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New unit costs for personal injuries in Finland

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Abstract

The report, *'Valuation of the human cost factor of traffic accidents'* (Ministry of Transport and Communications, Publication B 9/99), concluded that the current methods used in Finland for costing accidents are not theoretically completely valid and should be revised, along with estimating new respective unit values. Individual willingness to pay should be applied in order to capture the true nature of welfare impacts induced by accident risks and to quantify the lost quality of life in monetary units. Only those values that reflect subjective risk preferences represent the welfare consequences of accidents in an appropriate manner.

The Finnish accident-costing system has been re-examined in this report, and a set of new unit costs proposed accordingly. For presenting the arguments behind the adopted method for costing risk values, a review of the valuation methodology and its economic welfare foundations has been presented. The material accident costs have been adjusted according to the 1987 inventory only by a price index to current day values. The production losses have been costed according to the theoretically correct net of personal consumption approach, based on 1998 data on Finnish national accounting.

The other major change in the costing structure concerns the approach to valuing lost quality of life induced by personal injuries. As Finnish empirical risk value studies do not yet exist and there has been no time for conducting such a survey, the method of value transfer has been applied. Value transfers are commonly used in order to reduce the cost of arduous and time-consuming studies and to obtain information for decision-making with less research effort.

The Swedish risk value representing the quality of life lost due to a fatality has been transferred directly to Finland. The values assigned for representing the

quality of life lost due to non-fatal injuries has been scaled from the Swedish value of fatality according to the relative weights used in Norway. The reason for this is the similar injury severity classification used in Norway and Finland.

Transferred values never fully correspond to values obtained by empirical risk valuation studies. Therefore, performing such a study is strongly recommended for the near future. Since the data behind the current real economic accident cost estimates is already rather old, also an inventory on the overall cost structure of accidents is recommended.

If adopted into the decision-making system, the proposed new method adopted from contemporary accident costing literature and the unit values it produces, would clearly increase the emphasis given to human welfare impacts of traffic safety. This change simultaneously serves the purpose of directing more resources to implementing safety measures and policies. In particular, more emphasis would be given to the welfare impacts of minor injuries, which are rather often ignored in traffic safety discussions.

These new unit costs would raise the figures representing the social cost of road transport, in particular, in Finland. Therefore, also the pressure on collecting the funds for covering the costs would rise. If the principles of full-cost pricing and user pays were be applied, these costs should be covered. The user-pays principle and pricing transport respectively initiate a change in people's behaviour. This means that accident costing would lead to such prices of travelling that reflect these costs, which then would be reduced by a change towards risk averse behaviour. Thus, by using the correct management tools, the number of accidents and their social and private costs would be eventually reduced.

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Tiivistelmä

Julkaisussa on oikaistu Suomessa käytössä oleva liikenneonnettomuuksien henkilövahinkojen hinnoittelujärjestelmä teoreettisesti oikeaoppisen mallin mukaiseksi. Samassa yhteydessä myös yksikkökustannukset on arvioitu uudestaan ja niistä on muodostettu ehdotus. Uudet yksikkökustannukset perustuvat vuonna 1987 edellisen kerran suoritettuun kattavampaan reaalitaloudellisten kustannusten inventaariin, indeksikorotuksiin, kansantalouden tilinpitoon sekä ulkomailta lainattuihin hyvinvoinnin menetyksiä kuvaaviin yksikköarvoihin.

Suomessa käytössä olevan hinnoittelujärjestelmän keskeinen ongelma koskee inhimillisten hyvinvointitappioiden mittaamista. Niin sanottu ’yhteiskunnallinen maksuhalukkuus’ ei mittaa tilastollisten onnettomuusriskien hyvinvointivaikutuksia yksilötasolla. Raportissa kuvataan oikeaoppinen arvottamismenetelmä, yksilön maksuhalukkuus, sen teoria sekä empiirisiä havaintoja muissa maissa suoritetuista tutkimuksista.

Koska Suomessa ei ole tehty vastaavia empiirisiä maksuhalukkuustutkimuksia, on henkilövahinkojen hyvinvointivaikutusten hinnoittelemiseksi arvioitu mahdollisuutta käyttää vertailumaista siirrettäviä arvoja ainakin tilapäisesti suomalaisten onnettomuuskustannusten hinnoitteluun. Muodostettaessa oheinen uusien yksikkökustannusten ehdotus näin onkin päädytty tekemään.

Esitetyt yksikkökustannusten uudet arvot vastaavat menetelmällisesti talousteorian sekä Euroopan Komission käsitystä (COST313) onnettomuuskustannusten oikeaoppisesta arvottamisesta. Arvot ovat kuitenkin tekijän mielestä riittävän vahvat otettavaksi käyttöön siihen saakka, kunnes uusia onnettomuuskustannusten arvottamistutkimuksia suoritetaan Suomessa. Uutta kustannusten inventointia sekä turvallisuustutkimusta palvelevan riskinarvottamistutkimuksen suorittamista suositellaan.

Uudet yksikköarvot toisivat muutamia selviä muutoksia onnettomuuskustannusten laskentaan ja päätöksentekoon. Subjektiiviset riskiarvostukset otettaisiin huomioon kokonaan uudella tavalla, ja tuotantomenetysten laskenta perustuisi yksistään kansantaloudellisiin tappioihin ilman yksilön omaa kulutusta, joka kuvautuu teorian mukaan jo riskiarvoissa. Esitetyt uudet arvot lisäisivät selvästi onnettomuuksien aiheuttamien inhimillisten menetysten painoarvoa resursseja kohdentavassa päätöksenteossa.

Erityisesti toistaiseksi usein vähemmälle huomiolle jäävät lukumäärältään runsaat tilapäiset vammat saisivat kokonaan uutta painoarvoa Ruotsin ja Norjan tapaan. Ainoa yksittäinen yksikkökustannuserä, joka alenee entiseen verrattuna, on pysyvien vammojen aiheuttamat tuotantomenetykset. Nyt ne lasketaan vammojen tilastollisen esiintymisen ja vakavuuden mukaan painotettuna keskiarvona.

Henkilövahinkojen yksikkökustannuksista puuttuu edelleen selkeästi muutamia kustannuseriä. Onnettomuuskustannuksissa eivät enää kuvaudu pitkäaikaispotilaiden laitoshoidon kustannukset (joita käytettiin ennen kuvaamaan inhimillisiä menetyksiä). Tätä kustannuserää ei ole kuitenkaan otettu kustannusrakenteeseen mukaan vanhan datan pohjalta, vaikka se kuuluukin selkeästi osaksi henkilövahingon kustannusrakennetta. Muita puuttuvia kustannuseriä ovat kotitaloustyön arvo sekä ammatillisten kykyjen menetys. Yksikkökustannusten ehdotus todennäköisesti edelleen aliarvioi henkilövahinkojen todellisia kustannuksia, vaikka puutteet otettaisiinkin huomioon.

Arvojen nostaminen lisää liikenneturvallisuuden painoarvoa päätöksenteossa. Turvallisuustoimenpiteiden ja -ohjelmien kannattavuus paranee vaihtoehtoisiin varojen käyttökohteisiin verrattuna. Henkilövahinkojen yksikkökustannukset ovat liikennepolitiikan työväline ja sikäli arvojen korotus lisää työvälineen voimakkuutta. Toisaalta yksikköarvojen korotus lisää erityisesti tieliikenteestä aiheutuvaa yhteiskuntataloudellista kustannusrasitetta. Tämä vastaavasti kasvattaa paineita kerätä kustannukset takaisin liikkujilta tai toteuttaa liikennejärjestelmän turvallisuutta selvästi parantavia toimenpideohjelmia. Talousteorian mukaan hinnoittelu pitäisi toteuttaa joko verottamalla liikennettä yleisesti, väylien käyttömaksuilla tai mieluiten vakuutusmaksujärjestelmän piirissä.

Teorian mukaan liikennejärjestelmän käyttäjille kohdistetut todellisten kustannusten mukaiset liikkumisen hinnat saavat aikaan käyttäytymisen muutoksen, joka ennen pitkää alentaa yhteiskunnallisia kustannuksia. Näin ollen sekä oikeaoppisen hinnoittelun että tehokkaiden toimenpideohjelmien toteuttamisen lopputuloksena seuraisi turvallisemmin toimiva liikennejärjestelmä ja alhaisempi yhteiskunnallinen onnettomuuskustannusten rasite.

Preface

In January 1999, the Ministry of Transport and Communications commissioned VTT Communities and Infrastructure to provide a literature review of methods for estimating the cost of the lost quality of life induced by traffic accidents. In addition, the valuation method currently used in Finland, the so-called 'social willingness to pay', was critically examined in order to see whether it is theoretically consistent and valid for use, or whether it should be replaced by some other method.

The report *'Valuation of the human cost factor of traffic accidents'* (Ministry of Transport and Communications, Publication B 9/99) concludes that the method used in Finland is not theoretically valid and should be replaced. New unit values should be derived based on a theoretically consistent method for representing the lost quality of life induced by traffic accidents in decision-making in an appropriate manner.

This report provides a review of the theory and use of the values derived by the willingness-to-pay method for costing accidents in some European countries. The report also theoretically examines the method of value transfers for deriving a new set of unit values for Finnish traffic accidents from the selection of existing European values.

The Finnish National Road Administration is revising the unit values used in the transport economic calculus of project appraisals during 1999. The values will be verified by the Ministry of Transport and Communications at a later stage the same year. As the time-table does not allow conducting a full national risk valuation study, the value transfer method allows for making a swift proposal on up-dated unit values. As the accident cost structure is in any case inter-related, the whole set of values is reconsidered in this report.

The report was written by research scientist, Juha Tervonen M.Sc. (Econ.), during summer 1999. The project was led by the Ministry's traffic safety unit by chief engineer, Anneli Tanttu and chief engineer, Juha Parantainen from the research unit. Representatives of the transport modes in the work-group were Mr. Pauli Velhonoja from the Finnish National Road Administration and Mr. Tuomo Suvanto from the Finnish Rail Administration.

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1 Introduction

The valuation of lost quality of life primarily serves the function of improving individual and collective well-being by public choices. This is materialized as a set of management tools, such as unit values assigned to lost quality of life in transport economics manuals.

Assigning a value to lost quality of life is first and foremost a management tool for setting priorities in decision-making. In no circumstance is the aim to assign a value to life *per se*, but to estimate a range of surrogate values reflecting individual risk preferences for the use of resource allocation decisions and to estimate the social cost of transport.

Implicit decisions that affect individual and social well-being are constantly being made in the public sector. There are decisions made about, e.g. food and product safety, health care and national defence. Such decisions do not in all cases necessarily involve monetary estimations of benefits in the form of improved quality of life. These decisions are made intuitively without knowing the true benefit yield in relation to costs (see van Houtven & Cropper, 1996).

Several meta-analysis studies demonstrate that the costs of such decisions at times yield rather high values for preventing losses to the quality of life. Often these decisions and resulting safety standards are reflections of common ethical values of preserving and improving the quality of life and health. In some cases, the preservation of life is given highest priority. In the transport sector, this is the case in aviation, where the ‘safety-first’ principle rules. However, in other transport modes the situation is different.

In the road transport sector, fatalities and casualties have been assigned monetary unit values for some time now. Often the rail sector utilizes the same unit values for the sake of practicality and comparability. However, these values have been rather low and they have been considered only the real economic consequences of accidents. Even the real economic cost inventories are often incomplete. However, in most countries the greatest deficiency in accident costing is the often non-existent or inconsistently derived value of lost individual utility.

In the 1980s and 90s, the theoretical examinations and results of subjective risk preference studies convinced the decision-makers of several countries to assign the value of lost quality of life according to empirical findings. It was admitted that the prior methods used for assigning values to changes in the quality of life were not capable of covering the right magnitude of welfare impacts of risk and their unfavourable consequences.

Examination of the valuation methods and unit values of lost quality of life applied in the transport sector in some European countries nowadays alludes to the fact that the current unit values of life and health in the Finnish accident-costing manuals may not necessarily represent transport safety priorities with an adequate emphasis.

The current Finnish unit values have been derived with a theoretically inconsistent method. The so-called ‘social willingness to pay’, is technically incapable of producing comparable unit costs with countries using the risk preference approach (individual willingness to pay, WTP). Based on these two arguments, the valuation basis must be altered and at the same time new unit values estimated.

The main aim of this report is to ensure the decision-maker that the true weight of welfare impacts of safety is only represented after lost quality of life with its intangible characteristics is fully considered as a part of the total cost structure of personal injuries. The second but just as important provision concerns the necessity to use the correct theoretical welfare foundation and corresponding valuation method in monetarizing the welfare impacts of changes in risk.

Although the main emphasis of the report is on discussing the characteristics and estimation of the lost quality of life components caused by traffic accidents, touching the traditional, real economic cost components is unavoidable. Therefore, the overall cost structure of personal injuries is re-examined to the extent allowed by the readily available data. New unit values are proposed accordingly.

Although this report, and especially the documents it refers to, might use expressions such as ‘value of life’ or something very similar, the effort made in research does not in any circumstance aim at assigning a value to life *per se*. Costing the welfare impacts of lost quality of life is based on providing an estimate of people’s risk preferences. The term, risk value, corresponds better with the aims of approximating a value to changes in accident risks.

The report is structured as follows: Chapters 1 and 2 discuss the main aims of costing accidents. Chapters 3 and 4 present the economic theory of risk preferences. Chapter 5 examines the theory and conduct of value transfers. Chapter 6 presents the costs assigned to personal injuries in some countries. In Chapter 7 value transfers are performed and critically examined. Chapter 8 presents the calculus of new unit costs for personal injuries in Finland and Chapter 9 concludes the report.

2 Accident risk and the value of lost quality of life

2.1 Public Decisions and Safety

Safety in the context of this report stands exclusively for safety to human life and health, and protection from physical risk. Physical risk is here understood as an individual's exposure to the possibility of death or injury in a traffic accident during a specified time period.[1] This expectation, as well as the more favourable outcome of survival, is presented in the form of probabilities. Public decisions can have an effect on this probability and influence the well-being of people.[2]

Improved levels of safety (decrease in risk) can be normally only achieved at the cost of a curtailment in some of the other desirable ways in which society might allocate its scarce resources (Jones-Lee, 1989). The more society spends on safety, the less will be available for other publicly funded projects. Characteristically, public projects aim at maintaining and improving general well-being in some manner or the other.

According to empirical findings, people enjoying a certain standard of living generally prefer low risks to high risks. Therefore, changes in risk bear significant individual and socio-economic consequences, which should be considered when the trade-offs between competing resource allocation decisions are analyzed.

We prepare ourselves for these probabilistic costs by having both a public safety net (the social security system) for taking care of us at the accident site and treating our injuries, and a private safety net system for insuring ourselves against material loss and the lost/reduced ability to work and provide for our dependants. Nevertheless, these preparative measures are costly, and these costs should be minimized just as any other cost that reduces the productivity of the society.

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[1] Naturally the amount of exposure varies according to the volume of individual mobility.

[2] Safety is a partly public good. The risk imposed on people can be influenced by both private and public decisions. This report concentrates on the nature of the public good type of safety and corresponding changes risk.

Besides these costs, which we prepare ourselves for, there is a set of costs considered external, which is not directly covered by the users of the transport system, or more precisely the perpetrator of an accident. These costs fall either on the victim or the society, or both. In these cases, either the well-being of individuals is reduced without (full) compensation, or the taxpayers cover the costs collectively. Similarly, the loss of a productive member of society is a collective loss to us all.

The productivity of individuals and society can also be understood as something more than just our individual contributions to the gross national product (GNP), which in itself is only a national accounting presentation of production with its acknowledged limitations in measuring well-being. Subjective valuation methods have the benefit of allowing people to consider also the individual features of well-being, and therefore the statements are not solely based on material values.

It is estimated that in Finland the costs of road accidents were approximately FIM 4.1 billion in 1998 (Ministry of Transport and Communications, 1998). This estimate exclusively represents the real economic cost to society and individuals, since the current Finnish costing method does not account for subjective risk preferences and the corresponding welfare impacts. Therefore, these figures underestimate the total impacts of accidents in Finland by the magnitude of lost human utility.

Table 2.1 presents a break-down of the estimated total loss of utility in both material form and lost quality of life for fatal and non-fatal road traffic accidents in Great Britain in 1997. Great Britain applies the willingness-to-pay method for quantifying a monetary cost to the lost quality of life. Therefore, the British method represents a more comprehensive assortment of cost items than the Finnish method. The British costing structure corresponds to the one proposed in theory from literature on accident economics.

Table 2.1. Total value of prevention of road accidents by severity and element of cost, GBP million (DpT of the Environment, Transport and the Regions, 1997).

Cost element							
	Casualty-related costs			**Accident-related costs**			
Accident severity	**Lost output**	**Medical and ambulance**	**Human costs**	**Police costs**	**Insurance adminis-tration**	**Damage to property**	**Total**
Fatal	1 150	20	2 250	4	1	20	3 440
Serious	570	340	3 490	6	4	110	4 520
Slight	370	160	1 570	7	10	370	2 490
All injury	2 090	510	7 300	20	20	510	10 450
Damage only	-	-	-	10	120	4 230	4 360
All accidents	2 090	510	7 300	30	140	4 740	14 810

There are two ways of approaching safety considerations from the perspectives of economics. In order to reach an efficient solution at the level of society, both of these approaches must be applied.

a) First, costing accidents in the right manner and pricing transport respectively aims at internalizing full accident costs into the individual's decision making function. This will influence traffic behaviour and eventually reduce risks and their unfavourable consequences.

b) Second, accident costing serves to allocate resources to implementing safety measures, e.g. highway design and construction of pedestrian and bicycle lanes, or formulating safety policies.

Thus, estimating the true cost of risk and lost quality of life serves both the pricing of transport and allocating resources. The marginal cost of commuting and travelling for the individual should reflect the risks imposed to other users of the transport system. Defining the cost of this risk requires knowing the value of lost quality of life induced by traffic accidents. Concerning public budget allocations to improving the safety of the infrastructure environment and transport system, the decision-maker needs to know up to which sum of money a safety investment is worth making.

Trade-off decisions faced in resource allocation may be examined within the transport sector by mode, or between different sectors of society. Such allocation choices are confronted at each budget proceeding. However, both comparative settings may involve difficulties in aligning the units of measurement and the outcome of different types of allocations.

