SPEED CONTROL AND TRANSPORT POLICY

Stephen Plowden
and
Mayer Hillman

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SPEED CONTROL

AND TRANSPORT POLICY

Although speed limits exist in all countries, the great potential of speed limits as an instrument of transport policy has never been properly explored. This book aims to do so.

Stephen Plowden and Mayer Hillman trace the connections between speed and the various harmful effects of road traffic and discuss the likely effects of lower speeds on journey times and travel patterns. They calculate that the standard urban speed limit should be reduced from 30mph to 20mph and that the national speed limit should probably be no higher than 55mph. Large-scale trials to verify these calculations are recommended.

It is argued that the most effective method of enforcing speed limits is through the vehicle itself; in addition, if top speed and acceleration were lowered, vehicles could be much more fuel-efficient and much less polluting.

The authors have worked in transport planning and research since the mid-1960s, both together and independently. Their research has been concerned with the social consequences of transport, ways of reducing the danger and environmental impact of traffic and how to make the best use of existing roads. This book continues these themes.

Stephen Plowden and Mayer Hillman

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Introduction

1.1 Purpose and approach

This study is addressed to two questions. What should the speed limit be on each class of road? By what means should speed limits be enforced?

All the harmful impacts of traffic are connected with speed, and in most situations lower speeds would reduce these impacts, often very substantially. But lower speeds would significantly increase the time required for many of the journeys made at present. People would either have to accept this time penalty or modify their travel behaviour in order to reduce or avoid it. To determine the right speed limits involves predicting, with as much precision as possible, what would be the effects of enforcing different speed limits, including those which apply at present but are not observed, and then finding a way to strike a balance between the desirable and undesirable consequences.

This approach, though obvious, has rarely been attempted. Several studies were undertaken in Finland in the 1970s to define the optimal speed limits for rural main roads. This research, which is described briefly in Chapter 9 and was one of the inspirations for our study, is the only attempt we have come across to calculate an optimum. But very similar calculations, also described briefly in Chapter 9, have been made in the United States to determine whether the imposition of a 55 mph limit in 1973, and the raising of that limit to 65 mph in many states in the late 1980s, were beneficial moves. The only comparable study that we know of in Britain was undertaken by the Road Research Laboratory in the late 1960s to see whether the imposition of an experimental 70 mph speed limit on motorways had been worthwhile. It was calculated that the reductions in accidents and vehicle operating costs were worth more than the penalties in increased travel time, and so the limit was made permanent.[1]

The present study, however, differs from all these in several ways. It attempts to cover more speed-related nuisances, even though it has not been possible to include them in the formal calculations. These calculations make some allowance for the effect that a reduction in speeds would have on reducing the number and length of the longer journeys now made by road, whereas all the other studies we have seen have neglected this effect. As will be seen in Chapter 9, its inclusion makes a considerable difference to the calculations of the optimal speed limits on main roads outside towns. The treatment of taxation, which is important in relation to the fuel savings to be expected from lower speeds and modified travel behaviour, is also different in this study from previous studies.

These innovations make it even more important than usual to set out the data, reasoning and calculations in a way which enables other people to check them. We have tried to do that, but it was not possible, within reasonable limits of space, to reproduce all the computer calculations. All the relevant material can, however, be made available to interested researchers.

The reason why so little work has been done until now to calculate optimal speed limits is probably that it would have been regarded as of academic interest only. The main consideration in setting speed limits has been that drivers should accept them. Thus, until recently, it was thought that if more than 15 per cent of drivers regularly broke the 30 mph speed limit on a particular road, that was a good ground for raising it to 40 mph. It was argued that unless this was done, drivers would lose respect for speed limits on other roads as well, and the whole idea of speed limits would fall into disrepute.

Although it is certainly true that in a democracy laws have to command the respect of the public, this policy was always contentious. The alternative to raising speed limits that motorists regarded as unreasonable would have been to have put more effort into explaining why they were reasonable. In any case, policy on this point has now changed. To its credit, the Department of Transport is now promoting traffic-calming schemes and 20 mph zones and has also conducted extensive advertising campaigns to explain the benefits of lower speeds, or some of them at least, to the public. Since, in addition, the whole car-oriented basis of transport policy is now under attack from all sides, this is a propitious time to attempt to put policy on speed limits on a more rational basis.

An optimising approach to speed limits is, however, very difficult to apply. Sometimes, for example with air pollution and global warming, the basic scientific facts and relationships are still unclear. For noise, although the relationships between the volume, composition and speed of traffic along a road and the noise emitted from it are reasonably well established, the further work required to estimate how many people are exposed to different degrees of noise at present, and how that number would change if speeds changed, has not been done. No amount of study would enable precise predictions to be made about how travellers and firms would react to a general reduction in speeds. Even if all the various effects could be predicted with fair precision, there would still be room for argument about how to weigh up the different considerations and, where they conflict, to strike the balance between them.

Our response to these uncertainties has been to bias the argument against the case for lower speed limits throughout the study. The consequence is that although the conclusions reached are very firm, they are not always very precise. Where precision is not now possible, we have specified the work required to make it so. We have laid particular emphasis on large-scale trials, both because we believe they are the only way to clear up some of the present uncertainties, and because trials are likely to be more effective than theoretical calculations, however sound, as a means of convincing the public.

1.2 Arrangement of the report

The summary which follows this introduction is divided into two parts: a synopsis of the report and a list of its main recommendations. Chapter 3 is concerned with the philosophical problems raised by the attempt to find a common unit in which to evaluate the diverse consequences of changing the present speed limits. Chapters 4 to 6 trace the connections between speed and danger, fuel consumption and air pollution, and noise. Chapter 7 shows how lower speeds would weaken the case for the road programme, allow such new roads as might still be desirable to be built to more modest and less intrusive designs, and reduce the road maintenance bill. Chapter 8 draws on the experience of the increases in speed that have taken place in recent decades to suggest how present travel patterns might be affected if speeds were now reduced. Chapter 9 tackles the question of what the speed limits should be on motorways and other main roads outside towns, and

Chapter 10 discusses the same question for roads in towns. Chapter 11 is concerned with the best means of enforcing speed limits, and Chapter 12 with the politics of speed reduction. The Appendices contain supporting arguments and calculations too detailed for inclusion in the chapters.

1.3 Acknowledgements

Our particular thanks go to the sponsors of this study: the Rees Jeffreys Road Fund, the Anglo-German Foundation and the British Railways Board.

It will be plain from the numerous references to the Department of Transport and the Transport Research Laboratory in the report that this study would have been quite impossible without their help. We were disappointed that the Department decided not to help finance it, and alarmed that the reason given was that the subject was not a priority. But whatever our differences with the Department's policy-makers, we have enjoyed the closest cooperation with the statisticians, road safety specialists and other experts both in the Department itself and in the Transport Research Laboratory.

The other sources of information are acknowledged in the report, but we would especially like to thank our colleague Dr Rudolf Petersen of the Wuppertal Institute for his help throughout; Dr-Ing von Winning for information on the TempoMASTER speed limiter; Professor Markku Salusjärvi for information on the Finnish research on speed limits; Professor Christer Hydén for information on the experiments with enforcing speed limits in the Swedish town of Växjö; Martin Kroon of the Traffic and Mobility Division of the Ministry of Housing, Spatial Planning and the Environment in the Netherlands for his own papers and for referring us to the other Dutch research; Brian Parker for supplying almost all the material in Chapter 7 and for his help with Appendix J; and John Wilkes for his great skill and patience in making the computer calculations for Chapters 9 and 10. None of our helpers bears any responsibility for any errors or omissions in this report.

Reference

1. Ministry of Transport (1968) *How Fast? A Paper for Discussion*. London: HMSO, especially paras 7, 36 and 37.

2

Summary

2.1 Synopsis

Road safety

The lower speed limits imposed at the time of the first oil crisis produced very large reductions in accidents, both in Britain and abroad, even though, in Britain at least, the limits were very poorly observed. Evidence from this experience and from other sources has been used to estimate what effect lower speed limits on main roads outside towns might have on reducing accidents there. In the following table, the number of accidents that might be expected, on roads of different types, if various speed limits were enforced, is expressed as a ratio of the number of accidents that occur now. The figures may well be conservative, especially for the more severe accidents.

	Motorways	Non-built-up dual carriageway 'A' roads	Non-built-up single carriageway 'A' roads
Present	1.00	1.00	1.00
70 mph limit enforced	.84	.87	N/A
65 mph limit enforced	.71	.76	N/A
60 mph limit enforced	.62	.65	.975
55 mph limit enforced	.55	.58	.96
50 mph limit enforced	.50	.55	.89
45 mph limit enforced	.47	.52	.84
40 mph limit enforced	.45	.50	.80
35 mph limit enforced	N/A	N/A	.76

On urban roads, the best guide to the accident savings that might occur if speeds were lowered comes from traffic-calming schemes in which lower speeds have been enforced through speed humps, chicanes and other highway engineering measures. Some traffic-calming schemes in Denmark and the Netherlands have reduced casualties by more than 70 per cent. British experience with 20 mph zones has been that initially they reduce accidents by 70 per cent, but that after a time some of the effect is lost. The reason may be that when people become accustomed to driving in a traffic-calmed area they find that they no longer have to slow down as much as they did initially. If speed limits were enforced by on-vehicle means, rather than by changes to the road, a higher degree of compliance would be obtained and drivers might also feel less frustration. In those circumstances, it should be possible to maintain a reduction in accident rates of 70 per cent or more.

Accidents and casualties are not the only consequences of unsafe roads. They also distort the pattern of travel in a number of ways. Some journeys which people, especially children and the old, would like to make are frustrated altogether. People are also forced to make certain journeys, including many of those undertaken only to escort other people, which in better conditions would not be necessary. The choice of mode can also be affected: in particular, unsafe conditions deter would-be cyclists. Children's play and other forms of street life may also be deterred. If the travel and other activities still take place in spite of the conditions, they can be a cause of anxiety either to the road users concerned or to others on their behalf.

Social surveys and other evidence show that these non-accident costs are very important to people. These costs have increased in recent years: in particular, the mobility of children has very much declined and the number of escort trips has very much increased. Although much of the worsening of conditions can be attributed to increased traffic volumes, increases in the speed and acceleration of vehicles must also have played an important part. This is shown by the success of traffic-calming schemes, which have led to marked increases in walking, street life, people's feelings of security and their satisfaction with the towns they live in. Experience also shows that when the speed of motorised traffic is reduced, more people will cycle. Cycling is good for the health as well as the mobility of the cyclist, and any reduction in motor traffic is good for public health as well.
(Chapter 4 and Appendix F)

Fuel consumpton and air pollution

In 1994, road transport accounted for 44 per cent of the petroleum consumed in the United Kingdom and for 22 per cent of carbon dioxide emissions. If present trends in road transport continue, the amounts of petroleum consumed and carbon dioxide emitted by road transport will continue to rise, both in absolute terms and as a share of the national total. Petroleum is a finite resource and there is a duty on the present generation to use it sparingly in order to reduce the inevitable difficulties of making the transition to an economy powered by other energy sources. Carbon dioxide is the gas mainly responsible for global warming; very large reductions in emissions of carbon dioxide are required if the global climate is to be stabilised.

Road transport also produces varying but significant amounts of all the other main air pollutants, except for sulphur oxides. Catalytic converters and other technical developments will reduce these emissions greatly in future years, even if traffic continues to grow, but further reductions will still be necessary.

Lower and better enforced speed limits on high-speed roads outside towns would lead to substantial reductions both in fuel consumption and in emissions. But it is not clear that in towns lower speeds would always be beneficial, since more driving in lower gears would have an adverse effect. However, if methods of enforcement could be found which led to steadier and smoother driving in towns as well as to a lower average speed, there should still be net reductions both in fuel consumption and in emissions, even with vehicles of the present type, when, at least in the future, the great majority of vehicles will have catalytic converters. Large reductions could be guaranteed on roads of all kinds if vehicles were designed to comply with lower speed limits.
(Chapter 5)

Noise

Noise has little ecological significance, but it detracts from the quality of life of millions of people. Road traffic is the most important single source of noise nuisance. Noise from road vehicles is of two kinds, power train noise, which comes from the engine, transmission and exhaust, and rolling noise, which comes from the interaction of the tyres and the road surface. Much progress has been made in the last few decades in reducing power train noise by vehicle design, and more is still possible. This would have some beneficial effect in reducing noise nuisance in towns but only very little effect on noise from high-speed roads outside towns, where rolling noise dominates power train noise.

Noise increases with speed, but for power train noise it is the speed of the engine, rather than that of the vehicle, which matters. It follows that, with vehicles of the present type, a reduction in the speed of traffic which is already moving comparatively slowly, as often in towns, will not always reduce noise, since engine speeds may rise as drivers change to a lower gear. But a reduction in vehicle speeds on high-speed roads would always reduce noise.
(Chapter 6)

Road building and road maintenance

Lower speeds might not eliminate traffic growth but they would certainly reduce it. This would seriously weaken the case for the Department of Transport's road programme. Lower and better enforced speed limits would also increase the capacity of the existing roads, and so, even if more capacity really is required, the need to build more roads in order to provide it would be reduced.

Accident savings play a significant part in the Department of Transport's justification of its road schemes. It is claimed that traffic will be drawn off existing relatively dangerous roads onto new ones with lower accident rates. But if accident rates on the existing roads were greatly reduced by lower speeds, this argument too would be weakened.

Lower speeds, in conjunction with local traffic restraint schemes, could also help to improve conditions in towns for which bypasses are planned, and so perhaps obviate the need for a bypass. But some towns and villages, including some for which no bypass is planned at present, would still benefit from being bypassed. Lower speeds would enable more modest and less intrusive designs to be considered.

In some circumstances, lower speeds would have the added benefit of reducing the damage done to the road surface by heavy vehicles and would therefore save on maintenance.
(Chapter 7 and Appendix J)

Travel patterns

In towns, where most journeys are short, better enforced and lower speed limits should encourage cycling but are unlikely to have any other effect on the number and length of car journeys. The effect on long-distance car travel would, however, be significant. If speeds were reduced, some drivers would continue to make exactly the same

journeys as before, simply putting up with the longer travel times, while others would not find this time penalty acceptable and would adapt their travel behaviour in order to avoid or reduce it. Some would switch to another mode of travel, especially rail; there would be some substitution of shorter car journeys for longer ones; and some less important journeys would simply be abandoned.

An assessment of the costs and benefits of better enforced and lower speed limits must take account of these responses, even though they cannot be predicted precisely. The only feasible method is to study the effect that increases in speed have had on travel patterns in the past and to assume that decreases would have the opposite effect, allowing, however, that past changes may not be completely reversible.

The Standing Advisory Committee on Trunk Road Assessment (SACTRA) studied the relationship between speed and the amount of travel performed in its recent report on traffic generation. Its conclusion, based on the analysis of a large number of studies, was that in the short term about half the time saved through increases in speed might be used for additional travel, and in the longer term a higher proportion, perhaps all of it, might be. The National Travel Survey, which the Department of Transport has been carrying out for many years, also throws light on this relationship. Special analyses undertaken for this study showed that the speed of car travel has increased over the years for journeys of all lengths but especially for longer journeys. This increase in speed has been accompanied by an increase in the number and length of journeys, and the amount of time which people devote to travel has also increased substantially. Although other factors, such as rising incomes and the greater reliability of modern cars, must help to explain these trends, these findings support the cautious use of the long-term relationship between speed and travel suggested by SACTRA.

Road freight, if measured in tonnes, has not increased since the late 1960s, but tonne-kilometres and vehicle kilometres have both increased substantially. This is because lengths of haul have increased, both overall and, in varying degrees, in every major commodity group. The higher speeds brought about by the road programme, combined with increases in the permitted and actual size of lorries, have reduced the cost of road freight in general and the difference between the cost of a long haul and a short haul in particular. Road freight has therefore increased and long hauls have been substituted for short ones. A reduction in speed would lead to some reductions in lengths of haul as well as to some transfer of freight from road to rail and to coastal or short-sea shipping. *(Chapter 8)*

Striking a balance

In order to determine what speed limits would be appropriate for different types of road, some method of balancing the gains and losses arising from changes to the present limits must be found. The effects are too diverse and complex, and also too far removed from everyday experience, for it to be possible to determine the right balance only by judgement. Some method is required of evaluating them, or as many of them as possible, in terms of a common unit.

In spite of many difficulties, both of principle and practice, money is the most convenient common unit. But there is a problem of how to assign money values to intangibles such as noise or the risk of being injured in a traffic accident. The values should normally be those of the people directly concerned, but the question of what such an intangible is worth to a person can be interpreted in two different ways. It can mean 'what would he be prepared to pay to avoid this nuisance?' or it can mean 'what would he have to be paid as compensation for accepting it?' The sums of money that people would require as compensation are always likely to be greater, sometimes by very large amounts, than those they would be prepared to pay.

Although a great deal of ingenious research has been put into attempts to place money values on noise nuisance and on the various ill effects of air pollution, in our view this work has not yet produced figures which can be used with confidence in a planning context. The only intangibles for which the Department of Transport now uses money values are accidents and travel time, and these are also the only ones for which money values have been used in the calculations of this report.

The Department of Transport has allotted money values to road accidents and casualties for very many years, but the method of determining the values has recently been changed. The values it now uses are derived from surveys designed to ascertain willingness-to-pay values. We believe that in most situations compensation values would be more appropriate, so that the values produced by this research are likely to be too low. In addition, even if the willingness-to-pay criterion were accepted, there are some consequences of road casualties which the research does not allow for. Moreover, the values that the Department actually uses in a policy context are much lower than those

which the surveys suggest. In the formal calculations in this report, the Department's figure for the cost of a fatal casualty has been doubled, its figure for the cost of a serious casualty has been increased by 80 per cent, and its figure for the cost of a slight casualty has been increased by 75 per cent. It may be that even these revised figures still err on the low side.

A further problem is that the road accident statistics, which are derived from the forms filled up by the police when an accident occurs, are not complete. All fatalities are recorded, but there is a significant shortfall in the recording of serious and, even more so, of slight casualties. Data from hospital records, and also from household surveys in the Netherlands, which allow some estimates to be made of the number of casualties not recorded either by the police or by hospitals, have been used to correct these figures. Damage-only accidents are not included in the police records, but the Department of Transport estimates their number using an approximate ratio of damage-only accidents to injury accidents derived from insurance sources. Given this ratio, the revised estimate of the number of injury accidents also leads to an upwards revision in the number of damage-only accidents.

The revised estimates of the values to be attached to accidents and of accident numbers probably both err on the low side. It follows that the figures for the costs of accidents used in the calculations in this report are also probably too low.

The values placed on travel time in this report are the same as those used by the Department of Transport. Given these values, to evaluate the position of the people who would continue to make the same journeys as before, if traffic speeds were reduced, is relatively straightforward. But there is still a problem about how to evaluate the position of the people whose response to longer travel times would be to modify their journeys.

Since these people had the option of continuing to make the same journeys as before but chose to do something else, the penalty associated with forgoing their previous journeys in favour of that something else must be less than that of accepting the increase in travel time. For example, suppose that, as the result of the introduction of a lower speed limit, the time taken to drive from A to B goes up by ten minutes, and a certain driver decides to give up making that journey. It follows that (ignoring for the moment any effect that lower speeds would have on reducing his vehicle operating costs) the loss in satisfaction he experiences from abandoning his journey must be less than the value he places on avoiding ten minutes of travel. Provided that the increase in travel time is not too great, it is reasonable to assume that the average loss to people who are deterred by it is half its value – five minutes per person in this instance.

This rule of half can be applied to all costs perceived by travellers, money costs as well as time costs, or a mixture of the two. It does not apply only to the people who choose to give up their former journey altogether when the time it takes increases, but can also be used to evaluate the position of those whose response is to choose another mode of travel or another destination. It applies to the travel generated by reductions in journey time, arising from road construction, for example, as well as to the travel suppressed when speeds fall and journey times increase. But the rule rests on an important assumption which is rarely discussed and which often does not hold.

The assumption is that the development which gives rise to the generated or suppressed travel does not otherwise alter the situation. For example, if roadbuilding led to some people transferring from rail to road, the assumption would be that the service offered by the railway remained as good as before. But in reality, the loss of custom would contribute to the familiar vicious spiral of public transport decline. Again, if the faster speeds made possible by roadbuilding led more people to live in the country and commute to work, the countryside would lose some of its character, to the disappointment both of the newcomers themselves and of everyone else who values the countryside, but the rule of half would not take account of this deterioration.

It could be argued that the net effect of the increase in journey lengths which has taken place over the last several decades is simply that patterns of activity have become more dispersed, with no lasting benefit to anyone. Conversely, if lower speeds led to a general reduction in car travel, the rule of half would treat this simply as a loss of opportunity and satisfaction, without regard to any offsetting benefits such as a revival of public transport, a resurgence of local activities, or a reduction of the impact of traffic on the environment.

The rule of half has been used in the calculations in this report of the costs and benefits of reducing speed limits on main roads outside towns. The fact that the underlying assumption is unrealistic means that the losses from any changes in travel behaviour induced by an increase in journey times are exaggerated.

(Chapter 3, Section 4.2, Section 8.3, Section 9.1, Appendices A, B, C, D, H, I)

Speed limits on main roads outside towns

Calculations have been made to find the optimal speed limits for motorways, dual carriageway 'A' roads and single carriageway 'A' roads. The costs on which the calculations were based were travel time, accidents, fuel costs and non-fuel vehicle operating costs. Both because of the way these factors were treated, and because other important benefits of lower speeds were not taken into account, the calculations understate the case for lower speed limits.

The Department of Transport's traffic counts provide estimates of the number of vehicle miles driven in a year, by type of vehicle, on each class of road. Its speed surveys provide a distribution, again by type of vehicle and class of road, of the speeds at which vehicles are travelling at any one moment. The Department also has formulae showing how fuel costs and non-fuel vehicle operating costs vary with speed. Accident figures by class of road are also available. This information was used to calculate the present (1993) costs of travel on each class of road.

It was assumed that if present speed limits were enforced, or if new limits were imposed, any vehicle now exceeding the limit would reduce its speed so as to comply with it exactly. On this assumption, and making use also of the table relating accidents to speed limits given on page 5 above, calculations were made of what the costs of travel on each class of road would have been in 1993 if the present speed limit or some lower one had been enforced and if everyone had continued to make the same journeys. The optimal speed limits calculated in this way are somewhere between 65 mph and 70 mph for motorways, somewhere between 60 mph and 65 mph for dual carriageway 'A' roads, and somewhere between 45 mph and 50 mph for single carriageway 'A' roads. The omissions and biases in the calculations mean that these figures should be thought of as extreme upper-bound estimates of the true optima.

Calculations were then made of what the optimal speed limits would be on the more realistic assumption that increased travel times would lead some people to modify their travel behaviour. The Department of Transport believes that commercial operators take account of time, fuel costs and non-fuel vehicle operating costs in their decision-making, but that most private motorists take account only of time and fuel costs. On these assumptions, and also on fairly modest assumptions about the amount by which traffic levels would fall in response to increased journey times, it seems that the optimal speed limit on motorways should be no higher than 60 mph, with 55 mph a strong contender; the optimal speed limit on dual carriageway 'A' roads should probably be no higher than 55 mph; and the optimal speed limit on single carriageway 'A' roads might be as low as 40 mph. If the calculations are adjusted in an attempt to take account, albeit in rather a crude way, of the need to conserve fuel as a finite resource, and to discourage pollution, it seems that motorway speed limits should be no higher than 55 mph, and those on dual carriageway 'A' roads should be no higher than 50 mph, and perhaps considerably lower.

These calculations still leave out some important benefits of lower speeds, such as reduced stress and the reduction of the need for roadbuilding, with its damaging effect on the landscape. Also, the time increases are exaggerated by the very simple methods used to calculate them.

Although the case for lower speed limits on main roads outside towns can be taken as proven, much more work is required to determine precisely what the new limits should be and to win the confidence of the public. The work should include large-scale trials to allow the effects of a strict enforcement of the present limits to be compared with those of the strict enforcement of a range of lower limits.
(Chapter 9 and Appendices A to H and K)

Speed limits in towns

A speed survey carried out for the Department of Transport in Norwich was used to calculate the time penalties and accident savings that would result from replacing the present 30 mph and 40 mph speed limits on roads in built-up areas by a strictly enforced 20 mph limit.

