The Value of Life

The Value of Life:

The Rise and Fall of a Scientific Research Programme

By

Rune Elvik

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PREFACE

This book presents a historic reconstruction of research on the monetary valuation of road safety, based on the methodology of scientific research programmes, as developed by Imre Lakatos. It is based on a research report published in December 2016 by the Institute of Transport Economics.

Modern research designed to obtain a monetary valuation of the benefits to society of improving road safety started around 1970 when some prominent economists, notably Thomas Schelling and Ezra Mishan, called for basing this valuation on the willingness-to-pay approach. A large number of studies of willingness-to-pay have since been made. These studies have produced very diverse findings, many of which have for a long time been regarded as difficult to reconcile with the theoretical foundations of valuation studies.

The study presented in this book was funded by the Research Council of Norway. The funding of this research was a long-held dream come true and it was a great pleasure to delve into the many aspects of the topic covered by this book. Valuable comments on draft versions of the book have been given by (alphabetically): Peter Christensen, Beate Elvebakk, Ezra Hauer, Alena Høye, Gunnar Lindberg, Marika Kolbenstvedt, Sverre Strand, Michael Sørensen and Knut Veisten. I hereby thank for these comments, which greatly improved the quality of the book. Secretary Trude Kvalsvik edited the book for publication. The responsibility for any remaining errors remains mine.

List of Abbreviations

CV = Contingent valuation; a method for eliciting monetary valuations by means of direct questions ("how much are you willing to pay for …?").

GDP = Gross Domestic Product; i.e. the monetary value of all goods and services produced in a country during a specific period, usually one year.

QALY = Quality Adjusted Life Year, a numerical scale for rating health-related quality of life. Death has the value of 0, perfect health the value of 1.

SC = Stated choice; a method for eliciting monetary valuations by asking people to make choices between alternatives that are characterised by certain attributes, one of which is monetary.

SE = Standard error; an indicator of the statistical uncertainty of an estimate.

VSL = Monetary value of a statistical life, i.e. a reduction in risk corresponding to the prevention of one fatality.

WTA = Willingness-to-accept, i.e. the smallest sum of money needed to compensate for a loss, for example an increase in the risk of a fatal injury.

WTP = Willingness-to-pay, i.e. the largest sum of money a person is willing to pay for a good, for example a reduction in the risk of a fatal injury.

CHAPTER ONE

BACKGROUND AND RESEARCH PROBLEM

1.1 Background

Research for the purpose of assigning a monetary value to the saving of human life in the transport sector, often referred to as the cost of road accidents, has a history going back more than 60 years. The first studies were published in the nineteen fifties. Thus, Dawson (1967) quotes a study by Reynolds (1956), published in the Journal of the Royal Statistical Society in 1956. The first estimate of road accident costs for Great Britain, also briefly described by Dawson, dates to 1938.

All the early studies of the monetary value of life saving were based on the human capital approach (Becker 1964). According to this approach, the monetary value of saving a life was equal to the human capital that life represented. Human capital was estimated in terms of the discounted value of the future earnings of an accident victim. In some studies, the value of the accident victim's future consumption was subtracted, in order to gain a measure of the surplus of value an individual generated beyond what he or she needed to support himself or herself. This was referred to as the net lost output method. To obtain the total cost of accidents or injuries, direct costs, such as costs of medical treatment, property damage or costs of police investigations were added to the value of lost earnings.

In most estimates of the costs of road accidents made by means of the human capital approach, the value of lost output made up most of the costs. An example of the results obtained when using the net lost output approach is given in Table 1.1, which is taken from the report by Dawson (1967).

Table 1.1. Total cost of loss of output due to fatalities and average cost per fatality. Taken from Dawson, 1967, Table 3

	Value of net lost output for road accident fatalities in 1963 (GB pounds)					
	Urban areas		Rural areas		All areas	
Gender	**Per victim**	**Total**	**Per victim**	**Total**	**Per victim**	**Total**
Male	3720	10670000	5220	11360000	4360	22030000
Female	-1530	-2040000	-110	-60000	-1120	-2100000
Both	2040	8630000	4150	11300000	2880	19930000

It is seen that the value of net lost output is negative for females. Dawson remarks the following about this:

> *"A negative loss implies that from a strictly material point of view the community gains from a person's death: however, when the subjective factors are taken into account (see chapter 7) the losses became positive in all cases."*

It is obviously somewhat embarrassing when an estimate of the benefits to society of preventing road accident fatalities ends up by showing that society would be better off by simply killing some of the road accident victims. Indeed, according to the net lost output approach, all those who did not earn enough to contribute to supporting others, had negative values. This included children, the retired, and housewives not belonging to the market labour force.

Dawson specified the "subjective factors" as follows: (1) Pain, suffering and shock, (2) Loss of amenities of life, (3) Loss of expectation of life, (4) Inconvenience and discomfort, (5) Exemplary damages. These items were not further explained and would seem to involve some double counting. What, for example, is the precise difference between pain and suffering on the one hand and inconvenience and discomfort on the other?