The common cases of allocation choices within the transport sector include comparing the outcome of introducing alternative safety measures, or balancing, e.g. monetarized benefits like time savings and accident costs between each other in project appraisal. Between the sectors of society, traffic safety allocations are closely related, e.g. to the health care sector, product safety and occupational safety.

A theoretically valid valuation method for producing the right magnitude of risk values is essential for ensuring correct resource allocation in decision-making and designing management tools for influencing traffic behaviour. Too low a value for lost quality of life would not represent safety with the right magnitude, and resources will be allocated to secondary uses that would not efficiently improve well-being. On the other hand, too high values for lost quality of life would consume resources from other more salient uses.

2.2 Methods for valuing a statistical life

Various methods for deriving a value for statistical life (VOSL) exist. VOSL is used for representing the total economic value of the productive activities, which people pursue during their lifetime. Also the disembodied values of individual well-being are nowadays considered to be included in the total value. The approaches in estimation vary especially in the way they are capable of covering the human welfare implications of changes in risk. The primary objective of use has determined the form of the different approaches and the need for covering different increments of values.

Long before lost quality of life induced by traffic accidents was even considered, the welfare impacts of risks had been examined in the form of wage differentials between risky and non-risk occupations. Other applications are found in examinations of compensations paid due to deaths and injuries by insurance companies, or the sums which courts have awarded as compensation for deaths and injuries, either to the victims or their dependants.

Wage differentials, insured values of life and health, as well as court awards all serve different angles of assessing value losses compared to the current approach of costing traffic accidents. There are differences in the nature of the interests of the different parties involved, as well as the scope of coverage in the costing items.

In the methods mentioned above, the value losses are considered more within a private setting where the parties involved and their specific interests can be clearly identified. Public safety provision considerations treat the members of society as an anonymous aggregate, where the well-being of society is maximized as a sum of these anonymous units of utilities. If a certain number of these anonymous utility-yielding individuals are lost every year, the aggregate well-being of society is not maximized. The lower the number of casualties, the higher the well-being. Valid methods for defining the resulting pure, real economic loss to society do exist.

The traditional way is to account for private and public economic losses due to lost capability of maintaining income and consumption flows during an average life span. These losses are normally estimated from averaged national accounts per capita. Additionally, extra burden to society is induced as the care and rehabilitation of injured and disabled people consume both private and public resources. However, the traditional methods have been inadequate for capturing the value of subjective preferences towards risk and individual characteristics of well-being.

Following Jones-Lee (1989), the alternative methods for deriving a value for a statistical life can be summarized as:

a) Value of gross national product (the human capital method) – the value of a fatality or disabling injury is computed from lost gross national product per capita discounted over an average number of expected years to live.

b) Value of net national product – as above, but for a fatality the share of the casualty’s own consumption is deducted from gross national product per capita.

c) Life insurance method – the value of life and health is defined according to the sums for which people insure their own life or health, or the lives and health of thir dependants (net of the insurance costs).

d) Court awards – compensations awarded for casualties.

e) Implicit public sector valuation – values derived from *past* investments for improving safety, as treated indicative of the appropriate level at which to set explicit costs and values for *future* decisions.

f) Restitution costs - the costs of restoring the health and working ability of an injured or disabled person.

g) Value of time – the value of remaining life expectancy for an individual is defined as the aggregate value of time for the individual over remaining life expectancy.

h) Stated preferences (willingness to pay) – the sum of money, which people are willing to contribute to reducing risk, or equivalently, a sum of money, which is demanded for compensation if risk is increased.

i) Revealed preferences – the prices of products decreasing individual risk.

j) Risk wages – wage differentials between risky and ‘low-risk’ occupations.

Out of these methods, a) and b) serve a purpose in costing the total economic loss from traffic accidents. However, if the willingness-to-pay (WTP) approach is used for quantifying lost quality of life, only the national product net of private consumption is needed for measuring the cost of an accident imposed on the rest of the society. If WTP or any other method of valuing individual future utility is not used, the gross national product should be considered as a minimum proxy for valuing lost well-being, because it includes the value of private material consumption.

Methods c) to g) are more or less useless when the value of lost quality of life should be fully covered. Life insurances are taken for guaranteeing a certain level of consumption and wealth of the dependants of the casualty. Payments are usually for a fixed period and they rarely compensate fully for the actual loss. Court awards have the pre-emptive function of punishment and also account only (partially) for material values.

The prior safety investment reflects intuitive and possibly incorrect past values of society. The resource costs of patient treatment do not necessarily reflect how sufficiently individual well-being can be restored, and it does not provide any information on fatalities. The value of time is a disputed issue and no solid average estimates of time value exist.

Apart from the theoretically consistent method, willingness-to-pay (a stated preference method), the revealed preferences offer potential in their joint use with WTP. In fact, this is the direction towards which value elicitation research has progressed lately (see e.g. Beggs et al., 1981, Adamowicz et al., 1994 and Roe et al., 1996). The so-called con-joint analysis looks at different features of some market commodity to see how these attributes affect willingness to pay. Such an analysis of safety products offers potential for obtaining reference data for pure hypothetical valuation studies and examining private risk preferences more closely.

However, the prices of products that improve safety comprise various other features of the product besides its function for improving safety. The impact of these features on the price of the product should be isolated from the ones that solely reduce risk.

Wage differentials are another strong candidate for estimating VOSL. However, this difference between ‘common’ wages and wages paid in risky occupations may also be determined by various other elements of bargaining besides risk (Table 2.2).

Table 2.2. Wage differentials and the value of a statistical life (Maddison et al., 1996).

Wage differential values of statistical life	
Great Britain	**VOSL (million GBP 1993)**
Melenik 1974	0.5
Veljanovski 1978	5.5–7.6
Needleman 1980	0.2
Marin et al. 1982	2.4–2.7
Geourgiou 1992	8.6
USA	**VOSL (million GBP 1993)**
Coisineau 1988	0.8–2.6
Moore & Viscusi 1988	1.2–5.7
Viscusi & Moore 1989	5.4
Moore & Viscusi 1990	10.6
Kreisner & Leeth 1991	0.4

The variation in the value of statistical life in different wage differential studies is large, obviously depending on which occupations have been examined and in which countries the studies were undertaken. The estimation technique is yet another source of variation in results. Some wage differential values well exceed the value assigned to fatality in WTP studies, while others do not.

Nevertheless, these methods do arise from the same welfare theory foundation as WTP elicitation, where considerations on the substitution of income/wealth for risk lies at the core of the decision-making process of the individual. Therefore, the revealed preference studies and risk wage differentials offer the strongest reference points for the results of WTP surveys (Table 2.3).

Table 2.3. Values of statistical life in early WTP surveys (Maddison et al., 1996).

Value of statistical life in WTP surveys (million GBP 1993)		
Jones-Lee 1985	Great Britain	2.6
Persson 1989	Sweden	1.9–2.3
Maier 1989	Austria	2.44

When risk is valued in a clear public policy setting such as transport safety, the choice of the valuation method reflects the values of society. If the aim is only to maximize GNP and consumption, the losses are measured accordingly by the indicators provided by national accounting. The very clear and unambiguous conduct of calculus and outcome favours the method. If, on the other hand, the aim is to account for risk preferences and related welfare impacts, the only relevant methods are revealed and stated preference, or according to the latest development of methodologies, a combination of these.

As already stated above, when WTP is applied, the net national production per capita reflects the losses accruing for other members of the society. WTP estimates are assumed to cover the value of personal consumption in the future. Therefore gross national product cannot be used due to resulting double counting, because the private consumption share of GNP would represent some od the same private utility loss which is included in a preference statement.

3 Social welfare and individual preferences

3.1 Social welfare definitions

The premise of conventional social cost-benefit analysis is that public sector allocation decisions should reflect, as far as possible, the preferences of those who will be affected by the decisions (Arrow, 1963; Sen, 1970; Jones-Lee, 1989). An immediate question arises about how these preferences should be measured. The ‘one person, one vote’ principle would be quite costly for settling investment decisions and would fail to capture the strength of individual preferences. Individual willingness-to-pay expressions solve the problem of assigning weights to votes. The expression is also comparable to the monetary units describing the cost/benefit of alternative allocations.

The objection to this approach is that it gives the wealthy more say in issues than the poor, which does not serve equity. The advocates of cost-benefit analysis respond by formulating preconditions for (optimal) income distribution and ‘weighting mechanisms’, which justify the use of ‘monetary votes’. A conventional analysis of individual WTP will simply aggregate the expressions over all affected individuals and treat the results as the total benefit of a project, whereas an analysis with explicit distribution weights will clearly employ a weighted aggregate (Jones-Lee, 1989).

In valuation of safety (i.e. costing of risk) it is required to obtain information on the willingness to pay for safety improvements, or the requirement of compensation for tolerating increased risk. Often these changes in risk (probabilities) are quite marginal. Also death is treated as a homogenous ‘discommodity’ with no regard given to different ways death can occur in an accident. In the case of non-fatal injuries, variation in the unfavourable outcome of the probabilities would be present. However, WTP surveys on non-fatal injury are rare. Despite the theoretical inconsistency, often the value of lost quality of life of temporary or permanent non-fatal injuries is scaled from the unit value of fatality by some quality of life index that is used in the health sector.

The aggregate willingness-to-pay V for a small change in risk is approximated by (Jones-Lee, 1989):

$$V = - \Sigma m_i \delta p_i, \quad (i = 1 - n) \qquad \text{where,} \qquad (1)$$

$\delta p_i =$ a change in the probability of death during a forthcoming period for each of n individuals owing to a particular investment project $(i = 1 - n)$

$m_i =$ marginal rate of substitution of wealth for probability of death[3]

Consider the case in which for all i,

$$\delta p_i = - \frac{1}{n}, \text{ so that } \Sigma_i \delta p_i = - 1.$$

Now all individuals are afforded an equal improvement in safety, which reduces the expected number of lost lives during the forthcoming period by precisely one. Such a safety improvement is said to involve the avoidance of one statistical death, i.e. the saving of one statistical life.

Substituting the second equation to the first, it follows that, for the purposes of conventional cost-benefit analysis, the value of saving one statistical life is given conveniently by the arithmetic mean of sum m_i taken over the affected population as

$$V = \frac{1}{n} \Sigma m_i \qquad (2)$$

Social welfare maximization implies making choices affecting a number of people in such a way that an index of aggregate welfare increases. Social welfare maximization is characteristically utilitarian with its consequentialistic choices and assessment of the outcome of these choices being presented solely in terms of individual well-being (welfarism). The individuals themselves are the best

[3] See chapter 3.3.

judges of their own well-being, and one or another utility representation involves respecting the existence of preferences.

The Paretian value judgement expresses that

$$W = f(u_1, u_2, \dots, u_n) \qquad as\ \partial f/\partial u_i > 0 \qquad (i = 1, \dots, n). \tag{3}$$

Total welfare W is maximized as a sum of all the individual utilities, and a welfare increasing Pareto improvement can be made so that at least one individual gains $(\partial f/\partial u_i > 0)$ and no-one loses. In other words, if one person prefers arrangement A to arrangement B and no one prefers B to A or they are indifferent between the choices, arrangement A is to be recommended.

Next we introduce the term *expected* utility Eu_i. This concept corresponds to the value of future consumption and disembodied welfare of the individual. In a simple setting individuals' expected utility can be written as

$$Eu_i = (1-p_i)u_i(w_i) \tag{4}$$

where p_i is the probability of death during the forthcoming period for the i^{th} individual and w_i is his wealth. In addition, p_i depends upon public expenditure on safety, s, which is financed by individual lump-sum taxes, t_i. The choice of an optimal level of safety and taxes can be written as a constrained social welfare maximization problem:

$$max \Sigma a_i(1 - p_i)u_i(w_i - t_i) \qquad subject\ to\ s = \Sigma t_i. \tag{5}$$

After some manipulation of the first-order conditions for a constrained maximum yields the following result:

$$c = \frac{1}{n}\Sigma m_i - nc\,\mathrm{cov}(m_i, \frac{\partial p_i}{\partial s}) \tag{6}$$

where

$$c = -(\Sigma \frac{\partial p_i}{\partial s})^{-1}.$$

c can be interpreted as the marginal social cost of saving one statistical life, and

$$m_i = \frac{u_i}{(1 - p_i) du_i / dw_i} \qquad (7)$$

is the i[th] individual's marginal rate of substitution of wealth for the probability of death in the context of the simplified expected utility model. As a result, the value of statistical life at the margin is given mathematically by

$$V = \frac{1}{n} \Sigma m_i - nc \operatorname{cov}(m_i \frac{\partial p_i}{\partial s}). \qquad (8)$$

These welfare theory formulations are examined further, but in a simplistic manner in the next chapters.

3.2 Individual well-being and willingness to pay for risk reduction

Individual valuations are reflected in what people would be willing to pay in order to obtain benefits or to avoid costs of some kind. The WTP amount reflects a person's valuation of desired goods or services in relation to other objects desired. People are considered to be the best judges of their own welfare, and the values arise from a consumer sovereignty-oriented approach. In applying this method, one has to accept the people's ability to pay, i.e. the existing distribution of income and wealth. However, distributional weights may be applied.[4] (Persson, 1992)

Simplifying from Chapter 3.1, the willingness to pay (WTP) for reducing accident risks can be formulated generally as (Jones-Lee, 1989):

$$\text{WTP} = \sum_{t=0}^{t=T} \frac{U(t)}{(1 + r)^t} \text{A}, \qquad (9)$$

[4] Note that in costing lost production and consumption, the values are averaged GNP per capita.

where

T = remaining number of years to live
$U(t)$ = the utility from a healthy life (originating from income and leisure)
r = individual time preference (interest rate)
A = risk factor (perception of statistical accident risk)

The theoretical analysis of individual willingness to pay for safety is predominantly conducted within an expected utility maximization framework. It assumes that individual choices will, to an approximation, represent rationality in welfare theory (Jones-Lee, 1989).

Individual utility functions behind rational choices may be represented either based on lifetime streams of consumption, sometimes including bequests, or they are based on future states of wealth functions. Physical risk is then present in the form of the uncertainty imposed on either one of the utility representations.

It is assumed that the individual prefers a low probability of death or injury to a high probability because in the latter case the maximum expected lifetime yield of well-being may be considered too uncertain. Axiomatically, the individual also prefers more wealth to less wealth.

Based on these axioms, we can present a utility function (U), which comprises the component wealth and the time of death (w, τ). This function is an indirect presentation of utility derived from lifetime consumption (including individual utility elements) and bequest motives. This utility function is assumed to obey the following claims:

1. $U(w, \tau)$ behaves well, i.e. the curve representing the exchange of wealth and risk is smooth and does not contain discontinuities.

2. An individual prefers higher wealth to lower wealth: $\frac{\partial U}{\partial} > 0$

3. An individual prefers to die later than earlier: $$\frac{\partial U}{\partial \tau} > 0$$

4. An individual is averse to economic risk: $$\frac{\partial^2 U}{\partial w^2} < 0$$

An individual is evidently prepared to secure his or her own future enjoyments and the planned bequests. The changes in risk for an average person are marginal, and therefore the individual WTP statements are also within a reasonable range. However, aggregated over the population, the value of statistical life gained by the reduction of a statistical death or injury amounts to considerable sums.

Figure 3.1 presents the general features assumed characteristic to WTP and compensation demand behaviour. Empirical experiments have produced more specific information on risk valuation (see Chapter 4.2). In reality, the shapes of the curves strongly depend on the initial level of risk, the magnitude of risk change proposed, income, age and subjective risk preferences.

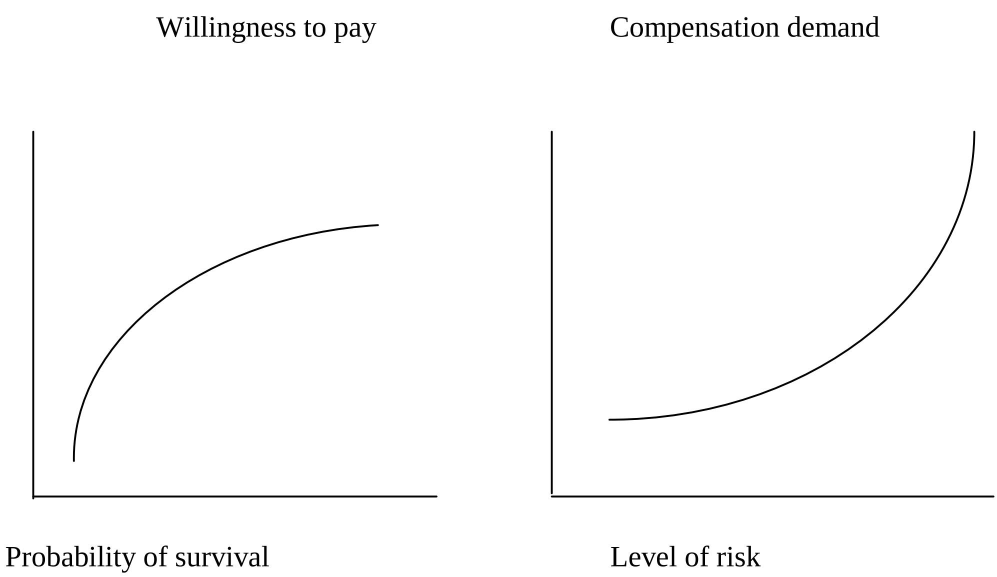

Figure 3.1. The relationship between WTP and compensation demand and changes in risk.

3.3 Marginal rate of substitution

Both of the figures above present a situation where wealth and the level of risk are weighted between each other. In a valuation survey, the respondents exchange marginal amounts of wealth for marginal decreases in risk. This is called the marginal rate of substitution (MRS) between wealth and risk. Mathematically (Vägverket, 1997):

$$WTP = p(t) * m, \tag{10}$$

where

WTP	=	willingness to pay
$p(t)$	=	risk of death at moment t
m	=	$\partial WTP / \partial p$, marginal rate of substitution

According to the consumer theory, both safety (low-risk) and wealth or income maintain an individual's well-being. However, based on individual weighting, exchanging some of the more abundant ones for the scarcer ones, well-being can be further increased. If an individual considers safety to be too scarce a commodity in relation to his present or expected future level of wealth, he will be willing to trade off some.

