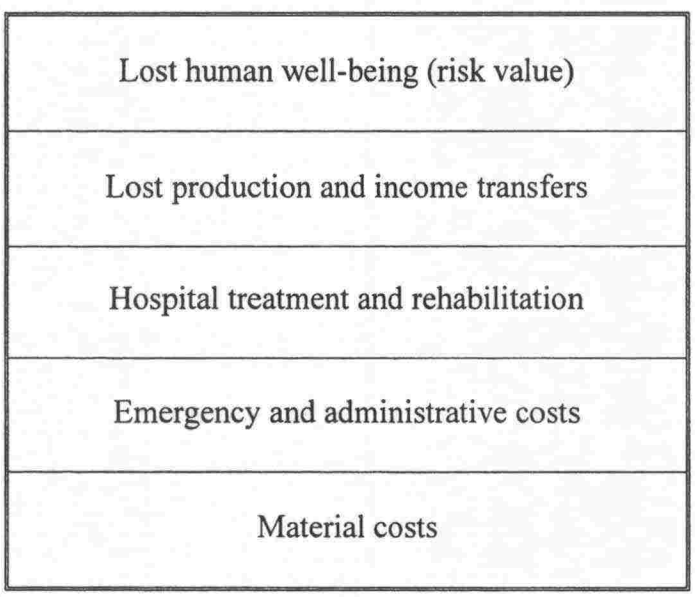

Figure 2.1. The cost structure of an accident leading to personal injury.

Material costs consist of property damage, such as vehicles and infrastructure with its appliances, the former being private property and the latter property of the society. Emergency and administrative costs consist of police, fire department and first aid personnel costs, as well as the costs to the authority caused by, for example, accident investigation and

reporting. The above costs are mostly present in railway accidents, even in those without personal injuries.

Medical and hospital treatment costs and costs of rehabilitation are present when personal injuries occur. In the case of serious personal injuries temporary or permanent losses of income and production occur, which are borne by both the victim and his/her employer.[2] The lost or reduced capacity of a productive individual is reflected in the decreased national capacity to produce. In addition to the above real economic losses, a personal injury involves losses of human welfare, which are also valued as economic losses. Losses of human well-being are often called risk values, due to the methodology of valuing reductions in accident risk by subjective monetary weighting (Jones-Lee, 1990; Tervonen, 1999a and 1999b).

The cost realization of each accident is incidental, but in socio-economic assessment they are defined as average unit costs per category of injury. The latest review of the unit costs of personal injuries assesses immediate economic costs, production losses to the society and lost human well-being primarily for road traffic accidents (Table 2.1).

Table 2.1. The unit costs of personal injuries in road traffic accidents (Tervonen, 1999b).

Injury category	Unit cost, FIM			
	Immediate economic costs*	Lost production	Risk value	Total
Fatality	46 300	2 502 500	8 710 0000	11 258 800
Permanent injury	21 000	1 470 400	4 808 000	6 299 400
Temporary injury				
- severe	21 000	14 100	1 450 000	1 485 100
- slight	21 000	3 500	250 000	274 500

The unit costs defined for the road transport mode have also been used in the rail sector for practical reasons, although in economic theory risk values are based on subjectively assessed (statistical) risk levels depending on the characteristics of accidents. The statistical risks of railway accidents are lower per unit of travel than on roads, but on the other hand, the catastrophe nature of a railway accident may impact subjective values (see e.g. Jones-Lee & Loomes, 1994; Jones-Lee & Loomes, 1995; Zeckhauser, 1996). However, the empirical evidence on the latter is controversial, and the issue is not analysed here further.

The recently updated unit costs of personal injuries represent lost human well-being (risk value) and lost national production perhaps in the best way. The other cost elements are based on relatively old cost inventories and need to be reviewed.

2.3 The costs of a railway accident

The cost structure and total cost outcome of a railway accident are naturally different from a road traffic accident. Yet, no official unit costs have been assessed separately for the railways. The material costs are borne by the operator or the infrastructure manager, as well as in most

[2] To be precise, compensations paid from insurances should be taken into consideration, since they are not borne by the society at large, but collectively by insurance takers.

cases of collisions at level crossings, by the owner of the road transport vehicle. The damage costs due to material losses in railway accidents have not been subjected to particular inventory, nor have the administrative costs been assessed.

For the costs of personal injuries, the cost of treatment and rehabilitation, as well as lost production and income transfers, the structure and total cost should be similar in rail and road traffic accidents. However, the distribution of injuries in categories of severity is likely to be different, i.e. the relative proportion of fatalities and severe injuries is higher in railway accidents. Thus, the relative weight of lost production and well-being is likely to be higher.

Railway accidents can be categorised broadly into accidents within the same transport mode (derailing or collision with another train) and collisions between other modes. The latter consists of level crossing accidents and collisions with pedestrians on the track line. Categorisation is important since it has an impact on the division between internal and external cost elements, as well as the allocation of cost responsibility.

Within traffic safety research, an accident between a motor vehicle and non-motorised modes (most often a pedestrian or cyclist) is described as an accident between a protected and non-protected road user. These concepts are used for determining risk relationships between the parties in accidents. In principle, vehicles of different sizes could be categorised according to mass and weight relationships (e.g. passenger car – truck; motorcyclist – passenger car). Furthermore, separating the right-of-ways for modes of different sizes is seen as the most efficient way to prevent accidents. However, the difference in size between vehicles and transport modes does not necessarily tell us everything about the relationship between imposing risk and being a target of risky behaviour. Thus, the principles of risk relationships should be used for allocating responsibility for (external) accident cost, and the size of vehicles should not be the only guideline.

Due to the fact that the guilty party in level crossing accidents is in legalistic judging always the motorist, the guilty party's traffic insurance covers the costs of material damages, treatments costs and compensations for lost income, and pain and suffering for both parties. In Finland, it is possible that mitigating circumstances are taken into consideration, which may lower the compensations levied on the motorist.

According to Miller *et al.* (1994), in the United States in 1989–1990, approximately 90% of the total costs of railway accidents were incurred at level crossings, for both passenger and freight trains. The share of costs incurred by derailing was 8% and 6% for freight and passenger trains respectively. The share of material damages was clearly below 10%, the rest resulting from personal injuries. Thus, an accident to a passenger train caused twice as high costs as freight train accidents. Two thirds of the costs of personal injuries were caused by accidents to people or cars run over by trains.

UIC (1999) refers to a study, according to which, 97% of the level crossing accidents that took place on German railways from 1991 to 1997 were caused by road transport. Thus, cost responsibility was allocated to the road mode.