According to this calculation, the gains and losses would almost exactly cancel out. However, the simple method used to calculate the time penalties to motor traffic vastly exaggerates them. In addition, pedestrians, whose travel was not taken into account in the calculation, would spend less time waiting to cross the road if traffic speeds were reduced. A properly enforced 20 mph limit would also release much of the suppressed demand for cycling and would reduce the need for escort trips.

Even if the calculations could be improved to give a more accurate estimate of the time losses and to include some of the missing considerations, it is unlikely that they would show a net benefit from reducing the urban speed limit from 20 mph to 15 mph. But a speed limit of 15 mph might be justified under a revised view of the proper role of the car in towns. It could be argued that walking, cycling and

public transport should be the modes normally used in towns and that the role of the car should be to cater for journeys which it would not be convenient to make by those modes even in greatly improved conditions. A 15 mph speed limit would help to ensure that cars could still be used for such journeys, perhaps rather more easily than at present, while at the same time discouraging their use for journeys well served by other modes.

Trials of 20 mph speed limits in a number of towns are required both as a check on the calculations and to allow people to experience the changed conditions for themselves. Trials of 15 mph speed limits in selected towns, such as holiday resorts or university towns, should also be undertaken.

The analysis of the Norwich data suggests that the time penalties of reducing the speed limits on roads where they are now higher than 40 mph would be very small. This finding should be checked by similar, but more sophisticated, calculations based on the speed surveys carried out in other towns and by trials.
(Chapter 10 and Appendices D, E, and L)

Means of enforcement

Lower speed limits would not bring the benefits that have been described unless they were properly enforced. There have been three important developments in the means of enforcement in recent years: traffic calming, speed cameras and top-speed limiters for coaches and heavy lorries. They have all been very valuable but they all have important limitations. The most effective enforcement strategy would involve three elements. The national speed limit would be enforced by prohibiting the sale or use of vehicles whose maximum speed exceeded it by more than a small margin. The urban speed limit, and any limit between that and the national limit, would be enforced by variable speed limiters, set to match the limit of the road on which the vehicle was being driven at any particular time. Speed limits lower than the urban limit, for example very low limits outside schools, could be enforced, as at present, by traffic calming.

A variable speed limiter could either be operated by the driver or triggered off automatically by equipment buried under the road or installed at the roadside. Driver-operated models seem more promising. Trials in Germany showed that they were both technically feasible and acceptable to drivers. If cars were manufactured with a variable speed limiter, the additional cost would be about £40. To retrofit cars already in use would cost about £250 per car, so it would cost nearly £6 billion to retrofit the existing stock of some 23 million cars and vans. Since the annual cost of accidents is about £24 billion, this once-and-for-all cost would be justified if it produced quite small savings in accidents – much smaller than the savings that could in fact be expected.

If cars were built to more modest performance standards, in terms of acceleration as well as top speed, their fuel consumption and emissions of pollutants could be much reduced. Thus, to limit the top speed of cars is not only the most effective way of enforcing the national speed limit but would bring great benefits at other speeds as well. The reduction in fuel consumption and pollution would be greater still if cars were lighter. Ways of making them lighter, in particular by the greater use of synthetic materials rather than steel, are now being explored by manufacturers. But the current trends in the market towards higher performance and greater weight will not be reversed without governmental intervention. The power to issue the necessary Construction and Use regulations now rests with the European Union, but national governments can use taxation to influence the type of cars people buy. In Britain, where most of the new cars sold each year are company cars, the restriction of tax concessions to cars which met stringent environmental standards, including modest speed and acceleration, would have a powerful effect.

Many people find it difficult to walk, cycle or use public transport either because of their physical condition (for example, the elderly or infirm), or because of their circumstances (for example, mothers with young children). A car would be especially useful to such people, but very often they cannot avail themselves of one, either because it is too expensive or because of difficulties with driving. A car designed specifically for local use, with a top speed of 20 mph or 30 mph, would suit many such people. It could also serve the needs of some young motorcyclists, and could replace those conventional cars, of which there are a large number, that are now used only for short local trips. Local runabouts should be substantially cheaper both to buy and to run than conventional cars, so even some people who do now use their cars for a certain amount of long-distance travel might decide to change their present car for a runabout and to take another mode of transport for their long-distance journeys. All these developments would be in the public interest, and it should therefore be an aim of policy to encourage runabouts. The strict enforcement of lower speed limits in towns and on minor rural roads would help to remove the feelings of threat and

intimidation which people in runabouts would feel, in present conditions, vis-à-vis conventional cars. In addition, the runabout should be recognised as a legally distinct category of car, which would be more lightly taxed than conventional cars and for which it would be easier to obtain a driving licence.

Large lorries designed for long-distance haulage are out of place in towns and on minor country roads. There is a strong case for restricting them to a limited network of motorways and some selected 'A' roads. Lorries allowed to drive on other roads would have to meet especially stringent environmental criteria. Some of these 'green' lorries would also operate on motorways, but others would be designed only for urban distribution and other local use. These vehicles, like the local runabout, would have a low top speed.

Motorcycles are very dangerous vehicles, both to their riders and to other road users. The more powerful ones are almost as noisy, even under test conditions, as the heaviest lorries. Motorcyclists are more likely to exceed the speed limit by a very large amount than any other road users. There is no need for very fast, powerful machines, and a study is required to determine what limits should be placed on the size and power of motorcycles. In the meantime, the Dutch suggestion of fitting them with top speed limiters should be adopted.

Motor manufacture is an international business, so international cooperation is required to exploit the potential of vehicle regulation as a policy instrument. Although the calculations in this report are based on British data, the conclusions should apply, broadly at least, to other developed countries with high levels of car ownership. Countries where the vehicle population is still low have much more still to gain from tough regulations. They might find a policy of restricting car ownership to local runabouts well worth considering. *(Chapter 11 and Appendix M)*

Politics and public opinion

The division of responsibilities between the European Union and member countries is such that once the European Union has legislated on a certain topic, member countries lose the power to do so. At present, speed limits are still the responsibility of the member countries, but the power to set Construction and Use regulations has passed to the European Union. Since the best way to enforce speed limits is through vehicle design, there would be some advantage in having a European speed limit, even if, for political reasons, it would have to be higher than an objective appraisal would suggest, provided that member countries could continue to set their own lower limits. This could be achieved by derogations, but it would be better to revise the system. In the United States, both the Federal government and the individual states can legislate in the same field: a state's regulations can be more stringent, but not less, than the Federal government's. That arrangement would be better for Europe as well. At present, those countries which wish to progress faster than the rest are frustrated, and other countries are deprived of the opportunity of learning from the experience of the avant-garde.

However strong the objective arguments for lower and better enforced speed limits, they could not be introduced, in a democratic society, if the majority did not accept them. Opinion surveys suggest that stricter enforcement of speed limits would be welcome; that a 20 mph limit in towns might be easy to sell; that there is some feeling which could be built on in favour of lower limits on main roads other than motorways outside towns; that there is, however, a large opposition to the idea of reducing the present 70 mph limit on motorways.

Given that no attempt has been made to explain the advantages of lower speed limits on main roads outside towns, and that until quite recently both the motoring organisations and the police were in favour of raising the motorway limit, these results are not surprising or discouraging. The Government has a substantial educational task on its hands, but the success of the Department of Transport's campaign to increase awareness of the relationship between a vehicle's speed and the probability that a child hit by the vehicle will be killed, shows that people will respond to well presented information. As well as publicising the facts that have already been established about the benefits of lower speeds, the Government should undertake large-scale trials of enforcing lower speed limits. For the most part, the lower limits will have to be enforced by an enhanced police presence and the greater use of conventional aids such as speed cameras, but trials with speed limiters are also required. Northern Ireland seems to be the most promising area within the United Kingdom for trying out speed limiters.
(Chapter 12)

2.2 Main recommendations

1. The Government should announce that it accepts the two principal conclusions of this study:

   (i) Speed limits on roads of all classes should be reduced. *(Chapters 9 and 10)*

   (ii) The principal means of enforcement should be through the vehicle. Motorway speed limits should be enforced by prohibiting the use on the public highway of vehicles capable of exceeding the motorway speed limit by more than a small amount. Lower speed limits should be enforced by variable speed limiters. *(Chapter 11)*

2. A research programme should be undertaken to determine the precise speed limits for roads of each class. The research would be of two kinds. In part, it would consist of theoretical calculations of the kind undertaken in this study, but based on more refined data and more sophisticated traffic models. This theoretical work would be supplemented by trials. *(Sections 9.6 and 10.4)*

3. On non-built-up roads, the speed limits to be considered would range for motorways from the existing 70 mph to 45 mph; for dual carriageway 'A' roads from the existing 70 mph to 40 mph; and for single carriageway 'A' roads from the existing 60 mph to 35 mph. *(Section 9.6)*

4. The Department of Transport should open discussions with the Home Office and the police to see whether resources can be made available for the better enforcement of speed limits on non-built-up single carriageway roads. If they can be made available, the speed limit on these roads, other than those selected for the trials, should immediately be reduced to 50 mph as an interim measure. *(Section 9.7)*

5. In towns, the principal speed limit to be tested would be 20 mph, but in some towns, such as university towns or holiday resorts, a 15 mph limit should be tried out. The research should also examine lower speed limits on those urban roads now subject to a limit of over 40 mph. *(Section 10.4)*

6. The rule that once the European Union has legislated in a certain field member countries can no longer do so should be changed. At

least as far as speed limits and vehicle regulation are concerned, member countries should be given the right to set more stringent regulations than those set by the European Union. *(Section 12.1)*

7. European and/or national regulations should ensure that in future both the top speed and the acceleration of vehicles are limited, and that speed limiters are fitted to all new vehicles, with the possible exceptions of a new legal category of car and a new legal category of lorry, both designed for local use. In addition, limits on weight, fuel consumption and the emissions of noise and fumes should be set for categories of vehicle defined in terms of their carrying capacity. *(Sections 11.6 and 11.7)*

8. Although most of the trials of lower speed limits would rely for enforcement on an enhanced police presence, some should be carried out by retrofitting vehicles with variable speed limiters. The feasibility and cost of carrying out the trials with variable speed limiters in Northern Ireland should be examined. *(Section 12.2)*

9. A programme to retrofit all existing cars with variable speed limiters should be worked out and costed. *(Section 11.5)*

10. A study should be undertaken to determine how best to limit the power of motorcycles so as to reduce the danger posed both to the motorcyclists themselves and to other road users. In the meantime, all new motorcycles should be fitted with top-speed limiters. *(Section 11.9)*

11. While it still lacks the powers to set its own Construction and Use regulations, the Government should use taxation as a means of encouraging the acquisition and use of vehicles slower and otherwise more environmentally friendly than those permitted by existing regulations. Tax concessions on company cars should normally only be available for cars meeting these higher standards. *(Section 11.6)*

12. The Government should set a limit to the mileage allowances which employers give their employees for using their private cars on business. The rates should be worked out by reference to what it would cost to run a slow and otherwise economical and environmentally friendly car. *(Section 11.6)*

13. The Government should recognise a new legal category of car, the local runabout. In addition to its low top speed, to qualify as a runabout the car would have to meet other stringent criteria relating to the environment and to pedestrian safety. Runabouts would not be permitted on motorways. Taxes on the runabout would be lower and the driving licence requirements less stringent than for ordinary cars. *(Section 11.7)*

14. The largest and most intrusive lorries should be confined to a limited network of motorways and some selected 'A' roads. Normally, only lorries meeting exceptionally stringent criteria should be allowed on roads not forming part of this network. Among these 'green' lorries there would be some which were designed only for urban distribution and which would therefore have low maximum speeds. Subject perhaps to the introduction of a simple road pricing scheme for lorries, 'green' lorries of either type should be accorded certain priorities in urban traffic both when on the move and in parking. *(Section 11.8)*

15. The work now in hand to use information from hospitals to supplement the police records on which the official road casualty figures are based should be put on a permanent basis. In addition, both surveys among GPs and household surveys should be carried out regularly in order to estimate the number of casualties not appearing in either police or hospital records. *(Appendix B)*

16. Surveys should be undertaken to estimate the money values to be attached to casualties if they were assessed not, as at present, on a willingness-to-pay basis but on a compensation basis. In the meantime, the Department of Transport should raise the values it uses for the cost of road casualties in order to bring them more in line with the results of the existing studies of willingness-to-pay values. *(Section 4.2)*

17. Studies should also be undertaken to evaluate the costs not now allowed for in the Department of Transport's estimates. For both injury accidents and damage-only accidents, more information should be collected on the disruption caused by accidents and the time required to sort things out when one occurs. For injury accidents, the studies should also examine the psychological effects on people other than the victims themselves. *(Section 4.2)*

18. Further work, using revised methods, should be undertaken to assign money values to noise nuisance. *(Section 6.4)*

19. The work now in hand to estimate the numbers of people now subject to traffic noise of varying degrees, and to assess how those numbers would change if traffic speeds fell, should continue, if necessary with more resources. *(Section 6.4)*

20. Psychological studies should be undertaken to throw light on people's reasons for driving fast other than saving time and on the stress associated with driving at high speeds. *(Sections 3.4 and 9.6)*

21. A campaign should be undertaken to inform the public about the connections between speed and all the harmful effects of traffic. This campaign should be accompanied by surveys to monitor the public's understanding of these points and its attitudes to lower speed limits. *(Section 12.2)*

3

Striking a balance

3.1 The need for a common currency

Changes to the present speed limits would have many diverse effects, some good and some bad, falling on quite different people. These effects can be described and many of them can be quantified, broadly at least, in some appropriate unit. Thus it is possible to make some predictions as to what the effect of lower speeds would be on the number and severity of road accidents, on noise levels near the roads concerned, on the amounts of different pollutants emitted into the air, on the time it would take to make certain journeys. Subsequent chapters in this report set out the relationships between speed and some of these effects. But when all the effects have been described and, where appropriate, quantified in their own terms, there is still a problem about how to weigh up the advantages and disadvantages in order to decide what limits to set.

When people have to make choices involving conflicting considerations in their everyday lives, they reflect on them and come to a decision based on judgement. For example, on a long car journey, a driver may have to decide whether to take a fast motorway route or another which runs through more attractive scenery and on which the driving is less stressful. Often politicians, or other people active in public life, are faced with decisions involving a choice between different groups of people and have to judge whose interests should prevail. School governors, for example, might have to choose between paying for extra staff to help certain pupils with learning difficulties or improving the playground for the benefit of all the children. But there are limits to what can be decided in this way. Sometimes the decision has so many effects, of so disparate a kind, and of a kind so far removed from everyday experience, that judgement becomes humanly impossible. In such circumstances, the only feasible method of weighing the various considerations against each other is to express them in some common unit and then to add up the positives and negatives. It is not possible in practice, and perhaps sometimes not in principle either, to treat all the considerations of a complex decision in this way. But if as many of the considerations as possible are quantified in a common unit, the role of judgement, though not eliminated, is reduced to something manageable and feasible.

Money is the most frequently used common measure and it has many advantages. Resources are already naturally expressed in terms of money, and most public decisions have resource implications. Also, people are well used to making choices, even those involving intangibles, in terms of money. Someone buying a vacuum cleaner may have to decide whether to spend an extra £20 for a quieter model; someone buying a car may have to decide whether to spend an extra £500 for a more comfortable one.

In this report we use evidence from various sources to assess the importance of different speed-related aspects of the transport problem. Not all the evidence is expressed in terms of money; some of it comes from social surveys in which people express their opinions and priorities in other ways. But sometimes the values are expressed in terms of money, and in Chapter 9, where we attempt to calculate the optimal speed limits for different classes of road in non-built-up areas, we use money values to 'trade off' the conflicting considerations against each other. Some brief discussion is therefore required about the validity of this approach.

3.2 Some points of principle

The first point can be put as two linked questions. Who is to decide what money values are appropriate, and how exactly should a question such as 'what is the money value of a quiet environment?' be interpreted? The answer given by conventional cost-benefit theory to the first question is that the relevant values are those of the people affected, and to the second that the precise meaning of the question depends on whether the course of action being evaluated would bring gains or losses. Gains, such as a reduction in noise or danger, should be evaluated by what the beneficiaries would be willing to pay to achieve them. The value of a loss or penalty, such as the destruction of an open space, if a new road were to be built, or the extra time required to drive to work, if a lower speed limit were imposed, is given by what it would be

necessary to pay those affected – the people who use the open space, the commuters whose journey times would increase – by way of compensation. The amount of compensation should be what is required to make the people who would have to suffer the loss as well off afterwards, in their own estimation, as they would be if it did not occur. For example, someone whose view over open space had been spoiled might think himself compensated if he were to be given enough money to improve his back garden and to take a foreign holiday once a year.

This theory is hard to reconcile with the principles of representative democracy. It seems to suggest that governments have no need to formulate their own principles and priorities; their role is reduced to that of a glorified market research agency. The important distinction between human needs and desires is blurred, but most people would think that to ensure that everyone's basic needs are met should take priority over satisfying the desires of people who are already well off. The power of rich people relative to that of poor people seems to be increased, since the principle of allocating resources and other good things on the basis of purchasing power is extended from those areas of life traditionally left to the market into other areas, such as environmental protection, where other principles have held sway. Sometimes the whole approach seems not only inappropriate but impossible to apply. If actions we take now have consequences for future generations, how are the wishes of those people to be ascertained?

These objections show that there are important limitations to conventional cost-benefit theory. It cannot deal with moral questions and it can never be a substitute for politics. But not all decisions that governments have to take raise difficult questions of moral or political principle, and cost-benefit analysis may still have a part to play even in those that do. A great advantage of the cost-benefit approach is that it obliges decision-makers to investigate the values and priorities of those affected by their decisions. In the absence of such an obligation, the decision-maker may simply impose his own views, so that considerations important to the people affected may not be given their due weight or may even be disregarded. There is also a danger that the vested interests of the decision-maker will influence his decision.

Many people have been put off the whole idea of cost-benefit analysis because they associate it with the COBA procedure used by the Department of Transport to evaluate its road schemes. But COBA does not represent good practice. It only looks at one way of tackling transport problems, namely road building, even in situations where there are good reasons to think that other approaches would be more promising. It takes no account of considerations which people are known to value highly, such as noise, stress, and the distortion of travel patterns caused by unsafe roads. It also rests on unsound methods of prediction, so that the potential benefits of road building which it does attempt to evaluate – savings in travel time, accidents and vehicle operating costs – are often very much exaggerated.

We believe that it is always desirable for decision-makers to study the wishes and preferences of the people for whom they are planning. It may also often be appropriate to express these wishes and preferences in terms of money and to base a decision on a simple summation as conventional cost-benefit theory suggests. But governments must always be on the lookout for occasions when this procedure may not be satisfactory. If in some particular case it would lead to the neglect of some people's basic needs for the sake of benefits of a less fundamental nature for other people, or inequities of other kinds, then governments can and should override the findings of the cost-benefit analysis.

The principle that benefits should be evaluated by reference to what people would be prepared to pay to achieve them (willingness to pay), and disbenefits by reference to what it would be necessary to pay the losers by way of compensation (willingness to accept), usually makes good sense. Disbenefits are the disadvantageous side effects of a proposal intended to bring worthwhile benefits to the wider community, and it is only fair that people who are forced to suffer such side effects for the general good should be properly compensated. If benefits were valued at less than people were prepared to pay for them, there would be a risk that desirable things would not be done. If they were valued at more, there would be a risk of allocating more resources to achieve some result than it was worth, to the neglect of more important opportunities elsewhere in the economy. Nevertheless, there are grounds for questioning whether the gains from lower speeds should be evaluated by reference to the willingness-to-pay principle.

Among the principal benefits of lower speeds would be a safer and quieter environment. Some people would argue that the cost-benefit approach simply cannot be applied to such considerations. Instead, they would prefer to tackle them by setting standards. On this view, the only relevance of cost is in choosing between different ways of meeting the standards. But even from the viewpoint of the cost-benefit economist, the willingness-to-pay principle may be thought unsuitable because it

does not take account of the historical process which has led to the present state of the environment. The growth in the volume and speed of traffic has led to a steady erosion in environmental quality and standards of safety. Individual citizens have been powerless to prevent this, however much they may have resented it, and the state has neither protected them nor compensated them. If they were not compensated when these things were taken away from them, it does not seem right that they should be asked to pay to get them back.

What approach to adopt also partly depends on what the existing conditions are. It could be argued that standards of safety on motorways are already very high, so that further improvements should indeed be sought only to the extent that people would be willing to pay for them, whereas in some residential neighbourhoods standards are so far below what a civilised community should accept that the willingness-to-pay principle becomes quite inappropriate. The extent to which an activity is undertaken voluntarily is also relevant. People can usually choose whether or not to drive on a motorway, but they have to go out in their own neighbourhoods. Yet another consideration is the degree of responsibility that society has towards different members of the community. Children cannot be expected to be as careful as adults, so more attention, and if necessary more resources, should be given to creating a safer environment for them. All this suggests that it might be correct to have different values to represent the importance of improving safety in different contexts, and in particular that values suitable for motorways might be too low for ordinary streets.

Some economists argue that the distinction between the willingness-to-pay and the willingness-to-accept principles is not very important in practice because they both give much the same numerical result. This may be true in some contexts, but certainly not in all. What people can pay is limited by their income. Poor people may simply be unable to pay very much to improve the quality of their environment, however much they resent its condition. But what people would be prepared to accept is not limited by their income, and some people would regard even large sums as insufficient compensation for a deteriorating environment and increased danger for themselves and their families.

As will be seen in Chapter 4, the Department of Transport's surveys to establish money values for road accidents are based on the willingness-to-pay principle. For the reasons just given, we believe that this principle is often inappropriate and that values based on it are likely to be too low. Since the values we have used to calculate optimal speed limits in Chapter 9 are also derived from the Department of Transport's surveys, they are also likely to be too low, and by using them we may have understated the case for lower speed limits.

Problems arise when some of the considerations relevant to a particular decision are expressed in terms of money while others are not. If, as often happens, those that are not tend to be neglected, the result is likely to be biased. The calculations in Chapter 9 take account only of those effects to which the Department of Transport now assigns money values. The effects omitted from the calculations are all ones which, if they could be included, would strengthen the case for lower speeds. The results must therefore be interpreted as upper bounds – the true optimal speed limits cannot be higher than these but could well be lower.

3.3 The evaluation of time savings or losses

Putting money values on travel time is less contentious in principle than putting them on accidents or the quality of the environment. But the practical problems of deciding what time spent travelling is worth are every bit as slippery.

Time spent travelling on business is usually evaluated by what it costs the employer in wages and national insurance to employ someone. This is a reasonable starting point; if anything, it might be argued that it is biased on the low side, since employers presumably make a profit on their employees' time. However, the extent to which a gain or loss of time on any particular journey makes a difference to a worker's output is extremely doubtful. Also, wage rates vary hugely, and the assumption that the time gained or lost by the people affected by a particular road-building scheme, traffic-calming measure or whatever, can be evaluated by reference to some national average, is a large one.

The values that the Department of Transport recommends for time spent in car travel rest on survey findings that 14 per cent of it is on business. Other car travel is valued less highly and the values are established in a different way, by inferences from situations where travellers can choose between a relatively slow and cheap means of transport and a quicker more expensive one. The example given in the COBA manual is the choice between a route which involves a tolled river crossing and one which does not.

It is very hard both to make such inferences and to know to what other situations the inferred values could apply. One obvious difficulty is that the options between which people have to choose rarely differ only in the two respects of time and money. The slower route may be the more scenic one; the tolled route may be easier for map reading. But it may be hard even to identify these other factors, still more to know how people value them. Another difficulty is that the value a traveller places on an amount of time spent travelling depends on how else he might be spending that time and on the value he places on that alternative use. People vary widely in these respects. One family starting off on holiday might regard the car journey as part of the fun, while another simply wants to get to the destination as soon as possible. The same person may put very different values on different occasions on the time spent travelling on the same journey purpose. A man driving home from work may be much more relaxed about getting there if, when he arrives, he has to help with the household chores than if he is getting ready to go out to the theatre. Such variations are completely rational, but it is difficult for the analyst to take them into account or even to know about them.