Dawson made use of a study by Thedié and Abraham (1961) in order to estimate the value of the "subjective factors". He apparently had some misgivings (or at least un-answered questions) about that study and suggested the following method for estimating the value to society of preventing road accident fatalities:

> *"A possible way of arriving at an estimate of the amount that the community is prepared to pay to save life is to examine what, in effect, is paid in a number of different circumstances. Costs, direct and indirect, are*

> *incurred in making trains, ships and aircraft safer, in providing firefighting and lifeboat facilities, and in a number of ways in the field of medicine. It is possible that, by examining a number of such cases, a value would be arrived at which provides a consensus of opinion. It is, however, possible that the scatter of values would be so wide that no useful result will emerge. In the meantime it is suggested that the following rather arbitrary, average values should be used ....”*

Thus, arbitrariness was regarded as the lesser evil when compared to the embarrassment of assigning a negative value to life saving. A very comprehensive study along the lines suggested by Dawson was reported by Tengs et al. in 1995 (Tengs et al. 1995). Tengs et al. studied the cost-effectiveness of 587 lifesaving interventions. Cost-effectiveness was stated as the cost of the intervention per life year saved. Costs per life year saved ranged from negative to more than 10 billion US dollars, confirming that (slightly paraphrasing Dawson) “the scatter of values is so wide that no useful result emerges”.

The scientific approach to estimating the value of preventing human death has changed fundamentally since the days of Dawson. Prominent economists called for switching to a different method not so long after Dawson published his report. The new approach, the willingness-to-pay approach, was firmly anchored in modern welfare economics. It was argued (Schelling 1968, Mishan 1971) that the only theoretically correct measure of the value of preventing a fatality for use in Cost-benefit analysis was one based on the willingness-to-pay for the safety improvement of those who would benefit from it (assuming potential beneficiaries can be identified in advance). They also argued that the safety improvement should be stated as a reduction in the risk of death. The papers arguing for adopting the willingness-to-pay approach are discussed more in detail in Chapter 4 of the book.

Figure 1.1 gives an overview of the methods that have been used to obtain a monetary valuation of reduced risk of death. All these methods are still used, although historically there is a clear trend towards using methods based on the willingness-to-pay approach. Even if nearly all economists today would recommend the willingness-to-pay approach, papers based on the net lost output approach continue to be published (Pukalskas et al. 2015). This book will focus on studies based on the willingness-to-pay approach.

There are two main methods for eliciting willingness-to-pay: stated preference methods and revealed preference methods. Most studies of the valuation of road safety have employed stated preference methods. There are two main versions of stated preference methods: the contingent valuation method and the stated choice method.

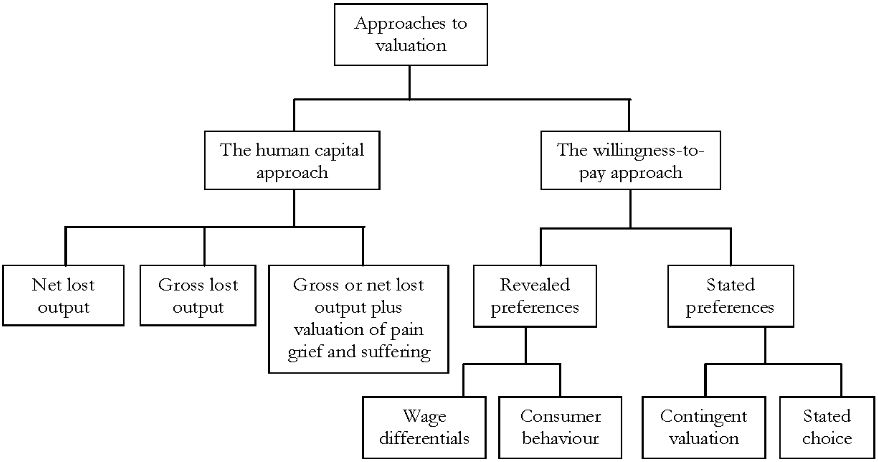

Figure 1.1: Approaches to the economic valuation of reduced risk of accidental death

In the contingent valuation method, a sample of the population is asked direct questions about how much they are willing to pay for a certain reduction of the risk of dying or getting injured in a road accident (or another source of risk, such as the risk of contracting a certain disease). There are many versions of the method. The simplest version is to ask directly about willingness-to-pay, without indicating any answer (open ended). Another version is to provide a so called "payment card", indicating different amounts and asking people to select one of these amounts. A third version is called "iterative bidding". Respondents are offered a bid (price) and asked to take it or not. If the first bid is rejected, a lower bid is offered. If that bid is accepted, iteration ends; otherwise it continues until the bid is accepted. Conversely, if the first bid is accepted, higher bids are offered until the last bid is rejected. A fourth version of the method, the "referendum method", involves stating a bid and asking people if they take it or not, by voting yes or no to it. This version of the method is perhaps the one that most closely resembles a real market in which consumers decide whether or not to buy a good based on its price.