2.4 Internal and external accident costs

External accident cost as a concept is associated with accident risk, which in turn is relative to kilometres travelled, speed, vehicle mix in a transport flow, risk behaviour and the causal relationship of risk exposure. External accident costs may differ by traffic situation, particularly when heterogenous traffic flows are in question.

The users of the network expose themselves and other users to risk, the realisation of which as an accident and associated cost is not necessarily completely borne by the risk taker. These uncovered costs are assumed to be higher in relation to higher travel performance and riskier behaviour.

According to the risk categories defined for road transport, while entering a traffic flow the user of the network (European Commission, 1999a):

- Exposes himself to the average risk in that transport mode.
- Increases or decreases accident risk for other users of that mode.
- Increases or decreases the risk for the users of other transport modes.

The Commission further defines:

"The risks for railway users are limited and consequently System and Traffic volume externalities are negligible. Nevertheless, accident externality charges are relevant because the Traffic category externality is significant. Even if the number of car/train accidents increases in proportion to the train traffic volume, the externality may be substantial. Given the relatively large number of non-user fatalities we expect a relatively high external accident cost on railways."

The above statement is in slight contradiction with the theory, which does not consider risk-taking situations different between an accident in one mode and an accident involving two modes. If the deliberate risk-taking of a motorist leads to an accident with a train, the accident cost is not external to a full extent and should not be assigned to the rail mode. This is also in line with the legal interpretation.

On the other hand, UIC (1999) states that statistical accident risks are so small that rational assessment of risk is impossible. For this reason, all accident costs, including lost well-being of the individual, are considered external. However, counter-arguments may be proposed. Risk-taking, for example, in level crossings and on the track line cannot be considered beyond rational perception.

The external marginal cost resulting from the realisation of accident risk consists of four generalised categories (Elvik, 1994):

- *System externalities* – the expected accident cost to the society when the user exposes himself to risk
- *Physical externalities* – the expected accident cost to other road users due to risk
- *Traffic volume externalities* – the WTP of a household, relatives and friends and the society associated with the increase in risk to other users of the same mode[3]

[3] The inclusion of altruistic values in accident risk based WTP is an issue of debate, not yet solved. Some researchers exclude altruistic concerns due to the possibility of double counting (See e.g. Jones-Lee, 1992).

- *Traffic category externalities* – the WTP of a household, relatives and friends and the society associated with the increase in risk to the users of other modes

The above costs are external if the users of the network do not consider these costs when they decide to travel or when they choose the means of travel. Thus, these costs have no impact on the risks taken. On the other hand, internal costs are the decision function and have an impact on the risks taken. In marginal cost pricing, the neglected external costs are identified and internalised into travel decisions and travel behaviour by means of pricing.

The parties eventually covering external accident costs are the interest groups involved either directly or indirectly in an accident. These consist of:

1) The users of the network,
2) The family and friends of the users of the network,
3) Private third parties and
4) The public sector.

The ones involved in an accident, both the guilty and the non-guilty parties, are in the first category. They, along with the second group, bear both material and immaterial costs, the former being material damage and lost income, and the latter being lost physical, mental and social quality of life. The premise of setting a value for lost well-being is based on individual valuation (Jones-Lee, 1992; Schwab Christe & Soguel, 1996). Altruism towards fellow men should not be included in these values due to the risk of multiple counting. For this reason, the second category is excluded from the analysis in this report.[4]

Private third parties consist of consumers covering the costs of accidents in market prices, i.e. insurance policies and more costly commodities and services. The public sector consists of taxpayers covering accident costs from public funds (e.g. emergency costs, administrative costs, hospital treatment, rehabilitation, income transfers and lost national product). Table 2.2 presents the above categorization.

Table 2.2. Classification of costs of injuries inflicted on others as internal (included in the utility function of road users who inflict injuries on others) or external (not included in the utility function). (Elvik, 1994).

Cost item	Other road users	Household of others	Private third parties	Public sector
Lost quality of life	*External*	*External*		
Travel time delays			*External*	
Medical treatment	*External*	*External*	*External*	*External*
Lost output	*Internal*	*Internal*	*External*	*External*
Repair of property damages	*Internal*	*Internal*	*External*	*External*
Administrative costs	*Internal*	*Internal*	*External*	*External*

The theories and approaches above all call for further development in definitions, assessment methods and allocation processes. Also, the costs covered within the insurance system need careful analysis. This is particularly important in Finland, where the applied principles of strict liability and full cost responsibility cover a large share of accident costs (medical costs,

[4] In Finland, the dependants of a fatal victim are compensated for lost income by the traffic insurance and liability insurance systems.

income compensations and compensations for pain and suffering). Thus, the cost coverage of the Finnish insurance system is more extensive than in general in other European countries.

3 MODELS FOR COSTING RAILWAY ACCIDENTS

3. 1 The Swedish model

Hansson (1997) presents a model on the categories and estimates of external accident costs in railway accidents involving personal injuries. The model is applied in decision-making and pricing by the Swedish rail administrator (Table 3.1).[5] The outcome of the model, i.e. accident cost component in the track-access charge is subject to the treatment of lost well-being in level crossing accidents and accidents occurring on the track line.

The model assesses all accidents that occur on the track line and lead to personal injuries in three categories of severity. Accidents are further categorized according to the characteristics of the incident. Material damages are excluded since they are covered by insurances.

Passengers and personnel on trains are considered to internalise the cost of personal risks in their decision to travel or work. Therefore, risk values (loss of personal well-being) of injuries are excluded in collision or derailing accidents without involvement of another mode. The remaining administrative and medical costs constitute the external costs in these accident categories.

Accidents in level crossings are examined in two groups, with and without warning device. This reflects the difference in the exposure of risk. In the former, precautionary actions have been taken for signalling of risks. Therefore, if these signals are neglected, an accident is considered to be a result of the risk-taking behaviour of the road user, and the corresponding risk costs are considered internal for the respective party.

On the other hand, in level crossings without warning signals the risk is considered imposed by the railways (since preventive actions were not maximized), and the risk costs along with administrative and medical costs of injuries are external. However, the external cost is allocated to both transport modes as a fifty-fifty split. This conduct is due to practical reasons, since explicit judgement on risk behaviour is evidently sometimes difficult.

The costs of accidents occurring in platform areas and elsewhere on the track line are also considered external and the responsibility of the rail mode irrespective of the cause of the accident.

[5] The unit costs of personal injuries vary from country to another due to differences e.g. in coverage of cost inventory, as well as subjective valuation of risks.

Table 3.1. External costs of railway accidents in Sweden in 1995 (Hansson, 1997).