It is also quite unlikely that the rate per minute will be the same for a long and for a short journey. For example, many people positively value a short journey to work because they do not want to lead their working lives and their social lives in the same setting, or because the journey provides a useful time for gathering their thoughts. Or, even if they do not positively value commuting time, they may not place as much importance on five minutes when it is the difference between a ten-minute and a fifteen-minute journey as when it is the difference between a fifteen- and a twenty-minute one.

This leads on to the contentious question of the value to be attached to very small gains or losses in travel time. In a road-building context, the time benefits can often be the sum of a large number of individually very small time savings, each one perhaps a matter of a only a few seconds. The validity of this has been widely questioned. Moreover, even if very small time savings can be given the values that have been assigned to them, it is unlikely that the analyst can predict with the necessary accuracy what the time savings will actually be. The difficulties are particularly acute for road schemes, the predictions for which may have to span a period of 30 years, but predictions of the changes in travel time that would follow from changes to the speed limit, or their better enforcement, can obviously not be accurate to within a few seconds.

3.4 Speeding for reasons other than to save time

It would be naive to think that the only motive for fast driving is to save time. Sometimes people drive fast for excitement, as an outlet for aggression or frustration or as a demonstration of status. This is a clear case where society does not have to put the same value on an activity as the participants themselves put on it. At the same time, if it is quite legitimate for society to say to young men on motorcycles or to drivers of sports cars that the public highway is not the place where they should seek their thrills, there is a danger that these feelings may find an outlet in some other equally anti-social behaviour. We have not pursued the point in this study, but it is possible that a policy on speed on the roads could be incomplete or counter-productive without investment in sporting or other recreational facilities.

Another reason for fast driving can be that people feel under pressure from other drivers to maintain a certain speed even when that means driving faster than they would wish and, very often, faster than the speed limit. To reduce such pressures would clearly be beneficial.

3.5 Conclusion

People can and do put money values on intangibles such as the quality of their surroundings. We approve of the attempt to find out what their values are and we think that it is often appropriate for public authorities to base their own decisions on them. However, although cost-benefit techniques can be a valuable aid to decision-making, they are not comprehensive and cannot eliminate the need for political judgement. We believe that the cost-benefit analyses of alternative speed limits in this report are a substantial help in determining what the speed limits should be. However, the decisions must also take account of the other considerations set out in this report but not included in the formal calculations.

4

Safety

4.1 Speed and accidents

The part played by speed in accident causation has been a matter of dispute since the early days of motoring. In the early 1980s, there was a tendency to underestimate the importance of speed. In 1983, the AA and the RAC, in joint evidence to the House of Commons Transport Committee, suggested raising the motorway limit on the grounds that the existing limit 'serves no real purpose'.[1] In its evidence to the same committee in the following year, the Association of Chief Police Officers called for a revision of speed limits, which were described as being 'in a mess', and urged that raising the motorway limit to 80 mph should be considered on grounds of realism.[2] A report by the Transport Research Laboratory (TRL) published in 1980 concluded that by the more appropriate use of speed limits, it would be possible to save five per cent of road accidents in Britain, although one reason why this figure was so low was that it was assumed that there would be a substantial degree of non-compliance with any new speed limit.[3]

Much of the Department of Transport's concern with speed limits at that time was directed to raising the speed limit in built-up areas from 30 mph to 40 mph on stretches of road where the 30 mph limit was poorly observed.[4] It was claimed that this would reduce accidents on those particular roads; also that retaining speed limits regarded by motorists as unrealistic had the effect of weakening respect for speed limits generally. A report of the Department's Road Safety Division issued in 1974 did not include lowering speeds as one of the seven basic options in its accident reduction strategy.[5]

Concern about these attitudes led to particular prominence being given to speed in PSI's report *Danger on the Road: the Needless Scourge*, published in 1984.[6] Chapter 3 contained a review of 30 studies from various countries where the introduction of speed limits on previously unrestricted roads, or the lowering of speed limits on roads already restricted, had been accompanied by statistical studies of the effect on accidents. The review showed very strong connections between speed and accidents. The Department of Transport's conversion to the view that speed is a very important factor in causing accidents is apparent from its road safety campaigns, which have concentrated on speed for some years now, especially with respect to the safety of children. Another important indication of the Department's changed view was its publication in November 1992 of the document *Killing speed and saving lives*. This drew on a review of international experience by the TRL which again demonstrated the prominent part played by speed in causing accidents. The review was published in 1994 with the title *Speed, speed limits and accidents*.[7]

Some of the most important evidence for the effect of speed on accidents on main roads outside towns comes from the lower speed limits imposed by many countries following the 1973 oil crisis. The experience of the United States is especially noteworthy. A 55 mph speed limit was introduced to save fuel but was kept because it saved lives. The Secretary of Transportation in a report to the President in 1977 described the 55 mph limit as 'perhaps the most important safety measure in modern times'.[8] In a study published in 1975, it was claimed that the 55 mph speed limit had reduced the injury rate by 28 per cent and the fatality rate by 50 per cent on interstate highways, and the injury rate by 34 per cent and the fatality rate by 70 per cent on other four-lane rural highways.[9]

In Britain, a 50 mph limit was imposed on 8 December 1973, but the 70 mph limit on motorways was restored on 29 March 1974 and normal limits on other roads on 8 May. The effect of the lower speed limits on accident rates was calculated in a TRL report published in 1976.[10] The rates that would have prevailed if the lower limits had not been imposed were predicted by a method which took account of the long-term downwards trend in accident rates, seasonal variations, traffic volumes, the incidence of two-wheeled vehicles, and the weather. These predicted rates were then compared with the observed ones. For motorways, over the four months December 1973 to March 1974, the daytime accident rates were 58 per cent and the night-time rates 86 per cent of the predicted ones. The lowest ratio was for the daytime accident rate in February when the observed rate was just under half the predicted rate. On non-motorway roads with normal speed limits of 50 mph to 70 mph, the observed daytime rates in the five months

December to April were 83 per cent and the night-time rates 79 per cent of those predicted.

The interpretation of these results is made difficult by the fact that very few data on speeds were collected while the lower speed limits were in force. The only work that was undertaken was on one section of the M3 motorway and one of the M4. This work was based on the moving observer method, with a test car being driven sometimes at 45 mph and sometimes at 50 mph. Nearly all the cars were moving faster than the test car, which limited the analysis that could be undertaken, but the average speed of vehicles on these two sections of motorway was estimated. In December 1973 the average was 52.5 mph, in January it rose to 55.5 mph and in February to 58 mph before falling slightly in March to 57.5 mph.[11]

In *Killing speed and saving lives*, the Department of Transport claims that the TRL's review of international experience suggests that a reduction in average speed of the order of 1 km/h could save 5 per cent of all injury accidents and 7 per cent of fatal accidents.[12] But it is now accepted that this is an optimistic interpretation of the evidence and that it would be safer to say that a reduction in average speed of 1 mph would be required to achieve these savings.[13] Although this relationship should apply to different classes of road with different initial speeds, it would, of course, only apply to the first few reductions in mph; otherwise, a reduction in average speeds of 20 mph would eliminate road accidents altogether.

Some studies have suggested that accidents are related to the variability in vehicle speeds as well as to the average speed and this is confirmed by recent work at the TRL.[14,15]

In Appendix F we have made some estimates of what accident reductions might follow from better enforced and lower speed limits on motorways and on non-urban 'A' roads. The estimates for the lower speed limits are inevitably less reliable than those for the higher ones, and trials are needed to confirm them, but, for the reasons given in the appendix, we believe that they are more likely to be underestimates than overestimates.

The most important British source of information on the effect of low urban speed limits on accidents is the experience of the 20 mph zones which have been introduced since 1991. A paper by three TRL researchers published in 1993 reviewed the results of the 23 zones which had been in existence long enough to provide enough accident data to analyse.[16] Overall, it was found that the annual frequency of accidents was reduced by 70 per cent and for accidents to child pedestrians and cyclists it was down by 80 per cent. It seems, however, that there has been some falling off from these initial reductions. Over a longer period, the reduction for all accidents in these zones was 56 per cent and for child pedestrians and cyclists some 60 to 64 per cent, although schemes started more recently have shown initial reductions more comparable with the earlier results.[17]

Reductions in accidents of 72 per cent and of serious injuries of 78 per cent have been reported from traffic calming schemes in Denmark. The Danish report says that trials in Germany and France have also shown very large reductions in accidents. In Denmark, there were also substantial reductions in accidents on the traffic-bearing roads which were not redesigned, so it does not seem that the reduction on the traffic-calmed streets was simply due to traffic and accidents being relocated. There was also an increase in the number of people using the roads and the number of pedestrians and cyclists crossing them, which shows that the accident reductions were not due simply to a decrease in exposure.[18]

In the Netherlands, reductions in casualties and casualty rates of at least 74 per cent, relative to the control areas, were achieved on residential streets in demonstration projects in Rijswijk and Eindhoven conducted between 1976 and 1986. These projects involved the redirection of through traffic from residential streets and also, in some cases, reducing the speed of the remaining traffic either by ramps or by other means. The greatest fall in the number of accidents, of 90 per cent, was experienced in those residential streets where the exclusion of the through traffic was combined with ramps (rather than with more elaborate measures) to slow down the traffic. The streets within the demonstration areas which retained their traffic-carrying function also experienced smaller but substantial reductions in casualties (13 per cent), and in casualty and accident rates (20 per cent and 16 per cent respectively), relative to the control areas.[19]

Thirty km/h zones introduced more recently in the Netherlands have produced significant, though smaller, decreases in accidents. A study of 151 such zones showed a decrease in injury accidents, relative to the control areas, of 22 per cent. There were considerable variations between the zones, which the Dutch road safety research institute suggests were probably due to differences in the magnitude of the safety problem before the introduction of the speed-reducing measures and to differences in the quality of the measures themselves.[20]

Although the reason why the initial reduction of 70 per cent in 20 mph zones in Britain has not been maintained is unclear, a plausible explanation is that drivers have learned to drive along roads which have been traffic-calmed by speed-control humps, or by other changes to the road's surface or geometry, without reducing their speeds as much as they had to at first. We believe that the best way to enforce speed limits is through the vehicle rather than through road engineering measures. This would both avoid the problem that some people might be prepared to drive over humps or round corners faster than the highway engineers intend, and also eliminate the possibility of speeding up between the speed-reducing measures. The variation between the speeds of different vehicles as well as the average speed should therefore be much lower than with highway engineering measures. It is also likely that drivers' psychology would be more favourable. It seems plausible to suppose that the discrepancy between what the vehicle is capable of, and what the conditions on a particular stretch of road allow, breeds frustration and a desire to exceed the limits if possible; such feelings should not arise, or only in a much less marked way, if the vehicle's own speed were limited. If this reasoning is correct, then the British and European experience suggests that the introduction of 20 mph zones with speeds enforced through the vehicle should give rise to lasting reductions in accident rates of 70 per cent or more.

4.2 The monetary evaluation of road accidents

In cost-benefit terms, the cost of a road accident is the amount of money that it would be worth spending to prevent it. For an injury accident this cost has two elements. The more important, and also the harder to evaluate, is the cost of the casualties involved. Non-casualty costs are taken to comprise damage to vehicles and other property, costs arising from the loss of use of the damaged vehicle, insurance administration and policing.

The Department of Transport's method of evaluating a fatal casualty is based on estimates of what people would be prepared to pay for a given reduction in the risk of being killed on the road. For example, if people were prepared to pay £4 to reduce the probability of dying in a road accident by 1/50,000, then the value to be attached to a 'statistical life', in other words the amount of money worth spending on a safety measure expected to save one life, would be £200,000.

Social surveys have been designed to ascertain what values people do in fact place on reducing the risk of being killed in a road accident. For example, in one survey respondents were asked how much they would be willing to pay, when buying a new car, for an additional safety feature that would reduce driver and passenger risks by various specified amounts. Other questions related to willingness to pay for coach safety on a foreign holiday and for local road safety.[21] These surveys have given rise to a range of estimates of the cost of a statistical life in the context of road safety. The figure of £744,060, in 1993 prices, selected by the Department of Transport,[22] lies towards the bottom of the range.

Other social surveys have sought to find out what people would be willing to pay to reduce the risk of suffering injuries of various severities in a road accident. The Department of Transport has drawn on this work to set the cost of a serious injury at £84,260 and of a slight injury at £6,540, both in 1993 prices.[23] These costs, however comprise both the 'human' costs, as ascertained by the social surveys, and estimates of medical costs and the value of lost production.[24]

There are various reasons for thinking that the Department of Transport's values are too low. The first is the point, discussed in Chapter 3, that it is far from clear that the values to be attached to road safety should be based on the willingness-to-pay criterion. This criterion is especially questionable when the risks people face result not from their own choices – for example, taking up a dangerous hobby such as mountaineering, or choosing a job or life style which involves a lot of motoring – but by dangerous behaviour on the part of other people – for example, when drivers speed down a residential street.

Even if the willingness-to-pay criterion is accepted, the Department of Transport's decision to select a figure for a fatal casualty towards the bottom end of the range suggested by the social survey evidence seems to have been more political than technical. The methods used to evaluate road safety before the present ones were adopted in 1988 were very crude. Lost production and consumption were estimated by reference to the number of years of life lost, in the case of a fatality, or the time spent incapacitated, in the case of an injury. Medical and other costs were estimated and then an arbitrary allowance was made for 'pain, grief and suffering'. Apparently, the Department was embarrassed by the fact that the new method produced very much higher values than the old one and selected a low figure in order to reduce the discrepancy. As two researchers closely concerned with the development of the new

method have diplomatically put it, the Department's decision 'almost certainly reflected a desire to temper a radical change of methodology with an element of caution in the selection of a particular numerical value'. They suggest also that this caution, if understandable in the late 1980s, is 'no longer necessary or appropriate' in the mid-1990s and that 'there would now seem to be a persuasive case for setting the value of preventing a road fatality at a figure well in excess of £1m and probably nearer to £2m'.[25] These figures are in 1992 prices; the Department's value for a statistical life in 1992 prices was £715,330.[26]

Among the reasons for thinking that the official value for a road fatality is too low is that for rail fatalities BR and London Underground take £2m to be the lowest value for a statistical life to be used in project appraisal. Although there are reasons why the value of a statistical life for a rail passenger really should be higher than that for a road user, if the figure of £2m were adjusted to take those reasons into account, it would be reduced only to £1.325m.[27] If the value placed on a road fatality is too low, then the value placed on an injury sustained in a road accident is also too low, since the method used to estimate the human element of the cost of a road injury relates it to the willingness-to-pay estimate of the cost of a fatality.

In addition to these underestimates, there also seem to be a number of costs not taken into account by the Department's method. One is the position of the friends and relatives of accident victims. Although the Department claims that the values for fatalities encompass the pain and distress felt by relatives,[28] it is not clear that this is always so. The questionnaire does not prompt respondents to pay attention to the implications for those they would leave behind. Some may do so without prompting, but even those people may not have the experience to make a good assessment. People involved in an accident without being victims themselves may also be very distressed, especially if they feel responsible in some degree, but even if they bear, or feel, no responsibility. Even to witness a road accident can be a traumatic experience.

The estimates of the economic costs of casualties do not allow for any surplus which an employed person makes to the economy from his work, over and above the income which pays for his own and his dependants' consumption. Neither is any allowance made for the disruption caused by an accident. For example, even a damage-only accident will require those involved to spend time dealing with garages, insurance companies and so on. If someone is suddenly absent from work because of an injury, the employer has to make emergency arrangements, such as hiring a temporary secretary or a supply teacher, which are unlikely to be fully satisfactory and may also be quite expensive. No allowance is made for the delays caused to other road users when an accident occurs, although as every listener to the traffic news knows, even a minor incident such as a lorry shedding its load can disrupt the traffic.

In Appendix D we have adjusted the Department of Transport's figure for the cost of a fatal accident by doubling the value given to the casualty element. We have also doubled the human cost element of injury accidents. Doubling these elements of cost is probably the least that should be done to correct for the Department's choice of low values from its willingness-to-pay surveys. No other adjustments have been made to take account of the other points discussed above, so the revised figures certainly err on the low side, probably by a substantial amount. It follows that their use in Chapter 9 to calculate optimal speed limits understates the case for lower limits.

4.3 Other consequences of vehicles driven at unsafe speeds

Personal injury and damage to vehicles and property are not the only consequences of unsafe conditions on the roads. The effects can be seen in frustrated journeys (for instance, when children and old people cannot make the journeys they would prefer), forced journeys (for instance, when escorting people is seen to be necessary to ensure their safety, and distortion of choice of mode (for instance, when cycling is considered too dangerous). Other activities, such as street life generally and children's play in particular, are affected by unsafe conditions. Even if the journeys are made or the other activities still take place in spite of the danger, they can be accompanied by anxiety either of the road users themselves or of others on their behalf.

Evidence of the extent to which unsafe road conditions impinge on people's lives in these ways has been apparent for many years. A national travel survey on traffic and the environment carried out in 1972 recorded over two in three respondents stating that they were bothered by the danger to which pedestrians were exposed by motor traffic, including a quarter who were bothered 'quite a lot' or 'very much', and danger was by far the most frequently cited disturbance caused by traffic.[29] Two-thirds of the respondents also said that they had difficulty in crossing roads in their area, over a quarter felt

threatened even when walking on the pavement, and over a half were worried about the safety of other pedestrians, especially children and old people.[30]

Respondents in an OPCS survey in 1980 cited 'speed of traffic' as the principal source of danger to them as pedestrians, with three per cent reporting that they had been knocked down by a vehicle during their adult life, and another 33 per cent recalling a near-accident as a pedestrian.[31] In a MORI poll commissioned by the National Consumer Council in 1986, 'too much traffic / busy roads' was the aspect most frequently cited by respondents as the main problem for pedestrians in their area.[32]

As traffic levels have risen during the last two decades, compliance with speed limits appears to have fallen. The latest national speed survey shows that 69 per cent of cars and 50 per cent of lorries are exceeding the speed limit on 30 mph roads at any given moment.[33] This must make walking more dangerous.

As well as the great increase in traffic, there has been a dramatic change in vehicle performance. Modern cars are capable of higher top speeds and much faster acceleration than their predecessors. A high top speed, which can only be achieved on the open road, is probably less of a danger to other road users than fast acceleration, which matters in all situations and is a particular threat to pedestrians, especially when crossing the road, and to cyclists.

Even excluding journeys made to accompany children to and from school, the latest National Travel Survey report records a 21 per cent increase in the last seven years alone in the number of journeys of one mile or more made to escort people.[34] While part of the increase may be attributable to the higher level of car ownership which enables this 'service' to be provided, it seems likely that some of it is accounted for by the recognition by the 'donors' of the more dangerous environment which then encourages them to act in this way.

Increased danger has had particularly severe consequences for the independent mobility of children. Recent research compared the extent to which children were allowed to get about on their own in 1971 and in 1990 in five sharply contrasting areas, ranging from an inner London suburb to a rural parish in Oxfordshire. It showed that there was far less independent travel and less activity among children in the later year.[35] For instance, in 1971, 80 per cent of the seven and eight year olds went to school unaccompanied but, by 1990, the proportion had fallen to 9 per cent. The reason most frequently cited by parents for restricting their children's freedom was the fear of their child being injured in a road accident.[36]

If children have suffered most from this reduction in their freedom, it has had consequences for other people as well. Parents are obliged to spend time in escorting them, and if the escort trips are made by car, this adds to congestion on the roads. Using the Department of Transport's methods of evaluation, it has been estimated that in 1990 the direct and indirect costs of escorting children were of the order of £10 to £20 billion annually.[37]

It is not only children but all vulnerable road users whose patterns of travel are significantly affected by dangerous conditions on the road. Pedestrians of all ages, in particular the elderly, owing to their declining faculties, are intimidated by traffic. Some of the changes of recent decades in patterns of travel must also be attributed to traffic speed, not least in formerly quiet residential streets.

A review of seven areas where local authorities have attempted to reduce vehicle speed by traffic-calming measures, such as a 20 mph zone limit and road humps, has shown that these have led to an increase in street life.[38] Residents living in the areas were asked about the changes they perceived in the environmental impacts of traffic once the measures were in place. Whilst responses regarding pollution and vehicle noise were mixed, the overwhelming majority agreed that car speeds and accident risk had been reduced, and a smaller majority that the number of both cars and lorries on their local roads had declined. In all the study areas, too, a large majority stated that they felt safer when crossing roads and had a greater sense of freedom as pedestrians. Moreover, in spite of a growing fear of child abduction or molestation (owing to considerable media coverage of a few incidents of this nature in the months preceding the surveys), as well as fear of traffic danger, the proportion of children allowed to play in the street, to travel alone to school, and to go to a local shopping parade alone went up, with those aged 7 to 9 being particular beneficiaries.[39]

The calming measures also reduced the severance effect of road traffic, with drivers deferring to pedestrians especially where road crossings were clearly marked and where a pavement-level causeway was provided rather than simply a device to reduce vehicle speeds. An average of over 70 per cent of respondents in all seven areas considered that the benefits to pedestrians outweighed the disbenefits to car users.

Before-and-after studies in Sheffield of traffic-calming in two small local shopping centres and a residential neighbourhood revealed a

reduction in the mean speed of traffic to 15 mph, a reduction in the volume of traffic to a third of its former level and a dramatic reduction in road casualties.[40] A large majority of people in the area felt that the roads posed less danger, and said that they drove more slowly and were pleased that the changes had been made. As a result of the improvements, between a third and a half of parents said that they are more likely to allow their child to travel unaccompanied to school and to the local shops, and a half said that they would now allow their child to go out to play on the streets.[41]

In an examination of the effect of a range of traffic management measures – rumble strips, road narrowing emphasised by a row of trees, an offset road crossing, zebra crossings and a road closure – aimed at achieving vehicle speed reduction on main roads in Vinderup in Denmark, the total volume of traffic was shown to have been unaffected.[42] However, very high speeds disappeared, intermediate speeds (above 60 kph) were reduced substantially, and traffic speeds overall, especially those of lorries, fell. The average delay for cars was no more than nine seconds. These changes were associated with an increase of 63 per cent in the numbers of pedestrians crossing the road, evidently owing to the reduction of the previous 'fence effect' of the volume of traffic along the roads benefiting from the measures, and with a substantial increase in the number of activities in the town. The vast majority of people felt that the road was much easier to cross and more than half that it was better for pedestrians. Almost all the inhabitants considered that the town had gained aesthetically and a large majority that the town was a better place in which to live.[43]

Other evidence of links between traffic speed and amenity can be inferred from a study of the effects of traffic restraint and traffic calming on retail turnover in some German towns. Traffic was removed altogether from some streets by pedestrianisation and slowed down on the other streets. The study recorded 'worthwhile effects on safety and on the pleasantness of the pedestrian environment', especially where the traffic management measures were carried out comprehensively.[44] Whilst retailers were generally found to be opposed to the measures at first, the turnover of many more of them subsequently increased rather than decreased, no doubt reflecting the level of satisfaction of shoppers with the improved quality of the areas for shopping. Moreover, it was found that retailers hardly ever campaigned for the abandonment of the schemes once they had experienced them.[45]

There is also evidence pointing to traffic speed acting as a deterrent to cycling by making the environment for it less safe. Attitudinal surveys aimed at establishing why people do not cycle have found that the main reason is fear of being hit by a motor vehicle, with the clear implication that it is being driven at a speed which is seen to pose a risk of injury to a cyclist.[46] This is perfectly understandable: of all reported deaths and serious injuries among cyclists, 90 per cent occur as a result of such an incident.[47] The fear also obliges those who nevertheless do cycle to exercise more vigilance than would otherwise be called for and therefore to do so in a less relaxed frame of mind, in turn affecting their enjoyment, if not the extent of their use of this form of travel.