The stated choice method asks people to make a choice between two options. The options are characterised by certain attributes, one of which is safety. Respondents do not state an amount they are willing to pay. They simply choose an option, and the valuation implicit in that choice is estimated by the analyst. The choices presented would typically be between two roads, two residential areas or two modes of transport.

Revealed preference studies examine actual choices in real markets. As far as road safety is concerned, such a choice might be the purchase of a new car. Cars differ with respect to safety features; if the relative importance of the factors that influence the choice of car, such as price, size, motor power, safety features, etc. can be determined, the implicit value placed on various safety features can be estimated. Studies of so called compensating wage differentials, i.e. extra payment for taking on risky jobs have been very common in the United States, but less common in Europe.

There is a distinct difference in the approaches taken in North America and Europe regarding the monetary valuation of safety. In North America, almost all studies are based on revealed preferences. In Europe, by contrast, most studies are based on stated preferences.

This book reconstructs the history of studies of willingness-to-pay for transport safety. It will not include studies relying on different approaches, as there is almost unanimity among economists that willingness-to-pay is the only meaningful approach. Several hundred studies have been made to estimate the willingness-to-pay for improved transport safety. These studies have produced a very wide range of estimates of the monetary value of transport safety. One critical observer, Ezra Hauer (2011A), notes that the values produced by studies of willingness-to-pay are all over the place. This is true.

A typical willingness-to-pay study deals with the monetary valuation of small changes in risk. These small changes are then aggregated into the value of preventing one fatality, often referred to as the value of a statistical life (abbreviated VSL). If, for example, the mean willingness-to-pay (arbitrary monetary units) for a risk reduction of 2 in 100,000 is 500, the value of a statistical life is:

$$\text{Value of a statistical life} = \frac{500}{\left(\frac{2}{100000}\right)} = 25{,}000{,}000 \text{ in any currency}$$

An equivalent measure of valuation is called willingness-to-accept (WTA). The problem then is how much an individual needs to be compensated in order to accept a certain risk. Willingness-to-pay is often abbreviated to WTP and willingness-to-accept abbreviated to WTA. The literature on the monetary valuation of reduced risk of death now contains more than one thousand estimates of the value of a statistical life. These estimates vary enormously. A recent meta-analysis by Bellavance et al. (2009) illustrates this. The meta-analysis dealt with studies of compensating wage differentials. Figure 1.2 is based on the study.

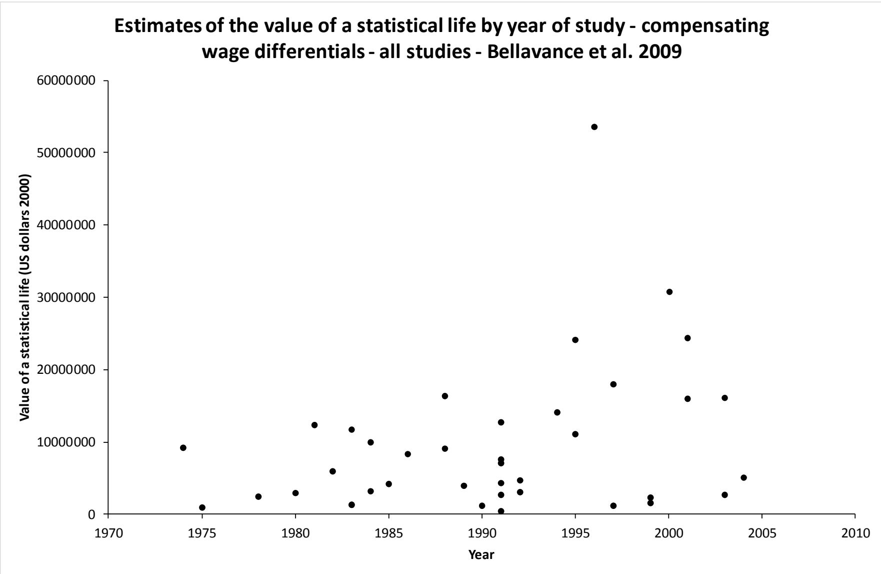

Figure 1.2: Estimates of the value of a statistical life by year of study. Taken from Bellavance et al. 2009

Studies have been listed chronologically. As can be seen from the figure, the diversity of the estimates has grown over time. Bellavance et al. remark (2009:453):

> *"After 30 years of research and publication on the topic, we might expect a certain convergence in the values obtained. When we examine Figure 1, we note quite the contrary. The most recent studies seem to diverge instead. And it is also interesting to observe a positive relation between the values of a statistical life and the year of publication."*

A more recent meta-analysis (Lindhjem et al. 2011) included a total of 856 estimates of the value of a statistical life based on stated preference studies, by far the largest number of estimates included in any meta-analysis so far. The estimates ranged from 4,450 US-dollars (2005-prices) to 197 million US dollars, a ratio of more than 44,000. The range of values was smaller when only the studies that were classified as "best" were included, but still substantial.