Accident type	Number	External cost/ personal injury (MSEK)	Total external cost (MSEK)
Passenger/employee*/**			
- fatality	2	0.948	1.896
- serious injury	3	0.533	1.599
- slight injury	6	0.031	0.186
Grade crossing accident			
With warning device **			
- fatality	5	1.200 * 50 %	3.000
- serious injury	6	0.600 * 50 %	1.800
- slight injury	12	0.060 * 50 %	0.360
Without warning device			
- fatality	3	14.200 * 50 %	21.300
- serious injury	0	2.600 * 50 %	0
- slight injury	0	0.150 * 50 %	0
Other accident			
*Station area***			
- fatality	1	13.948	13.948
- serious injury	0	2.533	0
- slight injury	0	0.121	0
*Track line***			
- fatality	7	13.948	97.636
- serious injury	1	2.533	2.533
- slight injury	2	0.121	0.242
Total external cost			**144.5**

* Without risk value.
** Without property damage.

3.2 The Norwegian model

In Norway, Hagen (1997) has prepared a framework for costing railway accidents in many respects similar to the Swedish framework, but with some alternative interpretations. The cost categories are presented in Table 3.2 and the statistical unit costs of personal injuries in Table 3.3. The Norwegian inventory first assesses all costs and then separates the share of the external cost. The cost inventory of a personal injury consists of administrative and emergency costs, medical expenses and treatment cost, lost income and lost well-being.

Table 3.2. Cost categories of railway accidents in Norway (Hagen, 1997).

Cost category	Type of loss
Personal injury	- Slight injury - Severe injury - Fatality
Vehicle damage (car/engine)	- Slight damage - Considerable damage
Infrastructure property damage	- Damage to switches - Track damage - Derailing
Indirect cost	- Delay cost of passenger train - Delay cost of freight train - Delay cost of bus or taxi - Motor vehicle damage in level crossing accident

Table 3.3. Average accident cost by category and type of loss in Norway, with the share of external cost in parenthesis, million NOK in 1995 (Hagen, 1997).

	Damage category		
Accident type	Fatality*	Injury	Material damage
Collision		8.40 (0.16)	
Derailing		3.03 (1.11)	0.44 (0.016)
Grade crossing accident	16.06 (16.03)	2.15 (2.03)	0.21 (0.020)
Fire			0.06 (0.003)
Other accident	16.02 (8.15)	1.35 (0.74)	0.25 (0.016)

* Including material damage.

External accident costs are defined according to the following principles:

- All personal injury costs borne by third parties are external, i.e. people hit by trains, excluding passengers and train personnel or railway workers.
- Most of the personal injury costs of train personnel and railway workers are internal. The external costs involved in these cases are the costs borne by private third parties, family of the victim and the public sector.
- All material damage costs are internal, except vehicle damages in level crossing accidents.
- 20% of the traffic delay costs caused by accidents are considered external.

In Table 3.3, the figures in parenthesis represent the shares of the external cost of all cost categories. The share of the external cost for personal injuries varies according to accident type and injury category. The highest external cost per accident type concerns level crossing accidents. The Norwegian model considers external costs to be present also in accidents without personal injuries, i.e. there are some external costs involved with material damages as well. The costs have been estimated as a statistical average for an accident cost inventory covering a sample of two years.

3.3 A comparison of the Swedish and Norwegian models

The features of the Swedish and Norwegian models are next summarised, since they will be utilised in the proposal for a Finnish model in Section 5. Because the theory of marginal accident costs on the railways remains un-established, both models partially apply interpretations on the principles of costing.

The Swedish model

The basic principles of the Swedish model are:

- The model defines accident costs on a categorical basis.
- For fome of the passengers and train personnel, the external accident cost consists only of the cost borne by the society. Personal loss of well-being (risk values) is considered an internal cost.
- Personal injuries are categorised by accident type and severity of injury.
- Level crossing accidents are divided into two categories: level crossings with and without warning device. In the former case, the costs of personal injuries are almost completely internal, whereas in the latter case they are completely external.
- In level crossings without warning device, the external accident cost is shared between the rail and the road mode (the principle is, however, not based on the theory).
- The costs of personal injuries elsewhere on the track line are considered as external.

The Swedish model can be considered exemplary in the following respects:

- It is clear in the categorisation of internal and external costs of personal injuries.
- It separates level crossings according to risk level. This leads to the allocation of resources to decreasing risks there where the accident costs are likely to be highest.

The Norwegian model

The basic principles applied by the Norwegian model are:

- The model defines accident types and unit costs by statistical incidences.
- Besides the costs of personal injuries, material damages are also included.
- The traffic delays caused by accidents are valued and partially considered external.
- The treatment of personal injuries to passengers and train/railway personnel is similar to the Swedish model, i.e. loss of personal well-being is an internal cost.
- All accidents leading to personal injuries on tracks are included irrespective of cause.

The Norwegian model can be considered exemplary since it also considers the traffic delay costs of accidents. However, since the unit values are based on a short statistical sample, it may not be completely representative. Furthermore, the different risk levels at level crossings with different warning device are not recognised.

3.4 Other models

UIC (1999) treats the total socio-economic value of a personal injury as external cost, but reduced by compensation payments from insurance companies. As already stated before, the study considers accident risks so low that rational risk perception is impossible. However, no scientific arguments are stated to back up the assumption. On the other hand, for railway workers the loss of personal well-being is considered an internal cost. Referring further to the lack of established risk models in rail transport, the marginal costs of accidents are not assessed in the UIC study.

In general, the simplified accident cost assessments on railways do not often separate between internal and external accident costs, nor consider risk levels, but the costs are assessed more or less *ex post* according to the total socio-economic loss and statistical traffic volume. Thus, the resulting cost figures represent more average socio-economic accident costs than marginal cost in definition, according to which costs should be assessed as *ex ante* accident realization relative to risk and future traffic performance. Such compromises are common. For example, this average cost principle has been used to define the accident cost component of the Finnish track access charge.

4 SAFETY ON FINNISH RAILWAYS

4.1 Accident statistics

A railway accident enters statistics when it leads to severe personal injuries or material costs to the value of EUR 10 000 (FIM 60 000). All level crossing accidents are, however, recorded irrespective of the degree of severity (Table 4.1). There are few incidences of accidents or risk situations involving transport of dangerous goods. The causes of collisions and derailing are investigated and recorded, as well as fires on rolling stock.

Personal injuries are recorded for passengers, people intending to travel, accompanying people, and railway personnel (including both train personnel, track workers and railway officials). A fatality is recorded when the victim dies within 30 days of the accident. Clear suicide cases are not recorded. A person is considered seriously injured if working capability is lost for more than 14 days.

Table 4.1. Personal injuries in railway accidents (VR, 2000).