A study in the 1970s, based on an analysis of Census data on the mode of transport used for commuting, showed that in topographically flat urban areas seven times as many people cycled to work where traffic conditions were classified as relatively safe rather than dangerous.[48]

It is not surprising that the incidence of serious injuries falls sharply where people can cycle in safer conditions. Comprehensive studies on a scale large enough to allow for meaningful analysis are rarely possible. However, in the City of Graz in Austria, comparison of the change in the incidence of accidents in the same nine months of the year before and after the introduction of 30 kph speed limits in all residential areas, that is on all roads other than main ones, revealed a reduction of nearly 40 per cent in the number of cyclists seriously injured on the City's roads.[49]

Further support for the view that the attractions of cycling are considerably enhanced by an environment free of the risk of exposure to traffic can be gained from the fact that the proportion of journeys to school by bicycle in this country, where little provision is made for cycling, is one to two per cent whereas in the Netherlands, where considerable investment has been made in creating networks either dedicated to cyclists or along roads shared with traffic subject to low speed limits, the proportion is 60 per cent.[50]

Given the remarkable advantages, in terms of improved health, of cycling on a routine basis to school and work or for leisure,[51] it could be argued that the fear of injury from vehicles being driven at speeds perceived to be dangerous has contributed to the decline in the population's physical fitness revealed in recent surveys.[52]

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5

Fuel consumption and emissions

5.1 Fuel consumption

The amount of petroleum consumed by road transport in the United Kingdom has increased steadily over the years, both absolutely and as a proportion of the total used for all purposes. In 1972, road transport accounted for some 21 million tonnes of petroleum out of a total consumption of 106 million tonnes. By 1994, nearly 36 million tonnes were used in road transport, 44 per cent of a total which, largely because of improved fuel efficiency elsewhere in the economy, had shrunk to 82 million tonnes.[1] If present trends in road traffic and vehicle design continue, so will these trends in fuel consumption. The growth in traffic and the tendency for cars to become heavier will continue to outweigh any improvements in engine efficiency.[2]

In addition to the pollution caused by burning fossil fuels, which is discussed below, these fuels have an ecological importance in their own right as a non-renewable resource. The worldwide proved reserves of oil in 1993 were only enough to supply 43 years of production at the rate experienced in that year.[3] It is true that similar calculations have always turned out to be pessimistic in the past:[4] further discoveries of oil, combined with improved methods of extraction, have meant that estimates of proved reserves have so far risen more rapidly than production and consumption. This may continue for some time, although increasing industrialisation in China, India and a number of smaller countries makes it unwise to count on it. But even if the current figure is very pessimistic, the change from an economy based on oil to one based on other fuels will be difficult, and the interests of future generations require oil to be used prudently so as to allow as much time as possible for the transition.

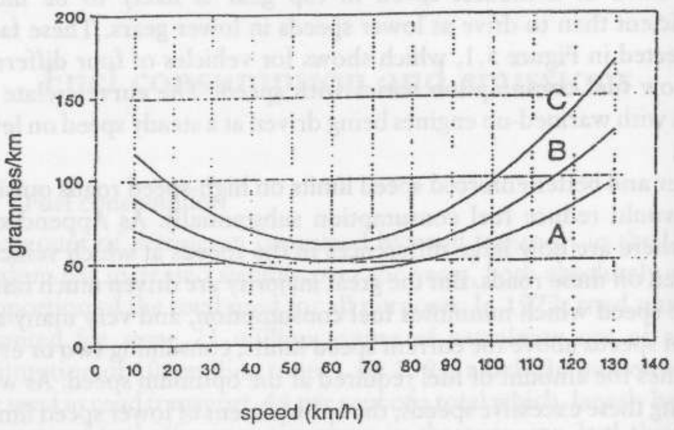
In order to maintain a constant speed a road vehicle has to overcome two forces: the friction between the tyres and the road surface, and air resistance. Friction increases linearly with the vehicle's speed, but air resistance increases with the square of the vehicle's speed. It follows that any increase in a vehicle's speed above that which allows it to be driven comfortably in top gear must also increase fuel consumption. But to drive at a modest speed in top gear is likely to be more fuel-efficient than to drive at lower speeds in lower gears. These facts are reflected in Figure 5.1, which shows for vehicles of four different kinds how fuel consumption varies with speed. The curves relate to vehicles with warmed-up engines being driven at a steady speed on level ground.

Lower and better enforced speed limits on high-speed roads outside towns would reduce fuel consumption substantially. As Appendix E shows, there are now large differences in the speeds at which vehicles are driven on these roads. But the great majority are driven much faster than the speed which minimises fuel consumption, and very many are driven at speeds above the current speed limits, consuming two or even three times the amount of fuel required at the optimum speed. As well as curbing these excessive speeds, the enforcement of lower speed limits would probably also lead to a steadier flow of traffic, with less overtaking and, therefore, less fuel-consuming acceleration. As will be seen in Chapter 8, lower speeds on long journeys would also reduce traffic volumes, which in turn would reduce fuel consumption. All these savings would come about with vehicles of the present type, but much more could be achieved if vehicles were designed for lower speeds. The potential for reducing fuel consumption by reducing vehicle performance is discussed in Chapter 11.

The curves shown in Figure 5.1 are not of much help in assessing what the effect of lower and better enforced speed limits in towns would be. Town driving inevitably requires a considerable amount of stopping and starting, and to maintain steady speeds at anything like the optima shown would be quite impossible. Assuming for the moment that the volume and pattern of motorised traffic were not affected, two opposing effects of lower speeds in towns can be distinguished. To the extent that they led to more driving in low gears, fuel consumption would go up. To the extent that they led to smoother, steadier driving, it would go down. Furthermore, lower speeds, especially if combined with other policies, could lead to some switching from motorised forms of transport to walking and cycling and thus to a saving in fuel. Again, if vehicles were designed with lower speeds in mind, and especially if some of them were designed only for local use and therefore to go no

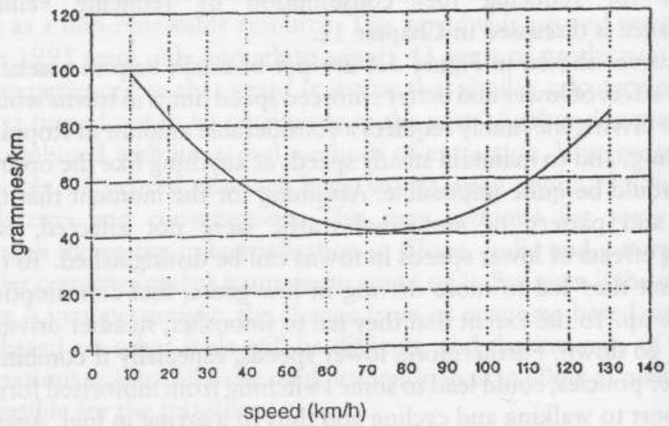
Figure 5.1 Speed and fuel consumption for petrol cars of different engine capacities and for diesel vehicles of under 2.5 tonnes

Petrol cars



A = under 1400cc; B = 1400-2100cc; C = over 2100cc.

Diesel vehicles under 2.5 tonnes



Source: Figures VI 1.1-27 and VI 2-5 of reference 5.

faster, or only a little faster, than the urban speed limit, lower speeds on built-up roads should always lead to a reduction in fuel consumption. The possibilities for introducing a new category of local car and a new category of local goods vehicle are also discussed in Chapter 11.

5.2 Emissions

Road traffic accounts for only a tiny share of emissions of sulphur oxides, which are the major cause of acid rain. Road traffic's shares, as an end user, of the other main pollutants were as follows in the United Kingdom in 1993:[6]

Carbon dioxide	22%
Carbon monoxide	91%
Nitrogen oxides	51%
Volatile organic compounds	45%
Black smoke	52%

Carbon dioxide is the main contributor to global warming. Carbon monoxide is a highly toxic gas, affecting the cardiovascular and central nervous systems; it can also contribute indirectly to global warming. Nitrogen oxides can adversely affect human health and plant growth. They also help to cause acid rain and are a precursor of ozone in the lower atmosphere. Ozone can damage vegetation and human health and is also an important greenhouse gas. Volatile organic compounds, which largely consist of hydrocarbons, can affect health in a variety of ways, and they also contribute directly to the formation of ozone in the lower atmosphere. Black smoke, which is caused by the particulates emitted from the exhausts of diesel engines, is visually unpleasant and causes much of the soiling of buildings in urban areas. Particulates, especially smaller ones, aggravate respiratory diseases, such as asthma and bronchitis, and are probably also carcinogenic.

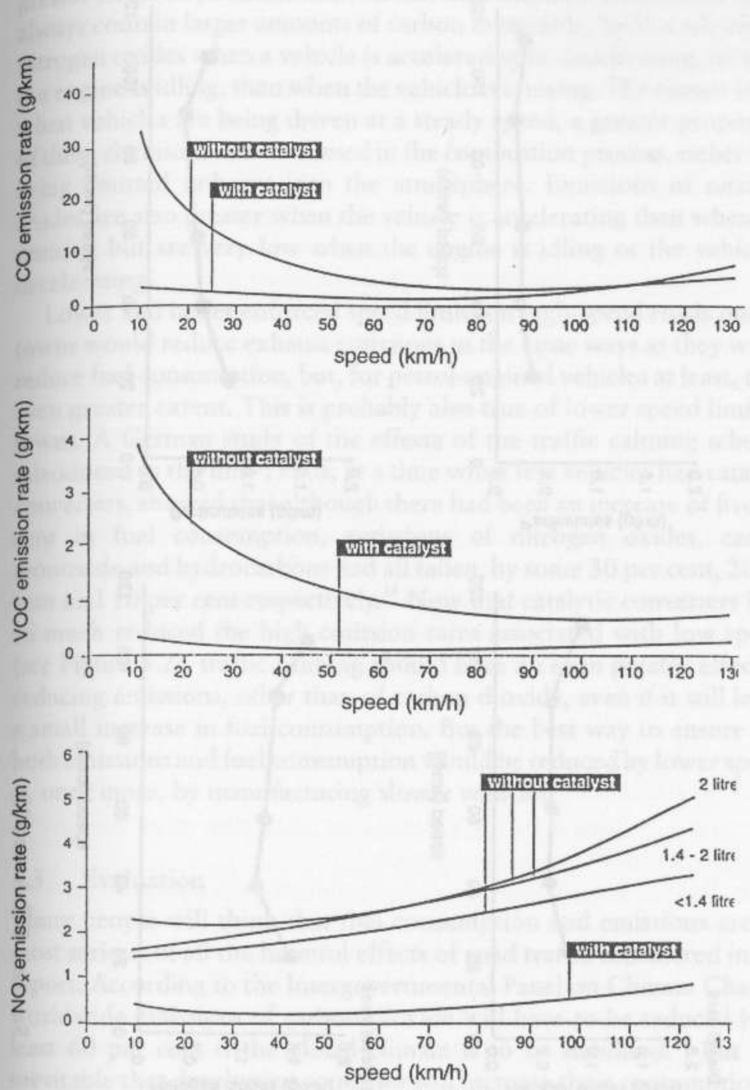
Between 1983 and 1993, the amounts of all these pollutants emitted by road transport went up, although with some decline from the end of the 1980s for carbon monoxide, nitrogen oxide and volatile organic compounds.[7] If present traffic trends continue, emissions of carbon dioxide from road transport will continue to rise in line with fuel consumption, but all other emissions should go down even if traffic growth continues.

The main reason for this is that since 1992, all new petrol-engined vehicles have had to be fitted with catalytic converters. Catalytic converters do not reduce carbon dioxide emissions – in fact, they slightly increase them – but when the engine is warmed up, a catalytic converter can reduce other emissions by up to 80 per cent.[8] However, it takes some four kilometres of driving from a cold start for the engine to warm up fully,[9] during which time the catalytic converter is working less efficiently. Many urban car journeys are under four kilometres in length, although not all of the short journeys will start with a cold engine, and the catalytic converter will also not work to full effect for the first four kilometres of the longer car journeys which start with a cold engine. Thus, the effect of catalytic converters in towns will be significantly less than the test results may suggest.

Simple catalytic converters which reduce emissions of carbon monoxide and hydrocarbons from diesel engines already exist, and manufacturers will have to fit them in order to meet the stringent emission standards for new diesel vehicles which are coming into force in 1996/97. To design a catalytic converter which will also reduce emissions of nitrogen oxides from a diesel engine is more difficult, but it is expected that such converters will be in mass production within about ten years. Cleaner fuel, together with changes in engine design to ensure that more particulates are consumed in combustion, will also reduce emissions of black smoke.[10]

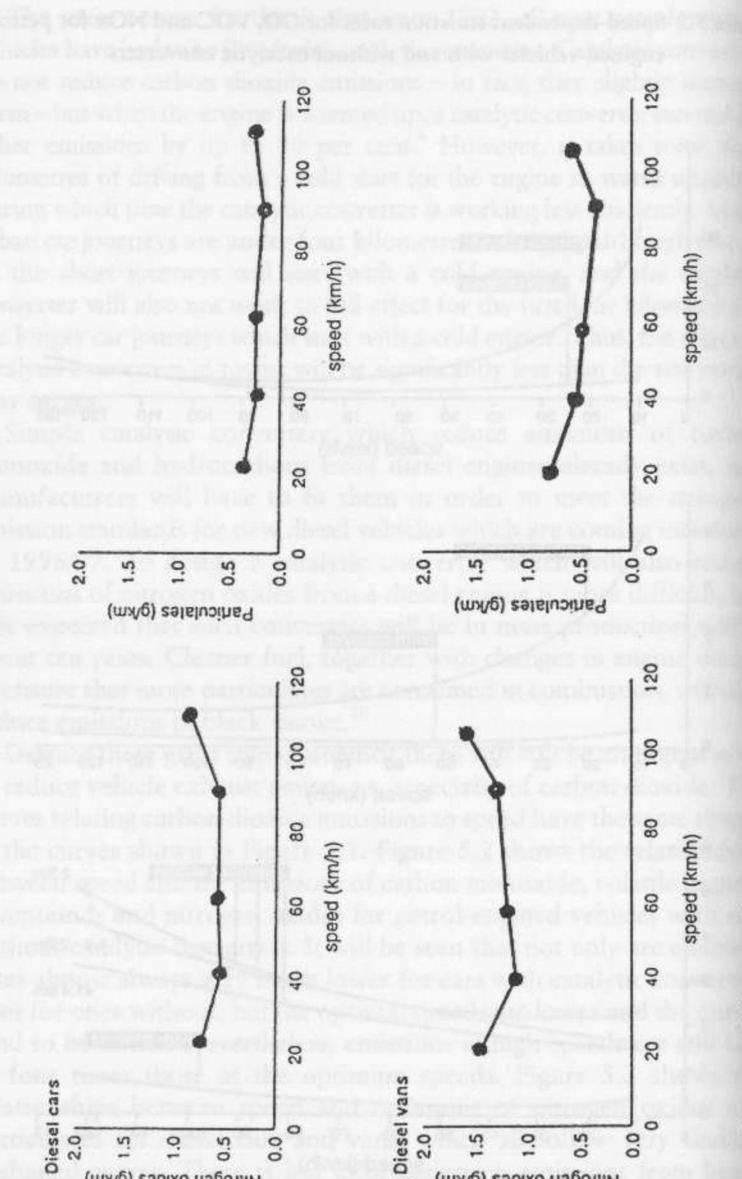
Despite these great improvements, there will still be an urgent need to reduce vehicle exhaust emissions, especially of carbon dioxide. The curves relating carbon dioxide emissions to speed have the same shapes as the curves shown in Figure 5.1. Figure 5.2 shows the relationships between speed and the emissions of carbon monoxide, volatile organic compounds and nitrogen oxides for petrol-engined vehicles with and without catalytic converters. It will be seen that not only are emission rates almost always very much lower for cars with catalytic converters than for ones without, but the optimal speeds are lower and the curves tend to be flatter. Nevertheless, emissions at high speeds are still two to four times those at the optimum speeds. Figure 5.3 shows the relationships between speed and emissions of nitrogen oxides and particulates for diesel cars and vans, which all follow very shallow U-shaped curves. There is less information on emissions from heavy goods vehicles, but a limited study in the Netherlands found that the lowest level of emissions occurred at the lowest speed tested in the study, which was 70 km/h.[12]

Figure 5.2 Speed-dependent emission rates for CO, VOC and NOx for petrol-engined vehicles with and without catalytic converters



Source: Reference 11.

Figure 5.3 Speed emissions curves for diesel cars and vans



Source: Reference 13.

All these curves are based on vehicles driven at steady speeds, but it is important to note that changes in vehicle speeds often have a far greater effect on pollution than on fuel consumption. Exhaust emissions always contain larger amounts of carbon monoxide, hydrocarbons and nitrogen oxides when a vehicle is accelerating or decelerating, or when the engine is idling, than when the vehicle is cruising. The reason is that when vehicles are being driven at a steady speed, a greater proportion of these chemicals are consumed in the combustion process, rather than being emitted unburnt into the atmosphere. Emissions of nitrogen oxides are also greater when the vehicle is accelerating than when it is cruising but are very low when the engine is idling or the vehicle is decelerating.

Lower and better enforced speed limits on high-speed roads outside towns would reduce exhaust emissions in the same ways as they would reduce fuel consumption, but, for petrol-engined vehicles at least, to an even greater extent. This is probably also true of lower speed limits in towns. A German study of the effects of the traffic calming schemes introduced in the mid-1980s, at a time when few vehicles had catalytic converters, showed that although there had been an increase of five per cent in fuel consumption, emissions of nitrogen oxides, carbon monoxide and hydrocarbons had all fallen, by some 30 per cent, 20 per cent and 10 per cent respectively.[14] Now that catalytic converters have so much reduced the high emission rates associated with low speeds (see Figure 5.2), traffic calming should have an even greater effect on reducing emissions, other than of carbon dioxide, even if it still led to a small increase in fuel consumption. But the best way to ensure that both emissions and fuel consumption would be reduced by lower speeds is, once more, by manufacturing slower vehicles.

5.3 Evaluation

Many people will think that fuel consumption and emissions are the most serious of all the harmful effects of road traffic considered in this report. According to the Intergovernmental Panel on Climate Change, worldwide emissions of carbon dioxide will have to be reduced by at least 60 per cent if the global climate is to be stabilised.[15] But it is inevitable that developing countries will increase their consumption of fossil fuels and hence their emissions of carbon dioxide. Developed countries such as the United Kingdom will therefore have to reduce their emissions of carbon dioxide by much more than 60 per cent; in fact, it has been calculated that reductions of over 90 per cent will be required.[16] If emissions were reduced by five per cent a year, it would still take 45 years to achieve a 90 per cent reduction.

In spite of the great importance of these topics, it has not been possible to treat them very fully in the consideration of optimal speed limits in Chapters 9 and 10. Although the formal calculations in Chapter 9 of the speeds that would be optimal on high-speed roads outside towns take account of savings in fuel that would be produced by lower and better enforced speed limits, the evaluation of this effect is very limited. Except at one point where the high taxation on fuel is treated as representing a wider concern for conservation, fuel savings are evaluated in Chapter 9 as if fuel was a renewable resource, and as if burning it had no damaging effect on the environment.

It might have been possible, given more time and resources, to have estimated what reductions in emissions from traffic on high-speed roads might come about if speeds were lowered. Even then, the difficulties of placing a money value on the different types of air pollution, and on global warming in particular, would, in our view, still have precluded the inclusion of these effects in the formal calculations of optimal speed limits. This opinion does not imply any lack of appreciation of the work of those economists who have been trying to assess how governments and others might cope with the various damaging effects of global warming and to calculate what the appropriate preventive or remedial action might cost. We respect this work,[17] but in view of the long timescale and the numerous uncertainties involved, scientific, economic and political, it would be surprising if it yielded reliable results in the form of pounds sterling per tonne of carbon emitted in Britain in a particular year. What can be said with certainty is that because these factors are omitted from the calculations, they understate the case for lowering speed limits on these roads.

To include these effects in a calculation of appropriate speed limits on urban roads of the kind attempted in Chapter 10 would be even more difficult. The problem is not just to evaluate the savings in fuel consumption and emissions that lower speeds might bring about, but, before that, to predict them. Much depends on the characteristics of the road network in a particular town, on the level of congestion obtaining at present, and on the precise restraint methods adopted. Prediction is further complicated by the great variations between makes and models of vehicle and in driving styles. It is fairly clear, however, that even if the traffic-calming schemes that have been implemented so

far may not always have reduced fuel consumption and emissions, in the reasonably near future, when the great majority of vehicles will be fitted with catalytic converters, any calming scheme which produced markedly steadier driving, as well as a reduction in average speeds, would almost certainly do so. A more radical approach to vehicle design would guarantee success.

Notes and references

1. Department of Transport (1983) *Transport Statistics Great Britain 1972-1982*. London: HMSO, Table 1.19; and Department of Transport (1995) *Transport Statistics Great Britain 1995*. London: HMSO, Table 2.1
2. Department of Transport (1995) op.cit., Table 2.6 shows that the fuel consumption of new cars remained almost steady, or possibly even rose slightly, between 1984 and 1994.
3. British Petroleum (1994) *BP Statistical Review of World Energy*.
4. The 1984 edition of the *BP Statistical Review of World Energy* shows that the proved reserves known in 1983 would have lasted for 33.4 years if exploited at the same annual rate as in that year.
5. H S Eggleston, N Gorissen, R Joumard, R C Rijkeboer, Z Samaras and K-H Zierock (1992) *CORINAIR Working Group on Emission Factors for Calculating 1990 Emissions from Road Traffic, Environment and Quality of Life: Vol 1 – Methodology and Emission Factors.*
6. Department of Transport (1995) op.cit., Tables 2.10 and 2.11.
7. Ibid.
8. M Z Acutt, 'Greenhouse Gas Emissions from the Car Model', unpublished paper, Department of Economics and Accounting, University of Liverpool.
9. Ibid.
10. All the information in this paragraph comes from a personal communication with the Department of Transport, 29 February 1996.
11. Quality of Urban Air Review Group (QUARG) (1993) *Urban Air Quality in the United Kingdom*. London: Department of the Environment.
12. R C Rijkeboer and K van Steesel (1991) *The Emissions of Cars under Real World Driving Conditions*. Dutch Consumer Association.
13. I K Farrow, J M Kisenyi, A C Simmonds, C A Savage and R S Cudworth (1993) *Legislated Emissions from the Seven Diesel Vehicles from the Large Scale Survey*. Report LR 931, Warren Spring Laboratory.

14. Personal communication with Dr R Petersen of the Wuppertal Institute, 7 February 1995.

15. International Panel on Climate Change (1990) *Report of Working Group 3*, UN Environment Programme and World Meteorological Organisation.

16. M Hillman (1992) 'Reconciling transport and policy objectives: the way ahead at the end of the road', *Public Administration*, Vol 70, No 2, pp. 225-234.

17. See, for example, J Selwyn (1995) *Atmospheric emissions from private motor vehicles*, UK Centre for Economic and Environmental Development, and S Fankhauser (1994) *Evaluating the Social Costs of Greenhouse Gas Emissions*, CSERGE, WP GEC 94.01.

6

Noise

6.1 The incidence and importance of traffic noise

Noise has little ecological significance,[1] but it seriously detracts from the quality of life of millions of people. Road traffic is the most prevalent source of noise and the cause of most noise nuisance.