The problem associated with consumption and wealth approaches has been the inability to capture the 'pure' utility of survival. An expansion of the utility representation has been later introduced into the willingness-to-pay studies in order to allow also the existence of individual values and individual statements accordingly. Particularly valuation research conducted within environmental economics has advocated this issue actively (see e.g. Cummings et al., 1986 and Smith & Desvousges, 1986).

The important effect of reducing rates of personal injuries means simply that, during a relevant time period, the likelihood of death is diminished for any particular person (or anyone he cares about). Life will be made safer for everyone in the population in the sense that the probability of death or injury is reduced. Therefore well-being is increased, which can be depicted either by streams of material and individual consumption or wealth. Only in certain rare cases is it possible to name the ones whose lives and health will be saved. For this reason, the concept of statistical life is used.

The welfare impacts of personal injuries are measured by risk preferences. This means obtaining a statement from people on their willingness to pay for the reduction of risks of death and/or injury. While making a statement, the individual ponders how his or her subjective risk perception affects the current and future level of well-being and whether it should be reduced or not.

If the perceived level of accident risk poses a threat to the individual's well-being, he or she is presumably willing to pay a certain sum of money to reduce the risk. The consideration and the resulting WTP statement are assumed to cover both the value of the future material consumption of the individual, as well as the intangible elements of well-being, such as enjoyment and comfort.

Following Jones-Lee (1989), the analysis of willingness to pay for safety has focused on a number of issues:

1. The way in which the marginal rate of substitution of wealth (or consumption) for risk of death varies with the level of risk, change in risk, income, age and life insurance expenditure.

2. The relationship between an individual's marginal rate of substitution and the volume of his potential human capital (gross output).

3. Non-marginal variations, acceptable increments and multi-period variations in risk.

4. Optimal provision of safety in maximizing social welfare.

5. Benevolence and other people's safety.

6. Compensating wage differentials and the value of a statistical life.

Considering point one, some empirical evidence on variation in risk is presented in Chapter 4.2. The value of a statistical life estimated by the WTP approach has usually resulted in considerably higher values than when the gross output approach is used. The implication is that pure economic values evidently do not reflect the value of risk comprehensively.

Multi-period variations in wealth and risk become very difficult when presented to people in interviews. The optimal provision of traffic safety is, in principle, guaranteed when the full costs of accidents are internalized into allocating decisions and the prices of transport. As mentioned before, wage differentials offer comparative information of the WTP results of traffic safety evaluations.

An important issue of debate has been whether altruism, i.e. concern for the well-being of others, should be considered. Would it be appropriate to augment the value of statistical life to reflect people's WTP for an improvement of safety of the close ones, e.g. family members, relatives and friends (Persson, 1992)? Evidently the well-being of an altruistic person is affected by the well-being of close ones.

Jones-Lee (1992) has shown, that "inclusion of the full amount that people would be willing to contribute to other's safety is appropriate if, and only if, altruism were purely safety focused". In this case, safety would be the only aspect of people's well-being that is of concern for another individual. However, this is evidently not the case. Depending on the degree of altruism, adding values of others' safety would finally result in an overvaluation of safety, as we would all simultaneously express our concerns. Therefore it is recommended to exclusively focus on individual safety when WTP for risk changes is assessed.

3.4 The economic value of risk change

Welfare economics assumes that people make considerations on their future well-being by taking also acknowledged risks into account. People are assumed to hold relatively stable and systematic risk preferences, and therefore they are able to make logical choices in trade-off situations between risk and wealth. If such trade-offs are analyzed in a hypothetical referendum setting (e.g. a questionnaire), the choices made by rational individuals can be considered relatively reliable.

According to empirical evidence, people can be broadly identified either as risk-averse, risk-neutral or risk-takers. Insurances act as a means for preparing for the unfavourable probabilistic outcomes of risk, and individual insurance policies reflect individual risk preferences. A risk-averse person insures himself and his dependants against risks, whereas a risk taker prefers to allocate the cost insurances in current and future personal consumption. In general, risk-averse people are assumed to be dominant in a population.

The economic value of risk changes can be modelled in a simple setting based on the value of expected utility derived from alternative future outcomes (Smith & Desvousges, 1987):

$$EU = RqV_D(y,Z) + (1 - Rq)V_L(y,Z), \tag{11}$$

where

EU	=	expected utility
y	=	the individual's income
Z	=	the individual's socio-economic characteristics
$V_D(y,Z)$	=	the individual's utility in the case of death (*D*)
$V_L(y,Z)$	=	the individual's utility in the case of survival (*L*)
R	=	statistical risk exposure of the individual
q	=	the statistical probability of death

The expected future utility of an individual (*EU*) depends on income (*y*), the risk parameters (*R*,*q*) and his or her socio-economic characters (*Z*). The utility expected from the outcome of death $V_D(y,Z)$ is evidently zero. The utility of survival $V_L(y,Z)$ is maximized with some probability 0 – 1 in the risk factor *(Rq)*.

According to the assumption of marginal rate of substitution presented earlier, an individual may sacrifice some sum of money (P) in order to reduce the risk threatening the realization of maximum expected utility (injury or premature death).

We can assume, that a safety programme reduces the risk (*R*) to a more favourable level (*R**). The utilities between two states of the world, one with a higher risk and no payment and the one with lower risk and a monetary sacrifice, can also be presented as an indifference equation from the individual's perspective:

$$R^{*}qV_{D}(y - P,Z) + (1 - R^{*}q)V_{L}(y - P,Z) = RqV_{D}(y,Z) + (1 - Rq)V_{L}(y,Z), \quad (R^{*}<R)$$

If a WTP statement (P) can be elicited from a representative sample of a population, the safety programme can then be valued as an aggregate. If the safety programme reduces one statistical life, the aggregate WTP value of this programme can be converted into a value of a statistical life (the same applies naturally for injuries). Finally, the calculus of deriving a value to a statistical life is presented.

Assume that an average (or median) individual WTP obtained from an inquiry representing a population of 100 000 people is FIM 70. Assume also that this value statement encompasses a reduction in the statistical probability of death annually by 1/100 000. The total WTP value of such a programme would then be FIM 7 000 000.

However, it is noteworthy that, if the individual WTP value is divided by the reduction in statistical risk, the value of a statistical life arrives at the same sum. Mathematically:

$$\textit{value of statistical life} = \frac{\textit{individual WTP}}{\textit{change in statistical risk}}$$

This result can also be expressed as the marginal rate of substitution between wealth and risk for the total population.

4 Valuing risk

4.1 Eliciting values for public goods

Safety can be considered to be a partially public good. Public provision of safety can reduce accident risk to a certain extent. This involves, e.g. infrastructure design and regulations. However, the eventual choice of traffic behaviour is made by the individual, and no matter how much public safety is provided, the private risk behaviour cannot be completely constrained (see e.g. Wilde, 1994).

Public provision of safety is traditionally still considered to be at least partly liable for the better or worse development of accident rates. Nevertheless, safety is a public good with no apparent market price attached for the use of weighting in economic decision-making, unless the value of safety is considered merely to equal the costs of safety measures and programmes.

Regardless of the absence of true market value based decision criteria, social welfare theory expects that the preferences of the members of the society should be consulted when public choices affecting risk are to be made. People are always capable of at least ranking favourable and unfavourable future outcomes affecting their personal well-being. Judging from empirical evidence, people are capable of even stating a monetary value for risk changes, which serves as an indicator of weight on the relative desirability or undesirability of changes in risk.

Many public goods lack the features of true market goods, and thus do not have a price. Therefore, preference statements aiding, e.g. the provision of safety must be obtained by using methods which enable imitating the function of the markets and price setting. The contingent valuation method (the methodological name for the WTP approach) has been developed for deriving surrogate values for public goods. These values are considered good enough to be used in resource allocation decisions.

The method has been industriously used in environmental economics for deriving values for non-market natural assets ranging broadly from the existence of individual species to atmospheric quality. Although safety is not necessarily such an universally regarded good as, e.g. many environmental amenities are, the valuation methodology is considered applicable for valuing changes in risk.

The method uses surveys to elicit people's preferences for public goods by finding out what they would be willing to pay for specified improvements in them. The absence of markets is circumvented by presenting consumers with hypothetical markets, where they have the opportunity to make a statement on the willingness to pay for the good in question. The hypothetical markets try to imitate real markets. The respondents face an interview consisting of (Mitchell & Carson, 1989):

1. A detailed description of the good being valued and the hypothetical circumstance under which it is made available to the respondent.

2. Questions, which elicit the respondent's willingness to pay for the good.

3. Questions about the respondent's characteristics, their preferences relevant to the good being valued and their use of the good(s).

The market is constructed with considerable detail to be as plausible as possible and communicated to the respondent in the form of a scenario. The baseline provision of the good in question, the structure in which it is to be provided and the method of payment are described. For tracing out a demand curve for the good, values are elicited in several subsections of the questionnaire.

The WTP questions are designed to facilitate the valuation process without biasing the value statements. Background information may be used to estimate a valuation function for explaining the outcome, partially validating the reliability and also for predicting people's behaviour. The typical value elicitation framework of a postal survey is presented in Example 4.1.

Example 4.1. Persson survey. See Hjalte et al. (1998).

A recent Swedish survey on willingness to pay for risk reduction of road accidents was conducted in 1998. The postal study included 5 400 randomly chosen citizens between 18 – 74 years of age. The study was divided into two sets of questionnaires, one aiming at estimating the value of statistical life, and one the value of risk reduction for non-fatal injuries.

The two sets of questionnaires were randomly split into 13 and 16 sub-samples, each presenting different sums (annual SEK 20 – SEK 2 000) and different reductions in risk (10 % - 99 %) in the elicitation questions. Some sub-samples presented the risk reduction as general statistical risk and some as personal risk.

The question formulations were:

a) *Would you be willing to pay SEK* <u>*xx*</u> *per year in order to reduce your own risk of being killed/injured in a traffic accident by* <u>*x*</u> *%?*

b) *How much would you at most be willing to pay per year in order to reduce your own risk of being killed in a traffic accident by* <u>*x*</u> *%?*

c) *How much would you at most pay for a safety advice for reducing your own annual risk of dying in a traffic accident with* <u>*x*</u> *%?*

The sub-samples included different approaches to describing the statistical baseline risks, which people were exposed to. Also subjective risk perceptions were inquired about and whether they considered themselves being exposed to higher than average risks.

This approach has been a part of the accident-costing methodology already for a decade at least in Great Britain, Sweden and the US. Norway supports the approach but has used transferred values in approximating a value for lost quality of life. Surveys have been conducted in each country during the 1990s for collecting empirical evidence to back up the value approximations. However, the unit values set in the official administrative documentation have not been defined directly according to research results, but with a conservative degree of moderation.

4.2 Empirical observations of risk preferences

A rough WTP curve has been drafted according to the coherent observations produced by some risk valuation studies in Figure 4.1. The curve is presented as a function of willingness to pay for reducing accident risk and the probability distribution of the risk of death (p). The presentation applies only for the examination of one period and the risk of death varies between 0 and 1.

Curve *m* presents how much an individual is willing to trade income and wealth for risk, taking the initial level of risk into consideration. In other words, curve *m* depicts the marginal rate of substitution of risk for income and wealth.

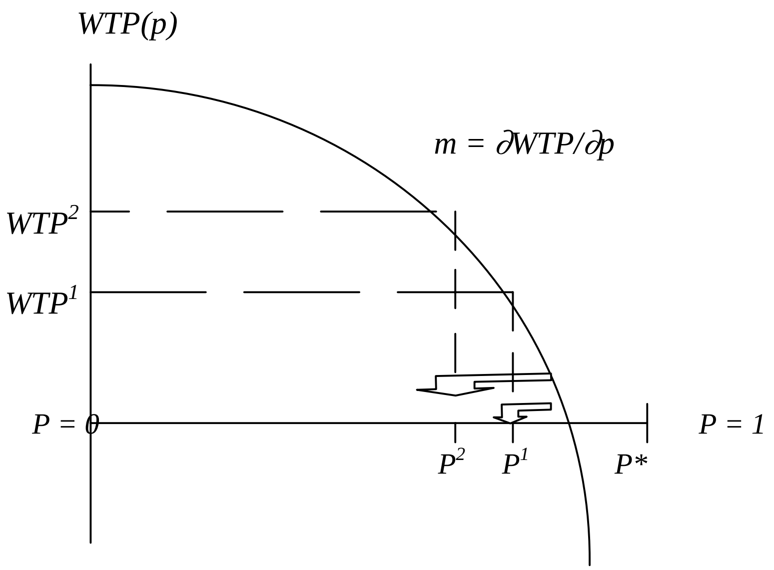

Figure 4.1. The relationship between the willingness to pay for risk reductions and the initial level of death risk.

Combining theoretical assumptions and empirical observations, the WTP behaviour has been concluded to contain the following approximate characteristics:

1. Some initial risk levels are perceived to be so high that individuals do not consider economic contributions for reducing risk relevant at all. In Figure 4.1 risk level *P** is a principle divider of risk perceptions.

2. Level *P** can be interpreted as a basic level of security, above which it is considered worth contributing to risk reductions. On the negative side of *P** (to the right) the initial level of risk is unacceptable and demand for contributions may even instigate protest.

3. On the safer side of *P** (to the left) curve *m* reflects how *WTP(p)* behaves according to the initial level of risk and the proposed change. At high initial levels of risk, WTP is rather low. The lower the initial level of risk (closer to the origin), the higher the WTP for safety improvements. However, the empirical evidence does not tell us how WTP behaves at very low levels of risk.

4. If initial risk is anchored to some point on the horizontal axis, WTP does not increase linearly according to proposed risk reductions. The marginal willingness-to-pay for risk reduction is therefore not linear, but decreases if continuously higher risk reductions are proposed. WTP^2 is not twice as high as WTP^1 although the reduction in risk level is $((P^* \Rightarrow P^2) = 2 * (P^* \Rightarrow P^1))$. The same phenomenon recurs in several empirical studies.

Table 4.1 presents some results of Swedish empirical experiments, i.e. how the initial level and change in risk affects WTP statements and the value of statistical life. Example 4.2 describes the general conclusions of a similar survey.

Table 4.1. The relationship between initial level of risk, the magnitude of change in risk and the value of statistical life (Vägverket, 1997).

Initial risk	**Change in risk**	**Value of statistical life (1993 currency)**
5/100 000	- 50 %	SEK 31.6 million
10/100 000	- 25 %	SEK 18.8 million
10/100 000	- 50 %	SEK 19.5 million
20/100 000	- 10 %	SEK 18.7 million
20/100 000	- 25 %	SEK 15.7 million

The behaviour of the WTP curve in relation to the initial risk level and magnitude of proposed risk change is not fully known. The existing results do, however, provide evidence of the nature of increasing regard for safety when both the basic standard of living and basic level of safety are initially at a decent level.

EXAMPLE 4.2. Persson 1992.

In 1993 approximately 500 Swedes were interviewed on their willingness to pay for the reduction of risk of being killed, crippled or slightly injured in road accidents. The target group received a description of the statistical risks and subjective risk perceptions were asked to be evaluated against statistical risks. WTP statements were elicited for ready-set sums, ranging between SEK 250 – 1 000 /year, one sum per questionnaire.

General observations include:

The level of initial risk raises WTP, but the correlation is not linear. For example, at the initial level of risk of death 24/100 000, the average WTP for a 50 % risk reduction was SEK 800 per individual, whereas at the initial level of risk of death 48/100 000 it was SEK 1 000.

The marginal willingness to pay is reduced as the level of risk is reduced. Average individual WTP for a 25 % risk reduction from risk level 24/100 000 was SEK 500, whereas risk reduction of 50 % from the same initial level of risk yields only an average WTP statement of SEK 800.

In a regression analysis the explanatory parameters are income, annual kilometres driven personally and the level of subjective preferences.

The resulting values of statistical life/health:

Death	SEK 31.7–36.2 million (initial risk 8/100 000, risk -50 %)
Serious permanent injury	SEK 76–121 million (initial risk 24-48/100 000, risk -50 %)
Serious permanent injury	SEK 12.8–19.1 million (initial risk 24-48/100 000, risk -25%)
Serious temporary injury	SEK 1.4–2.6 million (initial risk 138/100 000, risk -50 %)
Serious temporary injury	SEK 2.3 million (initial risk 138/100 000, risk -25 %)
Slight injury	SEK 70 00–480 000 (initial risk 667/100 000, risk -50/-25 %)

4.3 Criticism and advocacy towards the willingness-to-pay approach

Criticism of the WTP approach is meaningful also for the quality and validity of any application and thus it deserves closer examination. The most consequential claims can be summarized as:

1. Identifying an individual's preferences with his or her actual choices is suspect. Choices may be circumstantially assigned no matter what the preferences are.

2. People do not necessarily hold well-defined preferences towards marginal changes in, e.g. safety. Thus value statements are fuzzy and not valid.

3. People are poor judges of the nature and magnitude of the physical risks they face, especially considering the rather low statistical accident risks.

4. Even if people had access to full information concerning the sources of physical risk, they might form diverse subjective probability judgements, although 'experts' would advise differently. Then democratic decisions become difficult to make.

5. People may respond tactically in surveys due to egoistic motives, and the so-called strategic bias may be present.

6. Preference statements may reflect sentimental feelings towards the provision and additional financing of public goods, which are already considered as once paid for by existing taxes (value-added taxes, income taxes, motor vehicle taxes or excise duties).

These rather strong arguments can also be responded to by counter arguments. Although preferences do not always have the chance of becoming true, it does not undermine their desirability and the validity of ordering favourable outcomes according to people's wishes. However, it is evidently true that people do not constantly perform preference ordering towards all possible issues. This is why people are provided with information when value statements are elicited. The informative requirements of a survey are consciously set particularly high. Krieger and Hoehn (1999) report a WTP study where the method is capable of estimating the scope of sensitive values and complex information if applied according to good design.

Well-designed questionnaires should also allow expressing uncertainty towards the issue, which is then taken into consideration in interpreting the results and examining their validity. Well-informed respondents do not necessarily possess views totally in contradiction with 'expert' views. Also the expert may be a poor judge of people's subjective preferences towards certain issues.

Strategic behaviour has been empirically observed to be negligible, but naturally survey design as well as examination of the results must seriously consider the characteristics of the commodity in question. Surveys can also be designed to reveal strategic behaviour, as well as other acknowledged uncertainties.

After discussing the critics aimed at the method, it is only fair to list some of the arguments favouring the WTP approach.

1. In principle any commodity can be valued with the method, both market and non-market goods.

2. WTP statements can be obtained and tested with diversified questionnaires and the yield of the survey increased respectively.