	Fatalities				**Severely injured**			
Category	1996	1997	1998	1999	1996	1997	1998	1999
Passengers								
- Train related accident	3		9		3		9	
- Other incident		1	1	1		2		6
Personnel								
- Train related accident	1		1					
- Other incident		1				5	1	4
Other personal injuries								
- Level crossing accident	5	13	11	10	3	6	2	4
- Other track line	3	6	2	5	3	3	2	2
Total	12	21	24	16	9	16	14	16

4.2 Safety of the railway network

The main means for improving safety of the rail network are removal of level crossings, installing different types of warning devices and traffic signs, and speed limits (Table 4.2). A number of level crossings without any of the above devices or signs exist. However, many of these involve crossings from a field to another, no road connection as such. Also, typical unmarked crossing are located in industrial yards.

Entering tracks without permission in places not considered crossings, is prohibited by law. This applies to all track lines, as well as station and platform areas. Since access to the track line is not limited by, for example walls, it is impossible to enforce the law, and common behaviour provides evidence of deliberate risk-taking.

Table 4.2. The number of level crossings and warning devices on the Finnish rail network (VR, 1998 and Ratahallintokeskus, 1998a).

Part of the network	Number
Total network (incl. industrial track lines)	5 283
- Full bar	3
- Semi bar	820
- Light and (or) sound warning signal	140
- Crossing sign*	3 225
- No crossing sign	1 095
Total main track lines	527
- With warning device	204
- Without warning device	323

* Often both crossing sign and stop sign.

The number of level crossings has been significantly reduced from almost 8 000 to 5 000 since the 1970's. Also, the number of bar devices is now many-fold. As a result, the number of annual level crossing accidents has been reduced from approximately 170 to less than 50. Only a fraction involves personal injuries. (Ratahallintokeskus, 1999a)

During the year 2000 the Finnish Railway Administration has conducted a pilot inventory of level crossings on a particular link for finding measures to improve safety. Emphasis has been put on reducing the number of risky crossings on private roads and in agricultural areas, improving visual circumstances and guaranteeing safe crossing time for vehicles of different sizes and weights. New types of warning devices and practices have been developed.

Automated train control is constructed ahead of schedule on links with fast passenger transport. The automated train control monitors and controls maximum trains speeds and the compliance of traffic signs. Speeding and un-compliance leads to automatic breaking. By the end of 1999, the automated train control covered 1180 kilometres of track. In addition, train movement in railway yards is controlled at some stations. The aim is to supply the main trunk lines with automated control during 2001 and the whole network by the end of 2005 (Ratahallintokeskus, 1999b).

In transport of dangerous goods, international standards and regulation are followed in order to minimize risks. Accident risks mainly involve car switching in yards. Any measure to improve railway safety in general reduces the risks of accidents in transport of dangerous goods. (Ratahallintokeskus, 2000)

5 APPLICATION OF ACCIDENT COSTING IN FINLAND

5.1 The framework for cost division

The proposed Finnish framework applies both the Swedish and Norwegian examples and existing accident costing theory in defining cost categories and dividing them into internal and external elements (Table 5.1). Thus, the outcome is a synthesis of applications and theory, supplemented with some interpretation. It primarily focuses on personal injuries, but material damages and accidents during transport of dangerous goods are also included. Besides dividing the internal and external cost categories, the justifiable allocation of costs is also considered. Since the existing theory is not completely established, some 'grey areas' are solved by interpretation. Therefore, the framework will differ to some extent from other Nordic models.

The principle of separating the assessment of level crossing accidents according to risk level is adopted from the Swedish model. The assessment of traffic delays is adopted from Norway. The division of internal and external cost elements is partly based on the Nordic models, but also interpretation is applied. Some accident types are excluded from the framework if they can be attributed to deliberate risk-taking by walking on the track line.

In categorising the internal and external costs of lost well-being (risk value), the principle is awareness of risks as part of travelling or working for the rail transport sector, i.e. the choices to travel and work internalize the costs of risk. Furthermore, in accidents in level crossings with (ignored) warning device, lost well-being is considered an internal cost due to risk-taking behaviour. Since in level crossings without warning device even risk-averse behaviour may not prevent an accident, lost well-being (risk value) is considered an external cost.

Falling accidents in platform areas or from moving trains occur to passengers, people intending to travel or accompanying persons. According to theory, the accident risks of the first two groups are internalised in their decisions to travel. However, it should be examined whether unperceived risks are present, i.e. the ones that the track manager or rail operator should be responsible for. These include, for example, open doors on moving trains and slippery platforms.

The external accident costs borne by the society are present in the form of emergency, administrative and delay costs, as well as lost production in all accident types. However, they cannot be allocated to the railways in all cases. These cases include accidents in level crossing with warning device, and pedestrians, cyclists and vehicles being hit by trains on the forbidden track line (level crossing area not considered). For non-motorised modes of transport, there is no established category to which costs can be allocated. Otherwise, cost responsibility is either allocated to the road mode or left unallocated.

The hospital and rehabilitation costs of accidents are covered in Finland by the Acts on strict liability and full cost responsibility, applied in the traffic and liability insurance systems. Thus, these costs should be considered internal. In addition, the insurance system to a large extent compensates income losses and pain and suffering. Therefore, such accident costs should not be included in infrastructure user charges.

Table 5.1. Proposed division of internal and external accident costs of railway accidents.

Accident type	**Internal cost**	**External cost**	**Allocation of cost responsibility for external costs**
Passenger/railway employee	- personal risk value - hospital treatment, rehabilitation, income transfers	- emergency and administrative costs - lost production - delay to other traffic	- railways (unless accident is caused by other traffic modes)
Level crossing, personal injury			
- *With warning device*	- personal risk value		- road traffic party in level crossings with warning device
- *Without warning device*	- personal risk value, if risk of crossing track is low	- personal risk value, if the possibility to cross tracks is not risk free	
- *Without warning device or sign*	- personal risk value, if risk of crossing track is low	- personal risk value, if the possibility to cross tracks is not risk free	- rail and road transport together in level crossings without warning device
	All cases - hospital treatment, rehabilitation, income transfers	All cases - emergency and administrative costs - lost production - delay to other traffic	
Other personal injury			
- *Falling on platform or from moving train*	- hospital treatment, rehabilitation, income transfers	- personal risk value	- railways
- *Crossing forbidden track line (station area or other track line)*	- personal risk value	All cases - emergency and administrative costs - lost production - delay to other traffic	- no allocation within the transport sector
Property damage (vehicles and infrastructure)	- material damage to road traffic party, track manager and operator	- emergency and administrative costs - delay to other traffic	- railways
Transport of dangerous goods	- material damage to track manager and operator	- environmental accident costs - emergency and accident costs - delay to other traffic	- railways

5.2 Division of costs by accident type

The external accident costs (of personal injuries) allocated to the railway sector are presented in Table 5.2. The values are based on the socio-economic unit costs of personal injuries presented in Table 2.1, and the principles of cost allocation from Table 5.1. Since the socio-economic unit values have been defined from a different perspective than the theory of accident costing exactly expects, they need to be further refined into marginal accident costs by applying accident risk models. There are no unit values defined for delay costs, and they are therefore recommended for future examination. Next, the cost allocations are discussed in closer detail.