A study undertaken in 1990[2] to ascertain the incidence of noise showed that road traffic noise was noticeable outside over 90 per cent of dwellings in England and Wales, although only five per cent faced main roads. Fifty-six per cent of the dwellings were exposed to a level of daytime (7am to 11pm) noise exceeding that regarded by the World Health Organisation as constituting significant community annoyance, and 63 per cent were exposed to a level of night-time noise high enough to interfere with sleep. Although these exposure figures relate to noise from all sources, road traffic was the predominant source. In a survey in 1991 on the effects of noise on people at home, nearly half the sample of adults in England and Wales reported hearing road traffic noise and 28 per cent considered it a nuisance.[3] Noise can disrupt conversation, interfere with concentration, discourage people from opening windows, and prevent relaxation and sleep. The annoyance, anger, anxiety and resentment caused by noise can lead to physiological changes in the body.[4]

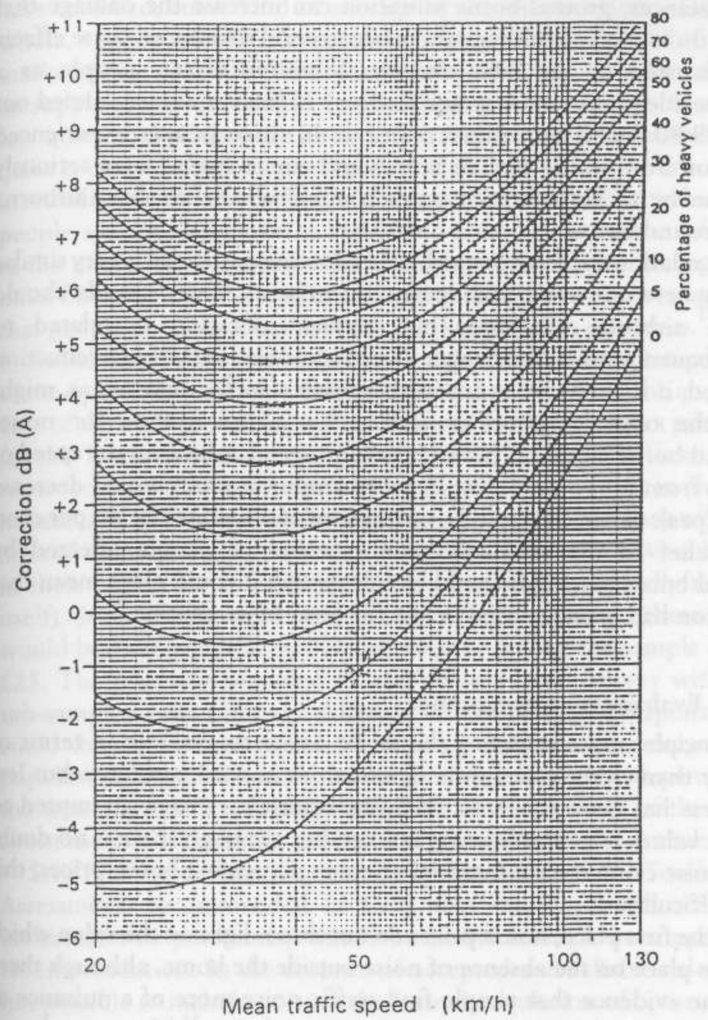
6.2 Ways of reducing road traffic noise

Noise from road vehicles is of two kinds. Power train noise comes from the engine, transmission and exhaust systems. Rolling noise comes predominantly from the interaction of the tyres and the road surface, although aerodynamic noise may also sometimes contribute. Power train noise dominates rolling noise at low speeds and is the chief source of road traffic noise in towns. Rolling noise dominates power train noise at high speeds. Substantial reductions in power train noise have been made in recent years through vehicle design and more are in prospect. This will help to alleviate noise nuisance in towns, but it will make very little difference to the noise from motorways or other high-speed roads. The extent to which rolling noise might be reduced by changes in the design of tyres is unclear, but the materials used for surfacing roads can make a significant difference: the noise from roads surfaced with porous asphalt is less by at least three dB(A) than the noise from conventional concrete or bituminous road surfaces.[5] But porous asphalt is more expensive than other materials and it also wears out more quickly, so that roads need more frequent resurfacing. Supplying the materials required involves environmental damage, and resurfacing is itself an intrusive operation.

Power train noise increases with the speed of the engine. With vehicles of the present design, a reduction in the speed of traffic which is already moving relatively slowly, as in many urban situations, will not always reduce noise, since engine speed may rise as drivers change to a lower gear. Rolling noise increases with the speed of the vehicle, and a reduction in the speed of traffic on motorways and other high-speed roads would always reduce noise.

Figure 6.1, which is taken from the official document setting out how noise should be calculated for the purpose of assessing eligibility for compensation for noise from new roads,[6] illustrates the connection between noise and speed. If the noise levels to be expected from a new road are calculated first as a function of traffic volumes, the diagram shows what corrections would have to be made to take account both of speed and of the proportion of heavy vehicles in the traffic stream. Thus, if heavy vehicles account for ten per cent of the traffic, a not uncommon proportion on main roads outside towns, least noise will be emitted when the traffic is moving at about 32 km/h (20 mph), and when it moves at 100 km/h (62 mph) the noise level will be higher than that minimum by about 5.5 dB(A). This figure is likely to understate the influence of speed, since the method of prediction does not take account of peaks in noise which might be caused by occasional bursts of speed or by particular speeding vehicles.[7] Psychological research shows that such peaks are particularly intrusive and annoying.[8]

Figure 6.1 Correction for mean traffic speed and percentage of heavy vehicles



Source: Reproduced from Chart 4 in reference 6.

6.3 Vibration

The movement of heavy vehicles causes vibration as well as noise. The vibration is of two kinds: ground-borne and airborne. In certain circumstances, ground-borne vibration can increase the damage that lorries do to roads, buildings and underground structures: these effects are discussed in the next chapter. Vibration affects people as a disagreeable sensation. A national survey of lorry nuisance carried out in 1979/80 found that more than one in three people experienced vibration from traffic in their homes and one in twelve were seriously bothered by it.[9] This vibration is much more likely to have been airborne than ground-borne.

The relationship between airborne vibration and speed is very similar to that between noise and speed. In general, lower speeds should reduce airborne vibration, but because vibration is related to low-frequency noise, the danger that in some circumstances a reduction in speed, if it led to more driving by heavy vehicles in low gear, might have the opposite effect is greater for vibration than for noise. Ground-borne vibration is also related to speed. Reducing the speed of lorries from 80 km/h (50 mph) to 48 km/h (30 mph) would decrease PPVs (peak particle velocities – a measure of vibration) by 40 per cent. The relief to the relatively small number of people affected by ground-borne vibration would be substantial; it could often mean that vibration had been reduced below the level of perception.[10]

6.4 Evaluating noise nuisance

In principle, noise nuisance should be easier to evaluate in terms of money than either travel time or casualties in road accidents, but less progress has been made on it. Some researchers have attempted to derive values from the housing market, but although there is no doubt that noise can have a substantial effect in depressing house prices, this is a difficult task.

In the first place, house prices do not throw light on the value which people place on the absence of noise outside the home, although there is some evidence that people find traffic noise more of a nuisance as pedestrians or drivers than when they are at home.[11] Moreover, house prices are difficult to interpret even with respect to the values people place on the absence of noise at home. An obvious difficulty is that houses always differ in ways other than the degree of noise to which they are exposed, and it is hard to know to what extent the difference

in the prices of a quiet and a noisy house is attributable to these other factors. But even if the premium due solely to relative quietness could be established, this premium does not represent, as most researchers have assumed, some kind of average of the values which people as a whole, or people in the relevant income bracket or sector of the housing market, place on a quiet domestic environment. The premium depends on supply as well as demand. In a busy, noisy town where there are very few quiet houses, they are likely to attract a higher premium than in a quiet country district where there is no difficulty in finding one. Except in conditions of severe housing shortage, the more noise-sensitive people are not likely even to consider a noisy house, so the difference in the prices of two houses which are exposed to different degrees of noise but are otherwise similar is likely to be less than the average value that people in the relevant income bracket place on quietness.[12]

Social surveys can be a useful guide, although the hypothetical nature of the questions must raise doubts about the reliability of the answers.[13] One of the most promising approaches was that adopted in a pilot study for the Transport Research Laboratory in 1974/75.[14] Traffic noise was recorded onto a 24-hour tape of a kind used to play music in clubs and restaurants. This noise was demonstrated to people, and they were then offered sums of money to accept a tape machine which would play it in their homes for a week (the 24-hour tape automatically repeated itself). Some people were offered £15 for the week and others £25; as would be expected, the take-up was higher among the sample offered £25. The pilot was intended to lead on to a larger survey with more sub-samples, each offered a different sum of money. A response curve could then have been calculated showing how the percentage of the population prepared to accept a specified degree of noise depends upon the sum offered. But although the pilot resolved many of the doubts about the feasibility of this approach, the main survey did not take place.

SACTRA (the Standing Advisory Committee on Trunk Road Assessment) recommended in 1992 that more research should be undertaken to put money values on traffic noise;[15] we support that recommendation. In the absence of accepted and reliable values, it is not possible to include noise in the formal calculation of optimal speed limits. Failing that, it would be desirable at least to be able to say what reductions lower speeds would bring in the number of houses and other premises and the amount of open space exposed to different degrees of noise. Unfortunately, that is not possible at present either, although we understand that the necessary work is now in progress at the

Department of Transport[16] – we recommend that it be given priority. But even though the reduction in noise that would follow from lower speeds cannot be given a money value, there is no doubt that it would be a major benefit.

Notes and references

1. This sentence originally read "Noise has no ecological significance ..." but our attention has been drawn to Dutch studies which have shown that traffic noise may reduce the area available for nesting birds. M J S Reijnen (1995) *Disturbance by car traffic as a threat to breeding birds in the Netherlands.* Delft: Directorate-General for Public Works and Water Management.
2. J W Sargent and L C Fothergill (1993) *The noise climate around our homes,* BRE Information Paper IP21/93.
3. C J Grimwood (1993) 'A National Survey of the Effects of Environmental Nuisance on People at Home', *Proceedings of the Institute of Acoustics,* Vol 15, Part 8.
4. P Nelson (1992) 'Controlling Vehicle Noise: A General Review', *Proceedings of a Eurosymposium (on traffic noise),* Nantes, France, pp.221-248.
5. J J Houdt and T Goeman (1992) 'Optimising Traffic Noise Measurements in Road Pavement' in *Part II: Environmental Implications Associated with Porous Asphalt Concrete.* Ministry of Transport and Public Works, The Netherlands.
6. Department of Transport and Welsh Office (1988) *Calculation of Road Traffic Noise.* London: HMSO.
7. The first step is to predict, for each hour between 6 a.m. and midnight, the level of noise that will be exceeded for only ten per cent of the time. Then the average of these 18 numbers is taken and it is that average which is shown in the diagram reproduced as Figure 6.1. It follows that if in any given hour there were some especially noisy episodes due to bursts of speed (or, indeed, to any other cause), they would not affect the result unless in aggregate they lasted for at least six minutes.
8. Private communication from R Petersen, Wuppertal Institute, Germany.
9. G R Watts (1990) *Traffic Induced Vibrations in Buildings,* TRRL Research Report 246. (The figures are derived from a further analysis of the survey reported in reference 10.)
10. Ibid.
11. C J Baughan, B Hedges and J Field (1983) *A National Survey of Lorry Nuisance.* TRRL Supplementary Report 774.

12. For a further discussion of this point see S P C Plowden and P R J Sinnott (1977) *Evaluation of Noise Nuisance: A Study of Willingness to Receive Payment for Noise Received into the Home.* TRRL Supplementary Report 261.
13. In a study carried out for the British Airports Authority, respondents were asked to imagine that they were moving house and to say how much they would be prepared to spend on a new one. It was then put to them that they had found one which met their requirements but which had some defect; they were asked to say by how much the price would have to be reduced in order for them to buy the house in spite of the defect. Among the defects listed were three concerned with varying degrees of noise. Some people said that no reduction in its price would induce them to buy a noisy house, especially if the noise was severe. It is hard to know how many of these replies were genuine and how many people might have given a different answer if the wording of the question had been altered or if they had been confronted with this situation in real life. British Airports Authority (1970) Evidence to the Commission on the Third London Airport, Commission reference numbers 5006 and 5006A.
14. S P C Plowden and P R J Sinnott, op.cit.
15. SACTRA (1992) *Assessing the Environmental Impact of Road Schemes.* London: HMSO.
16. Personal communication from the Department of Transport, 7 November 1994.

7

Road building and road maintenance

7.1 Speed and the case for road building

It will be seen in Chapter 8 that one of the effects of lowering vehicle speeds would be to reduce the number and length of journeys both by car and by lorry. This does not necessarily mean that traffic levels in future years would be lower than at present. That would depend on what other policies were adopted, with respect to such things as fuel taxation, traffic restraint in towns, more stringent rules for lorry routing, and investment in public transport, as well as on the development of the economy and the growth of the population. But it must at least mean that traffic growth would be less than if speeds were not reduced. Since the Department of Transport's justification of its road programme depends heavily on the assumption of very substantial traffic growth, anything which throws doubt on that assumption also throws doubt on the road programme.

Speed reductions would weaken the case for the road programme in other ways as well. Part of the justification for road building, according to the official COBA method, is accident reduction. This comes about, according to COBA, because traffic is drawn off the existing, relatively dangerous, roads onto new ones with lower accident rates. But COBA assumes that the accident rates for each class of road will be the same in future as they are today. If the rates were reduced by lower speeds, the accident toll on the existing roads in any given future year would be lower than if present speeds were maintained. It follows that the number of accidents saved by diverting traffic onto new roads would also be lower. In the same way, if noise and other nuisance from traffic on the existing roads were reduced by lower speeds, there would be less need to consider diverting the traffic onto new, purpose-built roads.

Lower and better enforced speed limits would also increase road capacity and so, even if traffic growth were to continue, would reduce

the need to build roads to accommodate it. The relationship between speed and capacity is discussed in Appendix J.

To increase capacity is not the only possible reason for road building. The purpose of a bypass may be to improve conditions in a town by taking out the through traffic, and there are some towns where a bypass would be worth considering if there were no growth in traffic and even some decline. But a bypass would always have to be compared with alternative means of bringing the desired relief. It may be possible to divert some of the through traffic to the existing main roads in the region. Means of diversion might include imposing a very low speed limit on the roads which it was intended to relieve and compulsory routing for heavy lorries. Alternatively, or in addition, the environment in the town could be improved by reducing some of the local traffic, through the various means of urban traffic restraint, and by traffic calming the remaining vehicles, both through and local.

Even when it could be shown that a bypass would bring more relief to the town than a combination of other measures, that would not be a sufficient justification for building it. It would also have to be shown that the extra relief would outweigh the expense of the bypass and, equally important, its adverse impact on the environment. That impact includes loss of countryside, the severance of the bypassed town from its surroundings, and the exposure of new areas to traffic noise and fumes.

Although these stringent conditions might rule out many of the schemes for bypasses in the present road programme, there may still be many towns and villages, including some for which no bypass is planned at present, which could benefit from one. As will be seen below, lower speeds would make it possible to consider more modest designs, costing less to build and fitting more easily into the landscape.

7.2 Speed and the design of new roads

The faster a vehicle is travelling, the longer it takes to stop, and the greater the radius of curvature which is required to avoid skidding. In addition, at higher speeds drivers need to see hazards, signs and other vehicles further ahead and to travel further apart. So if speeds are restricted, both the horizontal and the vertical curvature of roads can be reduced – in other words, roads can be built with sharper corners and steeper gradients. Table 7.1 shows the relationship between the design speed of a single carriageway road and its horizontal radius. The

Table 7.1 The relationship between the design speed of a single carriageway road and its horizontal radius

Design speed (km/h)	Road designed to allow overtaking (minimum value)	Road not designed to allow overtaking
	metres	metres
100	2880	510 to 1020
85	2040	360 to 720
70	1440	255 to 510
60	1020	180 to 360
50	720	127 to 255

Source: Reference 1

relationship between design speed and vertical curvature is even more pronounced.

Lower speeds should also make it possible to build narrower bypasses, although the scope for doing so is limited if the by-pass has to carry vehicles of all kinds, including coaches and the largest lorries. A recent report for the Civic Trust on freight transport[2] has revived the idea, first put forward in the 1970s, that the largest and most intrusive lorries should be confined to a network of motorways and selected 'A' roads, not only for reasons of safety and the environment but also to reduce the cost of maintaining minor roads. If bypasses were built to carry only light slow-moving vehicles, including mini-buses and other local buses, but not express coaches nor large lorries, their design could be quite modest.

As well as permitting more modest designs for bypasses, lower speeds would reduce the noise and fumes from vehicles driving along them. If vehicles were designed with lower speeds in mind, as suggested in Chapter 11, these reductions could be greater still.

A problem about building bypasses is that even though they may be intended to bring relief rather than to provide extra capacity, they often do in fact increase capacity even when accompanied by traffic restraint on the relieved roads, and any increase in capacity is likely to generate traffic. If a low speed limit were enforced, the risk of traffic generation would be much reduced.

In all these ways, therefore, lower and better enforced speed limits would reduce the objections to building bypasses and so would enable more towns and villages to be bypassed.

Bypasses are not the only new roads which might be built even if there were no overall traffic growth. In those circumstances, there would still be a need to build roads to serve new development. Lower speeds would permit narrower roads with sharper corners in new residential areas or other new developments.

7.3 Road maintenance

Road damage depends mainly on the weight and configuration of the vehicle and on the weight and distribution of its load, but speed can also have an influence in some circumstances.

The damage a vehicle does to a road depends on the number of axles and the weight on each axle raised to the fourth power. It follows that road damage is almost entirely caused by heavy vehicles – lorries and coaches – rather than by cars. For example, a fully loaded car is likely to have a load on each axle of about half a ton, whereas a fully loaded 16-ton lorry will have a load of six tons on one axle and ten tons on the other. It follows from the fourth power law that the lorry causes more than 90,000 times as much damage as the car.

On straight roads with smooth surfaces, the effect of speed on this relationship is small, although there is some evidence that lorries moving at very low speeds, below 15 mph, do more damage than lorries moving at speeds over 15 mph, and it is possible that at higher speeds too there is a slight decrease of dynamic reaction with speed.[3] When a vehicle moves round an unbanked bend, however, a disproportionate weight is transferred onto one set of wheels. The amount of weight transferred depends on the radius of the curve, the centre of gravity of the vehicle and its speed. Weight transfer is unlikely to be significant on motorways and other main roads outside towns, on which curves are gradual and are usually banked. But on minor roads, whether in the town or the country, and also on roundabouts, the transfer of weight can increase road damage by up to 30 per cent.[4]

When surfaces are not smooth, however, either because the road is already in a poor state of repair or for some other reason, the damage a vehicle causes increases with its speed. The effect can be very significant. An American test on bridges with irregularities (roughness) on the approach slabs or on the decks of the bridge itself found that restricting speeds to less than 15 mph resulted in a drastic reduction of impact.[5]

Damage to underground structures, such as gas mains or the foundations of buildings, also increases with speed. So does the damage done by a vehicle hitting a building, a verge or a roadside object.

References

1. Department of Transport (1993) *Design Manual for Roads and Bridges*, Volume 6, Section 1, Road geometry links, Part 1, TD 9/93, Highway link design, Chapter 7, Figure 24.
2. S Plowden and K Buchan (1995) *A New Framework for Freight Transport*. London: the Civic Trust.
3. G B Parker (1981) *Heavier Lorries and Road Damage: A Review of the Armitage Report's Assessment*. London. These findings are taken from large-scale experiments conducted by the American Association of State Highway Officials (AASHO) between 1958 and 1960 and on tests at the (British) Road Research Laboratory reported in A C Whiffin and N W Lister (1962) 'The application of elastic theory to flexible pavements', *Proceedings of an international conference on structural design of asphalt pavements*. Ann Arbor: University of Michigan.
4. G B Parker (1981) op.cit.
5. G B Parker (1981) op.cit. This finding is taken from AAHSO Report No 7.

8

Travel patterns

Lower speeds would lead to longer journey times. Travellers and shippers of goods would have to decide how to respond. Although some would continue to make the same journeys or shipments as before, simply putting up with the extra travel time, others would modify their patterns of travel in order to avoid or reduce this penalty. It is not possible to predict precisely what changes people would make, but some estimates must be made, since otherwise the evaluation of the costs and benefits of better enforced and lower speed limits would be seriously incomplete.

8.1 Personal travel

In towns, except perhaps for the largest conurbations, car journeys are generally too short for an increase in the time they take to have much effect in persuading people either to switch from cars to other modes or to reduce the number or lengths of their car journeys. This would be true even if lower speed limits did indeed lead to a noticeable increase in car journey times. In fact, as will be seen in Chapter 10, the increases in travel time that would arise from lower urban speed limits, even from a reduction from a 30 mph to a 20 mph speed limit, might be quite small.

There is, however, another very important way in which lower and well enforced speed limits would alter urban travel patterns. Although they would not act as a significant deterrent to motoring, they would remove a deterrent from cycling. As noted in Chapter 4, danger and fear are the most important reasons why would-be cyclists do not now cycle, and they are very much related to the speed at which the other traffic moves. One very recent instance was reported in the August 1995 issue of the *London Cyclist*. According to this report, the introduction of a 30km/h speed limit in the centre of Bruges resulted in an increase of 20 per cent in the number of cyclists and a reduction of 35 per cent in the number of accidents.

Many car journeys outside towns, or starting or finishing in them, are indeed long enough for the increases in travel times that would result from better enforced and lower speed limits to bring about a reduction in their number or length. Unfortunately, the experience of lower speed limits, such as those imposed in response to the 1973 oil crisis, is not of much help in quantifying these effects. The effect of lower speeds on accidents and accident rates is immediate, but its effect on travel patterns is longer-term and much harder to disentangle from the other influences affecting journey patterns.

There is, however, much more experience of the effect of increased speeds on travel patterns. Speeds increase not only or principally because speed limits are raised, but because new high-speed roads are built and because each generation of motor vehicles tends to have a higher performance, in terms of acceleration and top speed, than its predecessors. Most countries have experienced these changes. The only way to proceed seems to be to examine the effects that they have had on travel patterns and to assume that, if speeds fell again, those effects would be checked and reversed.

That is, of course, a contentious assumption. Some of the journeys which have become longer because of higher speeds might revert to their former lengths quite quickly. For example, there is anecdotal evidence that one of the effects of the construction of the motorway system has been that some people in the north of England drive down to the south coast for a day's outing. Longer journey times arising from lower and better enforced speed limits would presumably persuade such people to look to nearer countryside and beaches for their recreation. But there are other journey patterns which could not be reversed so easily, especially when they have been accompanied by locational changes. An example might be someone who has chosen to live a long way out of the city where he works because a nearby motorway makes it possible for him to drive to work in a reasonable time. He would not have bought his present house if the motorway had always been subject to a relatively low speed limit, but if such a limit were imposed now, he might not find it easy to move house again. In assessing the possible effects of lower speeds, it must therefore be borne in mind that it may take longer to reverse the travel patterns that have developed because of higher speeds than it took for them to form, and some of the changes

Table 8.1 Mean speeds on car driver journey stages

	mph
1972/73	20.8
1975/76	22.4
1985/86	23.7
1989/91	25.3
1991/93	25.7

Source: National Travel Survey, special breakdowns.

that have taken place may not be completely reversible even in the longer term.

A theory with a very long history about the way in which changes in speed affect travel is that people have a constant travel time budget. According to this theory, the consequence of speeding up travel is not that people make the same journeys as before and use the time saved in other ways, but that they use that time to make more or longer journeys. This theory is widely regarded in Germany as proven.[1] In Britain, the recent report of the Standing Advisory Committee on Trunk Road Assessment (SACTRA), *Trunk Roads and the Generation of Traffic*, concluded that in the short term about half the time saved through speed increases might be used for additional travel, and that 'the longer term effect is likely to be greater, with a higher proportion (perhaps all) of the time saved being used for further travel'.[2] In reaching this conclusion, SACTRA drew on studies of travel elasticities from various countries.[3]

In order to throw more light on the relationship between speeds and travel patterns, some special analyses of different years of the National Travel Survey were commissioned for this study and are set out in Tables 8.1 to 8.4. Table 8.1 shows that speeds of car journeys have increased steadily over the years. In fact, this table tends to understate the increases. Over the years, there has been a marked tendency for cars to replace walking, cycling and buses for short journeys. Since these short journeys are made at lower speeds than longer ones, an analysis such as Table 8.1, which does not distinguish between journeys of different lengths, masks the full extent of the speed increases. Table 8.2, which shows speeds on car journeys in 1972/73 and 1991/93 for journeys of different lengths, is more revealing. It shows that speeds rose over the 20-year period for journeys of every length and also that, broadly

Table 8.2 Mean speeds on car driver journey stages analysed by length of journey stage

Length of journey stage (miles)	1972/73 mph	1991/93 mph	% increase
Under 1	6.1	6.4	5
1 to under 2	9.0	10.7	19
2 to under 5	13.8	15.3	11
5 to under 10	19.1	21.1	10
10 to under 15	22.1	25.8	17
15 to under 20	23.4	29.4	26
20 to under 25	26.5	31.3	18
25 to under 50	27.4	35.2	28
50 to under 75	30.8	40.8	32
75 to under 100	33.8	44.5	32
100 to under 150	38.5	48.1	25
150 to under 200	42.1	51.1	21
200 and over	34.5	54.0	57

Source: National Travel Survey, special breakdowns.

speaking, the longer the journey, the greater the percentage increase in speed.