Is it possible to account for this huge range in estimates of the value of a statistical life? Can the sources of diversity be identified? If a single value is to be extracted from the literature for use in cost-benefit analysis, how can it best be done? Are all estimates found in the literature to be trusted, or should some of them be rejected? If so, on what grounds?

These are just a few of the questions that need to be asked in view of the huge variation in estimates of the value of preventing a fatality found in the literature. Hauer (2011A) notes:

> *"Variability of VSL estimates has several causes. First, what VSL is, is a matter of definition. The 'human capital' definition considers VSL to be based on a person's future earnings; the willingness-to-pay (WTP) definition is based on how much money people are willing to part with for a certain reduction in the risk to die. Different definitions lead to different estimates. Second, VSL estimates are extracted from imperfect data by methods based on assorted unsupported assumptions with all the attendant inadequacies. Third, VSL is not like a physical constant that has the same value for everyone, everywhere and always. For a homo economicus the VSL depends on that person's traits. As all VSL estimates are averages for a specific group of people at a particular time, they reflect the traits (age, wealth, norms, etc.) of those people at that time. Fourth, for a homo economicus the VSL depends on the specifics of the intervention options. To what extent these four reasons explain (the) very wide range of VSL estimates is not clear. The fifth reason for the diversity of VSL estimates is more basic. The Homo sapiens is cognitively badly equipped to contemplate small changes in small future risks. ... It is almost as if one surveyed the customers at a gas station about what they think is the molecular weight of unleaded gasoline."*

Hauer is by no means alone in voicing these concerns. Dorman (1996) argues that all studies relying on the compensating wage differentials model are methodologically flawed and should be rejected. The compensating wage differentials model is based on the assumption that workers are compensated for occupational risks by means of higher wages. Kahneman et al. (1999) argue that the results of valuation studies, in particular those relying on the contingent valuation method – by which people are asked directly how much they are willing to pay for a certain good – are expressions of attitudes towards the provision of the goods ("road safety is a good thing") rather than of decisions about how much money to spend on providing the goods. Loomes (2006) notes that the assumptions that underpin the conventional economic model of 'rational agents' tend to be substantially violated in studies designed to obtain valuations of health, safety and environmental goods. Hausman (2012) concludes that the contingent valuation method has gone from bad to hopeless and suggests that it should no longer be used.

In short, the current state of knowledge about the value of preventing a fatality based on studies of willingness-to-pay can be characterised as follows:

1. Research has not produced a firm estimate of the value of preventing a fatality. On the contrary, estimates vary enormously, by a factor of more than 44,000.
2. The huge variation in estimates of the value of preventing a fatality has not diminished over time. There is rather a tendency for estimates to become more diverse over time.
3. Nobody can account very well for the huge variation in estimates of the value of preventing a fatality, but it is clear that part of the variation can be attributed to factors that, according to economic theory, should not produce the variation found (such as anchoring effects in iterative bidding studies).
4. There is no consensus among economists about the best method for studying willingness-to-pay to prevent a fatality. Some economists reject methods that have been widely used.
5. There is no consensus about the interpretation of the results of studies designed to elicit willingness-to-pay. Some argue that these studies do not actually measure what they are intended to measure, but rather measure attitudes.

All these points could have been made with equal force 20 years ago. In the meantime, valuation research has continued unperturbed, almost as if the points of criticism listed above did not exist. One wonders why a field of research which does not produce meaningful results, and in which there is no consensus about research methods, continues to exist and, indeed, flourish. This forms the background of the research problems to be studied in this book.

1.2 Research problems

The following main research problems will be studied in this book:

1. What is the rationale for studying the monetary valuation of preventing fatalities and injuries in transport? Can effective and rational transport safety policies be developed without applying a monetary valuation of transport safety?
2. Can changes in the risk of dying be treated as a homogeneous commodity to which it makes sense to attach a fixed value, or is risk and changes in it a multidimensional concept for which the various dimensions cannot be reduced to a single monetary value? How do different academic disciplines conceive of risk and the possibility of assigning a monetary value to changes in it?
3. What is the appropriate theoretical foundation according to economic theory for studying the monetary valuation of transport safety? How did economists justify the need for, and the basic approach to this field of research?
4. How can one explain that a field of research producing so diverse findings as studies of the monetary valuation of transport safety, in which there is no agreement on the best method, continues to exist despite the diversity of findings and methods? Are there theories of science that may help in understanding and explaining the continuation of research in a field characterised by enormously varying findings that are difficult to explain?
5. One theory of science tries to explain the continuation of research in a field characterised by anomalous (i.e. unexpected and difficult to explain) findings: the methodology of scientific research programmes, proposed by Imre Lakatos. Can be the methodology of scientific research programmes be applied to reconstruct the history of research on the monetary valuation of transport safety? Can the concepts of this theory of science be used to identify phases in the history of valuation research? Does the methodology of scientific research programmes help in understanding the development of theories and methods in the study of willingness-to-pay for transport safety?
6. What are the principal sources of variation in willingness-to-pay for transport safety from a theoretical point of view? How have researchers developed hypotheses about this? Do the hypotheses make predictions that can be tested empirically?
7. One commonly applied method to try to summarise a large body of research and look for systematic patterns in results is meta-analysis.