Table 5.2. External unit cost of personal injury in railway accidents, FIM.

Accident type	Temporary slight injury	Temporary severe injury	Permanent injury	Fatality
Passenger/employee	24 500	35 100	1 491 400	2 548 800
Level crossing accident				
- with warning device*	-	-	-	-
- without warning device	274 500 (- insurance compensations) ***	1 485 100 (- insurance compensations) ***	4 808 000 (- insurance compensations) ***	11 258 800 (full value)****
Other personal injury				
- platform area/moving train	275 500 (- insurance compensations) ***	1 485 100 (- insurance compensations) ***	4 808 800 (- insurance compensations) ***	11 258 800 (full value) ****
- other track line**	-	-	-	-

* Cost responsibility on the road traffic party.
** Cost responsibility not defined, but not allocated to the railway sector.
*** Insurance compensations based on lost income and pain and suffering are deducted from the risk value of non-fatal injuries.
**** Insurance payments are not deducted from the risk value of a fatality, since they are paid to the dependants of the victim.

Passenger/employee

The lost well-being (risk value) of the passengers and people employed on railways are considered internal costs, since according to theory, the decision to travel or work on railways internalises the risks involved. On the other hand, the direct emergency and administrative costs and lost production are external costs borne by the society.

In Finland, the strict full cost responsibility applied within traffic and liability insurance systems covers at least most of hospital and rehabilitation costs. Thus, these accident costs are

also internal. As stated above, the direct costs to the society in emergency activities, administration, and accident investigation and reporting are accounted external costs.

If the cause of the accident can be attributed to the track manager or the operator, the responsibility for the external costs is allocated to the railway sector.

Personal injuries in level crossing accidents

It is recommended that level crossing accidents are categorised by the existence/non-existence of warning device in the crossing. In this way, a clear separation according to risk levels and signalling for risk is made.

If an accident occurs in a crossing with warning device, the road transport party is considered a risk taker. Thus, the lost well-being (risk value) is an internal cost. The direct costs to the society in emergency activities, administration, and accident investigation and reporting are accounted external costs. However, the responsibility of these costs is allocated to the road transport sector.

If crossing the railway at a level crossing is not possible without risk (no warning device), the following conduct is possible:

a) The total unit cost of personal injury is allocated to the railway operator as an external cost, reduced by compensations covered by insurances.

b) External accident costs are acknowledged, but are not assigned to the operator.

c) The cost responsibility of the acknowledged external cost is shared between the rail and road transport sectors, reduced by compensations covered by insurances.

Allocating cost responsibility to the railway sector can be argued by the expectation of ensuring safe passage at level crossings. There may be cases in which train speeds together with the characteristics of the crossing (and weather) do not guarantee safe crossing. The party crossing the tracks may not always have the possibility to perceive risks, e.g. if visibility is limited and safe crossing time is very short. Thus, it can be expected that it is the joint responsibility of the track manager and the operator to minimize, if not completely eliminate, risks. Allocation of at least partial cost responsibility to the rail mode will provide an incentive for risk reducing actions.

It is perverse to charge the operator the risks that it cannot reduce with the means at hand. However, accidents are without doubt dependent on the volume and speed of rail operations. Therefore, an adjusted approach of sharing cost responsibility with the road mode is recommended. The simplest way of allocation is an even split following the Swedish model. Another more sophisticated alternative is to apply a relative accident risk model considering traffic volumes of the both modes.

In level crossing accidents, the road traffic party covers all hospital, rehabilitation costs as well as compensations for lost income from traffic insurances, irrespective whether injuries occur to train passengers or personnel. In addition, the material damages to trains are covered.

These compensations should be considered already covered. However, careful assessment is needed, since the deduction process must be performed by injury type. Insurance coverage of lost income should be deducted only from the value corresponding to the value of lost income and human well-being (risk value) for non-fatal personal injuries. The compensations paid to the dependents of fatal victims must not be deducted from risk values of fatalities, since the value has been defined for the individual, not considering the victim's family. The compensations paid to the society for covering the costs of hospital treatment and rehabilitation cannot be deducted from any cost item, since they are deficiently represented in the socio-economic unit cost of personal injuries. Although the exact statistical compensations paid to accident victims are not assessed here, it is recommended that they be assessed later prior to setting accident charges to the rail operator.

Personal injuries in platform areas or on the track line

As above, it is recommended that accidents be categorised according to the risk characteristics of the incident. Personal injuries on platforms typically involve slipping onto tracks from the platform or moving train. Another typical case of accident to pedestrians is when people are hit by trains on the track line in sections not marked as crossings.[6]

In principle, it can be expected that being hit by trains on platforms or falling from moving trains can be prevented by precautionary actions. Thus, the costs of such accidents are considered external and allocated to the railway sector, unless the cause of an accident in this category can be attributed to deliberate risk-taking by the victim. Again, this conduct will provide an incentive to risk reducing actions. Yet, the consideration of the responsibility being either at the track manager or the operator is troublesome, since if the responsibility is allocated to the operator, charges may perhaps be levied based on incidents which the operator may not have means of preventing. Nevertheless, as the risks are directly related to railway operation, the costs are considered an externality and allocated to the railway sector.

On the other hand, a person entering a forbidden track line in a place not marked as a crossing refers to deliberate risk-taking. Thus, the loss of well-being (risk value) in such an accident is an internal cost. Yet, the costs borne by the society are external, since the victim does not cover them by any mechanism. In the likely case that the track manager or operator cannot be considered responsible for the accident, the costs are not allocated to any party (i.e. ultimately borne by the society).

Accidents during transport of dangerous goods

An external accident cost involves an incident where environmental damage costs occur. External costs are present if the accident results in personal injuries, or costs occur to society in the form of emergency and administrative actions.

[6] Clear suicide cases are not included in railway accident statistics. In some cases the actual cause of such an accident is impossible to be established, although circumstances refer to suicide.

Material damage

Risks of damage to vehicles are internalised in the choice to travel or operate vehicles, the realisation of which is then covered by insurances. This interpretation applies to both the victim and the guilty party of an accident, as well as the property of the infrastructure manager (although state property is not insured). In any case, the costs of material damages to vehicles and infrastructure property involved in accidents are excluded from the assessment.