3. The method enables approaching large target populations, which may be more heterogenic than consumers of certain market products.

4. The demographic profile of the respondents can be obtained, which increases the possibilities of controlling the results, as well as producing additional information.

5. In valuing a statistical life, there is no need for discounting procedures due to the assumption that preference statements already take the future into account.

6. According to the US Department of Transportation (1994), only WTP-based values are capable of capturing the future benefits gained by risk reduction. Costs of past accidents should not be used in estimating the benefits of future accident prevention.

If preference elicitation methods were not applied at all, a good number of non-market commodities would not enter the decision-making process with any kind of weight. As the method allows constructing laboratory-like conditions, the demand factors can be analyzed from even better data than is available for most market commodities. Also selecting a random target group aims at approaching a socio-economically and demographically representative sample of the population.

The consumers of selected market goods tend to possess certain common characteristics, which cannot necessarily be generalized over the population, whereas this bias is smaller if a good coverage of statements is obtained from the population. Finally, the method is reproducible for the same or other populations, when the systematics of the results can be tested and compared.

5 Value transfers

5.1 Background

A value transfer is a transfer of existing estimates of non-market values to a new location, which is different from the original study location where the values were estimated (Loomis, 1992; Boyle & Bergström, 1992; Downing & Ozuna, 1996). Secondary data is simply applied to examining a new policy issue. Such transfers are in fact rather common in every day decision-making and impact assessment in both the private and the public sector, where gaining results is critically dependent on the existence of data. Often there is not enough time or funds available for developing primary data and corresponding site-specific estimates. However, until the early 1990s, these studies had not been subjected to scholarly review.

Using transferred values saves time and cost, and is therefore very attractive for application. The performance of borrowed values in producing impact information is evidently better when true market values are applied than when estimates of non-market values are used. However, the formal study of value transfers has distinctly focused on values derived for environmental goods or detriments, which lack traditional market characteristics to a varying extent (Luken et al., 1992; Navrud, 1998). Despite the fact that the true nature of most welfare impacts of, e.g. public policies is very dependent on the characteristics of the target population and location, the impacts are assessed according to some average value estimates.

The demand for value transfers is increasing. Primary data collection is expensive, time-consuming and uncertainty of the possibility of conducting systematic publicly funded data retrieval prevails. At the same time, a range of new issues should be merged into the established frameworks of impact assessment. Environmental and safety impacts of transport developments, including both the direct physical impacts as well as the direct and indirect welfare impacts on people should be assessed.

Unfortunately, data on these impacts is still scarce. The methods for measuring these impacts are only now beginning to reach the status of accepted usable tools. However, depending on the issue, not too many robust monetary estimates yet exist on, e.g. the welfare impacts of transport safety improvements in

Europe. The conducting of value elicitation is not yet such a standard procedure of impact assessment.

However, some countries have a longer tradition in risk valuation than others, and robust enough empirical data exists so that the empirical results have been introduced to the set of management tools in national policy making. These value estimates offer potential for value transfers to policy sites where primary data does not exist, or obtaining the data is considered too great a task.

The process of transfer involves either a direct transfer of a value estimate or a transfer of an entire function behind the value estimate. The former can be a simple and straightforward process involving only some, if any, rough value adjustments according to the most evident site-specific differences, e.g. in the well-known demand factors and levels of income of the population involved. The latter process involves computing site-specific values with the aid of transferred functions. This process is evidently more of a task, but if successful, may produce more reliable values for the use of decision-making.

The most common area of value transfer applications is in the assessment of environmental impacts, i.e. quantifying the positive or detrimental welfare impacts of policies either improving or deteriorating the environment. The impacts may affect people directly or indirectly. Direct impacts involve either users or people involuntarily under the influence of some environmental detriment or benefit. Users may include, e.g. visitors of recreational sites, the quality of which is changing, and therefore information on the welfare impacts of these quality changes are needed.

Similar recreational sites exist close by at other locations and the measured user welfare impacts of quality changes at one site may reflect the user welfare impacts of quality changes imposed at another site. If we can assume that the preferences of the users and the value functions respectively at these two sites are sufficiently similar, either the value estimates or estimated value functions can be utilized for assessing impacts at the other site.

The welfare impacts of atmospheric pollutants are a typical case where people are unwillingly under the influence of detriments and their well-being suffers as a result. The common conduct of assessing, e.g. the monetarized emission impacts of transport projects is performed according to some national average unit cost estimate (e.g. FIM 180 per ton of CO_2 emissions; Tielaitos, Finnra, 1995). The varying individual preferences are not taken into account but only the average value, which is assumed to represent the impact over the population robustly enough. The monetary cost of a personal injury in a traffic accident serves a similar purpose.

In this report, the object of transfer is the monetary value of lost quality of life induced by traffic accidents that lead to personal injuries. It is examined whether such values estimated in some European countries can be transferred to Finland by adjusting them according to country-specific characteristics. Such an operation has been performed in Norway (Elvik, 1993), and it may be justifiable also for Finland as a comprehensive national risk preference survey cannot be conducted with the time constraints given.

5.2 Objections to value transfers

The objections to value transfers include first and foremost doubt about the original value estimation method, willingness-to-pay. Also the importance of site-specific attributes for yielding robust enough value estimates that are meaningful in decision-making in circumstances different from the original empirical site has been addressed.

The first claim has been fought within the field of valuation research and the outcome of the facts remains as providing support for the robustness of the valuation results obtained in a well-disciplined setting (see e.g. Smith & Desvousges, 1986; Mitchell & Carson, 1989; Cummings et al., 1986).

The latter statement claims that there would always exist such differences between the characteristics of the study site and the transfer site, as well as the preferences of the target populations, that the value estimates or value functions transferred would not provide sufficiently robust information for making judgements on the outcome of policies at the transfer site.

Boyle & Bergström (1992) call this the ‘impossibility myth’ and provide counter-arguments. These differences must be studied in order to see whether they are of importance and how much they affect the validity of using secondary data at a policy site. If the differences are not too large, they may be statistically controllable and the transferred values can be adjusted accordingly.

Naturally, standards should be followed with discipline for guaranteeing the quality of the transfers. However, a balance between assuring quality and pragmatic aspects should be found. Value transfers are never designed to fully replace primary data, and they should therefore be used accordingly, accepting trade-offs between accuracy and savings in research effort.

5.3 Conceptual framework

An economic model organizes an analyst's hypothesis about what motivates and constrains people's decisions. Such a behavioural model is present also when people's risk preferences are examined. Even if a behavioural model were not used in computing policy site risk values, it must be specified for presenting the essential hypothesis assumed to explain people's behaviour.

Analysts will never know the true form of the process underlying people's behaviour. Complete observations of all the factors influencing people's decisions and their choices are impossible. In other words, all models are incomplete, or even wrong. What is at issue, then, is how important these errors are to their intended use. (Smith, 1992)

Model development is directly relevant to value transfers because existing empirical evidence has aimed at estimating how much people's well-being would be improved by some policy action. However, once the models are recognized as approximations, we can ask whether specific applications affect their usefulness in the transfers associated with different goals. As no completely correct models exist, the decisions implied by this information would involve balancing different types of potential errors. (Smith, 1992)

The first step in conducting a transfer is to specify a theoretical definition of the values under examination, and to examine the characteristics of the study sites and their population (Boyle & Bergström, 1992). Considering the 'commodity' under examination, comparability between the study and policy sites is essential for the credibility of the experiment.

In the case of lost quality of life induced by traffic accidents, the ‘universal’ value function of safety is primarily based on accident risks perceived by the study population. In other words, the issues which should be considered in an attribute vector of safety are statistical (or subjective) accident risk, average expectancy of remaining years to live and the standard of living. Also, traffic intensity and mobility parameters should be taken into consideration.

The technical formulation of the WTP function (see chapter 3.1 and 3.2) applies everywhere equally. The variation in the main elements between countries appears mainly in the statistical accident risk imposed on people in traffic and the utility derived from healthy low-risk life. However, the risk factor is a relatively subjective element, as people perceive accident risks differently.

Transferability has to be examined by objective criteria. In the case of transferring risk values of traffic safety, two criteria must be considered:

1. The commodity in question must be very similar between the study and the transfer site.

2. The populations at the original sites and transfer site must have identical characteristics.

The commodity under examination now is a marginal improvement in (road) traffic safety. There are evidently differences between the statistical level of risk at the original sites and the policy site Finland.[5] Also the characteristics of the transport systems, as well as the population characteristics, vary between the countries. However, the differences may not be of such a magnitude that transfers would be totally out of the question.

The risk value estimates in contemporary European studies have been mostly derived for general safety improvements (anonymous casualties), but also the results from studies addressing private safety investments have been utilized. Nevertheless, in defining the unit values of lost quality of life, the difference between private and general risk change may have become mixed as the scarce data has been fully utilized.

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[5] See Elvik 1997 for a rough value transfer experiment performed for the Netherlands.

According to Desvousges et al., (1992), the following criteria should be employed to select the study site.

1. In order to reduce transfer error, it is necessary to use studies that are based on adequate data, sound economic method and correct empirical technique.

2. The changes in the provision of the public good should be of the same magnitude at the study and the policy site.

3. The study site and the policy site should be relatively similar, which now refers to the transport system.

4. The socio-economic characteristics of the populations should be relatively similar.

5. The ‘markets’ for safety should be relatively similar between the study and the policy site. This would mean similarities in the institutional arrangement, where safety is publicly provided.

In judging whether transferred values are applicable at the destination site, the outcome may vary. The use of values may be rejected, or they may be accepted for use due to an acceptable range of errors, or third, they may be systematically adjusted in order to remove existing bias (Boyle & Bergström, 1992). Sites that have values in common are exchangeable because they share a common structure of benefits generation (Atkinson et al., 1992). Example 5.1 highlights the potential outcome of using incorrect transferred values in social cost-benefit analysis.

EXAMPLE 5.1. Navrud-case study on value of air quality (Navrud, 1998)

Navrud performed a comparative survey on damage costs of air pollution in the form of health impacts. Due to the lack of European valuation studies on morbidity impacts, transport and energy externality studies and green accounting exercises in Europe have used values from ten-year-old US valuation studies.

Navrud points out that, comparing the results of a Norwegian valuation study and the US results acquired with a similar methodology produces different results. Thus, transferring US values to Europe and adjusting them only with the consumer price index would lead to biased values in Norwegian applications.

The difference in values can be explained, on the one hand, by improved survey design and methodology, but on the other hand to a large extent by different preferences of the population in Norway and the US, as well as differences in the health care system securing treatment in the case of illness. The conclusion is that Norwegian values are better estimates of morbidity values in European countries than transferred values from US studies. In other words, when value estimates are available, transfers within Europe are preferable to transfers from another type of society and circumstances.

The conclusion concerning risk values is that, although WTP estimates are used in the US, there are cultural differences as well as differences in the coverage of private and public accident costs in general, which makes the US values less attractive for transfer to Europe. However, in our case this is not a big problem because European and even Scandinavian values are available.

5.4 Direct value transfer vs. value function transfer

The literature considers the transfer of value functions to be the more desirable approach whenever possible. Transferred functions may enable the estimation of values for the policy site based on a function constructed at the original study site. The value function is based on explanatory parameters identified in regression analysis from the study site data. Estimation of the equation at the policy site requires knowledge of the characteristics of the target population.

Norinder et al. (1995) estimated the following function for explaining the willingness-to-pay for risk reductions for fatal and non-fatal injuries.

$$\ln WTP = f(\ln inc, \ln km, \ln age, \ln(age\text{-}mean)^2, exp, \ln risk),$$

where

WTP	=	willingness to pay for a risk reduction of 50 % for a fatal, and a serious disabling injury
inc	=	household income per consumption unit (household income divided by the number of persons in the household and weighted according to age
km	=	number of km/year by car
age	=	the respondent's age
$(age - mean)^2$	=	$(\text{age} - \text{mean})^2$
exp	=	experience of accidents (a dummy variable, 1 = the respondent has been previously injured in an accident)
risk	=	the respondent's subjective baseline risk

According to the estimations of Norinder et al. (1995), WTP increases by income, which is also the most powerful explanatory variable (Table 5.1). Others include the number of kilometres driven and subjective risk. Only a minor part of the variation in WTP can be statistically explained besides income.

Table 5.1. The results of the regression analysis (Norinder et al., 1995).

Dependent variable	**WTP for reducing the risk of a fatal injury (n = 281)**	
	Coefficient	*t*-value
Inc	0.462	3.92[a]
Km	0.168	2.18[b]
Age	-0.197	-1.00
(age – mean)^2	-0.020	-0.54
Exp	0.036	0.20
Risk	0.191	1.74[c]
Constant	0.516	0.37
R^2	0.100	

a = significance 0.001, *b* = significance 0.05, *c* = significance 0.10

Unfortunately, duplicating this function and estimating policy site values accordingly is not possible because data on subjective risk perceptions cannot be created without an actual survey. Other parameters could possibly be randomly sampled from national data. For this reason, now the direct transfer of unit values must be accepted.

6 Accident costing in some European countries

6.1 Sweden

Sweden applies the WTP approach for valuing individual welfare impacts of changes in risk (Table 6.1). Risk values have been obtained by conducting several willingness-to-pay surveys. It is emphasized that the values do not represent the value of the quality of life *per se*, but they only reflect how much the members of society are willing to pay for risk reductions and prevention of accidents. The Swedish system is well founded in economic theory.

*Table 6.1. The proposed unit costs of personal injuries in Sweden, SEK (Vägverket, 1999).**

Injury type	**Material and resource cost to society**	**Risk values**	**Total**
Death	1 300 000	13 000 000	14 300 000
Serious casualty	600 000	2 000 000	2 600 000
Serious casualty, correction coefficient applied	1 400 000	4 800 000	6 200 000
Slight casualty	60 000	90 000	150 000
Slight casualty, correction coefficient applied	140 000	220 000	360 000

* These values are to be validated in 1999 by Vägverket. The only change from the 1997/1998 values is a rise in the material costs of fatalities by SEK 100 000.

The real economic costs include costs of medical treatment, damaged property, administration and lost production.[6] In 1999 researchers recommended raising the risk values considerably, according to the results of recent WTP surveys (Lindberg & Li, 1999). The suggestion was that the risk value of death should be raised to SEK 21 000 000, for severe casualty to SEK 3 400 000 and for slight casualty to SEK 300 000 (price level of 1999). This suggestion was followed by

[6] The costing of real economic losses is thoroughly documented in *Samhällsekonomiska kalkylmodeller (Vägverket, 1997).*

an extensive debate, where information on the problems of traditional contingent valuation and recent development of joint methodologies served as stimulators. Based on this discussion, the Swedish Road Administration made a decision in June 1999 to abstain for the time being from revising the existing risk values.

6.2 Norway

Norway has also adopted the principle of valuing lost quality of life by using estimates that originate from willingness-to-pay (Table 6.2). In the early 1990s, the value of lost quality of life due to fatality was assigned NOK 10 000 000 as result of an extensive review of existing WTP estimates in other countries. The unit value was derived by using the so-called value transfer method, i.e. values used in other countries were transferred to Norway.

The unit values for different injury types were scaled from the value of fatality by a state of health index. The injury severity scale was assigned according to the results of an extensive accident victim interview (Haukeland, 1991 & 1996). Since then, the values have been only adjusted by the cost-of-living index.

Table 6.2. The unit values of personal injuries in Norway in 1995.

Degree of injury	Total unit value (NOK)	Share of lost quality of life
Fatality	16 600 000	67 % (NOK 11 122 000)
Very severe casualty	11 370 000	54 % (NOK 6 139 800)
Severe casualty	3 780 000	49 % (NOK 1 852 200)
Slight casualty	500 000	64 % (NOK 320 000)

6.3 Great Britain

In Great Britain the valuation of both fatal and non-fatal casualties has been based on the WTP approach since 1993. The 1997 values are derived by uprating the 1996 values by taking into account the growth in GDP (Tables 6.3 and 6.4). A recent research by RAGB (1997) describes the results of a survey on the value of preventing a road accident, which recommended a range of GBP 750 000 – 1 250 000 for a broadly acceptable value for a fatality. Therefore, the current unit values are considered empirically supported and remain unchanged.

Table 6.3. Average values of prevention per casualty in 1997 (DpT of the Environment, Transport and the Regions).

Injury type	**Unit value (GBP)**
Fatality	902 500
Serious casualty	102 880
Slight casualty	7 970
Average, all casualties	30 250

Table 6.4. Average value of prevention per accident by severity and element of cost, GBP, June 1997. (DpT of the Environment, Transport and the Regions).

Cost element							
	Casualty-related costs			**Accident-related costs**			
Accident severity	**Lost output**	**Medical and ambulance**	**Human costs**	**Police costs**	**Insurance adminis-tration**	**Property damage**	**Total**
Fatal	349 070	4 470	680 590	1 180	190	6 910	1 042 410
Serious	15 750	9 440	95 990	160	120	3 150	124 610
Slight	1 840	780	7 840	40	70	1 860	12 430
All injury	8 720	2 140	30 420	70	80	2 120	43 550
Damage only	-	-	-	2	30	1 180	1 210

6.4 Denmark

In Denmark the value assigned to human welfare losses is not estimated by the WTP approach (Table 6.5). Instead, its quantification is based on implicit public sector decisions. The origin of the value estimate can be traced down to a specific safety investment made in the late 1980s.

Table 6.5. Unit costs for personal injuries in Denmark, DKK (Vejdirektoratet, 1999).

Costing category	Cost per reported death	Cost per reported serious injury	Cost per slight injury
Person-related real economic costs	1 990 000	357 000	91 000
Loss of well-being	3 980 000	119 000	6 000
Total	**5 970 000**	**476 000**	**97 000**

After a political debate a safety investment was made at a particular road intersection, which saved an estimated 1-2 lives per year. The cost of this investment divided by the reduction in the expected number of fatalities saved has from thereon been treated as the value of a fatality in the Danish costing system. Denmark does not offer a potential site for transfer values, but it serves as a reference point for comparing the unit values and valuation methodologies used in different countries.

6.5 Finland

The Finnish unit costs of personal injuries are reported in the costing manual of the Finnish National Road Administration (Tables 6.6 and 6.7; Tielaitos, Finnra 1995). The unit value corresponding to the cost of lost quality of life is estimated according to the so-called ‘social willingness to pay’, which is a method not comparable to the individual willingness-to-pay approach. The method resembled the one used in Sweden, until it was there replaced by the individual willingness-to-pay in the late 1980s.