The National Travel Survey also shows the great increases in personal travel, by all modes and by car, that have taken place over the years. The changes between 1975/76 and 1991/93 are summarised in Table 8.3. For journeys by all modes, it can be seen that the total number of journeys per person per head increased both in total and for each separate journey purpose, with the exceptions of commuting, which was affected by the recession, and education, which was affected by demographic changes.[4] Mileage per person per year increased substantially more than journeys. Hours spent travelling per person per year increased rather more than journeys but less than mileage. Travel by mode car driver increased much more than travel by all modes.

There are some doubts about the accuracy of the 1975/76 survey; it is possible that some of the increases shown are exaggerated. However, as Table 8.4 shows, increases, sometimes quite substantial ones, are apparent even over the relatively short time between the 1985/86 and 1991/93 surveys.

What is hard to establish is the extent of any causal connection between the increased speed of travel by car and the increases in

Table 8.3 Changes in personal travel by purpose: 1991/93 compared with 1975/76

Journey purpose	Journeys per person per year A	Journeys per person per year B	Miles per person per year A	Miles per person per year B	Hours per person per year A	Hours per person per year B	Miles per journey A	Miles per journey B	Minutes per journey A	Minutes per journey B
Commuting	-10	28	25	68	6	43	39	31	19	12
Business / work	13	20	43	44	23	25	27	20	9	4
Education	-24	*	4	*	-17	*	37	*	9	*
Shopping	27	114	66	138	36	125	31	11	7	5
Personal business	6	48	31	56	13	80	24	6	7	22
Social	10	37	47	66	20	47	33	22	9	7
Entertain. / public activity	8	*	66	*	31	*	54	*	21	*
Participate in sport	53	*	64	*	40	*	7	*	-9	*
Holiday / day trip	3	*	10	*	11	*	6	*	8	*
Escort	129	121	160	135	127	117	14	6	-1	-2
All purposes	14	56	40	69	21	58	23	8	6	1

A Percentage increase, 1991/93 over 1975/76, all modes of transport.
B Percentage increase, 1991/93 over 1975/76, mode car driver.
* Not shown because of the small number of journeys in the base year. However there was always an increase in journeys per person per year, miles per person per year, and hours per person per year, though not always in miles per journey or minutes per journey.

Notes:

1. Some minor journey purposes not shown separately are included in the 'All purposes' row.
2. Some journeys classified as escort in 1985/86 and 1991/93 would have been classified as some other journey purposes, such as education, shopping and personal business, in 1975/76. The figures in the Car Driver columns are not affected by this change in definition, but those in the All Modes columns are. The increase in escort trips between 1975/76 and later years is overstated and the increases in travel for some other purposes must therefore be slightly understated.
3. The precise percentages shown are affected by rounding and should be treated with caution, especially for minutes per journey.

Source: National Travel Survey, special breakdowns.

Table 8.4 Personal travel in 1985/86 and 1991/93

	All modes			Car driver		
	1985/86	1991/93	% increase	1985/86	1991/93	% increase
Journeys per person per year	1,035	1,064	3	330	406	23
Miles per person per year	5,418	6,580	21	2,518	3,316	32
Hours per person per year	342	365	7	105	134	28
Miles per journey	5.2	6.2	19	7.6	8.2	8
Minutes per journey	20	21	5	19	20	5

Note: It is known that the reporting of short walk journeys is not always reliable. The Department of Transport's statisticians believe that if all walk journeys had been correctly recorded, the increase in journeys per person per year by all modes would be higher than the three per cent shown in this table.

Source: National Travel Survey, special breakdowns.

personal travel. Clearly, there are other influences at work. Cars have not only become faster over the years, they have also become more comfortable and more reliable, which must also have encouraged people to make longer car journeys. As people get richer and have longer holidays, they could be expected to travel more, especially for leisure purposes. The NTS does not cover foreign travel – for a holiday abroad, only the journey stages within Britain to and from ports and airports are recorded. Since there has been a great increase in foreign travel, the increases shown in Table 8.3 for the purpose holiday / day trip will be underestimates. Shopping journeys will have been affected by the increase in the number of very large retail outlets. In a sense this is a speed-related phenomenon, in that it would not have taken place without increased car ownership, and the effect of the acquisition of a car is to increase the speed at which the new car owner can travel, but it is not related to changes in the speeds at which cars can be driven. The growth in car ownership may also help to explain some of the increases in travel, whether measured in miles or hours per person, or in miles or minutes per journey, which have taken place for other journey purposes as well as for shopping.

Further analysis of the NTS might help to separate the effects of increases in the speed of car journeys from those due to other causes. In particular, an analysis of changes in car travel over the years, expressed not in terms of travel per person (that is, per head of the population) but perhaps in terms of travel per adult member of a car-owning household, might be useful. That analysis has not been attempted here, but the analyses discussed above, taken together with the conclusions of other studies mentioned earlier in this chapter, support the hypothesis that there is an important connection between speed and car mileage. They also help in the interpretation of the calculations in Chapter 9 about the effect that better enforced and lower speed limits would have on reducing car travel.

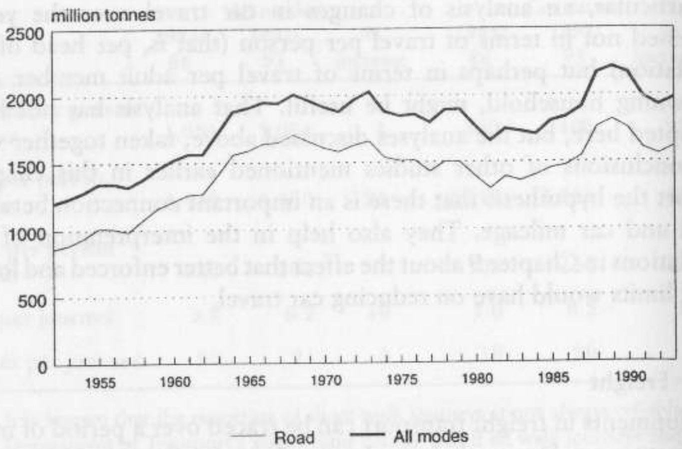
8.2 Freight

Developments in freight transport can be traced over a period of more than forty years. During that time lorry mileage has increased by a factor of more than 2.5. An obvious explanation would be that more goods are being produced and consumed: this was indeed an important reason during the first part of the period, but, as Figure 8.1 shows, not since that time. Lorry traffic has grown because hauls have become longer. The average length of haul by road increased year by year, with very few checks, from 36 kilometres in 1952 to 84 in 1993.[5]

The increase in lengths of haul is sometimes attributed to changes in the structure of the economy: it is said that relatively more goods of the type that always had long hauls are being carried and relatively fewer of those that always had short ones. But it has been shown that such changes account for only a very small part of the increase; all major commodity groups have shown increases in lengths of haul.[6] The most important reason seems to be a decrease in the number of points of supply. Firms have concentrated production in fewer factories, and importers who 30 years ago would have used several ports, so as to have a short journey by land to the customer, have also concentrated on a smaller number. In addition, road has captured some of the long-distance traffic that used to go by rail, and changes in the way that the distribution of goods by road is organised – in particular, a reduction in the number of depots – mean that goods take a less direct route between the supplier's and customer's premises than they used to.

There is a common underlying cause for these trends. The road programme, which has brought about much faster travel, together with

Figure 8.1 Freight lifted by road and in total: 1952 to 1993



Note: Figures are for Great Britain except that from 1972 onwards all UK coastwise and one-port traffic is included. This change in coverage and a change in the coverage of pipeline traffic which occurred in 1990 have the effect of exaggerating the increase which has occurred in the total tonnes lifted.

Source: *Transport Statistics Great Britain 1994*, Table 9.3

the increase in the permitted and actual weights and dimensions of lorries, have reduced the cost (the internal cost, not the cost to society) of road freight transport in general and the difference between the cost of a long haul and of a short one in particular. Consequently, more road freight has been consumed and long hauls have been substituted for short ones.

Reductions in cost have also meant that people have become less concerned about ensuring high load factors. A recent report for the Civic Trust on freight has shown that because of this and the other changes, users are not paying less for road transport than they used to.[7] But they probably are getting a faster and more reliable service, which they can use to achieve cost savings elsewhere in their operations, especially in stock holding.

The same report has identified very great opportunities for reducing lorry mileage and the social costs associated with it while still maintaining an efficient service to the economy.[8] More use could be made of rail and of coastal and short-sea shipping for longer hauls; there could be some reversal of the tendency towards the reduction in the number of points of supply; and vehicle utilisation could be improved both by increasing load factors and in other ways. To exploit these opportunities to the full requires a whole set of policy measures. As well as better enforced and lower speed limits, the proposed package includes higher fuel taxes (which are already being introduced); some form of road pricing for lorries, as has been tried successfully abroad; the restriction of the largest and most intrusive lorries to a limited network of motorways and selected 'A' roads; and the much stricter enforcement of all the other rules affecting lorry operation, such as drivers' hours, maximum loads and vehicle maintenance. Lower and better enforced speed limits by themselves, without the rest of the package, would have a much smaller effect, since the increase in journey time would be offset by lower fuel consumption and a reduction in other costs. This fact is reflected in the calculations in Chapter 9.

8.3 The evaluation of traffic reductions

To evaluate the penalty imposed on those people who, if speeds were lowered, would simply make the same journeys as before, is straightforward in principle, even though it may present practical difficulties. Their journeys would take longer, but they would make some savings in fuel and other items of vehicle cost. If the cost savings can be calculated and a money value assigned to the extra travel time, the net penalty to these travellers can be calculated by a simple sum. But to estimate the penalty to those who would respond to lower speeds by changing their travel behaviour requires a different method.

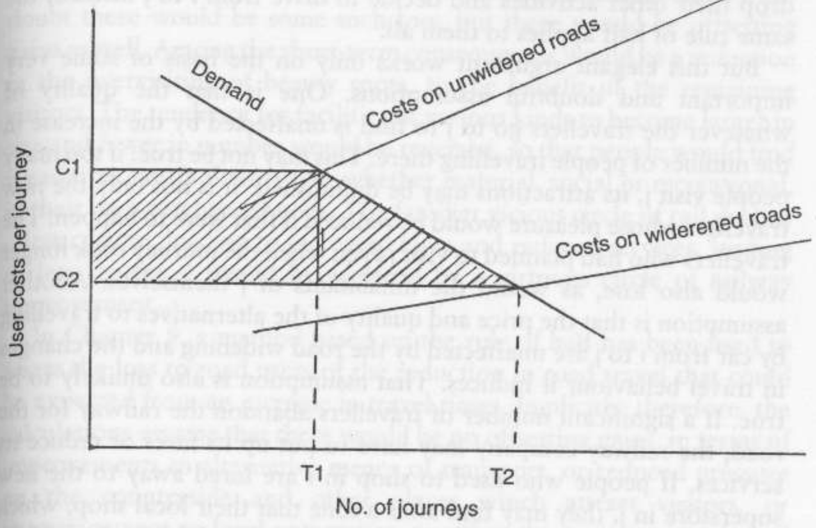
It may be easiest, once again, to approach this problem via the more familiar one of assessing the benefit to those people who increase their travel when journey times fall. The reasoning adopted can be illustrated by a simplified example. A road joining two points, i and j, is widened. The road serves no intermediate points, nor does it form part of a route which traffic going between some other pair of points might take. For the example, only motorists need be considered, and only those travelling from i to j, but the argument works just as well for vehicles other than cars and for people travelling in the opposite direction. To simplify yet further, travel time is the only cost considered.

As a result of the road widening, the time taken to drive a car from i to j falls by t minutes. Those travellers who would have made the journey whether the road had been widened or not have each therefore gained t minutes. Among the travellers who make the journey after the road is widened, but who would not have made it otherwise (or not by car, some might have gone by train or some other means), are those who would have been on the margin of making the car journey even if the road had not been widened. It did not need the full reduction of t minutes to induce them to make it: a reduction of a few seconds would have sufficed. There is very little error in treating these people as if they had indeed made the journey on the unwidened road and crediting them with the full gain of t minutes. At the other extreme, some travellers who make the journey when the road is widened are on the margin of doing so even then. If the reduction in travel time had been less than t by only a few seconds they would not have made it. There is very little error in treating these people as if they had not made it, in which case they would have gained nothing from the road widening. If the new travellers are distributed in a roughly symmetrical way between these two extremes, then on average the benefit to each of them will be t/2 – this is the 'rule of half'.

If money values for time savings are available, and if it is assumed that all travellers have the same value of time, then this argument can be represented by the familiar demand and supply lines shown in Figure 8.2, in which T stands for the number of journeys, or trips, by car between i and j and C for the cost of each such journey. The rectangular section of the trapezium represents the benefit to the travellers who would have made the journey even if the road had not been widened: its area is T1(C1-C2). The triangular part of the trapezium represents the benefit to those who made the journey when the road was widened but who would not have made it otherwise: its area is (T2-T1)(C1-C2)/2.

A similar line of reasoning can be used to evaluate the position of those motorists who cease to make the journey from i to j, or who switch from the car to some other mode, when the driving time increases because the speed limit is more strictly enforced or a lower one is imposed. At one extreme are the people who would have continued to drive from i to j if the increase in time had been less by only a very small amount. The penalty to them can be taken as the same as to those people who chose simply to accept the extra time. At the other extreme are the people who attached so little importance to the journey that even a very small increase in travel time would have induced them to abandon it, and who can therefore be treated as if the reduced speed of travel had

Figure 8.2 Journeys by car from i to j



T1 is the number of journeys made on the unwidened road
C1 is the cost to the user of each such journey
T2 is the number of journeys made on the widened road
C2 is the cost to the user of each such journey

caused them no loss of benefit. If, once again, the other travellers who decide no longer to drive from i to j are distributed evenly, or at least symmetrically, between these extremes, then their average loss is t/2 – the rule of half again – and the same supply and demand diagram (except that both T1 and T2 and C1 and C2 would be transposed) can be used to estimate the losses to motorists caused by the change in the speed limit.

This line of reasoning is ingenious and economical. It is not necessary to know what the people who made the extra car journey when the travel time decreased would otherwise have done, nor what the motorists who abandoned the journey when the time it took increased chose to do instead. Some of the people who decided to drive from i to j when the road was widened might otherwise have made the journey by train; some might have gone for a walk near i rather than visiting the sights at j; some might have stayed at home and dug the garden. It is all the same to the analyst. When the road is widened, some people drop their other activities and decide to drive from i to j instead; the same rule of half applies to them all.

But this elegant argument works only on the basis of some very important and doubtful assumptions. One is that the quality of whatever the travellers go to j to find is unaffected by the increase in the number of people travelling there. This may not be true: if too many people visit j, its attractions may be diminished. It is not only the new travellers whose pleasure would be reduced if that were to happen. The travellers who had planned to visit j even when the journey took longer would also lose, as would the inhabitants of j themselves. Another assumption is that the price and quality of the alternatives to travelling by car from i to j are unaffected by the road widening and the changes in travel behaviour it induces. That assumption is also unlikely to be true. If a significant number of travellers abandon the railway for the road, the railway company may have to put up its fares or reduce its services. If people who used to shop in i are lured away to the new superstore in j, they may find after a time that their local shop, which they might still occasionally want to use, has closed down. Even if the closure does not matter too much to them, it matters to those other inhabitants of i who have no wish or perhaps no opportunity to drive to j. People who were content to find their recreation in their own gardens or in open space near i may find their pleasure diminished by the increased noise from the traffic on the widened road.

Appendix A sets out an algebraic proof that the validity of the rule of half does indeed depend on these 'other-things-being-equal' assumptions. It is unfortunate that this fact is rarely discussed or even acknowledged. For example, the recent SACTRA report *Trunk Roads and the Generation of Traffic* endorses the use of the rule of half in the evaluation of plans to build new roads without any mention of its assumptions. It is unlikely that they will hold when road schemes are assessed individually, and even less likely when the cumulative effects of the whole road programme are considered. It is arguable that the net effect of the road programme has not been to enrich life by allowing a wider choice of activities, as its advocates claim, but to promote a more dispersed pattern of activities, at a cost to travellers of considerable extra time and expense, and to the community as a whole of huge damage to the environment and a loss of social cohesion.

Conversely, if motorised road travel were reduced because of longer travel times brought about by better enforced and lower speed limits, the result would not just be a reduction in choice and opportunity. No doubt there would be some such loss, but there would be offsetting gains as well. Among the short-term consequences would be a reduction in the overvisiting of beauty spots, to the benefit of the remaining visitors. The tendency for facilities of various kinds to become larger in size and fewer in number would be reversed, so that people would find it easier to satisfy their needs, whether material, social or recreational, in their own neighbourhoods. The familiar vicious circle of rail decline – less custom, leading to increased fares and reduced services, leading to less custom – would be replaced by a virtuous circle of railway improvement.

In Chapter 9, a method based on the rule of half has been used to assess the loss to road users of the reduction in road travel that could be expected from an increase in travel times. Implicitly, therefore, the calculations assume that there would be no offsetting gains, in terms of improvements to alternative means of transport, or reduced pressure on the countryside and other places which attract visitors, or encouragement to local enterprises, to offset the greater cost of road travel. It follows that the disbenefits of lower and better enforced speed limits have been overestimated, perhaps very seriously.

Notes and references

1. The information that in Germany the constant travel time budget theory is regarded as established comes in the first place from our colleagues in the Wuppertal Institute. In a recent article by two German authors the theory is referred to as a law. See R H H Pfleiderer and M Dieterich (1995) 'New roads generate new traffic', *World Transport Policy and Practice*, Vol.1, No.1. Among the studies on which these authors rely are R Herz (1985) *Verkehrshalten im zeitlichen und räumlichen Vergleich: Befunde aus Kontiv 76 und 82*. Schriftenreihe der Deutschen Verkehrswissenschaftlichen Gesellschaft e.V. (*Behaviour of Travellers in Temporal and Spatial comparison: Findings from a Continuous Survey of Behaviour of Travellers in 1976 and 1982*), German Association of Traffic Science, Series B85, pp.238-272; and John Allard and Frank Graham and Partners (1987) *A Review of the Traffic Generation of Road Improvements*. PTRC Europe, Road Improvements, Transport and Planning, 15th Summer Annual Meeting, September 1987, Highway Appraisal and Design, Proceedings of Seminar E, pp.57-75.
2. Standing Advisory Committee on Trunk Road Assessment (1994) *Trunk Roads and the Generation of Traffic*. p.47. London: HMSO.

3. P B Goodwin (1992) 'A Review of Demand Elasticities with Special Reference to Short and Long Term Effects of Price Changes', *Journal of Transport Economics and Policy*, Vol.24, No.2.
4. Rates of unemployment more than doubled in the interval between the two surveys and the number of school-age children under the age of fifteen fell by one fifth.
5. *Transport Statistics Great Britain 1994*, Table 9.3. London: HMSO.
6. S Plowden and K Buchan (1995) *A New Framework for Freight Transport*, Table 3.3. London: The Civic Trust.
7. Ibid., Table 3.12.
8. Ibid, see especially Chapter 7.

9

Speed limits on main roads outside towns

Previous chapters have discussed the advantages that lower speeds would bring in improved safety, reduced fuel consumption and reduced environmental impacts, and also the possible penalties in longer travel times and/or altered journey patterns. The aim of this chapter is to calculate what speed limits would be optimal on motorways, dual carriageway 'A' roads outside towns and single carriageway 'A' roads outside towns.

The optimal speed limit is the one which, if properly enforced, would produce the right balance between the conflicting considerations. The calculations in this chapter take account only of those considerations for which widely accepted money values exist: fuel, other vehicle operating costs, travel time and accidents. Although an assessment based only on these factors is incomplete, once the calculations have been made, it is possible to discuss in broad terms how the inclusion of the other factors might affect the results.

In general, the money values used in these calculations are the same as those used by the Department of Transport in the assessment of its road plans. The exception is accidents, where, as was seen in Chapter 4, the Department's values are too low. They have been revised upwards as described in Appendix D. For the reasons given in Chapter 4, it is possible that even the revised values err on the low side.

The calculations have been made on two assumptions about how road users would react to lower speeds. The first, the 'constant flow' hypothesis, is that road users would continue to make exactly the same journeys on the same routes and at the same times of day as before (except that the journeys would take longer). The second, more realistic assumption is that road users, or some of them, would reduce the amount of their travel by road.

The calculations are complicated by the existence of taxation, especially the high rate of tax on fuel. The calculations based on the constant flow hypothesis fall into two groups. Those in the first group take no account of tax either on fuel or on other elements of vehicle operating cost. Although to ignore taxation is incorrect, these calculations are a useful way of introducing those in the second group, which do allow for taxation, and some things can be learnt even from these preliminary calculations. All the calculations which allow for some reduction in traffic do also take taxes into account.

9.1 Calculations based on the constant flow hypothesis without taking fuel tax and taxes on other elements of vehicle operating costs into account

The Department of Transport has a formula for how fuel costs and other vehicle operating costs vary with speed. The general form of the formula is $p = a + b/v + cv^2$, where p is the cost in pence per kilometre, without any element of indirect taxation, and v is the speed in km/h. The values of a, b and c depend on whether fuel costs or other vehicle operating costs are in question and also on the type of vehicle and, with respect to fuel costs for cars and light goods vehicles, on the class of road. For the fuel costs of cars on motorways, for example, the Department's values are: a = 0.49, b = 25.524 and c = 0.000063. Hence the pre-tax fuel cost of driving one kilometre at 80 km/h would be 1.212 pence and the pre-tax fuel cost of driving one kilometre at 120 km/h would be 1.610 pence, both at 1993 prices.

Given the distribution of speeds of cars on motorways in 1993, and also the volume of car traffic in vehicle kilometres, it is possible to calculate the total pre-tax fuel costs for cars on motorways in 1993 in the manner shown in Table 9.1. It will be seen that the total comes to £755m at 1993 prices.

Non-fuel vehicle operating costs can be calculated in exactly the same way, using the appropriate values for a, b and c. The calculation is not shown here, but can be reproduced from the data in Appendix E. The total for cars on motorways comes to £3463m at 1993 prices.

The calculation of travel time costs is similar, but instead of the cost formula, an average value of the cost of an hour's car travel has to be known. This value depends on the number of people in the car and on the value of time per person per hour, which itself depends on the

Table 9.1 Calculation of pre-tax fuel costs for cars on motorways in 1993 in the existing situation of the unenforced 70 mph speed limit

(1) Speed mph (km/h)	(2) % of cars driving at each speed	(3) Cost of fuel for one car to drive 100 km at each speed £	(4) (2) x (3) £
Under 50 (72.4)	4	1.17	4.68
50 to 60 (88.5)	12	1.27	15.24
60 to 65 (100.6)	11	1.38	15.18
65 to 70 (108.6)	17	1.47	24.99
70 to 75 (116.7)	25	1.57	39.25
75 to 80 (124.7)	13	1.67	21.71
80 to 90 (136.5)	16	1.86	29.76
90 and over (152.9)	2	2.13	4.26
Fuel cost of 10,000 vehicle kilometres			155.07
Car traffic in bn. vehicle kilometres			48.7
Total fuel cost, £m.			755.19

Sources: The speed distribution comes from the Department of Transport's Statistics Bulletin (94)30, *Vehicle speeds in Great Britain 1993*. For the other sources see the text and Appendix E.

purpose of travel. The value of a car's travel time in 1993 at 1993 prices was £6.948 per hour (the derivation of this figure is also explained in Appendix E). The calculation of the costs of travel time of cars on motorways in 1993 is shown in Table 9.2: the total comes to £3063m at 1993 prices.