5.3 Considerations

Computation of external accident costs

The external accident costs can be computed in two alternative ways:

- By expected risks – *ex ante, or*
- By past statistics – *ex post.*

The former approach is closer to the theory of marginal cost pricing, but mathematically more challenging. It requires accident statistics and risk models, the outcome of which may perhaps be later adjusted according to actual realisation. The latter approach is simple methodologically although it is based on past information (past traffic behaviour), which is less consistent with the presentation of the theory of expected future risk (future traffic behaviour).

The Swedish railway administrator applies the following model to forecasting the risks of level crossing accidents:

$R = (Qt * Qv/TFPmedel) * f(Sth) * Omf$, where

R	= relative risk, i.e. number of accidents per year,
Qt	= average rail traffic volume per day,
Qv	= average daily traffic of motor vehicles and non-motorised transport modes,
$TFPmedel$	= average produce of the traffic volumes per type of warning device,
$f(Sth)$	= accident factor, by maximum train speed and type of warning device,
Omf	= average accident probability by type of warning device.

The model recognises the main influencing risk factors, i.e. traffic volumes and speeds, and the warning equipment in crossings. The model will tell how accident risks change if any of the influencing factors changed.

The costs to be covered in accident charging

The European Commission has emphasised the role of the insurance system in charging external accident costs. In Finland, the coverage of the hospital and rehabilitation costs, as well as compensations for lost income and grief and suffering by insurances is already in use to a large extent (although the insurance system does not charge exactly according to marginal cost). However, it is unlikely that the insurance system will consider in the near future, if ever, lost national production and lost human well-being as costs to be included in insurance

premiums. Thus, the charging system of the infrastructure manager is the likely instrument of charging these costs.

Development of calculation methods

In the future, level crossings without warning device should be provided with accident risk models, as well as traffic elsewhere on the track line.

It is also necessary to clarify the role of the compensations paid by insurance companies, and how they should be considered in setting charges on the remaining external accident costs. Some of the compensation payments may be long lasting, and require computation for defining average sums for a set of compensation categories. This, however, has no significant implication on treatment and rehabilitation costs, since in practice the socio-economic accident cost inventory available in Finland does not cover such costs. Instead, the compensations for lost income and pain and suffering should be assessed for non-fatal injuries and deducted from corresponding cost elements in the unit value of personal injury. Yet, the compensations paid to the families of fatal victims have no implications on assessing external accident costs.

The delays caused by accidents to other transport should be included in the costing of accident externalities. Thus, it is recommended that these costs be examined further in the future.

6 IMPACTS ON TRACK CHARGING

6.1 Current track access charge

Basic principles of levying the charge

The principles of levying track access charges were first adopted in 1996, based on a particular law on supplying track services[7] as well as principles of the economic theory on infrastructure charging (Suvanto, 1999).

The law regulating the Finnish rail network states, among other things, that

- The principles of levying track access charges must take into consideration the socio-economic impacts of rail transport, and
- Rail transport should not be burdened with higher charges than the prevailing socio-economic cost recovery of competing transport modes.

The underlying principles led to establishing a two-part charge with a fixed and variable element. The variable charge covers the socio-economic variable (marginal) costs of rail transport, and the fixed part is based on the fixed costs of track maintenance. The process of setting the variable charge covers four phases. The first phase assesses the maintenance, emission and accident costs variable to traffic volume separately for passenger and freight trains (Table 6.1).

Table 6.1. Variable costs of rail transport in 1997, million FIM (Suvanto, 1999).

Cost item	Passenger trains	Freight trains	Total
Track maintenance	75.4	176.6	252.0
Accidents	20.8	10.2	31.0
Emissions	25.6	60.3	85.9
Total	121.8	247.1	368.9

In the second phase, these socio-economic variable (marginal) costs of rail transport are adjusted in comparison with the corresponding cost recovery ratios of bus and freight transport on roads. For 1997, it was assumed that bus transport covers 78% and heavy goods vehicles 75% of their variable socio-economic costs. Thus, the total variable charge would be FIM 95.1 million for passenger rail transport and FIM 185.3 million for freight transport. In the third phase, the fuel and electricity taxes paid by the operator are deducted from the above sums (Table 6.2).

[7] Suomen säädöskokoelma 21/95. Laki valtion rataverkosta, radanpidosta ja rataverkon käytöstä.

Table 6.2. "Equalisation" of variable transport costs in 1997, million FIM (Suvanto, 1999).

	Passenger trains	Freight trains	Total
Variable (marginal) costs as adjusted with the corresponding costs of bus and HGV transport	95.1	185.3	280.3
Deduction of energy taxes	12.9	21.3	34.2
Remaining cost to be charged	82.2	164.0	246.3

In the fourth phase, the above sums are divided by the supposed annual performance of passenger and freight trains (in gross ton kilometre), which yields the variable charge FIM/unit of performance. The variable charge is equal on all parts of the network and for all types of vehicle equipment. The total share of all external costs in the track access charge has added up to 30% of the charge.

The principles of levying the track access charge have never been officially published. However, the new directive on infrastructure charging on railways defines the principles of charging, and expects that the track manager would prepare a track statement on the principles and charges applied to the Finnish network.

Accident costs in the track access charge

The accident charges levied up to now are based on principles set out in a study by VATT (Liikenneministeriö, 1995). Accident costs are estimated based on a five-year statistical average, and they are allocated separately to passenger and freight transport according to the ratio of fatal to non-fatal injuries occurred.

In Finland, the Ministry of Transport and Communications together with the Finnish National Road Administration and the Finnish Railway Administration have defined unit costs for personal injuries in road traffic accidents. These cost estimates consist of some real economic costs and expenditure, lost production as well as the value of lost well-being. The latter cost element is now estimated based on subjective individual willingness to pay for risk reductions.

The lost well-being of a non-guilty party is considered an external cost. The lost well-being of the guilty party is considered an internal cost. The costs of personal injuries to railway workers and injuries to road traffic parties in level crossing accidents are excluded from the assessment. Injuries to train personnel are considered internal to the transport mode, and injuries to road traffic parties are considered road traffic accidents.

A train has never been judged guilty for a level crossing accident or running over people on the track line. Therefore, the victims are not considered to be the responsibility of the rail sector, and costs of lost well-being are not considered. Instead, the lost well-being of injured train passengers are included in the accident cost as external to the rail mode.

6.2 Impacts of the proposed model on the track access charge

The proposed new division of internal and external cost components will change the categorisation of costs and the level of the accident component in the track access charge. In some cases, the rail sector will be released of cost responsibility, whereas in some other cases cost responsibility will be increased or shared with the road mode.