Can meta-analysis make sense of the widely diverging estimates of the value of a statistical life? Can meta-analysis identify sources of this huge variation and help in selecting studies of high methodological quality?

8. There is a growing understanding of the fact that trying to find a single monetary value of transport safety that can be applied to any decision influencing transport safety is doomed to failure. It is argued that, in theory, there is no uniform monetary valuation of transport safety; rather the value depends on the context. What are the implications of adopting a variable monetary valuation of transport safety? Which sources of variation are legitimate and which are not? How should the range of values be determined?
9. Viewed as a whole, can the results of studies of the monetary value of transport safety be trusted? Do the results of these studies show true valuations of transport safety, or do they mostly or fully reflect methodological shortcomings of the studies, or, more fundamentally, that the phenomenon these studies aim to study does not exist?
10. Given the fact that the studies reported so far on the monetary valuation of transport safety have produced an extremely wide range of estimates, one must ask: Are there alternative approaches to valuation that are likely to produce less divergent estimates? Which alternative approaches can be applied? What are the strengths and weaknesses of these approaches?

The first point on this list will be discussed in Chapter 2. It will be argued that although it is possible to develop effective transport safety policies without resorting to a monetary valuation of transport safety, an implicit monetary valuation is inevitably made when developing policy. Rather than leaving this valuation implicit and unspoken of, making it explicit can help in developing more effective policies than those that are not based on an explicit monetary valuation. The ways in which an explicit monetary valuation can inform policy making are described.

The second point, dealing with the concept of risk, its dimensions and its measurement is discussed in the Chapter 3. Studies of the monetary valuation of changes in risk asks people to assign a value to such changes, thereby treating changes in risk as a commodity to which standard demand theory can be applied. What reasons have people got for treating changes in risk, in particular reductions of it, as something they ought to spend money on? Different academic disciplines have developed quite different perspectives on risk. Some of these perspectives argue that risk is difficult, if not impossible, to meaningfully quantify at the individual level. If one accepts this point of view, changes in risk cannot easily be quantified the way most valuation research assumes.

Together, Chapters 2 and 3 define and discuss the societal and epistemic context within which valuation research has taken place. This context has clearly influenced the course of this research. However, in order to explain why valuation research has continued despite its many problems, it is not sufficient to describe the societal context. Quite the opposite, many, perhaps most, people who are not themselves engaged in valuation research regard this type of research as meaningless. Had their opinion prevailed, valuation research might never have started or been given up long ago. Yet, it continues. Research is often strongly influenced by norms that are internal to the scientific community, i.e. by what researchers who are active in a field regard as appropriate topics for study and appropriate methods for studying these topics.

Points 3, 4 and 5 on the list above are dealt with in Chapter 4. That chapter both introduces a theory of science that may help explain the history of valuation research, and the formulation of the theoretical foundation for valuation research by some prominent economists. The theory of science which is introduced is the methodology of scientific research programmes, proposed by Imre Lakatos (1968, 1970, 1971, 1978). This is a theory of science intended to help in a rational reconstruction of its history. The methodology of scientific research programmes is unique by explaining how a field of study can proceed despite many results that apparently contradict the theoretical foundations of research.

Chapter 5 – point 6 on the list above – shows how hypotheses about systematic variation in willingness-to-pay for changes in fatality risk can be interpreted as forming a "protective belt" for this research. A protective belt is a key concept in the methodology of scientific research programmes, explained in Chapter 4.

In subsequent chapters, the methodology of scientific research programmes will be applied as a frame of reference for interpreting and structuring the history of research on the monetary valuation of transport safety. Chapter 6 describes the progressive phase of valuation research. This was the period roughly from 1980 to 1995 when the research programme was launched, attracted researchers and produced results that were, at the time, regarded as encouraging. The next chapters, 7 and 8, describe the increasing problems faced by valuation research and the attempts to solve them.

Chapter 9 discusses attempts to make sense of the results of valuation research by performing meta-analyses of the results of this research – point 7 on the list above. It is concluded that meta-analysis is only partly able to explain the huge variation in estimates of the value of a statistical life. Chapter 10 (points 8 and 9 on the list) discusses whether valuation as a scientific research programme has come to an end, or during the course of its development undergone changes that have changed its basic objective and intended application.