In brief, the ‘social willingness-to-pay method’ assigns a value to the human loss incurred by a fatality, by the treatment cost of a 100 %-institutionalized invalid person, discounted over 30 years (an average remaining number of years to live). The human loss of a permanently disabled person is defined according to an average medical degree of invalidity, which is 46 % of the fully disabled. A temporary disability corresponds to a 0.5 % loss of the fully institutionalized victim.

The ‘social willingness-to-pay’ method confuses changes in individual well-being and patient costs of hospital treatment, which have been used as a proxy for representing lost quality of life. The method does not truly measure individual risk preferences or welfare impacts whatsoever. The real economic cost components include lost production of the casualty (GDP/labour force), medical expenses, administrative costs and vehicle damage.

From the historical perspective, the method raised the unit costs of lost quality of life to the top of the range of European values in the beginning of the 1990s. Despite its theoretical inconsistency, the method served policy making relatively well by prioritizing safety considerations and human welfare impacts. A considerable decrease in fatalities and injuries has been experienced during the last decade, although the trend cannot be directly attributed to the higher unit values.

Table 6.6. The unit costs of personal traffic injuries on public roads (Tielaitos, Finnra, 1995).

	Unit cost (FIM)		
Injury type	**Material cost and production loss to society**	**Lost quality of life**	**Total**
Death	2 700 000	5 100 000	7 800 000
Permanent injury	2 470 000	2 330 000	4 800 000
(disability)	37 000	15 000	52 000
Temporary injury	59 000	23 800	83 500
- Severe degree	12 900	6 100	19 000
- Slight degree			
Injury average	89 500	56 900	146 400

Table 6.7. The unit costs of accidents leading to personal injuries (Tielaitos, Finnra, 1995).

	Unit cost (FIM)	
Accident type	**Basic cost**	**Correction factor applied***
Accident leading to death	9 100 000	9 100 000
Accident leading to permanent injury (disability) Accident leading to temporary injury Accident leading to injury	5 600 000 58 500 170 000	5 600 000 93 000 218 000
Personal injury accident	900 000	975 800
Property damage accident	14 350	46 500
Average road accident	256 500	328 000

* The factor corrects for statistical loss in accident reporting.

By the end of the 1990s, several countries had applied the theoretically consistent individual willingness-to-pay method in costing welfare impacts of accidents, and the unit values assigned rose considerably. A direct conclusion is that the Finnish valuation method and the unit values should be revised.

The Finnish valuation method is not based on welfare economics and risk evaluations as theory suggests for valuing lost quality of life. It accounts only for the economics costs of production and resource losses, which society wishes to avoid.

Examining the method leads to the following conclusions:

- Deriving a value for lost quality of life of a fatality by accounting for the treatment costs of an institutionalized person is unfounded. No long-term treatment costs are involved in the death of a person within 30 days from the accident.

- The costs of the treatment of an institutionalized person do not necessarily reflect the subjective experiences of a person at all, and at any rate are not related to the experiences present in death. However, in the case of institutionalized persons it may reflect welfare impacts to some extent.

- The costs of the treatment of an institutionalized person do not measure subjective risk preferences or the individual willingness to pay for risk changes in any way.

- The costs of the treatment of an institutionalized person only account for the resource costs of society, not individual changes in the quality of life.

Summarizing, the Finnish method does not measure the lost quality of life arising from traffic accidents and the level of risk exposure at all. The only aspect related to individual welfare impacts is reflected in the consumption losses accounted for in the form of lost GNP per capita. Revision of the methodology is a well-founded claim.

6.6 The United States

Estimates of economic costs that result from motor vehicle accidents are routinely published by several public and private organizations in the United States. The values are often derived from a different base or for different purposes, which results in different estimates. According to the US Department of Transportation (1994), past accident costs should not be used in computing the dollar value of future benefits, because they do not include what people are willing to pay for improved safety, i.e. the value of a person's desire to live longer or for protecting the quality of one's life. Estimates under the willingness-to-pay concept should be used for cost-benefit analysis wherever feasible.

The preferred measure for accident costing (*comprehensive cost*) includes 11 components: property damage, lost earnings, lost household production, medical costs, emergency services, travel delay, vocational rehabilitation, workplace costs, administrative cost, legal costs and pain and lost quality of life.[7] Table 6.8 presents the costs by the Abbreviated Injury Scale (AIS), recommended for accident costing by the US Department of Transportation.

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[7] See Blincoe (1994) for a detailed breakdown of U.S accident costs.

Table 6.8. Comprehensive costs in police-reported crashes by AIS severity (USD 1994).

Severity	Descriptor	Cost per injury
AIS 1	Minor	5 000
AIS 2	Moderate	40 000
AIS 3	Serious	150 000
AIS 4	Severe	490 000
AIS 5	Critical	1 980 000
AIS 6	Fatal	2 600 000

7 Transferring European values to Finland

7.1 Examination of the study and policy sites

From here on the countries providing candidate values will be referred to as study sites, and Finland as the target of application is referred to as the policy site. The study sites offering values for Finland have been chosen to be Great Britain, Sweden and Norway. They all apply a willingness-to-pay approach for costing lost quality of life in a risk change setting (see Chapter 6). Denmark serves as a reference case, where an alternative approach of implicit public sector valuation is used.

Great Britain has the longest tradition in European WTP-based risk valuations. At the end of the 1980s, the value of lost quality of life induced by personal injuries was estimated by this method and it was soon introduced to local highway economics. Sweden followed closely by implementing a number of risk preference surveys providing strong empirical basis for value assignment.

Several repetition surveys have been conducted over the years, and thus both theoretical and empirical evidence is strong in Sweden. Norway also decided to switch into subjective risk valuation by the mid-1990s, but no local valuation surveys were implemented. Instead, Norway implemented a value transfer (Elvik, 1993).

The criteria, which the values and transfer sites must fulfil, are:

1. The commodity valued at the study site must be sufficiently similar to the commodity valued at the policy site.

2. The populations affected by the commodity at the study site must be sufficiently similar to the population at the policy site.

3. The institutional arrangement, by which the commodity is supplied, must be close to identical between the sites.

4. The study site valuations must be able to endure scientific analysis, i.e. they have been obtained according to standard procedures.

Once study site values are available, there are three alternative avenues open, according to Boyle & Bergström (1992):

1. The study site values may be rejected as unsuitable for policy site use.

2. The study site values may be identified to be slightly skewed considering the characteristics between the study and policy site, but the skewness is accepted and the values are used as they are.

3. The study site values are systematically adjusted according to the identified differences in main attributes.

In this experiment the value transfers may not necessarily fulfil the strictest criteria set for applicability. The final result of a transfer will inevitably be a combination of accepting some inaccuracies and adjustments. The result will be critically examined after the transfer experiment. However, the prospects are worth examining in order to see whether certain approximations and inaccuracies can be accepted for the sake of practicality. The value transfer is in any case recommended to be only a temporary arrangement, until a Finnish empirical survey on risk valuations is conducted.

7.2 National risk exposure and demographics

The most important attributes affecting risk preferences are a) the existing level of risk exposure and b) the standard of living. These are the attributes that are present when the marginal rate of substitution between safety and wealth/income is examined in actual valuation studies. The sites from where the original values are to be transferred should be as similar as possible to Finland with respect to these two attributes.

The attributes presented here may not be very precise indicators of prevailing conditions in different countries, but such assisting proxy indicators must be used. The statistical risk exposure is never exactly the same as the subjective risk perception of people, but on average they should correlate with each other. The standard of living cannot be represented fully by one indicator, e.g. the level of income, but on the other hand it is almost impossible to perform thorough and perfectly well-matching welfare comparisons.

In critical appraisal, the British and Swedish risk values are naturally the ones most appealing for transfers due to their primary empirical origin. Norway offers a useful illustration and reference point for the conduct of value transfers. However, as the values themselves are not of local empirical origin, they are not most appealing for actual transfer.

The commodity under examination, a (marginal) change in statistical accident risk not assigned to any named person or group of people, is sufficiently similar in both study site countries compared to the safety policy goals in Finland. The population characteristics are naturally more similar between the Nordic countries, and therefore Great Britain is least suited to Finland.

The same applies presumably also to the institutional arrangement, which primarily means the public provision of safety in the transport sector, as well as the arrangement available for the restitution of damage.[8] Criteria number four was already commented on above, i.e. Great Britain and Sweden can offer empirically obtained 'original' values, unlike Norway.

Table 7.1 presents a three-year average for the number of deaths and injuries from the study sites of our examination. An average figure takes into account the annual fluctuation in the number of deaths and injuries, and it is for that reason a more reliable indicator for the risk level than one-year point data.

[8] The United States also applies risk values obtained by WTP (see chapter 6.6). The unit value assigned to a fatality (all cost items included) corresponds to well over 15 million FIM at the exchange rate in summer 1999. However, the institutional arrangement of public transport safety policies, as well as the arrangement of cost coverage, are that much different from the European arrangements that the US values are not very appealing for transfer (see also example 5.1 in chapter 5.3).

Table 7.1. Casualties of road traffic accidents. For the Nordic countries averaged from 1995 – 1997 data (Central Organization for Traffic Safety in Finland).

Country	**Number of fatalities per annum**	**Number of fatalities per million capita**	**Number of injured***
Finland	428	83	9 482
Sweden	560	63	21 228
Denmark	527	100	9 888
Norway	288	66	11 868
Great Britain	3 654	63	320 068

* The numbers are not comparable between countries due to different data coverage and injury definitions.

Fatalities presumably enter the statistics in a comparable way in all countries. All fatalities are officially reported to the cause of death statistics. A fatality is considered traffic accident-related if the casualty dies within 30 days of the accident. Therefore the number of deaths can be considered to be a reliable indicator of traffic safety. However, it does not indicate the whole truth because the number of injuries should be also considered, and if possible, in different classes of severity.

Unfortunately, the coverage in injury reports is not as comprehensive as in the case of fatalities. A good percentage of injuries do not enter the statistics and this data loss is considered by applying some coefficient of correction. Each country applies a different coefficient. Also, the injury classifications differ between countries, and therefore comparability in injury statistics is questionable.

From this small set of comparative data on fatalities we can see that Denmark has the highest risk of fatality per million capita, with Finland being the second highest. Sweden, Great Britain and Norway are within a very small margin with approximately the same risk rate per capita. However, the risk rate should be examined by also considering the characteristics of the transport system and the rate of motorization in order to obtain a better view.

According to the aggregate figures provided by statistics, Denmark has the highest per-capita rate of mobility on roads. It is interesting to note that the relative rate of risk is highest in that country where the lowest cost is assigned to a fatality. The relative weight given to safety investments and programmes may be too low to promote safety improvements. However, this is a conclusion without strong evidence, because also other factors influence safety besides the values assigned to lost quality of life. Nevertheless, it is a management tool with a significant role to play in safety developments.

The injury statistics clearly indicate differences in the classification and coverage of injuries in different countries. Otherwise there would be no explanation the twice as high number of injuries in Sweden compared to Finland and Denmark. Unfortunately no conclusions on the differences between injury risks can be drawn from this data due to incomparabilities.

Table 7.2 presents a recent comparison of the average annual GNP in the study site countries. The GNP is also adjusted by purchase power for better cross-national comparison.

Table 7.2. Gross national product per capita 1996 (Statistical office of Finland).

Country	Market price, USD	Adjusted by purchase power
Finland	23 240	18 260
Sweden	25 710	18 770
Denmark	32 100	22 120
Norway	34 510	23 220
Great Britain	19 600	19 960

Considering the relevance of income level on subjective risk preferences, Finland relates closest to Great Britain and Sweden judging from averaged aggregate annual GNP per capita.[9] Because the differences are not that large in

[9] At the level of 1999 Finland has presumably gained on the other countries due to higher economic growth. Besides affecting the standard of living, economic growth impacts the value of production loss.

general, we can assume the standard of living to be approximately the same in all countries.

However, it is commonly acknowledged that the GNP is a very rough indicator of the standard of living and that there is a number of issues related to the institutional arrangement, which affects overall well-being. Due to, e.g. high taxation, lower wages and to some extent higher consumer prices, Finland does worst in this comparison. The adjusted GNP does not tell anything about how much the people in each country receive benefits in the form of income transfers and public services, which all promote the well-being of the population.

If societal attributes are considered important in a value transfer, Finland relates closest to Sweden in the type of institutional arrangement, often called the 'safety net' of society. This arrangement provides for the emergency and restitution services and facilities for the unlucky members of society. With a good 'safety net', people on the one hand will not be left alone to cope with unfavourable outcomes, but on the other hand may also value safety higher.

A contradictory argument can be presented based on evidence from the US, where people cover a larger share of the medical accident costs, as well as the outcomes of lost productive capability, and privately in the form of insurance payments or risks taken. Therefore relatively high WTP for risk reduction (see Chapter 6.6) may be favoured purely on a private economic basis. Nevertheless, the similarities in the institutional arrangement to Finland favours choosing Sweden as a study site for the transfer.

Consideration of the other influencing indicators (Tables 7.3. and 7.4) supports the suitability of any of the Nordic study sites for transfers. The annual volume of road transport, and thus the statistical risk exposure per capita is reasonably within the same magnitude. However, the characteristics of the transport system are different in all countries.

Table 7.3. Some geographic and demographic indicators (Tilastollinen vuosikirja/Statistics Finland 1997).

Country	**Area 1 000 km²**	**Population 1 000 inh.**	**Pop. per km²**	**Life expectancy years**
Finland	338	5 117	15	77
Sweden	411	8 587	22	79
Denmark	43	5 146	122	75
Norway	324	4 248	14	78
Great Britain	242	56 352	243	77

Table 7.4. Road transport indicators (Tilastollinen vuosikirja/Statistics Finland 1997).

Country	**Road network km**	**Passenger cars per 1 000 capita**	**Mio passenger km by passenger car**	**Annual passenger car kms per capita**
Finland	77 782	367	50.4	9 850
Sweden	138 000	407	84.5	9 840
Denmark	71 600	319	63.5	12 340
Norway	91 323	380	42.3	9 960
Great Britain	372 000	370	620.0	11 000

Also here, Finland relates closest to Sweden, although the road network, vehicle fleet and annual performance are larger in Sweden. On the other hand, the Swedish average traffic flow densities are definitely closer to Finland than Great Britain.

If a lifetime income flow or wealth should be considered as the basis of welfare maximization, the length of the discounting period is an important factor. For lifetime consumption or wealth, life expectancy should be examined. The average life expectancy at birth is practically the same in all the study countries (varying between 75 – 79 years. If this were examined in relation to the current level of GNP per capita, approximately the same magnitude of economic interests would be at stake.[10] Despite the fact that all the countries are different in geographical characteristics, the degree of motorization is relatively similar.

As a conclusion for the national comparisons, the most preferable study site is considered to be Sweden. However, the analysis of the costing systems and unit costs of different countries in Chapter 7.3 will provide further information worth considering before performing the transfer.

7.3 Index adjusting and exchange rates applied

The current Finnish unit costs of accidents were last adjusted by an index in 1995, and therefore at least a new adjustment is necessary. Table 7.5 presents the existing unit costs and the ones corrected to the present day value by using the consumer price index (index point April 1999=104.4; 1995=100). At the minimum, the Finnish unit costs should be marked up by this index rise.

The marked up unit costs are not considerably higher than the existing ones, but high enough to make a difference in priorities of decision-making. Furthermore, unless at least these corrections are made, the simultaneous mark-up of other highway economic costing elements would entail a discrimination of safety priorities as the prior balance between unit costs would alter at the cost of safety.

[10] Aggregate and average examinations are often treat the diversity of the micro level with cruelty. In disaggregated examination there would be meaningful differencies identifiable between these countries, but which are often bypassed for the sake of practicality.

Table 7.5. The current and index adjusted unit costs of traffic injuries on public roads (Tielaitos, Finnra, 1995).

	Unit cost (FIM)		
Injury type	**Material cost and production loss to society**	**Lost quality of life**	**Total**
Fatality 1995	2 700 000	5 100 000	7 800 000
Fatality 1999	*2 818 800*	*5 324 400*	*8 143 200*
Permanent disability 1995	2 470 000	2 330 000	4 800 000
Permanent disability 1999	*2 578 680*	*2 432 520*	*5 011 210*
Temporary disability 1995	37 000	15 000	52 000
Temporary disability 1999	*38 628*	*15 660*	*54 288*
- Severe degree 1995	59 000	23 800	83 500
- *Severe degree 1999*	*61 596*	*24 847*	*86 443*
- Slight degree 1995	12 900	6 100	19 000
- *Slight degree 1999*	*13 468*	*6 368*	*19 836*

In order to transform the current accident cost values from the study site countries to comparable units for this examination, they are next converted to Finnish marks by the exchange rates presented in Table 7.6.[11]

Table 7.6. Exchange rates on the 10th of May 1999.

Original currency	**Value in FIM**
1 GBP	9.09
1 SEK	0.67
1 NOK	0.73
1 DKK	0.80

Tables 7.7. – 7.10 present the cost item breakdowns in FIM according to the original national presentations. Unfortunately the British document does not report the cost breakdown in components of real economic costs and lost quality of life. Table 7.11 compiles the converted values including all costing elements and Table 7.12 presents only the values assigned to the lost quality of life in

[11] The exchange rate is yet another fluctuating variable, which affects the final outcome of the experiment. At least the value of GBP is perhaps above the longer term average at the time of this experiment.

different countries. Next, the observations on the unit costs and their structure are briefly analyzed.

Table 7.7. British values converted to FIM.

Injury type	Total unit cost
Fatality	8 203 700
Serious casualty	935 200
Slight casualty	72 400
Average, all casualties	275 000

Table 7.8. Swedish values converted to FIM.

Injury type	Material and resource cost to society	Risk value	Total unit cost
Fatality	871 000	8 710 000	9 581 000
Serious casualty	402 000	1 340 000	1 742 000
Serious casualty, corrected	938 000	3 216 000	4 154 000
Slight casualty	40 200	60 300	100 500
Slight casualty, corrected	93 800	147 400	241 400

Table 7.9. Norwegian values converted to FIM.

Degree of injury	Total unit cost	Share of lost quality of life
Fatality	12 118 000	8 120 000 (approx.)
Very severe casualty	8 300 100	4 482 000 (approx.)
Severe casualty	2 759 400	1 352 000 (approx.)
Slight casualty	365 000	233 600 (approx.)