It is assumed that if the 70 mph limit were enforced, those car drivers who were driving at more than 70 mph would drive at 70 mph but the others would not change their speeds. The calculations for the costs of cars on motorways can therefore be repeated on the basis of this modified speed distribution, with 56 per cent of cars being driven at 70 mph. So the following comparison can be made for cars on motorways in 1993, between the costs of driving in the existing situation, with the unenforced speed limit, and what the costs would have been if the speed limit had been enforced. Total driving costs would have risen slightly,

Table 9.2 Calculation of travel time costs for cars on motorways in 1993 in the existing situation of the unenforced 70 mph speed limit

(1) Speed mph (km/h)	(2) % of cars driving at each speed	(3) Time take for one car to drive 100 km at each speed £	(4) (2) x (3) £
Under 50 (72.4)	4	1.381	5.524
50 to 60 (88.5)	12	1.13	13.56
60 to 65 (100.6)	11	.994	10.934
65 to 70 (108.6)	17	.921	15.657
70 to 75 (116.7)	25	.857	21.425
75 to 80 (124.7)	13	.802	10.426
80 to 90 (136.5)	16	.731	11.696
90 and over (152.9)	2	.654	1.308
Time taken to drive 10,000 vehicle kilometres			90.53
Car traffic in bn. vehicle kilometres			48.7
Total time, m. hours			440.881
£ per hour			6.948
Time costs, £m			3063.24

Sources: The speed distribution comes from the Department of Transport's Statistics Bulletin (94)30, *Vehicle speeds in Great Britain 1993*. For the other sources see the text and Appendix E.

because, although fuel costs and other vehicle operating costs would have fallen, this gain is outweighed by the increase in the cost of travel time. All costs are in £ million at 1993 prices.

	Speed limit not enforced	Speed limit enforced
Time costs	3063	3228
Pre-tax fuel costs	755	706
Pre-tax non-fuel vehicle operating costs	3463	3409
Total	7281	7343

If the speed limit were reduced, it is again assumed that all those car drivers now driving at a speed higher than the new limit would drive at that speed but that other drivers would not change their speeds. After the speed distribution has once more been modified in line with this assumption, new calculations can be made along the lines of those in Tables 9.1 and 9.2.

Similar calculations have been made for vehicles of other types, with a slight variation for articulated lorries, for which the motorway speed limit is now 60 mph. It is assumed that if the present speed limit were enforced, or if the general speed limit were reduced to 65 mph, all articulated lorries now exceeding 60 mph would reduce their speed to 60 mph. The whole process has then been repeated for dual carriageway 'A' roads and single carriageway 'A' roads. The data required to make the calculations for these roads are also set out in Appendix E.

To calculate the costs of accidents on each class of road at present, it is necessary to know the number of accidents that occur, by severity, and the money value to be attached to an accident of each severity.

Accident numbers by severity and class of road are given in Tables 13 and 15 of *Road Accidents Great Britain 1993*. In Table 13, major roads are classified by speed limit rather than by number of carriageways, so it has been assumed that non-motorway major roads with a speed limit of 70 mph can be identified with dual carriageway 'A' roads and that non-motorway major roads with a speed limit of 60 mph can be identified with single carriageway 'A' roads. This means that the accidents which occur on major roads with a 50 mph limit have been excluded. The number of such accidents is small but not insignificant; the effect of excluding them is to understate the case for lower speed limits on non-motorway roads.

The statistics in *Road Accidents Great Britain 1993* are based on police records. The police records relate only to injury accidents, to the exclusion of damage-only accidents. Their coverage of fatal accidents is complete, but it is known that some serious accidents and a larger number of slight accidents are not recorded. In addition, there is some misclassification of casualties as between the slight and serious categories, with the net effect of understating the number of serious casualties. Since accidents are classified according to the most severe injury involved, this means that the number of serious accidents is also understated.

There have been a number of studies to compare road accident casualties recorded by the police with those recorded by hospitals, and it is possible to draw on these studies to amend the statistics based on the police records. However, some casualties, almost all of which are likely to be slight, are not recorded either by the police or by hospitals. There is at present no British source for these casualties, but in the Netherlands a household survey has been used to estimate their number. The TRL has used insurance records to make estimates of the ratio of damage-only to injury accidents.

We have drawn on all these sources to make estimates of the cost of accidents on motorways, dual carriageway 'A' roads and single carriageway 'A' roads in 1993. The working is shown in Appendices B, C and D; the resulting estimates, for accidents of all degrees combined, are for motorways £785m, for dual carriageway 'A' roads £1034m, and for single carriageway 'A' roads £3790m.

Better enforced and lower speed limits would lead to a reduction in the number and cost of accidents. Calculations have been made in Appendix F of the extent to which different speed limits on each class of road would reduce the present (1993) accident costs. The resulting ratios are as follows:

	Motorways	Non-built-up dual carriageway 'A' roads	Non-built-up single carriageway 'A' roads
Present	1.00	1.00	1.00
70 mph limit enforced	.84	.87	N/A
65 mph limit enforced	.71	.76	N/A
60 mph limit enforced	.62	.65	.975
55 mph limit enforced	.55	.58	.96
50 mph limit enforced	.50	.55	.89
45 mph limit enforced	.47	.52	.84
40 mph limit enforced	.45	.50	.80
35 mph limit enforced	N/A	N/A	.76

Table 9.3 shows how each element of cost and total costs vary with the speed limit and Tables 9.4 and 9.5 summarise the corresponding information for dual carriageway 'A' roads and single carriageway 'A' roads respectively.

For motorways, it will be seen that both the enforcement of the existing 70 mph speed limit and the lowering of the limit to 65 mph would reduce total costs. Costs are lower when the 70 mph limit is

enforced than when the limit is reduced to 65 mph, but if the input data had allowed intervals of one mph rather than of five mph to be shown, presumably the lowest costs would have occurred at somewhere between these two speed limits, perhaps at 68 mph. Table 9.4 shows that for dual carriageway 'A' roads, a reduction in the speed limit even to 55 mph would reduce the present costs. Costs are at their lowest with a 65 mph limit, although there is very little difference between those costs and the costs of a 60 mph limit. Table 9.5 shows that for single carriageway 'A' roads the lowest cost occurs with a 45 mph speed limit, but there is not much difference in cost between the 45 mph limit and the 50 mph limit. It should be emphasised, once again, that these calculations are only an introduction to more realistic calculations which allow for taxation and for some reduction in traffic volumes in response to lower speeds.

9.2 Calculations based on the constant flow hypothesis taking fuel tax and taxes on other elements of vehicle operating costs into account

Tables 9.3 to 9.5 represent what the situation would be, assuming lower speeds did not lead to a modification of travel behaviour, in an economy run without taxes or subsidies. In such an economy, the benefits to travellers in performing a given pattern of travel at lower speeds are the value of the resources, in fuel and other elements of vehicle operating cost, which are saved by driving more slowly. But the existence of taxation, and, in particular, the fact that the rate of tax on fuel for motor vehicles is so much higher than the rate of tax on most other items, complicates the assessment.

If, as a consequence of driving more slowly, a motorist finds that his annual expenditure on petrol goes down by £100, it is of no importance to him whether all that money would have gone to oil companies or other producers or whether some of it would have gone to the Inland Revenue. Either way, he has an extra £100 to be spent on other things. But from the point of view of the economy as a whole, these are two different situations, which have to be treated differently in a cost-benefit analysis.

How taxation should be treated depends on what it represents. Why is fuel so highly taxed? One explanation might be that fuel tax is a tax like any other, whose purpose is simply to raise money for the Government to carry out its normal functions, and it is only because a tax on fuel is easy to administer that the rate is so high. If that were so,

Table 9.3 How travel costs on motorways vary with the speed limit, assuming constant flows and disregarding taxation

Units: £m

Speed limit (mph)	Travel time cost	Fuel cost	Non-fuel cost	Total	Travel time cost	Fuel cost	Non-fuel cost	Total
	Cars				*Light goods vehicles*			
Present	3,063	755	3,463	7,281	626	105	782	1,513
70 enforced	3,228	706	3,409	7,343	643	101	777	1,521
65 enforced	3,377	677	3,378	7,432	664	98	773	1,535
60 enforced	3,590	646	3,345	7,581	699	94	768	1,561
55 enforced	3,858	618	3,314	7,790	743	91	763	1,597
50 enforced	4,225	591	3,288	8,104	812	87	759	1,658
45 enforced	4,673	571	3,270	8,514	897	84	757	1,738
40 enforced	5,255	559	3,262	9,076	1,008	83	755	1,846
Speed limit (mph)	*Buses and coaches*				*Heavy goods vehicles*			
Present	467	31	257	755	873	493	2,966	4,332
70 enforced	470	31	257	758	884	488	2,961	4,333
65 enforced	484	30	257	771	888	486	2,960	4,334
60 enforced	510	30	256	796	897	482	2,957	4,336
55 enforced	544	29	255	828	927	473	2,950	4,350
50 enforced	595	28	255	878	1,008	455	2,938	4,401
45 enforced	658	27	256	941	1,109	440	2,931	4,480
40 enforced	740	27	256	1,023	1,247	428	2,928	4,603

continued

Table 9.3 Continued

Units: £m

Speed limit (mph)	Travel time cost	Fuel cost	Non-fuel cost	Total	Accident ratios	Accident cost	All road user cost
	All vehicles						
Present	5,029	1,384	7,468	13,881	1.00	785	14,666
70 enforced	5,225	1,326	7,404	13,955	0.84	659	14,614
65 enforced	5,413	1,291	7,368	14,072	0.71	557	14,629
60 enforced	5,696	1,252	7,326	14,274	0.62	487	14,761
55 enforced	6,072	1,211	7,282	14,565	0.55	432	14,997
50 enforced	6,640	1,161	7,240	15,041	0.50	393	15,434
45 enforced	7,337	1,122	7,214	15,673	0.47	369	16,042
40 enforced	8,250	1,097	7,201	16,548	0.45	353	16,901

Table 9.4 How travel costs on dual carriageway 'A' roads vary with the speed limit, assuming constant flows and disregarding taxation

Units: £m

Speed limit (mph)	Travel time cost	Fuel cost	Non-fuel cost	Total	Accident costs	All user costs
	All vehicles					
Present	4,060	1,098	5,401	10,559	1,034	11,593
70 enforced	4,201	1,055	5,360	10,616	900	11,516
65 enforced	4,310	1,032	5,337	10,679	786	11,465
60 enforced	4,481	1,004	5,311	10,796	672	11,468
55 enforced	4,714	977	5,283	10,974	600	11,574
50 enforced	5,100	945	5,254	11,299	569	11,868
45 enforced	5,595	916	5,234	11,745	538	12,283
40 enforced	6,277	898	5,223	12,398	517	12,915

Table 9.5 How travel costs on single carriageway 'A' roads vary with the speed limit, assuming constant flows and disregarding taxation

Units: £m

Speed limit (mph)	Travel time cost	Fuel cost	Non-fuel cost	Total	Accident costs	All user costs
	All vehicles					
Present	7,978	1,204	6,827	16,009	3,790	19,799
60 enforced	8,052	1,194	6,817	16,063	3,695	19,758
55 enforced	8.081	1,190	6,815	16,086	3,638	19,724
50 enforced	8,221	1,180	6,803	16,204	3,373	19,577
45 enforced	8,403	1,171	6,795	16,369	3,184	19,553
40 enforced	8,986	1,155	6,789	16,930	3,032	19,962
35 enforced	9,772	1,150	6,799	17,721	2,880	20,601
30 enforced	11,277	1,166	6,837	19,280	2,729	22,009
25 enforced	13,382	1,211	6,982	21,575	2,577	24,152

although any benefits to road users arising from lower speeds would be calculated in terms of the reduction in their expenditure, including taxes, a correction would be needed to allow for the fact that the consumption of resources had not gone down to the same extent. But another explanation for the high rate of tax on fuel might be that the

Government wishes to discourage its consumption. The reason might be to conserve the stocks of this non-renewable resource for future generations, or it might be to reduce pollution. In either case the correction, if still required at all, would be much smaller.

Even though in reality at least part of the reason for high taxes on fuel is that the Government wishes to restrain consumption, for the purposes of the calculations in this section that point has been disregarded. The correction factors used are those which would apply if fuel taxes were simply a means of raising revenue for the general purposes of government.

The easiest way to understand these corrections is to think of the Inland Revenue as a separate economic agent whose interests have to be taken into account in the cost-benefit analysis. If road users travel more slowly and therefore use less fuel, they save money but the Inland Revenue loses revenue. How much it loses depends on how road users spend the money they save. If they spend it on items, such as alcohol, which are also very highly taxed, then the Inland Revenue may lose very little; it could even collect more tax than it did before. If they spend it all on untaxed items such as food, then the Inland Revenue is worse off by the total amount by which the tax take on fuel has fallen. If the money is spent on items taxed at the standard rate, then the Inland Revenue's loss is given by the tax component of expenditure saved on fuel less the tax take from the same expenditure on items taxed at the standard rate.

Even though it is convenient to treat the Inland Revenue as a separate economic agent for the purpose of setting out the calculations, the Inland Revenue, is, of course, only an intermediary. When the Inland Revenue experiences a loss, the ultimate losers are citizens who have to reduce their consumption. The example was given above of a motorist who, by driving more slowly, reduces his fuel bill by £100 a year. About £31 of that will be a genuine resource saving and £69 tax (see below). If the motorist spends the £100 he has saved on goods which bear VAT at the standard rate of 17.5 per cent, the tax take from this expenditure will be £14.89. The net loss to the Inland Revenue from this switch in the motorist's expenditure is therefore £54.11. If the Government wishes to maintain the same level of tax revenue, then it will have to increase other taxes to recoup this loss, which means that the taxpayers concerned will have less to spend on consumption. If the Government decides not to increase other taxes, then the ultimate losers are the people who benefit from State-financed services.

Table 9.6 How travel costs on motorways vary with the speed limit, assuming constant flows and taking account of taxation

Units: £m

	Travel time cost	Fuel cost	Non-fuel cost	Total	Travel time cost	Fuel cost	Non-fuel cost	Total
Speed limit (mph)		*Cars*				*Light goods vehicles*		
Present	3,063	2,435	4,069	9,567	626	263	782	1,671
70 enforced	3,228	2,277	4,006	9,511	643	253	777	1,673
65 enforced	3,377	2,184	3,969	9,530	664	245	773	1,682
60 enforced	3,590	2,084	3,930	9,604	699	235	769	1,703
55 enforced	3,858	1,994	3,894	9,746	743	228	763	1,734
50 enforced	4,225	1,906	3,863	9,994	812	218	759	1,789
45 enforced	4,673	1,842	3,842	10,357	897	210	757	1,864
40 enforced	5,255	1,803	3,833	10,891	1,008	208	755	1,971
Speed limit (mph)		*Buses and coaches*				*Heavy goods vehicles*		
Present	467	78	257	802	873	1,233	2,966	5,072
70 enforced	470	78	257	805	884	1,220	2,961	5,065
65 enforced	484	75	257	816	888	1,215	2,960	5,063
60 enforced	510	75	256	841	897	1,205	2,957	5,059
55 enforced	544	73	255	872	927	1,183	2,950	5,060
50 enforced	595	70	255	920	1,008	1,138	2,938	5,084
45 enforced	658	68	256	982	1,109	1,100	2,931	5,140
40 enforced	740	68	256	1,064	1,247	1,070	2,928	5,245

continued

Table 9.6 Continued

Units: £m

	Travel time cost	Fuel cost	Non-fuel cost	Total	Cars	Light goods vehicles	Buses and coaches	Heavy goods vehicles	All vehicles
Speed limit (mph)		*All vehicles*					*Loss to Inland Revenue*		
Present	5,029	4,009	8,074	17,112	0	0	0	0	0
70 enforced	5,225	3,828	8,001	17,054	86	6	0	8	100
65 enforced	5,413	3,719	7,959	17,091	136	11	2	11	160
60 enforced	5,696	3,599	7,912	17,207	190	17	2	17	226
55 enforced	6,072	3,478	7,862	17,412	239	21	3	30	293
50 enforced	6,640	3,332	7,815	17,787	286	27	5	57	375
45 enforced	7,337	3,220	7,786	18,343	321	32	6	80	439
40 enforced	8,250	3,149	7,772	19,171	342	33	6	98	479
Speed limit (mph)	Accident costs								Total costs
Present	785								17,897
70 enforced	659								17,815
65 enforced	557								17,808
60 enforced	487								17,920
55 enforced	432								18,137
50 enforced	393								18,555
45 enforced	369								19,151
40 enforced	353								20,003

The calculations in this section rest on the following assumptions about what taxes road users pay at present, how they would spend any money they save by driving more slowly, and what the rates of tax are.

It is assumed that motorists pay both fuel tax and VAT on fuel, that they also pay VAT at the standard rate of 17.5 per cent on non-fuel items of motoring expenditure, and that they are not in a position to recover any VAT. Any money saved on motoring because of lower speeds would be spent on items bearing the standard rate of VAT. The proportion of the pump price of fuel accounted for by fuel tax and VAT has been taken as 69 per cent.[1]

It is assumed that operators of goods vehicles and of buses and coaches would pay both fuel tax and VAT on fuel, that they would also pay VAT on non-fuel items, but that all VAT could be recovered. Any money saved by driving at lower speeds would also be spent on items for which they could recover any VAT. The proportion of the pump price of fuel, not including VAT, accounted for by fuel tax has been taken as 60 per cent.[2]

The inclusion of tax on fuel (and also for motorists, though not for other vehicle operators, on non-fuel items of vehicle operating costs) obviously increases the gain (or reduces the loss) to road users of driving more slowly, as compared with the gain calculated with taxation left out of account. But for vehicles other than cars, the effect of these assumptions is that the extra gain to operators is exactly cancelled out by the loss to the Inland Revenue. For cars, however, the gain to motorists is only partly offset, not completely cancelled out, by the loss to the Inland Revenue. (Appendix G gives the algebraic proofs of these statements and also sets out two worked examples.) Hence the net gains from lower speed limits are higher when taxation is taken into account than when it is not.

Table 9.6 refers to motorways. It shows how the costs to the users of each separate class of vehicle, and of all vehicles in aggregate, vary with the speed limit when taxes are included. A comparison with Table 9.3 shows how the inclusion of taxation has reduced the penalties to vehicle users of having to drive more slowly. In fact, the penalty is sometimes converted into a gain, since the saving in fuel and other operating costs now sometimes outweighs the extra travel time costs. The table also shows the loss to the Inland Revenue, vis-à-vis the present situation, arising out of the reduction in fuel consumption. The accident costs are the same as those shown in Table 9.3. The net effect of the inclusion of taxes is to increase, though only slightly, the advantage of

lower speed limits. Costs are now lower with a 65 mph limit than with the existing 70 mph limit enforced, although the difference between these two situations is very small.

Table 9.7 gives the same information as Table 9.6, except that the vehicle types are not shown separately, but in a different form. Costs are shown not as absolute figures but as differences from the present situation. This is done for consistency with the presentation that has to be used when the constant flow hypothesis is dropped: it then no longer makes sense to talk of absolute costs and benefits but only of incremental changes.

Table 9.7 How travel costs on motorways vary with the speed limit, assuming constant flows and taking account of taxation: differences from the present situation

Units: £m

Speed limit (mph)	Extra travel time cost	Saving in fuel cost	Saving in non-fuel cost	Total extra cost	Loss to Inland Revenue	Saving in accident costs	Net gain
			All vehicles				
70 enforced	196	181	73	-58	100	126	84
65 enforced	384	290	115	-21	160	228	89
60 enforced	667	410	162	95	226	298	-23
55 enforced	1,043	531	212	300	293	353	-240
50 enforced	1,611	677	259	675	375	392	-658
45 enforced	2,308	789	288	1,231	439	416	-1,254
40 enforced	3,221	860	302	2,059	479	432	-2,106

Tables 9.8 and 9.9 are similar to Table 9.7 but relate to dual carriageway 'A' roads and single carriageway 'A' roads respectively. Table 9.8 shows that the inclusion of taxation changes the optimal speed limit on dual carriageways (assuming that the speed limit has to be one of those shown in the table, rather than some intermediate figure) from 65 mph to 60 mph. On single carriageway 'A' roads, Table 9.9 shows that it is still the case that a reduction of the speed limit to 45 mph gives the greatest gain, but the inclusion of taxation increases the advantage of the 45 mph limit over the 50 mph limit.

Table 9.8 How travel costs on dual carriageway 'A' roads vary with the speed limit, assuming constant flows and taking account of taxation: differences from the present situation

Units: £m

Speed limit (mph)	Extra travel time cost	Saving in fuel cost	Saving in non-fuel cost	Total extra cost	Loss to Inland Revenue	Saving in accident costs	Net gain
			All vehicles				
70 enforced	141	129	46	-35	72	134	97
65 enforced	250	202	73	-25	112	248	162
60 enforced	421	290	103	28	160	362	175
55 enforced	654	374	135	145	206	434	84
50 enforced	1,040	473	168	399	260	465	-194
45 enforced	1,535	559	191	785	308	496	-597
40 enforced	2,217	612	203	1,402	338	517	-1,223

Note: These figures do not always check exactly because of rounding errors.

Table 9.9 How travel costs on single carriageway 'A' roads vary with the speed limit, assuming constant flows and taking account of taxation: differences from the present situation

Units: £m

Speed limit (mph)	Extra travel time cost	Saving in fuel cost	Saving in non-fuel cost	Total extra cost	Loss to Inland Revenue	Saving in accident costs	Net gain
			All vehicles				
60 enforced	74	28	11	35	16	95	44
55 enforced	103	40	13	50	23	152	79
50 enforced	243	72	27	144	40	417	233
45 enforced	425	99	36	290	55	606	261
40 enforced	1,008	147	43	818	82	758	-142
35 enforced	1,794	160	33	1,601	90	910	-781
30 enforced	3,299	110	-9	3,199	62	1,061	-2,200
25 enforced	5,404	-30	-163	5,597	-15	1,213	-4,370

Note: These figures do not always check exactly because of rounding errors.

9.3 Calculations allowing for reduced travel

The penalties to drivers and operators from lower and better enforced speed limits have so far been calculated on the assumption that road users would make the same journeys as at present but would take longer to do so. This assumption simplifies the calculation of the penalties but it is unrealistic. Some people would respond to lower speeds by changing their travel behaviour. The problem is how to calculate the penalty to the people who choose that response.

It is clear that the penalty to people who choose to travel less – or at least the penalty as they perceive it, since they may not be fully aware of how their costs vary with speed – must be lower than the perceived penalty they would have incurred if they had simply accepted the longer journey times, since that option was open to them and they chose not to take it. In calculating how much lower, we have used the 'rule of half' procedure described in Chapter 8, but with one important variation. In Chapter 8, journeys were used as the unit of demand, but the calculations in this chapter are based on vehicle kilometres. It would be preferable to take journeys as the unit since they relate better to the reasons for travel. People travel in order to arrive at a destination which contains some attraction not available to them at the place where their journey starts; they do not consume vehicle kilometres for their own sake. In the time available, however, we were not able to devise a satisfactory method based on journeys.

The calculations make use of the familiar economic concept of the price elasticity of demand. If the price elasticity of demand for a product is one, then an increase of x per cent in the price of the product would lead to a decrease of x per cent in the amount sold or consumed. If the elasticity is 0.5, then an increase of x per cent in the price of the product would lead to a decrease in the amount sold or consumed of 0.5x per cent, and so on. In this case, when the 'product' in demand is vehicle kilometres, the concept of price has to be elaborated. It has to take account of all the costs which people take into account in making their travel choices; in particular, it has to take account of time as well as the direct money costs of travel.

It is very hard to know exactly what costs people do take into account in making their travel decisions. The Department of Transport's COBA manual suggests that when vehicles are used for business purposes, drivers or operators take account of all the costs included in the calculations shown so far in this chapter, travel time, fuel and other vehicle operating costs, but that when cars are used for non-work purposes, motorists take account only of time costs and fuel costs.[3]

The suggestion that motorists' behaviour varies in this way between work and non-work trips is not plausible. If anything, people driving for their own purposes, especially if they are driving their own cars rather than a company car, are likely to be much more careful about all the costs involved than people driving on their employers' business. No distinction has therefore been made in our calculations between car travel for work and for other purposes. (The National Travel Survey shows that work journeys accounted for less than 12 per cent of car mileage in 1991/93, so this distinction, even if it were relevant, is not very important.)