Chapter 11 discusses alternative approaches to the monetary valuation of transport safety (point 10 on the list). Finally, Chapter 12 summarises the main conclusions of the study.

CHAPTER TWO

THE SOCIETAL CONTEXT

2.1 The inevitability of trade-offs and the impossibility of infinite values

If one asks a person how much money he or she would demand in order to give up his or her life, the person will most likely react by taking the question as somewhat insulting, but then say: No amount of money could make me give up my life. In that sense the value of life is infinite. We cannot, except perhaps for those who are suicidal, terminally ill, or live in extreme poverty, be bribed to die voluntarily.

The matter is somewhat different when it comes to saving life. How much are you willing to pay for a life-saving operation? Well, essentially as much as you possibly can without having to live in great poverty and discomfort after the operation. You may certainly be willing to pay more than your annual income; any amount up to the maximum size of a loan you could service after the operation could be acceptable. Only if the operation cost more than the maximum amount of money you could bring forward would you have to forgo it.

Thus, maximum willingness-to-pay is constrained by the ability to pay. This is no different at the societal level than it is for an individual. Even if the entire gross national product was spent to save a single life, it would still be a finite amount. In that sense, life does have a finite value. Indeed, the idea of infinite values cannot make sense as long as the resources available to protect these values are limited. This, of course, does not mean that all trade-offs are allowed or possible to make. However, prohibiting certain trade-offs does not imply that values are infinite or resources unlimited.

It is, for example, illegal to trade your right to vote in a public election. You cannot sell the right to vote to your underage daughter because she takes a keen interest in politics and you do not care about voting. The trade is not allowed. But does the right to vote therefore have an infinite value?

No, it does not. Like any human right, upholding it comes at a cost and there are probably limits to how much of its resources society can commit to upholding the right to vote.

The purpose of assigning a monetary value to human life is not to engage in trading in the usual sense of that term. It is simply to provide a guideline with respect to the amount of resources we would like to spend on the prevention of accidents or injuries, given the fact that not all of our resources can be spent for this purpose. Some form of economic reasoning – that is some form of thinking that recognises the fact that resources are limited and can be put to very many alternative uses – is simply inevitable, given the following basic facts (Elvik 2012):

1. A limited amount of resources is at our disposal for the prevention of accidents or injuries, or indeed for catering to any human need.
2. Human needs and value systems are complex and multi-dimensional. While safety is certainly one of the more basic human needs, it is not the only one, and no society would ever be able to spend more than a fraction of disposable resources on the prevention of accidents or injuries.
3. How much to spend on the prevention of accidents or injuries will depend, and ought to depend, on how important people think this good is, seen in relation to all other goods they would like to see produced.
4. It is, in principle, possible both to provide too little safety and to provide too much of it. The objective of monetary valuation and cost-benefit analysis is to help us find the right balance between safety and other goods.

If these observations are accepted as a fair description of the choices we are facing, then some kind of cost-benefit reasoning, although not necessarily formalised, is simply inevitable: We engage in this sort of thinking whether we are conscious of it or not. In short: Trade-offs are inevitable; resources are limited; the number of uses resources can be put to virtually unlimited; and different values are compared to each other all the time.

It does not follow from these observations that trade-offs have to be made in monetary terms or that everything can be meaningfully converted to a monetary scale. Thus, one can adopt, for example, an air pollution standard stating the maximum permitted concentration of certain pollutants in air. The lower the limits, the higher is the priority given to clean air. Yet, any limit implies a trade-off. By the same token, one may set a certain target for the maximum number of traffic fatalities. Reaching the target has a certain cost, which indicates the priority given to reducing traffic fatalities. One does not have to convert the reduction in the number of traffic fatalities to a monetary value, although such a value will be implied by the ratio of the cost of reaching the target to the number of fatalities prevented (i.e. the benefit of preventing a fatality must be valued at least as high as the cost of doing so).

The question of whether a monetary valuation of transport safety is needed in order to develop effective policy is discussed in the next section. Following that, the arguments economists have made in favour of an explicit monetary valuation of safety are presented. An example of inefficient priorities is then given. Finally, it is noted that economic theory actually speaks with more than one voice as far as standards of consistency and efficiency in priority setting are concerned, and that the efficiency argument in the form it was originally put by economists to justify the monetary valuation of safety represents just one of several norms of consistency and efficiency proposed in economic theory. Herein lies the germ of contradictions that lay dormant for a long time, but in the end surfaced and lead some researchers to propose a reformulation of the chief objective of valuation research.

2.2 Is monetary valuation needed for making trade-offs?

While making trade-offs, in the sense of choices about how much to spend on, for example, road safety, health care, primary school, national defence, etc. is an inevitable part of public policy, it does not follow that these trade-offs have to be made by relying on an explicit monetary valuation of the different objectives. Indeed, no meaningful monetary valuation exists, or is relevant, for deciding how much to spend on primary education. In modern, western societies, it is regarded as a human right not to be illiterate. The question is never asked whether the benefits of learning children to read and write exceed the costs of doing so. So why should cost-benefit analysis be used to set priorities for road safety? Can we manage without it?