Table 7.10. Danish values converted to FIM (excluding vehicle damage cost).

Costing category (person related costs)	Cost per reported fatality	Cost per reported serious injury	Cost per slight injury
Real economic costs	1 592 000	285 600	72 800
Loss of well-being	3 184 000	95 200	4 800
Total unit cost	**4 776 000**	**380 800**	**77 600**

Total unit costs assigned to a fatality

Table 7.11 presents the total unit costs assigned to fatalities and non-fatal injuries in different countries. The British total unit cost for fatality coincides in magnitude with the preliminarily index adjusted Finnish unit cost. The Swedish unit cost exceeds the Finnish cost by over FIM 1 million and the Norwegian cost by FIM 4 million. The Danish valuation method produces the lowest unit cost per fatality. The relatively high values assigned to severe injuries in Finland and Norway clearly increase the emphasis given also to the non-fatal outcomes of accidents.

Due to the differences in costing real economic losses, the total unit costs do not yet imply how the Finnish values should be adjusted. The cost assigned solely to representing lost quality of life is examined further below.

Table 7.11. Unit costs compiled, all costing components included, FIM (rounded).

Country	Fatality	Very serious injury	Serious injury	Slight injury
Finland (index adjusted)	8 143 200	4 800 000	86 400	19 800
Great Britain	8 203 700	-	935 200	72 400
Sweden	9 581 000	-	1 742 000	100 500
Norway	12 118 000	8 300 100	2 759 400	365 000
Denmark	4 776 000	-	380 800	77 600

Total unit costs assigned to non-fatal injury

The non-fatal injuries and their losses respectively are classified into three categories in Finland and Norway, whereas Great Britain, Sweden and Denmark apply only two categories.[12] This naturally reduces the comparability of the unit costs. Finland assigns a relatively high value to very serious injury (permanent disability), but temporary injuries are in turn assigned rather low values irrespective of the degree of injury severity.

Applying a three-category classification clearly increases the ability of this management instrument to cover the consequences of traffic accidents. The variety of non-fatal injury types is evidently large. Therefore, also the impacts of different types of injuries (temporary and permanent) on the quality of life are diverse and should receive serious consideration.

The dominant problem, however, is that although unit costs can be defined according to a variety of degrees of injuries, the existing accident-reporting conventions do not provide sufficient casualty data to enable costing, which would reflect reality more correctly.

Material and resource costs

Norway clearly calculates the material and resource costs to society with a more comprehensive coverage than Sweden, Great Britain and Finland (see also Chapter 6). The Finnish high real economic cost is attributed to the convention of calculating for gross production loss and the costs of hospital treatment in the case of permanent injury. The pure material costs are also relatively low in Finland.

If the true cost of accidents should be revealed, and the user-pays principle were followed in assigning the accident costs to their perpetrators, the approach of full-cost accounting is inevitably necessitated. However, the costing process is laborious and some countries may simply refrain from the effort. (Chapter 7.3

[12] Although the non-fatal accidents are categorised in three classes of severity, the current Finnish accident reporting system can provide statistics only in maximum of two categories.

describes the last cost inventory made in Finland in 1987.) As the costs are eventually collectively borne by society in the form of taxes (excluding the costs compensated by insurances), the decision maker may see no reason for tracking down the true cost for the sake of assigning it to the perpetrator.

The costs assigned purely to lost quality of life

Table 7.12 compiles the values assigned solely to lost quality of life in the case of fatalities and non-fatal injuries. Denmark assigns the lowest costs to lost quality of life for fatalities and Sweden the highest. The explanation for the low Danish value is simply in the deficient costing methodology. However, the Finnish (and Norwegian) way of assigning a value to permanent disability advocates the costing system favourably.

Table 7.12. Values assigned solely to lost quality of life, FIM.

Country	**Fatality**	**Very serious injury**	**Serious injury**	**Slight injury**
Finland (index adjusted)	5 324 400	2 432 520	24 847	6 368
Great Britain	*	*	*	*
Sweden	8 710 000	-	1 340 000	60 300
Norway	8 120 000	4 482 000	1 352 000	233 600
Denmark	3 184 000	-	95 200	4 800

* No exact information available on the share of real economic costs in the British unit values.

7.4 Inventory and valuation of real economic costs in Finland in 1987

In order to restructure the Finnish accident-costing system, the former approach to valuations and cost inventories must be examined. A comprehensive review of the costs of accidents in Finland was performed in 1989 (LTT, 1990; see Appendix 1). The examination considered the cost structure of accidents from the year 1987.

A good number of years has passed and presumably changes have taken place in the real economic costs of providing emergency care, short and long-term medical treatment, rehabilitation and restitution for accident casualties. Additionally, the per capita contribution to the GNP has changed due to growth of the economy and increase in productivity. Therefore, in order to set the new unit values of accidents correctly, a full inventory of the cost items should be implemented.

As there is an urgent need for reconsidering the existing unit value of particularly lost quality of life at the time of this study, the re-examination of the real economic costs is made only for the gross/net GDP loss per casualty. The other real economic cost components are left as they were inventoried in 1989, and only corrected by the consumer price index from the 1995 level to 1999. However, it is recommended that the coverage of the cost items with their current cost levels is re-examined in the future.

Direct and indirect material costs[13]

The direct material and resource costs included vehicle and property damage, costs of ambulance and other casualty transport, costs of medical and hospital treatment, funerals as well as rehabilitation and re-education. The administrative costs included insurance company costs, costs of the police department and judicial system, costs of the correctional treatment and costs of research and compiling statistics. The indirect costs, other than production loss, included costs of keeping up spare resources and losses to employees.

Production loss due to premature death

The 1989 inventory considered a premature death to cause production loss when the casualty is a member of the potential labour force of society. The potential labour force consists of the employed, unemployed, school children, students, conscripts and people doing household work.[14] The premature deaths of those

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[13] It is important to note, that although in principle a comprehensive list of cost items can be produced, the actual costing process will never succeed in covering all the costs due to difficulties in data retrieval.
[14] Note that the potential labor force is larger than labor force presented in employment statistics.

incapable of working (the disabled) and people above the age of 65 (the retired) are not considered to induce production losses.

The average age of fatal casualties under the age of retirement (65 years) in traffic accidents of 1987 was 33 years. Therefore it was assumed that society loses an average of 32 years of work input from one traffic accident fatality. In accounting the production losses, two things must be considered: 1) the probability of dying before the age of retirement, 2) the probability of being a member of the labour force.

The starting value for estimating the production loss in 1987 was obtained by dividing market value GNP (FIM 391 billion) by the head count of the potential labour force at the time (2 432 000), which yielded a production loss of FIM 161 600 per individual.

As the potential losses induced by accidents apply to future production, the growth in productivity must be considered. Therefore, the losses per individual were expected to grow at the rate of 2.4 % per annum. These future annual production values were then converted to present values (for 1987) with a discount rate of 4 %. This yielded a production loss of FIM 3 190 200 per premature death of a member of the potential work force.

As the number of fatalities in this group in 1987 was 421, the deaths induced a total loss of FIM 1 343.1 million. This total value was averaged by the total number of deaths in 1987, which was 581 people. Therefore the production loss of a fatality per individual was approximated to FIM 2 311 600.[15]

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[15] Note that choices made on the discount rate and economic growth, as well as the constantly slightly changing demographic characteristics of the population (average age, average income, mortality probabilities, retirement age) have a considerable impact on the resulting values.

Production loss due to invalidity and sick leave

The 1987 inventory considered invalidity to cause production loss only when the casualty is a member of the potential work force. Casualties suffering 100 % invalidity were considered to induce the same production loss as a fatality. The less severe degrees of invalidity were valued according to a scale of disabilities. Sick leaves due to less severe injuries also cause production loss. There was no reliable data available on the number of sick leave days caused by traffic accidents. Estimates vary in Finland and abroad as an average of up to 35 – 40 days per injury. The 1987 inventory used an average of 25 sick leave days for slight and severe injuries.

8 A new accident-costing structure for Finland

8.1 Recommended costing structure

One of the main aims of this report is to align the accident-costing methodology of Finland according to theoretical consistency. Table 8.1 presents the accident costing structure recommended by the European Commission in the COST 313-report (1994).

Table 8.1. Summary of EU recommendations for estimating road accident costs. (COST 313, 1994).

	Recommended method for estimating costs	
Cost elements	*Fatally injured victims*	*Surviving victims*
Lost quality of life	Willingness to pay	Willingness to pay
Lost productive capacity	Human capital: net loss	Human capital: gross cost
Medical costs	Restitution cost	Restitution cost
Property damage	Restitution cost	Restitution cost
Administrative costs	Restitution cost	Restitution cost

There is no methodological controversy in costing property damage and administrative and medical costs. Also, the willingness-to-pay method has finally gained sufficient support as the correct method for estimating lost quality of life. However, according to the EU recommendation, there is one difference in the costing methodology between estimating lost production capacity for a fatality and a surviving victim.

This cost component of lost production capacity is usually referred to as human capital. The human capital method is generally used to estimate the costs of lost output caused by accidents. These indirect costs do not manifest themselves in the form of additional expenses, but rather in the form of reduced income, or a smaller volume of production than would have otherwise taken place. They are less visible than the direct costs, but no less real. (Elvik, 1997)

There are two ways of estimating the human capital costs. In the net approach, the value of the victim’s own consumption is subtracted from the gross production value. This net part of lost output corresponds to the losses experienced by the rest of society as a whole. In the gross output approach, the sum of production input and personal consumption of an individual is used. The selection of method depends on how the individual welfare losses are accounted for, both for the fatal and non-fatal injuries.

According to theoretical examination, in the case of fatalities, the WTP value along with net loss of production corresponds to the total human capital/quality of life losses with both material and individual aspects included. In the case of surviving victims, it is recommended to use a combination of gross lost output and WTP to represent total human capital/quality of life losses.

The difference arises for two reasons. An accident victim who dies ceases to consume, whereas those who survive continue to consume. Therefore, personal consumption has a value for surviving victims, but not in the case of death. It is assumed, that WTP statements for risk reductions include considerations of future consumption, whereas statements for reducing the risk of non-fatal accidents do not (i.e. the person continues to consume despite the unfavourable outcome).

The WTP risk value studies for non-fatal accidents have been scarce so far, and for this reason the lost quality of life induced by non-fatal accidents has often been derived from the WTP value of death by some state of health index. This procedure is not completely consistent with theoretical requirements, but it is applied due to the simplicity of the approach.

Contradicting slightly with the EU recommendations, in order to avoid double-counting, and provided that the value of risk reduction of both fatalities and non-fatal injuries originates from WTP statements for the reasons described above, the net personal consumption values of production loss must be applied for costing the losses induced by two types of casualties, fatal and fully hospitalised (100 % invalid).

In the current Finnish accident costing methodology, the value of gross output is used together with the so-called ‘social willingness to pay’. The conduct has not been correct because the ‘social willingness-to-pay’ measure does not have anything to do with the personal consumption of the victim. It solely represents hospitalization costs and therefore personal consumption has been represented in the output estimate. However, if the theoretically correct individual willingness-to-pay method is to be applied, the human capital loss of a fatality must be accounted for only by the production loss accruing to other members of the society, i.e. GNP net of personal consumption.

8.2 Value assignment

Material, administrative and reserve resource cost

Because no cost inventories are now conducted, the coverage of these cost components will remain unchanged as they were accounted for in the 1987 inventory, and they will only be updated to the price level of 1999 (see Chapter 7.4).

Table 8.2 presents the material costs assigned to different severity degrees of accidents in 1987 and the index adjusted to the value of the 1999 price level (1987 = 100; 1999 = 138). In Table 8.3 the cost items are summed up.

Table 8.2. Material costs induced by an accident leading to a personal injury, FIM.

Severity of accident/injury	**1987 value**	**1999 index adjusted value**
Vehicle damage		
- Fatal	32 000	44 200
- Permanent injury	13 700	18 900
- Severe and slight temporary injury	13 700	18 900
Administrative cost, all injury classes	1 000	1 400
Reserve resources, all injury classes	500	700

Table 8.3. Material accident cost per injury type at 1999 value (vehicle damage, administration and reserve resources).

Severity of accident/injury	FIM
- Fatal	46 300
- Permanent injury	21 000
- Severe and slight temporary injury	21 000

Production loss due to fatalities[16]

The costing of production loss presumes that costs are incurred when a member of the potential work force is killed (see Chapter 7.4). According to the 1987 accident data, an average of 32 years of work input was lost due to fatalities of the members of the work force.[17]

When production loss is costed, the probability of the victim being a member of the potential labour force at different ages and the 'natural' probability distribution of death prior to retirement age must be considered. In addition, the present day production per capita is expected to increase due to economic growth. Finally these future production flows must be converted to present day values.

The 1987 inventory provides an all-set table of these necessary items for the calculus of production loss (see LTT 1990, Appendix 2). We now assume the same number of lost production years induced by fatalities (32), the same long-term average economic growth (2.4 % per annum), the same discount rate (4 %) as well as the same probability distributions mentioned above.

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[16] There are alternative ways of estimating the loss of productive capacity (human capital) of individuals. Another method used in Sweden is presented in Appendix 3.
[17] In 1987 the average age of fatally injured casualties under the age of 65 was 33 years. All minors under the age of 15 are treated as 15 year olds in production loss costing due to their productive capabilities.

The calculus provides a simple production loss multiplier of 19.7411, which can be applied to any per annum/per capita production value, and thus yield the net present day value of future losses.

- The main statistical indicators required in the calculus now, for 1998 are:
- The total labour force included 2 507 000 persons (ages 15 – 74).[18]
- Gross national product was FIM 676.1 billion (market price).
- National product net of private consumption was approximately FIM 317.8 billion.
- National product net of private consumption thus yields FIM 126 765 per member of the labour force.

Applying the production loss multiplier 19.7411 to FIM 126 765 yields a net production loss of FIM 2 502 481 per both a fatally injured individual and an individual totally losing the ability to work (100 % invalidity). We can assume the 1998 value to represent the 1999 cost sufficiently well.

Production loss due to non-fatal injuries

The production losses of permanently injured surviving individuals must be considered separately according to the distribution of injury severity. Not all those permanently injured lose their ability to work completely.

Utilizing the data on severity distribution of permanent injuries from the 1987 inventory and the production loss induced by 100 % invalidity, we can estimate a weighted average for the production losses (see LTT, 1990, Appendix 3). By

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[18] Since 1987 the statistical concept of labour force has changed. It now corresponds to a larger group of people. However, the number of people already actually working at the age of 15 and after the official retirement age 65 is small.

doing so, we assume that the injury severity distribution would be the same in accidents occurring in 1999 as they were 1987.[19]

This calculus yields an average production loss of FIM 1 470 400 per permanently injured individual, while the degree of loss of ability to work varies between 0 - 100 %.

Finally, the production losses due to sick leave of the temporarily injured are noted. This cost component is assigned a value according to the unit costs estimated in the 1987 inventory, but adjusted with the price index presented above. This yields a production loss for a severe temporary injury the value of FIM 14 100 and for a slight temporary injury the value of FIM 3 500. Table 8.4 sums up the production losses induced by fatal and non-fatal injuries.

Table 8.4. Production loss per injury type.

Degree of severity of injury	**FIM**
Fatality (and 100 % invalidity)	2 502 500
Permanent disabling injury	1 470 400
Temporary severe injury	14 100
Temporary slight injury	3 500

Lost quality of life due to fatal and non-fatal injuries

According to the arguments presented in Chapters 7.1 and 7.2, the Swedish risk values are now transferred to Finland for representing the value of lost quality of life induced by traffic accidents. The risk value assigned to fatality in Sweden currently corresponds to approximately FIM 8 710 000 (see Chapter 7.3, Table 7.8). This value is transferred directly to Finland to represent the human welfare loss of a fatality.

The national attributes examined in Chapter 7.2 refer to no such fundamental differences between Finland and Sweden, that the unit value should be either raised or decreased. It is true that statistical accident risks are somewhat lower in

[19] In 1987, 225 persons where permanently injured, out of whom 75 suffered a 100 % invalidity.

Sweden than in Finland. However, considering the empirical observations of risk preferences, Finland and Sweden are within such a similar margin in statistical accident risks that it is difficult to make any assumptions about whether Finnish risk values should be higher or lower than in Sweden. Therefore, the unit values are transferred directly to Finland (however, slightly rounded).

The risk values of non-fatal injuries are then scaled from the unit value of fatality adopting the Norwegian scale of relative magnitudes of risk values between different injury types (see Chapter 7.3, Table 7.9). This is done because the Norwegian injury type classification corresponds better with the Finnish classification than the Swedish one.[20] Furthermore, the relative magnitudes between welfare losses of different injuries on the Norwegian scale have been assigned according to the results of a comprehensive empirical survey of injury victims (Haukeland, 1991 & 1996). The unit values assigned for Finland are presented in Table 8.5.

Table 8.5. Values assigned to lost quality of life for different injuries.

Degree of severity of injury	**FIM**
Fatality	8 710 000
Permanent disabling injury	4 808 000
Temporary severe injury	1 450 000
Temporary slight injury	250 000

These unit values would clearly increase the emphasis given to human welfare losses arising from traffic accidents, and simultaneously serve the purpose of directing more resources to safety measures and policies respectively. Especially more emphasis would be given to minor injuries, which are rather often ignored in discussions concerning traffic safety.

[20] The varying severity classifications of injuries are naturally a source of bias in comparisons and transfers.

8.3 A proposal for new Finnish unit costs

Based on the above calculus and arguments, the unit costs presented in Table 8.6 are proposed for adoption into the Finnish accident costing manuals. Table 8.7 presents the old unit values for comparison. The proposed values may be slightly rounded up, because the unit costs of production loss were estimated based on 1998 data. The values representing lost quality of life are recommended to be named *risk values* following the trade-off situation between risks and wealth, or income.

Table 8.6. New unit costs of personal injuries induced by traffic accidents.

	Unit value (FIM)			
Injury type	**Material costs**	**Production loss to society**	**Risk value**	**Total**
Fatal	46 300	2 502 500	8 710 000	11 258 800
Permanent injury	21 000	1 470 400	4 808 000	6 299 400
Temporary injury				
- Severe degree	21 000	14 100	1 450 000	1 485 100
- Slight degree	21 000	3 500	250 000	274 500

Table 8.7. The unit costs of personal traffic injuries on public roads (Tielaitos, Finnra, 1995).