Besides the new principles, the accident charge will also rise due to the recently revised (internal and external) unit costs of personal injuries. The final impact on the accident charge is known only after accident statistics have been examined by categorising the severity of non-fatal injuries, after the principle of cost division with the road mode in level crossing accidents without warning device has been agreed upon, and after the insurance compensations to be deducted from the external cost components of non-fatal injuries have been assessed. The recommendation is that these issues are considered prior to redefining accident costs in track access charges.

Applying these principles will attract attention there where uncovered external accident costs are highest. According to statistics, it is likely that cost are high for accidents occurring in level crossings without warning device. On the other hand, serious derailing accidents have taken place in the late 1990s.

7 CONCLUSIONS

The report presents a theoretical framework on the categorisation and estimation of internal and external costs of the most significant accident types leading to personal injury in rail transport. Besides personal injuries, accidents in transport of dangerous goods are considered. Also, a proposal for the allocation of cost responsibility is presented.

There are not many established models for assessing the internal and external accident costs of rail transport. The Swedish and Norwegian models are among the few. They mainly follow the principles of accident costing theory, but also apply independent choices. On the other hand, the theory of accident costing is not very established either. The framework presented here is a synthesis of the above models, but it also solves some theoretically grey areas by reasoning.

Since the division of internal and external costs is dependent on the type of the accident, it is recommended that accidents be categorised. Accident categories include:

a) Derailing and collision on railways, leading to personal injuries to passengers or train personnel,
b) Level crossing accident with and without warning device, leading to injuries to the road transport party, train passengers or train personnel,
c) Accident leading to personal injury in platform areas or falling from a moving train, and
d) A personal injury on the forbidden track line.

In providing a monetary value for personal injuries, the recently redefined socio-economic unit costs of personal injuries in road traffic accidents are applied. Thus, the cost categories of administration, lost national product and well-being are either internal or external costs, depending on the accident type.

External accident costs are always involved in personal injuries, at least in the form of treatment and rehabilitation costs, as well as lost income and production. However, the first three cost items are covered in Finland either by road traffic or liability insurances of the operator. Therefore, they should not be charged to the operator.

The core criteria for separating between internal and external costs is the relationship of imposing risk and being imposed, and the awareness of risks in typical accident situations and travel in general. According to the theory, passengers, other travellers, and train personnel consider the risks involved in the choice to travel and work on the railways or on roads. In these cases, the risk value (value of personal well-being) included in the cost of personal injury is considered an internal cost. The remaining external costs involve emergency and administrative costs and lost national product. This interpretation applies to derailing and collision accidents within the railways.

When the responsibility of imposing risk is strongly at the rail mode, the cost responsibility (for the identified external cost elements) is also allocated to the rail mode. If the risk taker is some other mode of transport, the cost responsibility is not allocated to the rail mode. There also are situations where sharing the cost responsibility is recommended.

The cost responsibility of the rail mode is either partial or total, when:

a) Accidents occur within the rail mode,
b) Accidents occur in level crossings without warning device and
c) Accidents occur by falling from platforms or moving trains.

The costs of accidents occurring to people walking on the forbidden track line (in other places than marked crossings) are not allocated to the rail mode, since the accident is considered to result from deliberate risk-taking.

The presented framework considers three accident categories, in which the responsibility of external costs should be allocated to the rail mode. The first is an accident in level crossings without warning device (bars, light or sound warning), the second is falling from a platform, and the third is falling from a moving train. In these cases it is assumed that the individual has not been able to prevent the accident by taking precautions. Thus, the total socio-economic value of a personal injury is the external cost. In the case of level crossing accident with no warning device present, it is recommended that the external cost be shared with the road mode, since risk-taking behaviour is also assumed to occur there in some cases.

The risk values of non-fatal injuries should in principle be deducted from compensations (lost income, rehabilitation, pain and suffering) covered by the insurance system. Since such an inventory was not possible within this study, it is recommended that it be conducted prior to defining the accident costs charged to the rail operator.

Theoretically correct marginal accident costs have not been defined anywhere in Europe, so far, taking into consideration risk relationships by the volume of traffic and between different transport modes and vehicle types. Unless such risk assessment is performed in Finland, average costing should be used. However, it seems possible that level crossing accidents can be forecasted according to the theory.

Railway accidents cause delays to transport, and also possibly environmental costs. These external costs should be considered in the future.

The framework presented does not impact track access charges dramatically, although the level of charges may rise. Instead, the impact of the framework is greater on separating between the situations where the railways have a stronger cost responsibility and where it is released of cost responsibility. A greater pressure on accident cost charging is due to the recently revised (raised) socio-economic unit values of personal injuries. It is likely that accident risks at level crossings without warning device will draw greater attention in the future, which corresponds to an incentive process arising from economic theory of infrastructure charging.

Accident costing and charging are currently being developed in national and international European research projects. Therefore, proposals for a common conduct are likely to appear. The framework presented here already follows the underlying theory. Other transport modes, the road mode in particular, should follow this process and develop similar principles.

References

CAPRI (1998). Valuation of transport externalities. Deliverable 3. Concerted Action on Transport Pricing Research Integration. Project Funded by the European Commission 4th Framework – Transport RTD. ITS University of Leeds.

Elvik, R. (1994). The External Costs of Traffic Injury: Definition, Estimation, and Possibilities for Internalization. Accident Analysis and Prevention, Vol. 26, No. 6, pp. 719 – 732.

Eriksen, K., Markussen, T. & Putz, K. (1999). Marginale kostnader ved transportvirksomhet. Transportökonomisk institutt. TÖI rapport 464/1999.

European Commission (1999a). Calculating Transport Accident Costs. Final Report of the Expert Advisors to the High Level Group on Infrastructure Charging (Working Group 3).

European Commission (1999b). High Level Group on Transport Infrastructure Charging. Final Report on Estimating Transport Costs.

European Commission (1999c). High Level Group on Transport Infrastructure Charging. Final Report on Options for Charging Users Directly for Transport Infrastructure Operating Costs.

Hagen, K. (1997). Ulykkeskostnader for jernbanen. TÖI notat 1081/1997. Oslo.

Hansson, L. (1997). Kostnadsansvaret för trafikens externa effekter. En jämförelse mellan vägtrafik och tågtrafik. IIIEE Communications 1997:4. Lund University.

Haukeland, J.V. (1996). Welfare Consequences of Injuries Due to Traffic Accidents. Accident Analysis and Prevention, 28(1): 63 – 71.

Jansson, J-O. (1994). Accident Externality Charges. Journal of Transport Economics and Policy, Vol. 28, No. 1, pp. 31 – 43.