One option is to use of cost-effectiveness analysis to help set priorities between road safety measures. In cost-effectiveness analysis, no monetary value is assigned to safety effects. These effects are stated in "natural units", i.e. the number of accidents, fatalities and injuries prevented by a road safety measure or set of measures. The less a road safety measure costs per fatality or injury prevented, the more cost-effective it is.

Cost-effectiveness gives sufficient information for setting priorities between road safety measures when the following two conditions are fulfilled (Hauer 2011B):

1. Either two road safety measures, A and B, are expected to prevent accidents of the same severity, or one of the measures dominates the other.
2. The question of when a road safety measure becomes “too expensive” does not arise.

Suppose that measures A and B cost the same. If A (as a long-term statistical average) prevents 5 injuries and 1 fatality, it will dominate B if B only prevents 3 injuries and 0 fatalities. If, on the other hand, B prevents 4 injuries and 2 fatalities, the choice is no longer obvious. It depends on what we think is most important (or “valuable” an economist might say): Preventing fatalities or preventing injuries. There is probably consensus that it is more important to prevent fatalities than to prevent injuries. But how much more important? To help answer this question, a widely applied weighting scheme in the United States is the EPDO, or Equivalent Property Damage Only weight. A case of property damage is given the weight of 1. Larger weights are given to injury accidents and fatal accidents, reflecting how much more important it is to prevent these accidents than to prevent a property-damage-only accident. Table 2.1 shows the weights assigned in some American States, as well as the weights resulting from a monetary valuation of injuries of different severities (based on Miller 1993 and Hauer 2011B).

Table 2.1: Relative weights assigned to preventing accidents of different severity in some states of the United States. Based on Miller 1993 and Hauer 2011B

State	Property damage	Injury accident	Fatal accident
Colorado	1	5.4	154.0
Massachusetts	1	5.0	10.0
North Carolina	1	8.4	76.8
Ohio	1	6.9	292.8
All states (Miller 1993)	1	13.7	1053.9

It is seen that the weights vary considerably. Hauer (2011B:3) remarks:

> *"It is hard to believe that road users in Ohio would value fatalities 29 times more than in Massachusetts. Whether one fatal accident is equivalent to 10 PDO accidents or to 292.8 accidents will determine which of several alternative actions appears to be more cost-effective."*

To this can be added that none of the weights applied by the states listed in Table 2.1 are anywhere close to the weights based on the monetary valuation of preventing fatalities and injuries based on willingness-to-pay (Miller 1993, Tables 6 and 8).

Hauer (2011B) notes that cost-effectiveness analysis can never determine whether spending public money can be justified. It does not define a "cost limit" beyond which a safety measure is regarded as too expensive. In practice, as shown by the study of Tengs et al. (1995), see further details in section 2.4, such a limit does not exist. The amounts spent per fatality prevented vary enormously and erratically.

While it is certainly possible to develop public policy without resorting to any monetary valuation of human life and limb, such a valuation can support policy in three ways that are not possible without a monetary valuation:

1. Monetary valuation of public policy objectives makes it easier to compare different objectives to each other and find solutions that maximise the overall realisation of the objectives when they are partly or fully conflicting. When all objectives are stated in the same metric (money), they are made comparable.
2. A uniform monetary valuation of life and limb makes it easier to set policy priorities that maximise the number of fatalities or injuries prevented with a given budget.
3. Monetary valuation of life and limb makes it possible to determine how much to spend in total on the prevention of fatalities or injuries.

The reader of this study is not asked to agree with these arguments or find them persuasive. The objective of this study is not to persuade readers about the blessings of a monetary valuation of life and limb. It is rather – given the fact that many economists have argued in favour of a monetary valuation of life and limb, and tried to obtain this valuation – to try to explain why a field of research many observers would say has failed utterly to realise its purpose has continued to thrive and grow despite the apparent lack of success.

2.3 The consistency argument in favour of a uniform value of a statistical life

The consistency argument in favour of a uniform monetary valuation of life and health was forcefully put by Hills and Jones-Lee (1983). Their argument is worth quoting at length. They use examples of policy choices to illustrate their points. The first example is given in Table 2.2.