	Unit cost (FIM)		
Injury type	**Material cost and production loss to society**	**Lost quality of life**	**Total**
Death	2 700 000	5 100 000	7 800 000
Permanent injury	2 470 000	2 330 000	4 800 000
(disability)	37 000	15 000	52 000
Temporary injury	59 000	23 800	83 500
- Severe degree	12 900	6 100	19 000
- Slight degree			

Judgement on the acceptance and final calibration of these values is left to the Finnish National Road Administration and the Ministry of Transport and Communications. A thorough debate should precede the final value assignment. However, as the structure valuation now corresponds to the one recommended in economic theory and also in the COST 313 of the European Union, here its use is highly preferable compared to the current costing system. The next chapter examines the value assignments critically.

8.4 A critical review

The main alterations in values

The main difference in the proposed set of values compared to the existing ones is that, besides being theoretically consistent, the value of lost quality of life is now represented with a clearly stronger magnitude than before. The total unit value assigned to a fatality rises by over FIM 3 million. Furthermore, the temporary non-fatal injuries, in particular, now receive much stronger recognition than before.

This adjustment would raise the Finnish unit cost assigned to a fatality higher than in Sweden and Great Britain, but not as high as in Norway. The unit costs proposed to be assigned to temporary injuries would be adjusted closer to the ones in Sweden and Norway.

Technically, the costing system now accounts for production losses net of private consumption, whereas gross production values were used before. As the origin of the existing unit costs is already far outdated (1987 inventory), the unit cost proposed now, based on fresh economic data for a fatality, is of the same magnitude as the existing value despite the gross to net conversion. However, as the production loss for a permanent injury is now costed as an average of injury degrees between 0 and 100 %, it drops almost to half of the existing unit cost.

The robustness of the unit cost estimates

This costing exercise is not based on a fresh inventory of accident cost items or willingness-to-pay surveys of Finnish origin, but instead it uses material costs from the previous Finnish inventory from 1987 and transferred risk values from Sweden. The production losses have been partly re-estimated from fresh economic data, but the same estimation formula has been used as in the 1987 inventory. Some very rough assumptions, generalizations and approximations have been made. This is, however, unavoidable in any accident-costing study.

Concerning the 1987 cost inventory, it is acknowledged that the process has been rather thorough and the cost coverage is satisfactory. However, in over a decade both the cost items have presumably changed and a better coverage of the items would be desirable. The costs do now serve the purpose of adjusting new accident costs, but at the same time the need for a re-inventory is obvious. Performing such an inventory would require mobilizing a project of its own with sufficient funding.

According to the presumptions made on the validity of value transfers in Chapter 5.3, the WTP estimates of empirical origin from Sweden can be considered applicable. An obvious need for national willingness-to-pay surveys exists, because transferred values never fully compensate for original study site values. A well-planned survey of Finnish risk preferences and traffic safety perceptions would serve safety research also generally, besides yielding national value estimates.

Missing cost items

The change in the costing structure resulted in leaving one of the prior major cost items aside. According to the 1987 inventory, the long-term treatment costs of a fully institutionalized person (100 % invalid) were FIM 3 787 900. At the present day price, these costs would correspond to approximately FIM 5 231 00. The treatment costs of less severe degrees of invalidity are also considerable, although smaller.

These costs are avoided when accident risks are successfully reduced, and could therefore also be fully taken into consideration in accident costing, as well as cost-benefit analysis of accident prevention measures and policies. If these costs were included in the unit costs in Table 8.6, the total unit cost assigned to a permanent injury would rise considerably closer to the value of fatality.[21]

Other missing cost items can be identified, for example, by examining the Norwegian cost inventory (Appendix 2). The most important ones include lost

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[21] Despite of the cruelty of the argument, from the society's point of view it seems likely that the real economic costs induced by a permanent severe disability are higher than the costs of a fatality.

household production and loss of professional competence. As the inventory of real economic costs is not fully comprehensive, and taken that the transferred risk values are considered representative for Finland, the total values assigned here to represent the benefits of avoiding personal injuries in traffic accidents are still likely to underestimate the true benefits of safety improvements.

9 Conclusions and recommendations

Changes in the accident-costing system

The report '*Valuation of the human cost factor of traffic accidents*' (Tervonen, 1999), concluded that the methods used in Finland for costing accidents are not theoretically completely valid and should be replaced, along with estimating new unit values respectively.

A theoretically consistent method, individual willingness to pay, should be applied in order to capture the true nature of welfare impacts induced by accident risks and to quantify the lost quality of life in monetary units. Only values that reflect subjective risk preferences represent the welfare consequences of accidents in an appropriate manner. Otherwise decision-making is flawed as a result of using wrong weights assigned to the human welfare impacts of changes in the provision of safety.

As a result of the above finding, the Finnish accident-costing system has been re-examined in this report, and a set of new unit costs proposed accordingly. In presenting the arguments behind the adopted method for costing risk values, a review of the valuation methodology and its economic welfare foundations has been presented.

Although this report and the documents it refers to use expressions such as 'value of life' or something closely similar, this research does not under any circumstance aim at giving a value to life *per se*. Such is impossible. The approach of costing the welfare impacts of lost quality of life is based on providing an estimate of people's risk preferences. The term *risk value* corresponds better to the aims of approximating a value to changes in accident risks by eliciting monetary statements about people's preferences.

Value assignment

The material accident costs have been adjusted according to the 1987 inventory only by a price index to current day values. Thus, for this part the costing structure and cost coverage remains unchanged. The production losses have been costed according to the theoretically correct net of personal consumption approach, based on 1998 data from Finnish national accounting. This procedure induces a change in the costing structure, as gross production values were used before.

The other major change in the costing structure concerns the approach to valuing lost quality of life induced by personal injuries. As Finnish empirical risk value studies do not yet exist, and there has been no time for conducting such a survey, the method of value transfer has been applied. Value transfers are commonly used in order to reduce the cost of arduous and time-consuming studies and to obtain information for decision-making with less research effort.

Potential transferable values have been examined in the accident-costing systems of the United States, Great Britain, Norway and Sweden. As a result of an analysis of the main affecting attributes, Sweden has been selected as a site suitable for value origin. The Swedish risk value representing the quality of life lost due to a fatality has been transferred directly to Finland without any particular adjustment. The values assigned for representing the quality of life lost due to non-fatal injuries has been scaled from the Swedish value of fatality, according to the relative weights used in Norway. The reason for this is the similar injury severity classification used in Norway and Finland.

It is emphasized that transferred values do not fully correspond to the values obtained by empirical risk valuation studies. Therefore, performing such a study is strongly recommended for the near future. Since the data on real economic costs is already rather old, also an inventory of the overall cost structure of accidents is recommended.

Policy implications

If adopted into the decision-making system, the new method and the unit values it produces would clearly increase the emphasis given to human welfare impacts of traffic safety. This change simultaneously serves the purpose of directing more resources to implementing safety measures and policies respectively. More emphasis would especially be given to the welfare impacts of minor injuries, which are rather often ignored in discussions concerning traffic safety.

These new unit costs would immediately raise the figures representing the social cost of road transport in particular in Finland. Therefore, also the pressure on collecting the funds for covering the costs would rise. If the principles of full-cost pricing and user pays were applied, these costs should be covered either by motor vehicle taxes or preferably, insurance payments as proposed by the European Commission (European Commission, 1999).

The unit values of injuries set by the Finnish National Road Administration have also been applied in project appraisal and social costing by other transport modes, mainly railroads and to some extent sea faring (whereas aviation uses different principles). However, the statistical risk levels as well as subjective risk perceptions presumably differ by mode. As a result, risk valuation would presumably produce different results compared to risk valuation in road transport. Nevertheless, the conduct of using same unit values is argumented by practicality and maintaining comparability between the modes. It would also be perhaps difficult to explain the use of varying values to the public. As far the rail sector is concerned, the accident frequencies are on the average low. The distribution of casualties is also dominated by deaths and very severe injuries, with very few minor injuries occuring. Therefore, the recommended new unit values would not cause a considerable difference in project appraisal and socio-economic costing of railroads. Nevertheless, level crossing accidents would receive slightly higher recognition in economic terms.

According to economic theory, the aim of the user-pays principle and pricing transport respectively is, besides covering the costs, to initiate a change in people’s behaviour so that the social cost burden is reduced. This means that accident costing would lead to such prices of travelling that reflect these costs, which then would be reduced by a change towards risk-averse behaviour due to the tendency of people to be cost minimizers on average. Thus, by using the correct management tools the number of accidents and their social and private costs would be eventually reduced.

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APPENDIX 1. THE COST STRUCTURE OF AN ACCIDENT

Table 1. The cost structure of an accident leading to personal injury (compiled from various sources).

Lost quality of life • loss of expected years to live (death) • loss of future health (non- fatal injuries)
Loss of production and consumption + income transfers • lost production capacity of an individual • lost consumption of an individual • loss of household and voluntary work • replacement cost of an employed person • income transfers due to incapacity to work
Costs of rehabilitation, re-education and converting of operational environment • aiding equipment • conversion of apartment • physical rehabilitation • re-education • special education for child casualties
Direct medical costs • ambulance and first aid • hospital treatment • home treatment
Administrative costs • police • fire department • court
Material costs • vehicles • load • infrastructure environment
Σ TOTAL ACCIDENT COST

Table 2. The cost items accounted for in the Finnish inventory of accident costs in 1989 (LTT, 1990).

Cost item	
Direct costs - Repair of vehicle damage - Transport of casualties (ambulance, taxi, private car) - Clinical and hospital treatment - Extended treatment - Rehabilitation - Re-education - Premature burial	**Administrative costs** - collegial procedure of insurance claims - cost to the police - judiciary cost - cost of correctional treatment - cost of research and statistics **Indirect costs** - cost of temporary replacement of damaged vehicles - production loss due to premature death - production loss due to invalidity - production loss due to sick leave - lost quality of life (treatment cost)

APPENDIX 2. THE COVERAGE OF ACCIDENT COSTS IN NORWAY

Table 1 breaks down the cost components considered in the valuation system of Norway. Although this breakdown provides a view of the items based on the information available, it not possible to judge how the proportional cost coverage is made. Presumably, a choice must be made about which costs of, e.g. the authorities are included.

The services of the authorities are available for various purposes of use and are financed by general taxes. When an accident occurs, variable costs are induced to, e.g. the police, the fire department and health care system. These costs can be ascribed to accidents according to real usage. However, should a share of the fixed costs also be appointed, because in any case the safety network of the society is sized according to an expected number of accidents and victims? Other related causes of variation in costs and the number of costing components are the difficulty and expense of cost monitoring, so too is the difference in the price of just about everything from one country to another. Furthermore, cost monitoring is usually not a too frequent operation and the cost information may originate from different eras.

Table 1. Real economic costing items and estimated total cost of accidents in Norway in 1991 (Elvik, 1993).

Cost component, Million NOK	**1991**		**1995**
Costs of medical treatment		SUM	
- treatment of injuries in hospital	334.1		
- treatment of injuries in other institutions	182.4		
- clinical treatment of injuries	53.2		
- intensive care	22.0		
- home care	3.5		
- ambulance transport	3.0		
- private medical costs	203.0	801.2	850
Loss of production			
- lost occupational production	3 592.1		
- lost household production	907.3		
- loss of professional/occupational competence	71.8	4 571.2	4 900
Material costs			
- vehicle damage covered by insurance	2 403.9		
- vehicle damage privately covered (own risk)	303.3		
- vehicle damage not insured	624.7		
- damage not reported to insurance companies	450.0		
- damage to road environment	21.8	3 803.7	4 500
Administrative costs			
- insurance administration	1 670.0		
- safety administration	73.0		
- police work	54.0		
- court costs	36.0	1 833.0	2 000
TOTAL REAL ECONOMIC ACCIDENT COSTS		**11 009.1**	**12 250**

Reference

Elvik, R. (1993). Hvor mye er ungåtte trafikkulykker verd for samfunnet. Oppsummeringsrapport. TÖI Rapport 193/1993. Oslo.

APPENDIX 3. VALUATION OF PRODUCTION LOSS NET OF PERSONAL CONSUMPTION PER CASUALTY IN SWEDEN (Vägverket 1997)

The loss of gross production corresponds to the value of goods and services that would have been produced if a person had not been severely injured or killed in an accident. Loss of net production corresponds to this production value minus the goods and services the person would have consumed himself.

The value of an individual's work corresponds to his or her wage including the social security payments. Thus, the lost production value of an individual is estimated to be the current average wage plus social securities respectively.

The net present value of net production loss per casualty (s) who is involved in an accident at the age of (a) can be expressed as:

$$NPV_{a,s} = S * W_{a,s} + \sum_{n=a}^{64} \frac{P_{a,s}^{n} * G * W_{n,s} * (1+\hat{p})^{n-a}}{(1+r)^{n-a}} \qquad (1)$$

where

S	= the share of annual income lost due to an accident the year the accident took place
$W_{n,s}$	= average annual income from a full-time job of sex (s) at age (n)
$P^{n}_{a,s}$	= the probability of a person of sex (s) at age (a) to live up to the age (n)
G	= degree of invalidity (death = 100 %)
r	= rate of discount (5 % in Sweden)
p	= expected rate of increase in productivity

The term S* $W_{n,s}$ corresponds only to the losses of society due to temporary injuries. The second term corresponds to the production loss due to sustaining and permanent injuries. The probability function of survival and average incomes is obtained from national statistics. The income loss of a temporary injury/sick leave causes an average loss of 10 % of annual income. Permanent injuries causing disabilities are accounted for in a straightforward manner by the degree of invalidity, i.e. a 50 % invalidity causes a 50 % reduction in production.

APPENDIX 4. HENKILÖVAHINKOJEN UUDET YKSIKKÖKUSTANNUKSET

Taustaa

Raportissa on oikaistu Suomessa käytössä oleva liikenneonnettomuuksien henkilövahinkojen hinnoittelujärjestelmä teoreettisesti oikeaoppisen mallin mukaiseksi. Samassa yhteydessä myös yksikkökustannukset on arvioitu uudestaan ja niistä on muodostettu ehdotus. Uudet yksikkökustannukset eivät perustu kotimaisiin empiirisiin tutkimuksiin vaan vuonna 1987 edellisen kerran suoritettuun kattavampaan reaalitaloudellisten kustannusten inventaariin, indeksikorotuksiin, kansantalouden tilinpitoon sekä ulkomailta lainattuihin hyvinvoinnin menetyksiä kuvaaviin yksikköarvoihin.

Suomessa käytössä olevan hinnoittelujärjestelmän keskeinen ongelma koskee inhimillisten hyvinvointitappioiden mittaamista. Niin sanottu ’yhteiskunnallinen maksuhalukkuus’ ei mittaa tilastollisten onnettomuusriskien hyvinvointivaikutuksia yksilötasolla. Oheisessa raportissa kuvataan oikeaoppinen arvottamismenetelmä, yksilön maksuhalukkuus, sen teoria sekä empiirisiä havaintoja muissa maissa suoritetuista tutkimuksista. Ainakin Yhdysvallat, Iso-Britannia, Norja ja Ruotsi käyttävät tähän menetelmään perustuvia arvoja osana onnettomuuskustannusten hinnoittelua. Nämä hinnoittelujärjestelmät on myös kuvattu raportissa.

Koska Suomessa ei ole tehty vastaavia empiirisiä maksuhalukkuustutkimuksia, on henkilövahinkojen hyvinvointivaikutusten hinnoittelemiseksi arvioitu mahdollisuutta käyttää vertailumaista siirrettäviä arvoja ainakin tilapäisesti suomalaisten onnettomuuskustannusten hinnoitteluun. Vastaava toimenpide on suoritettu aiemmin Norjassa. Muodostettaessa oheinen uusien yksikkökustannusten ehdotus näin onkin päädytty tekemään.

Koska hyvinvoinnin mittaamisen menetelmämuutos edellyttää joka tapauksessa muutoksia myös yksilökohtaisten tuotantomenetysten mittaamisessa, on koko henkilövahinkojen yksikkökustannusten valikoima käyty saman tien läpi.

Uusien yksikköarvojen asettaminen

Materiaalikustannukset, hallinnolliset kustannukset sekä vararesurssien ylläpitokustannukset

Tässä yhteydessä ei ole suoritettu onnettomuuksien reaalitaloudellisten kustannuserien inventointia, joten kyseiset kustannuserät käsitellään vuoden 1987 inventoinnin (LTT, 1990) pohjalta ainoastaan korottaen arvoja hintaindeksillä vuoden 1999 tasolle (taulukko 1). Taulukossa 2 kustannuserät on laskettu yhteen. Indeksikorotus on suoritettu siten, että kun vuoden 1987 kustannus on 100, on vuoden 1999 kustannus 138 (Tilastokeskuksen indeksiaikasarjat).

Taulukko 1. Henkilövahinko-onnettomuuksien materiaali- ja hallinnolliset kustannukset.

Henkilövahingon vakavuus	1987, mk	1999 indeksikorjattu arvo, mk
Ajoneuvovahingot		
- kuolemaan johtava onnettomuus	32 000	44 200
- pysyvään vammaan johtava onnettomuus	13 700	18 900
- vakavaan tai lievään tilapäiseen vammaan johtava onnettomuus	13 700	18 900
Hallinnolliset kustannukset		
- kaikki henkilövahinko-onnettomuudet	1 000	1 400
Vararesurssit		
- kaikki henkilövahinko-onnettomuudet	500	700

Taulukko 2. Yhteenlasketut henkilövahinko-onnettomuuksien materiaali- ja hallinnolliset kustannukset indeksikorjattuina vuoden 1999 tasolle.

Onnettomuuden vakavuus	mk
- Kuolemaan johtava	46 300
- Pysyvään vammaan johtava	21 000
- Vakavaan tai lievään tilapäiseen vammaan johtava	21 000

Kuolemaan ja loukkaantumiseen liittyvä tuotannon menetys

Tuotantomenetysten arvioinnissa käytetään myös hyväksi vuoden 1987 kustannusinventaarin määrittelemiä perusoletuksia. Kansantaloudelle aiheutuu tuotantomenetyksiä kun onnettomuuden uhri on osa potentiaalista työvoimaa (ks. luku 7.4). Vuoden 1987 inventaarissa tällaisten kuolemaan johtavien onnettomuuksien uhrien osalta menetettiin keskimäärin 32 työvuotta yksilöä kohti. Koska kaikki onnettomuuksien uhrit eivät kuitenkaan kuulu työvoimaan, on se huomioitava todennäköisyyslaskennan keinoin. Lisäksi on huomioitava tilastollinen todennäköisyys, jolla ihminen kuolee joka tapauksessa ennen eläkeikää.