Jones-Lee, M. (1990). The value of transport safety. Oxford Review of Economic Policy, Vol. 6, No. 2, pp. 39 – 60.

Jones-Lee, M. (1992). Paternalistic Altruism. The Economic Journal, 102, pp. 80-90.

Jones-Lee, M. & Loomes, G. (1994). Towards a willingness-to-pay based value of underground safety. Journal of Transport Economics and Policy, Vol. 28, pp. 83 – 98.

Jones-Lee, M. & Loomes, G. (1995). Scale and context in the valuation of transport safety. Journal of Risk and Uncertainty, Vol. 11, pp. 183 – 203.

Liikenneministeriö (1995). Liikenteen ulkoiset kustannukset huomioon ottava hinnoittelu. L 4/95.

LTT (1990). Tieliikenteen onnettomuuskustannukset Suomessa. Laskentaperiaatteet ja suuruus. Liiketaloustieteellinen tutkimuslaitos.

Miller, T., Douglass, J. & Pindus, N. (1994). Railroad Injury: Causes, Costs, and Comparisons with Other Transport Modes. Journal of Safety Research, Vol. 25, No. 4, pp. 183 – 195.

Ratahallintokeskus (1999a). Suomen rautatietilasto 1999.

Ratahallintokeskus (1999b). Vuosikertomus 1999.

Ratahallintokeskus (2000). RHK ja ympäristö. http://www.rhk.fi

SIKA (1999). Översyn av samhällsekonomiska kalkylprinciper och kalkylvärden på transportområdet. SIKA Rapport 1999:6.

Suvanto, T. (1999). Tulisiko ratamaksun periaatteita muuttaa? Muistio. Ratahallintokeskus.

Schwab Christe, N. & Soguel, N. (1996). The Pain of Road-Accident Victims and the Bereavement of their Relatives: A Contingent-Valuation Experiment. Journal of Risk and Uncertainty, 13:277-291.

Tervonen, J. (1999a). Inhimillisten onnettomuuskustannusten arvottaminen. Liikenneministeriön mietintöjä ja muistiota B9/99.

Tervonen, J. (1999b). Accident costing using value transfers. New unit costs for personal injuries in Finland. VTT Publications 396. Technical Research Centre of Finland, Espoo.

Tielaitos (1995). Tieliikenteen ajokustannukset 1995.

UIC (1999). External Costs of Transport. Accident, Environmental and Congestions Costs in Western Europe. International Union of Railways. Prepared by INFRAS and IWW.

UK DETR (1997). UK Department of the Environment, Transport and the Regions. Highway Economics Note 1/1997. http://www.roads.detr.gov.uk/roadsafety.

US DOT (1997). Federal Highway Cost Allocation Study. Final Report. US Department of Transportation. Federal Highway Administration. http://www.ota.fhwa.dot.gov.

Zeckhauser, R. (1996). The economics of catastrophes. Journal of Risk and Uncertainty, Vol. 12, pp. 133-140.

VR (1995 – 2000). Junaturvallisuustilastot 1995 – 1999. Oy VR-Rata Ab. Sisäinen julkaisu.

Vägverket (1997). Vägverkets samhällsekonomiska kalkylmodell. Ekonomiska teori och värderingar. Publication 1997:130. Borlänge.

Publications of the Finnish Rail Administration **A**

1/1997	Railway Industry Structures and Capital Investment Financing
2/1997	Nopean junaliikenteen aluekehitysvaikutukset
3/1997	Rautateiden henkilöliikenteen ennustemalli (RALVI)
4/1997	Kilpailuedellytykset ja niiden luominen Suomen rataverkolla
5/1997	Rataverkon tavaraliikenne-ennuste 2020
1/1998	Rataverkon jatkosähköistyksen yhteiskuntataloudellinen vaikutusselvitys
2/1998	Suomen rautatieliikenteen päästöjen laskentajärjestelmä (RAILI 96)
3/1998	Rautateiden tavarakuljetusten laatutekijät
4/1998	Ratahallintokeskuksen tutkimus- ja kehittämistoiminta 1997 - 99
5/1998	Rataverkon kehittämisen yhdyskuntarakenteellisten vaikutusten ja menetelmien arviointi
6/1998	Yksityisrahoituksen käyttömahdollisuudet Suomen ratahankkeissa
1/1999	Ratarakenteen instrumentoinnin kirjallisuustutkimus, 250 kN:n ja 300 kN:n akselipainot
2/1999	Rautatieliikenteen polttoaineperäisten päästöjen aiheuttamat ympäristökustannukset
3/1999	Rautatieliikenteen aiheuttama tärinä, 250 kN:n ja 300 kN:n akselipainot
4/1999	Ratarakenteen instrumentointi- ja mallinnussuunnitelma, 250 kN:n ja 300 kN:n akselipainot
5/1999	Rautatietärinän mittauskäytäntö Pohjoismaissa
6/1999	Radan tukikerroksen ja alusrakenteen kirjallisuustutkimus, 250 kN:n ja 300 kN:n akselipainot
7/1999	Rautatiesiltojen luokittelu ja inventointi rataosuudella Rautaruukki–Haaparanta akselipainojen korottamista varten
8/1999	Ratarumpujen maastoselvitys, 250 kN:n ja 300 kN:n akselipainot
1/2000	Rataverkko 2020 -ohjelman väliraportti. Kehittämisvaihtoehtojen vaikutustarkastelut
2/2000	Bantrummor, 250 kN och 300 kN axellaster
3/2000	Liikkuvan kaluston kirjallisuustutkimus
4/2000	Raidesepelin lujuuden vaikutus tukikerroksen ikään
5/2000	Ratarakenteen instrumentointi ja mallinnus, 250 kN:n ja 300 kN:n akselipainot
6/2000	Väliraportti 250 kN:n ja 300 kN:n akselipainojen ratateknisistä tutkimuksista
7/2000	Intermediate Report, 250 kN and 300 kN axle loads
8/2000	Ratatekniset määräykset ja ohjeet -julkaisun käytettävyystutkimus
9/2000	Ratakapasiteetin perusteet
10/2000	Instrumentation and Modelling of Track Structure, 250 kN and 300 kN axle loa
11/2000	Rautatieonnettomuuksien sisäiset ja ulkoiset kustannukset

FINNISH RAIL ADMINISTRATION
KAIVOKATU 6, P.O. Box 185
FIN-00101 HELSINKI

STRATEGY UNIT

For further information, please contact:
Mr. Tuomo Suvanto, Tel. +358 9 5840 5125, e-mail: tuomo.suvanto@rhk.fi
Mrs. Arja Aalto, Tel. +358 9 5840 5121, e-mail: arja.aalto@rhk.fi

ISBN 952-445-045-3
ISSN 1455-2604