Table 2.2: Impacts of two transport projects. Only one can be chosen. Based on Hills and Jones-Lee, Table 1

	Investment cost	Annual savings in vehicle operating costs	Annual reduction of fatalities
Project A	5,000,000	450,000	1
Project B	5,000,000	150,000	4

A policy maker choosing project A reveals that his or her valuation of saving a life must be less than 100,000 – otherwise project B would be better. Conversely, a policy maker choosing project B reveals that his or her valuation of saving a life must be at least 100,000. Unless the monetary valuation of saving a life is made explicit, choices between options such as A and B in Table 2.1 are likely to be inconsistent. On one occasion, A may be chosen. On a different occasion, B may be chosen. The study by Tengs et al. (1995), quoted in Chapter 1, shows that this is indeed the case. In general, that means that society does not get as large safety benefits from spending a given amount of money as it could by spending the money efficiently. If a monetary valuation of, for example, 125,000 was adopted for saving a life, cost-benefit analysis would always find that project B is better than project A.

To maximise benefits, it is important that the value of saving life is uniform, i.e. only a single, constant value is applied. The next example shows this. It is given in Table 2.3.

Table 2.3: Comparison of safety investment in rail transport and bus transport. Based on Hills and Jones Lee, Table 2

Rail transport			Bus transport		
Fatalities per million personkm	**Expected number of fatalities**	**Annualised cost (1,000) of reducing risk**	**Fatalities per million personkm**	**Expected number of fatalities**	**Annualised cost (1,000) of reducing risk**
1.0	10	0	4.0	40	0
0.9	9	15	3.0	30	80
0.8	8	40	2.0	20	250
0.7	7	65	1.5	15	420
0.6	6	100	1.2	12	590
0.5	5	160	1.0	10	750
0.4	4	220	0.9	9	860
0.3	3	350	0.8	8	1000
			0.7	7	1180
			0.6	6	1420

It is assumed that the two modes transport the same number of people. Rail is much safer than bus (lower number of fatalities per million personkm). Suppose, first that a safety standard has been set allowing a fatality rate of not more than 0.9 for each mode. Achieving this level would cost 15 for rail and 860 for bus, for a total of 875. It would prevent 1 fatality in rail and 31 for the bus, in total 32. The mean cost per prevented fatality would be 875/32 = 27.3. The marginal cost (the cost of the last fatality prevented) is (860-750)/(10 – 9) = 110/1 = 110. Closer inspection of the data suggest that this would not be an efficient use of money. The marginal cost of preventing one fatality is 15 (the difference between 15 and 0) for rail and 110 (860 – 750) for bus. This suggests that one could prevent more fatalities per unit of money spent (and possibly more in total) by shifting spending from bus to rail.

If an equal maximum marginal cost of 60 per fatality prevented is assumed (equivalent to a uniform monetary valuation of preventing a fatality of 60), one should aim for 5 fatalities in rail (marginal cost 60 = 160 – 100) and 12 fatalities for the bus [(590 – 420)/3 = 56.7)]. The number of fatalities prevented would be 5 in rail and 28 in bus, in total 33. Total cost would be 750, which is less than if the safety standard was introduced. Moreover, if the maximum marginal cost of 60 is interpreted as the monetary value of preventing a fatality, net benefit for rail would be 140 (300 – 160) and for bus 1090 (1680 – 590).

Suppose next that rail is safer because safety has been valued more highly there than for the bus, i.e. differing monetary valuations have been applied. For simplicity, suppose the relative valuation of safety is inversely proportional to risk. This means that preventing a fatality is valued four times higher for rail than for the bus. If, say, the valuation is 100 for rail and 25 for the bus, rail should reduce the number of fatalities to 4 (going further down to 3 has a marginal cost of 130, exceeding the value of the benefits). The bus should aim for 20 fatalities. The total number of fatalities prevented would be 26 for a total cost of 470.

Finally suppose that a uniform monetary valuation of safety of 100 is used for both modes of transport. The optimal levels of safety would be at 4 fatalities in rail and 10 for the bus. Total number of fatalities prevented would be 36 for a total cost of 970.

The following lessons can be learnt from this simple numerical example. First, setting a safety standard, or a quantified target for that matter, without considering what it costs to meet the standard is likely to generate an inefficient use of resources, since the marginal costs of achieving the safety standard are likely to vary between different organisations or types of activity subject to the standard. Whenever marginal costs vary, one may in principle increase efficiency by shifting spending to equalise marginal costs.

Second, setting priorities according to a uniform valuation gives a more cost-effective solution than adopting the safety standard. The cost is 22.7 per fatality prevented (750/33) when a uniform valuation of 60 is adopted versus 27.3 (875/32) when the safety standard is adopted.

Third, if a uniform monetary valuation of life-saving is adopted, it will be most efficient to prevent fatalities when the cost of doing so is low; hence, mean expenditure per prevented fatality will be minimised. In short, if improving safety is very costly (costs more than the valuation of safety), one should shift resources to areas where the prevention of a fatality costs less.

Thus, a uniform monetary value of saving a life supports an analysis designed to find the least costly way of preventing fatalities. This set of priorities will maximise the number of fatalities that can be prevented within a given budget. Departure from a uniform value of saving a life will, all else equal, result in a lower number of lives saved. It seems clear from the examples discussed by Hills and Jones-Lee (1983) that they