Kun yksilön kansantaloudellinen tuotantopanos on ensin arvioitu nykyhetkellä esimerkiksi vallitsevan koko kansantalouden tuotantotason pohjalta, on tulevat menetykset arvioitava huomioimalla tuotantopanoksen kasvaminen talouden yleisen kasvun mukana sekä näiden tuotantomenetysten arvo on diskontattava nykyhetkeen.[1]

Tässä yhteydessä käytetään samoja tilastollisten todennäköisyyksien jakaumia, menetettyjen työvuosien lukumäärää (32) sekä talouden pitkän aikavälin kasvuoletusta (2,4 %) ja diskonttokorkoa (4 %) kuin vuoden 1987 inventaarissa. LTT:n selvityksen liitteessä 2 on esitetty laskelma, jossa nämä tekijät on puristettu kätevästi yhdeksi tuotantomenetysten kertoimeksi, jonka arvo on 19.7411. Tällä kertoimella voidaan tuottaa tuotantomenetyksen kokonaisarvo 32 vuoden laskentaperiodille minkä tahansa tämän hetkisen vuositasolla arvioidun tuotantomenetyksen arvon suhteen.

Tuotantomenetysten arvioinnissa tarvittavat tilastostotiedot on poimittu vuoden 1998 tilastoista (Suomen tilastollinen vuosikirja, Tilastokeskus, 1998):

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[1] Liite 3 esittää vaihtoehtoisen ruotsalaisen tavan laskea tuotantomenetysten arvo palkkojen pohjalta.

- Työvoiman koko oli 2 507 000 henkilöä (ml. työttömät työnhakijat).
- Bruttokansantuote oli 676,1 miljardia markkaa (markkinahintaan).
- Kansantuote, josta on vähennetty yksityisen kulutuksen osuus, oli noin 317,8 miljardia markkaa. Tämä vastaa 126 765 markan tuotanto-osuutta työvoiman jäsentä kohti (vuoden 1998 hinnoin).

Tuotantomenetysten kerrointa hyväksi käyttäen tuotantomenetysten nettoarvoksi kuollutta työvoiman jäsentä kohden saadaan koko laskentaperiodille 2 502 481 markkaa. Tämä summa vastaa kuolleen ohella 100 %:sti työkykynsä menettäneestä henkilöstä kansantaloudelle aiheutuneen tuotantomenetyksen arvoa 32 vuoden periodilla 4 %:n korolla nykyhetkeen diskontattuna.

Pysyvästi vammautuneiden henkilöiden tuotantomenetyksiä on tarkasteltava erikseen ottaen huomioon vammojen vaihteleva aste. Kaikki pysyvästi vammautuneet eivät menetä työkykyään kokonaan. Vuoden 1987 inventaarista lainataan jälleen kyseisenä vuonna vammautuneiden henkilöiden vamma-astejakaumaa ja lasketaan tuotantomenetys niiden painotettuna keskiarvona (LTT 1990, Liite 3). Näin tehtäessä oletetaan, että eri asteisten vammojen suhteellinen jakauma olisi lukumääräisesti sama vuonna 1999. Kun pysyvän vamman aiheuttama työkyvyttömyyden aste jakautuu 0 ja 100 %:n välillä, saadaan pysyvän vamman aiheuttamaksi keskimääräiseksi tuotantomenetysten nykyarvoksi 1 470 400 mk.

Lopuksi on vielä määriteltävä tilapäisten vammojen aiheuttamat tuotantomenetykset sairaspäivien mukaan. Tämä kustannuskomponentti määritellään vuoden 1987 inventaarin pohjalta indeksikorotuksin korjattuna. Näin vakavalle tilapäiselle vammalle saadaan arvo 14 100 mk ja lievälle tilapäiselle vammalle 3 500 mk. Taulukko 3 vetää yhteen tuotantomenetysten arvot kaikille henkilövahinkojen luokille.

Taulukko 3. Tuotantomenetysten arvo eri henkilövahinkojen luokissa.

Henkilövahingon luokka	**mk**
Kuolema (sekä 100 %:n invaliditeetti)	2 502 500
Pysyvä vamma	1 470 400
Vakava tilapäinen vamma	14 100
Lievä tilapäinen vamma	3 500

Menetetyn elämän laadun arvo kuolemantapaukselle sekä vammoille

Oheisen raportin luvuissa 7.1 ja 7.2 esitettyjen perustelujen pohjalta ruotsalainen elämän laadun menetystä kuolemantapauksessa kuvaava riskiarvo, 8 710 000 mk, siirretään Suomeen sellaisenaan vastaamaan kuoleman aiheuttamaa hyvinvointitappiota (ks. myös luku 7.3, taulukko 7.8). Myös ruotsalainen termi, *riskiarvo*, suositellaan otettavaksi käyttöön tämän kustannuselementin osalta.

Luvussa 7.2 esitetyt kansalliset indikaattorit eivät poikkea Suomesta niin paljoa, että ruotsalaista riskiarvoa voitaisiin perustellusti säätää suuntaan tai toiseen. Tosin on totta, että Ruotsissa kuolemaan johtavan onnettomuuden tilastollinen riski on alhaisempi kuin Suomessa. Riskitasot ovat kuitenkin niin pienen tilastollisen marginaalin sisällä, ettei johtopäätöksiä sen vaikutuksesta yksilötason riskiarvostuksiin voida tehdä ilman täkäläisiä empiirisiä tutkimuksia.

Pysyvien ja tilapäisten vammojen osalta menetetyn elämän laadun arvo (riskiarvo) määritellään kuoleman yksikköarvosta skaalaamalla norjalaisen käytännön mukaan. Norjalainen vamma-asteikko vastaa paremmin suomalaista vamma-asteikkoa kuin Ruotsissa käytössä oleva. Norjalainen vamma-asteikko ja menetetyn elämän laadun arvottaminen perustuu lisäksi kattavaan empiiriseen onnettomuusuhrien haastatteluun (Haukeland, 1991 & 1996). Menetetyn elämän laatua eri henkilövahinkojen osalta kuvaavat riskiarvot on koottu taulukkoon 4.

Taulukko 4. Menetetty elämän laatu (riskiarvo) henkilövahingon eri luokissa.

Henkilövahingon luokka	**mk**
Kuolema	8 710 000
Pysyvä vamma	4 808 000
Vakava tilapäinen vamma	1 450 000
Lievä tilapäinen vamma	250 000

Edellä esitetyn pohjalta taulukossa 5 on vedetty yhteen ehdotus liikenneonnettomuuksissa aiheutuneiden henkilövahinkojen uusiksi yksikkökustannuksiksi. Taulukko 6 esittää vanhat arvot vuodelta 1995. Arvoja voidaan pyöristää hieman ylöspäin, koska niiden käyttöönotto toteutuisi vuonna 2000. Lopullinen päätös arvojen käyttöönotosta ja niiden mahdollisesta kalibroinnista jää liikenneministeriölle sekä väylälaitoksille.

Taulukko 5. Henkilövahinkojen ehdotetut uudet yksikkökustannukset.

	Yksikkökustannus, mk			
Vahingon vakavuus	**Materiaali -kustannus**	**Tuotanto-menetys**	**Riskiarvo**	**Yhteensä**
Kuolema	46 300	2 502 500	8 710 000	11 258 800
Pysyvä vamma	21 000	1 470 400	4 808 000	6 299 400
Tilapäinen vakava vamma	21 000	14 100	1 450 000	1 485 100
Tilapäinen lievä vamma	21 000	3 500	250 000	274 500

Taulukko 6. Henkilövahinkojen yksikkökustannukset yleisillä teillä (Tielaitos, Finnra, 1995).

	Yksikkökustannus, mk		
Vahinkotyyppi	**Taloudellinen kustannus**	**Hyvinvoinnin menetys**	**Yhteensä**
Kuollut	2 700 000	5 100 000	7 800 000
Pysyvästi vammautunut	2 470 000	2 330 000	4 800 000
Tilapäisesti vammautunut	37 000	15 000	52 000
- vaikea vamma	59 000	23 800	83 500
- lievä vamma	12 900	6 100	19 000

Kriittinen arvio

Esitetyt yksikkökustannusten uudet arvot vastaavat menetelmällisesti talousteorian sekä Euroopan Komission käsitystä (COST313) onnettomuuskustannusten oikeaoppisesta arvottamisesta. Arvojen tausta ei kuitenkaan ole suomalaisittain empiirisesti kovin vahva. Niiden asetannassa on käytetty hyväksi jo varsin vanhaa materiaali- ja hallinnollisten kustannusten inventaaria sekä lainattuja riskiarvoja. Lisäksi yksikkökustannusten arvioinnissa on tehty useita tarkastelua yksinkertaistavia oletuksia sekä nyt että lähtöaineistossa.

Arvot ovat kuitenkin tekijän mielestä riittävän vahvat otettavaksi käyttöön siihen saakka kunnes uusia onnettomuuskustannusten arvottamistutkimuksia suoritetaan Suomessa. Yksinkertaistavilta oletuksilta ja rajauksilta ei voida kuitenkaan välttyä uudessa kustannusten inventaarissa ja kotimaisessa arvottamistutkimuksessa. Joka tapauksessa uutta kustannusten inventointia sekä yleisestikin turvallisuustutkimusta palvelevan riskinarvottamistutkimuksen suorittamista suositellaan.

Uudet yksikköarvot toisivat muutamia selviä muutoksia onnettomuuskustannusten laskentaan ja päätöksentekoon. Subjektiiviset riskiarvostukset huomioitaisiin kokonaan uudella tavalla ja tuotantomenetysten laskenta perustuisi yksistään kansantaloudellisiin tappioihin ilman yksilön omaa kulutusta, joka kuvautuu teorian mukaan jo riskiarvoissa. Esitetyt uudet arvot lisäisivät selvästi onnettomuuksien aiheuttamien inhimillisten menetysten painoarvoa resursseja kohdentavassa päätöksenteossa.

Erityisesti toistaiseksi usein vähemmälle huomiolle jäävät lukumääräältään runsaat tilapäiset vammat saisivat kokonaan uutta painoarvoa Ruotsin ja Norjan tapaan. Ainoa yksittäinen yksikkökustannuserä joka alenee entiseen verrattuna, on pysyvien vammojen aiheuttamat tuotantomenetykset. Nyt ne lasketaan vammojen tilastollisen esiintymisen ja vakavuuden mukaan painotettuna keskiarvona.

Henkilövahinkojen yksikkökustannuksista puuttuu edelleen selkeästi muutamia kustannuseriä. Nyt kun arvottamismenetelmää on muutettu, ei onnettomuuskustannuksissa enää kuvaudu pitkäaikaispotilaiden laitoshoidon kustannukset (joita käytettiin ennen kuvaamaan inhimillisiä menetyksiä). Tätä kustannuserää ei ole kuitenkaan otettu kustannusrakenteeseen mukaan vanhan datan pohjalta, vaikka se kuuluukin selkeästi osaksi henkilövahingon kustannusrakennetta. Kustannuserän käyttö synnyttäisi käytännön erikoisen tilanteen, jossa pysyvästi vaikeasti vammautuneen henkilön yksikköarvo nousee kuolemaa korkeammaksi.

Muita edelleen puuttuvia kustannuseriä ovat kotitaloustyön arvo sekä ammatillisten kykyjen menetys (vrt. norjalainen kustannusinventaari liitteessä 2). Nämä puutteet huomioiden, esitetty henkilövahinkokustannusten ehdotus todennäköisesti edelleen aliarvioi henkilövahinkojen todellisia kokonaiskustannuksia. Ehdotettu kustannustaulukko suositellaan otettavaksi käyttöön sellaisenaan ja puuttuvien kustannuserien mukaan liittämistä suositellaan harkittavan tulevaisuudessa.

Politiikkavaikutukset

Kuten edellä jo todettiin, lisää arvojen perusteltu nostaminen liikenneturvallisuuden painoarvoa päätöksenteossa. Turvallisuustoimenpiteiden ja –ohjelmien kannattavuus paranee vaihtoehtoisiin varojen käyttökohteisiin verrattuna. Henkilövahinkojen yksikkökustannukset ovat liikennepolitiikan työväline ja sikäli arvojen korotus lisää niiden merkitystä.

Toisaalta yksikköarvojen selvä korotus etenkin lukumääräisesti runsaiden tilapäisten vammojen osalta lisää erityisesti tieliikenteestä aiheutuvaa yhteiskuntataloudellista kustannusrasitetta. Tämä vastaavasti kasvattaa paineita kerätä kustannukset takaisin liikkujilta tai toteuttaa liikennejärjestelmän turvallisuutta selvästi parantavia investointeja ja toimenpideohjelmia. Talousteorian ja Euroopan Komission mukaan (1999) turvallisuutta parantava hinnoittelu pitäisi toteuttaa joko verottamalla liikennettä yleisesti, väylien käyttömaksuilla tai mieluiten vakuutusmaksujärjestelmän piirissä.

Talousteorian mukaan liikennejärjestelmän käyttäjille kohdistetut todellisten kustannusten mukaiset liikkumisen hinnat kuitenkin saavat aikaan käyttäytymisen muutoksen, joka ennen pitkää alentaa yhteiskunnallisia kustannuksia. Liikenneturvallisuuden parantamiseksi hinnoittelulla pitäisi nimenomaan edistää riskejä karttavaa liikennekäyttäytymistä. Näin ollen sekä oikeaoppisen hinnoittelun että tehokkaiden toimenpideohjelmien toteuttamisen lopputuloksena seuraisi turvallisemmin toimiva liikennejärjestelmä ja alhaisempi yhteiskunnallinen onnettomuuskustannusten rasite.

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Title

Accident costing using value transfers
New unit costs for personal injuries in Finland

Abstract

The study deals with valuation of economic losses resulting from personal injuries of road traffic accidents. In particular, valuation of human welfare losses is examined. The study presents an analysis of valuation methodogies currently used in Finland and some other countries for estimating the unit values of personal injuries. The theoretically correct method for valuing human welfare losses according to economics is presented and recommendations for a new practice for Finland are made accordingly. The individual willingness-to-pay method is proposed to be adopted for valuing the changes in accident risk subjectively. This method will produce theoretically consistent *risk values* for representing human losses of traffic accidents. The theoretical foundation of the methodology also highlights how economics considers the welfare impacts of living in risky environments.

A change in valuation methodology immediately calls for revising the currently used unit values in Finnish highway economics. Therefore, the study examines the whole range of existing value estimates and their components. However, no empirical cost inventories or valuation surveys are carried out. The new unit costs for personal injuries are based on both an earlier cost inventory and values transferred from Sweden. The applicability of such value transfers is discussed theoretically. Finally, the study presents a proposal on unit costs for personal injuries recommended to be applied in project appraisals and socio-economic costing of transport in Finland.

Keywords
unit costs, traffic accidents, accident costs, Finland, transportation, injuries, values, risks, economic analysis, value transfers

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Nimeke

Liikenneonnettomuuksien arvottaminen ja arvojen siirtäminen

Tiivistelmä

Suomessa käytössä oleva liikenneonnettomuuksien henkilövahinkojen hinnoittelujärjestelmä on oikaistu raportissa teoreettisesti oikean mallin, yksilön maksuhalukkuuden, mukaiseksi ja uusista yksikkökustannuksista on muodostettu ehdotus. Yksikkökustannukset perustuvat aiempaan reaalitaloudellisten kustannuserien inventointiin, kansantalouden tilinpitoon sekä ulkomailta lainattuihin inhimillista hyvinvoinnin menetystä kuvaaviin yksikköarvoihin.

Yksikkökustannusten uudet arvot vastaavat menetelmällisesti talousteorian sekä Euroopan komission käsitystä onnettomuuskustannusten oikeaoppisesta arvottamisesta. Arvot ovat tekijän mielestä riittävän vahvat otettavaksi käyttöön, kunnes Suomessa suoritetaan omia onnettomuuskustannusten arvottamistutkimuksia. Reaalitaloudellisten kustannuserien tarkempi päivitys sekä onnettomuusriskien arvottamistutkimuksen suorittaminen on kuitenkin suositeltavaa.

Uusien yksikköarvojen käyttöönotto toisi muutamia selviä muutoksia onnettomuuskustannusten arvottamiseen. Subjektiivinen riskiarvo otetaan huomioon kokonaan uutena kustannuseränä. Tuotantomenetysten laskenta perustuu yksistään kansantaloudellisiin tappioihin ilman yksilön omaa kulutusta, joka kuvautuu teorian mukaan jo riskiarvoissa. Usein vähemmälle huomiolle jäävät lukumäärältään runsaat tilapäiset vammat ja niiden aihettamat hyvinvointivaikutukst saavat kokonaan uutta painoarvoa.

Uudet arvot lisäisivät selvästi onnettomuuksien aiheuttamien inhimillisten menetysten painoarvoa päätöksenteossa. Turvallisuustoimenpiteiden ja -ohjelmien kannattavuus paranee vaihtoehtoisiin varojen käyttökohteisiin verrattuna. Toisaalta yksikköarvojen korotus lisää erityisesti tieliikenteestä aiheutuvaa yhteiskuntataloudellista kustannusrasitetta. Tämä vastaavasti kasvattaa paineita joko kattaa kustannukset liikenteen hinnoittelulla tai toteuttamalla turvallisuutta selvästi parantavia toimenpiteitä.

Teorian mukaan liikennejärjestelmän käyttäjille kohdistettu todellisten kustannusten mukainen liikkumisen hinta saa kuitenkin aikaan käyttäytymisen muutoksen, joka ennen pitkää alentaa yhteiskunnallisia kustannuksia. Myös päätoksentekijällä on vankemmat perusteet toteuttaa yhteiskunnallisia kustannuksia alentavia toimenpiteitä. Lopputuloksena on odotettavissa turvallisemmin toimiva liikennejärjestelmä ja alhaisempi yhteiskunnallisten kustannusten rasite.

Avainsanat

unit costs, traffic accidents, accident costs, Finland, transportation, injuries, values, risks, economic analysis, value transfers

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