There is some evidence that some motorists base many of their decisions on time alone, to the exclusion even of fuel costs.[4] To cover all the possibilities, three sets of calculations were made on different assumptions about what costs motorists would take into account when deciding whether to modify their travel behaviour in response to being forced to drive more slowly: all three elements of cost; only travel time and fuel; only travel time.

For vehicles other than cars, it has been assumed that drivers or operators would always take account of all three elements of cost. Although this is an implausible assumption, especially with respect to the smaller haulage firms, its effect is to bias the calculations against the case for lower speed limits. This can be seen from Appendix H, which sets out the formulae for the calculation of the gains and losses of imposing a new speed limit and gives some worked examples. This appendix shows that the fewer the costs that drivers perceive, the greater the net gain (or the smaller the net loss) to them of reducing their travel when forced to drive more slowly. Among the reasons is the fact that if drivers do not perceive those elements of their costs which go down with speed, they experience an unexpected saving by driving less, and this saving is credited to them in full rather than being subject to the rule of half.

If flows are reduced, accidents will also be reduced. It has been assumed that the reduction in accidents will be in direct proportion to the reduction in flows, so that if flows were reduced by x per cent following the imposition of a new speed limit, accident costs would be x per cent lower than were calculated for that speed limit under the constant flow hypothesis.

The calculations based on the assumption that motorists perceive all their costs gave rise to predictions about the effect of lower speed limits on traffic volumes which cannot be reconciled with the evidence cited in Chapter 8. For example, if the speed limit on motorways was reduced to 55 mph and that limit was enforced, the average speed of cars on motorways, which is now a little over 70 mph, would fall by more than 15 mph. This would certainly result in a substantial reduction in car mileage, but the calculations which assume that motorists perceive all their costs show comparatively little reduction in mileage even with high elasticities. The reason is apparent from Table 9.6. With a 55 mph speed limit, travel time costs would increase by 26 per cent but, because fuel costs and other costs would fall substantially, total costs would rise by less than two per cent.

Because of these results, and of the Department of Transport's independent findings about what costs most motorists perceive, it was decided not to proceed further with the calculations based on the assumption that motorists would take account of all their costs when deciding how to respond to lower speed limits.

In order to make the calculations, it is necessary to decide not only what costs to include but also what elasticities to use. This question has been approached in the following way. The calculations in the last section showed that under the constant flow hypothesis, in other words when elasticities are zero, the apparent optimal speed limit for motorways is 65 mph, for dual carriageway 'A' roads 60 mph, and for single carriageway 'A' roads 45 mph. (The word 'apparent' is used as a reminder that the calculations relate only to intervals of 5 mph; if they could be performed with finer data, some intermediate speed limit might turn out to be optimal.) For motorways, calculations have been made to answer the question: what is the minimum elasticity required for the apparent optimal speed limit to fall to 60 mph, 55 mph, and so on? Similarly, for dual carriageways and single carriageways the calculations answer the question: what are the minimum elasticities required for the apparent optimal speed limit to fall by 5 mph, 10 mph, and so on?

It was found that the model could answer these questions only over a certain range. For certain combinations of large cost reductions and high elasticities, it gives results which are clearly not credible. In particular, it sometimes suggests that the optimal speed limit would be very low indeed. The reason why the model can produce such a result is easy to understand. If the elasticity is very high, this is another way of saying that the importance people attach to their travel is very small. It would therefore be better if they saved themselves the time and money, and society the accidents, by refraining from travelling. But in reality, some travel is very important. The mistake is to assume, as anyone who tried to use the model over too wide a range of circumstances would be assuming, that the demand curve for travel can still be represented by a straight line even when the increases in cost are very large.

Table 9.10 shows the minimum elasticities required to bring about the specified changes in the apparent optimal speed limits. It should be emphasised that where it is said that the model is not suited to assess a certain change in the apparent optimal speed limit, this does not necessarily mean that the speed limit in question is too low to be optimal. It may only mean that a more refined model and/or better data are needed to assess the merits of that limit.

For each elasticity required to bring about a fall in the apparent optimal speed limit, Table 9.9 also shows another number, the index of the increase in travel time for cars. This has been included as an indication of whether the elasticity required, and hence the new apparent optimal speed limit itself, should be regarded as reasonable. In Chapter 8, it was reported that SACTRA had concluded that when speeds increase, it is likely that somewhere between half and all the travel time saved will be used for additional travel. If the converse is true, then when speeds fall, people will reduce their travel so as to avoid the greater part of the time penalty that they would incur if they did not reduce it. The index of the increase in travel time for cars is the increase in vehicle hours on the network, as compared with the present situation, that would occur once people had reduced their travel to the extent indicated by the elasticity assumption, expressed as a percentage of the increase in vehicle hours that would occur if there were no reduction in travel. (The calculations shown in Appendices H and K help to explain this.) If the converse to the SACTRA finding holds, the value of the index should be between 50 per cent and zero. If the value of the index is greater than 50 per cent, the corresponding elasticity value should be regarded as conservative and the apparent optimal speed limit as probably erring on the high side.

If it is assumed that motorists would take account only of time and fuel costs when deciding how to react to lower speeds, Table 9.10 suggests that the apparent optimal speed limit on motorways should be no higher than 60 mph and that 55 mph is a strong contender. For dual

Table 9.10 Minimum elasticities required to produce changes in the apparent optimal speed limit

	Costs perceived by motorists			
	Travel time and fuel		Travel time only	
Apparent optimal speed limits changes to:	Elasticity	Index of the increase in travel time for cars	Elasticity	Index of the increase in travel time for cars
Motorways				
60mph	1.68	63%	0.30	65%
55mph	2.00	38%	0.45	43%
50mph	*	*	0.61	16%
Dual carriageway 'A' roads				
55mph	1.37	64%	0.27	68%
50mph	*	*	0.50	35%
45mph	*	*	0.56	20%
40mph	*	*	0.61	2%
Single carriageway 'A' roads				
40mph	1.33	11%	0.61	30%
35mph	*	*	0.71	12%

* Model not suitable to assess this change.

Notes:

1. For the explanation of the index of the increase in travel time for cars, see the text.
2. For more detail of these calculations, see Appendix K.

carriageway 'A' roads, the apparent optimal speed limit should probably be no higher than 55 mph and for single carriageway 'A' roads the possibility that it should be as low as 40 mph cannot be dismissed. If motorists took account of time costs alone in deciding how to react, then it seems that apparent optimal speed limits as low as 50 mph for motorways, 40 mph for dual carriageway 'A' roads and 35 mph for single carriageway 'A' roads are all possible. However, these findings must be looked at in the light of the various approximations and assumptions on which the calculations rest.

9.4 Discussion

There are a number of ways, some of which have already been mentioned, in which the calculations described above are biased against lower speed limits.

It has been seen that the estimates of the costs of the accidents that now occur on roads of each class still probably err on the low side, even after having been adjusted to allow for under-reporting of accident numbers and for the Department of Transport's low values for casualties. The calculations of the savings in accident costs arising from lower speeds did not take account of the fact that the more severe accidents, to which much higher values are given than to slight ones, would experience the largest falls. In addition, the estimates of the likely reductions in accident numbers were based on studies of situations where compliance with the speed limits was imperfect. Consequently, the variations about the average speed, and hence the accident rates, must have been higher than they would have been if the limits had been strictly enforced. No allowance has been made for a psychological effect, which might be important, that if speed limits were strictly enforced, especially if they were enforced through the vehicle, that might lead to a more relaxed and a less competitive and aggressive style of driving, with more consideration shown to other road users. Finally, the assumption in Section 9.3 that if flows were reduced, accidents would be reduced in the same proportion, is almost certainly too modest, since the lower density of traffic should reduce the number of conflict situations to which each vehicle is exposed.

The evaluation of travel time losses was based on the 'rule of half' procedure which, as was seen in Chapter 8, rests on quite unrealistic other-things-being-equal assumptions. In effect, it assumes that neither the land-use pattern nor the competing transport systems would adapt in any way to the changed conditions, whereas both are very adaptable. Another implicit assumption is that the only reason why people drive at high speeds is the rational one of saving time. Some may do so unwillingly, because of pressure from other road users or from their own passengers. Some seem to have an internal compulsion to drive at about the speed limit or a little faster, whether or not they can put any time saved to good use. Others enjoy the speed for its own sake or to show off.

The calculations probably also overstate the extent to which lower speed limits would in fact increase journey times. No allowance has been made for the fact that if speeds were reduced, the time losses would

be partly offset by a narrowing of the gaps between vehicles. (It might be better to preserve large gaps so as to reduce accidents and driver stress rather than to save time, but at present there is no way of making drivers keep a set distance from the vehicle in front.) Also, in congested conditions lower and more uniform speeds can actually lead to time being saved, because they reduce the likelihood of an incident occurring of a kind which disrupts the smooth flow of traffic and leads to stop-start conditions. These points are discussed in Appendix J. Accidents also lead to serious traffic delays, but no allowance has been made for the time savings that would follow from a reduction in accidents.

The assumption that users of vehicles other than cars base their decisions on all their operating costs and correctly perceive the way in which these costs vary with speed is implausible. Some of them probably behave more like motorists in giving disproportionate importance to travel time. A calculation which took that into account would produce a lower estimate of the optimal speed limit. The assumption that these people would spend all the money they save by driving at lower speeds, or by reducing their mileage, on untaxed goods also biases the calculation to the maximum possible extent against the case for lower speeds. If only some of the money saved were spent on goods which attract VAT at the standard rate, the losses to the Inland Revenue from lower speeds would be reduced and so the estimate of the optimal speed limit would be lower.

The calculations take no account of noise or air pollution, nor of the need to conserve fuel as a non-renewable resource, except in so far as that is reflected in the price demanded by the oil-producing countries. Fuel consumption and the emission of noise and fumes are generally minimised when a vehicle is moving at the lowest speed at which it can comfortably be driven in top gear. This speed varies from vehicle to vehicle. It is always likely to be under 40 mph, so let it be assumed that it is 40 mph, so as not to overstate the case for lower speed limits. The optimal speed limit when these considerations are included must, on this assumption, be somewhere between 40 mph and whatever speed limit is optimal when these considerations are excluded. Thus, if the optimal speed limit on motorways ignoring these considerations were 55 mph, which the calculations in Section 9.3 suggest may well be the case, then the true optimal speed limit would be somewhere between 40 mph and 55 mph.

Another way of allowing for the missing considerations is to assume that their importance is reflected in fuel tax. In that case, it would no longer be correct to include the loss to the Inland Revenue in the cost-benefit calculation. (This loss would still exist, of course, and it would still represent reduced consumption somewhere in the economy, but it would be balanced by the environmental gains.) Table 9.11 is addressed to the same question as Table 9.10 – what would the elasticity of demand have to be in order for the apparent optimal speed limit with zero elasticity to fall by five mph, ten mph etc? – but without allowing for the loss to the Inland Revenue. The table suggests that, on the assumption that motorists base their decisions on time costs and fuel costs, the motorway speed limit should be no higher than 55 mph, while 50 mph is a serious contender. For dual carriageway 'A' roads, on the same assumption, a speed limit of 50 mph, 45 mph or even possibly 40 mph might be appropriate, and for single carriageway 'A' roads a speed limit of 40 mph becomes a possibility. If it is assumed that motorists take account only of time costs, a case can be made for lower limits still.

The calculations have treated the traffic on each class of road separately, but that is not altogether realistic. It has been known for many years that some drivers avoid motorways, even though they are safer than other roads. It seems that among the reasons are the high speeds and the difficulty and stress of joining a motorway.[5] If both these deterrents were reduced by lower and better enforced speed limits, more people might use motorways when to do so would save them time or money. In addition to these gains to the drivers concerned, there should be benefits to others in reduced accidents, intimidation and pollution, and possibly reduced congestion as well.

Most driving is done on roads with speed limits lower than the 70 mph national limit, but vehicle design is heavily influenced by motorway requirements. The consequence is that vehicles are over-designed, in terms of top speed and acceleration, for most of the work they do. They therefore create more danger, burn more fuel and cause more pollution on urban roads and on rural roads with speed limits of less than 70 mph than they would if they were designed for use on those roads. If the difference between speed limits on motorways and those on other roads were reduced by lowering the limit on motorways, and if manufacturers then designed vehicles to suit the new speed limits for motorways (this might require legislation), that would have a significant effect on reducing the cost, in the widest sense of that term, of vehicle miles driven on other roads.

Table 9.11 Minimum elasticities required to produce changes in the apparent optimal speed limit, assuming losses to the Inland Revenue can be disregarded

	Costs perceived by motorists			
	Travel time and fuel		Travel time only	
Apparent optimal speed limits changes to:	Elasticity	Index of the increase in travel time for cars	Elasticity	Index of the increase in travel time for cars
		Motorways		
60mph	0.49	89%	0.10	88%
55mph	1.02	68%	0.26	67%
50mph	1.39	42%	0.42	42%
45mph	*	*	0.51	22%
40mph	*	*	0.55	6%
		Dual carriageway 'A' roads		
55mph	0.48	87%	0.11	87%
50mph	1.24	54%	0.34	56%
45mph	1.33	35%	0.42	40%
40mph	1.37	14%	0.49	21%
		Single carriageway 'A' roads		
40mph	1.00	33%	0.49	44%
35mph	*	*	0.61	24%

* Model not suitable to assess this change.

Note: For the explanation of the index of the increase in travel time for cars, see the text.

Although it is not easy to identify them, it is possible that some of the assumptions underlying these calculations exaggerate the case for lower speed limits. The formulae, taken from the COBA manual, used to calculate fuel and non-fuel items of vehicle operating costs are obviously very approximate. There is only one formula for all types of car and, perhaps even more implausibly, only one for all types of heavy goods vehicle. The extreme simplicity of each formula suggests that it is unlikely to give very precise results even for the make and model of vehicle which it represents best. The fact that the formulae are approximate does not necessarily mean that they are biased in either direction, but they may be. In particular, it may be that they do not fully reflect the increases in vehicle efficiency which have taken place over the years, in which case there would be a bias in favour of lower speed limits.

It is possible that the strict enforcement of the existing speed limits, or perhaps of slightly lower limits, such as a 65 mph limit for motorways, would have such a large effect on reducing accidents that there would be little extra to be gained from lowering the limits further. This seems to be the only way in which the treatment of accident costs in the calculations might be biased towards lower speed limits.

There may be some roads, motorways in particular, on which the average value of travel time is higher than the average value of travel time on the road network as a whole. Any underestimation of time values would give rise to a bias in favour of lower speed limits.

9.5 Studies in other countries bearing on the calculation of an optimal speed limit

The only attempt we have come across to calculate optimal speed limits in the way suggested here was in Finland in the 1970s.[6] The Finnish study, which was briefly described at an OECD conference in 1981, was indeed a principal inspiration for this one.

Extensive experiments with different speed limits were undertaken in Finland in the 1960s and 1970s. The data for the study on optimal speed limits came mostly from the experiments conducted in the period 1973-76. The factors taken into account in calculating the optima were the same as those in this study: travel time, fuel and other items of vehicle operating costs (shown as a single combined cost in the report) and accidents. The optimal speed limits calculated for each class of road were: motorways, 100 km/h; trunk roads in southern Finland, 78 km/h; trunk roads in northern Finland, 83 km/h; other highways in southern Finland, 70 km/h; other highways in northern Finland, also 70 km/h.

There are a number of points to be borne in mind in interpreting these results. Vehicle operating costs excluded taxation and the calculations rested on a constant flow hypothesis, with no account taken of the effect that reducing speeds would have on depressing traffic volumes. So the calculations corresponded to those in Section 9.1 above, which give rise to substantially higher estimates of the optimal speed limit than those in Section 9.3. Presumably, therefore, if the

Finnish study had allowed for taxation and for some connection between speed and vehicle kilometres, it would have arrived at lower estimates of optimal speed limits.

The money values attached to accidents by the Finnish authorities in the 1970s, though higher than those used in other countries at that time, were probably lower in real terms than those now officially recommended by the British Department of Transport, which in turn are lower than those used in the calculations in this chapter.[7] The value of travel time was taken in the Finnish study to be 51 per cent of the average wage for a male worker,[8] whereas the British value of time for a car occupant, used in this study, is on average 47 per cent of the wage of a male worker.[9]

The Finnish calculations, like those in Sections 9.1 to 9.3 of this report, took no account of the need to preserve fuel as a non-renewable resource, nor of air pollution, noise and driver stress. Clearly the estimates of optimal speed would have been lower if it had been possible to include these considerations. All in all, therefore, the results of the Finnish studies strongly support the case for lower speed limits.

The 55 mph speed limit was imposed in the United States in 1973 in order to save fuel but it was retained because it saved lives. Although the various effects of this measure were extensively studied, the decision in 1987 to allow states to raise the limits to 65 mph was not taken on the basis of a comprehensive cost-benefit analysis. The chief reason for the decision seems to have been the growing difficulty of enforcing the lower limit. Although we have not come across any American studies of what speed limits would be optimal, there have been studies of whether the effects of the 55 mph limit justified its imposition and also of whether the benefits of raising the limit to 65 mph, as most states have now done, outweighed the costs.

One study of the effects of imposing the 55 mph speed limit attempted to distinguish between inter-state highways and the other rural roads concerned. It concluded that the 55 mph limit had probably been beneficial on the other roads but, unless unusually low values of time and high values of accidents were adopted, not on the interstate highways.[10]

A study of the effects of raising the limit from 55 mph to 65 mph compared the travel time savings gained by raising the limit with time lost through an increase in the number of accidents.[11] This time consisted either of the amount by which lives were shortened, in the case of fatalities, or loss of days of normal functioning, in the case of a non-fatal injury. It was concluded that unless time lost because of accidents was discounted at a rate of four per cent or more,[12] more time had been lost by raising the speed limit than had been saved. It was further argued that an hour of travel time saved should not count as highly as an hour of life lost, and that, on grounds of equity, a certain number of lost or wasted hours spread over a large population should be considered less important than the same number of lost or wasted hours borne by a few people. This study also considered the direct money costs and savings of the change from the 55 mph to the 65 mph speed limit and concluded that they were roughly equal.

Both these American studies were structured in a way which, according to the arguments given earlier in this report, understated the case for lower speed limits. Both rested on the constant flow hypothesis, which overstates the penalty to road users of a low speed limit. Both evaluated fuel consumption in terms of pre-tax prices and made no attempt to take account of the benefits to society of conserving a non-renewable resource nor of reducing air pollution and noise. Neither took account of driver stress or fatigue from driving at high speeds, nor of the distress and disruption, of the kinds discussed in Chapter 4, which a road accident can cause to people other than the victims themselves.

Even if the American experience allowed firm conclusions to be drawn about the right speed limits for the United States, it would not be possible to transfer those conclusions to Britain with its different conditions. But the American and Finnish studies, which are both based on experience of lower speeds, not just on modelling, both lend credence to the idea that the optimal speed limits on main roads outside towns in Britain might be much lower than the present speed limits.

9.6 Further work required

It is clear that speed limits on major roads outside towns should be lower than at present, but more work is now needed to establish the right levels.

The model used to make the calculations in this chapter is well suited to explore the issues further, but it should first be refined. In its present form it can only examine speed limits at five mph intervals. The reason it was constructed in this way is that the Department of Transport publishes the results of its speed surveys as distributions with intervals of five mph. But the data can be made available in intervals of one mph,

which would be more suitable. The reason is not that one would then be able to make estimates of optimal speed limits which would be accurate to one mph; the model is still too approximate, even apart from the important considerations which it omits entirely, for that to be possible. But if the data were less aggregated, that would reduce any risk of minor distortions due to the 'lumpiness' of the input. The Department of Transport's speed surveys are conducted annually, and any further work should, of course, be based on the most recent possible data.

One immediate use for the refined model might be to try out different speed limits for different classes of vehicle. One possibility is to set a higher speed limit (even though not as high as the present limit) for coaches than for cars. In the short term, the justification of this would be that both the accident rate and the fuel consumption rate, per passenger kilometre, are lower for coaches than for cars. In the longer term, increasing the relative attractiveness of public transport vis-à-vis cars for long journeys should have a beneficial effect on car ownership. Some people, especially residents of large cities, might decide to give up cars altogether. Others might decide that the right strategy for them would be to own a car designed for local use and to hire a conventional car or to use public transport, perhaps combined with car hire, for their longer journeys. Even if the theoretical case for a higher limit for coaches than for cars can be established, however, it is not clear that this would be operationally feasible on the roads. Trials would be required to explore the practical possibilities.

Other uses of the model require better data, on the costs of road transport at present, on the relationship between speed and each of these costs, and on the way in which reductions in the speed limit might affect travel behaviour.

To refine the estimate of what accidents cost at present, more accurate statistics are needed both for injury accidents and damage-only accidents. The way that such information might be provided is discussed in Appendix B. More accurate costing will also require more work on evaluation. It was pointed out in Chapter 4 that the various ways in which an accident disrupts the lives of those affected are not allowed for at present. Ideally, a sample of accidents should be taken and the victims, their relatives, employers and others connected with them should be followed up to see what adjustments they have had to make and what was involved in distress, strain, time, activities forgone and expenses. This would be very difficult and delicate work but with the right interviewers it should be possible. At a more mundane level, the delays imposed on other road users when an accident occurs should be quantified.

The monetary evaluation of travel time also needs to be refined. As part of this, psychological studies are needed to explore the reasons why people choose to drive at their present speeds. To what extent are their choices governed by the desire to save travel time, as economists assume, and to what extent by pressure from other road users, a liking for speed for its own sake, competitive considerations, the desire to show off and other less rational motivations? The same studies could be used to throw light on the stress which people feel when driving on high-speed roads and the other things they dislike about them.

It would be desirable to put money values on some of the other social costs of transport so that they too can be included in the formal calculations of optimal speed limits. To assign money values to noise nuisance and to the more immediate effects of air pollution is no more contentious in theory and rather less slippery in practice than to assign them to travel time and casualties. The research required for noise was discussed in Chapter 6.

Trials are needed to show the effects of different speed limits, each strictly enforced, on roads of different kinds. The effects to be studied would include accident rates, by severity, noise levels and air quality alongside the road, and possibly also travel times and stress. The trials would have to be maintained for a long period, perhaps a year, over stretches of road each several miles in length. The calculations earlier in this chapter suggest that for motorways the speed limits to be tried out should vary between 65 mph and 45 mph, for dual carriageway 'A' roads between 60 mph and 40 mph and for single carriageway 'A' roads between 45 mph and 35 mph. But in order to carry conviction with the public, and also to check on the accident reduction ratios used in the calculations, the trials should also cover higher speed limits, up to and including the present ones. For the time being, the speed limits would have to be enforced by the police, equipped with speed cameras, even though in the longer term enforcement through the vehicle makes better sense.

It is clearly desirable to update and refine the very approximate formulae used to relate fuel and non-fuel items of vehicle operating cost to speed. This work would have to take account of developments in vehicle design which are already taking place and of those which could be induced by policy. There is already a strong move towards designing

more fuel-efficient vehicles; this is likely to continue, especially if the policy of raising fuel tax, to which the Government is committed until the year 2000, is continued beyond that date. Even if the national 70 mph speed limit were retained, it seems self-evident that Construction and Use regulations should be introduced which would preclude vehicles capable of exceeding that limit by more than a small amount. If a lower national limit were set, the regulations should again ensure that vehicles were designed in such a way that the new limit, whatever it might be, could not be broken. In order to make more precise calculations of where the limit should be set, we therefore need separate formulae for vehicles designed to fit different national speed limits between 45 mph and 70 mph.

The vital question of what the time penalty of lower speed limits would actually be should be studied in a variety of ways. The Transport Research Laboratory already has a microsimulation model for traffic on motorways and the immediately adjacent sections of the road network. This would allow much more accurate estimates of the time penalties associated with lower speeds to be made than were fed into the calculations of this chapter. The trials recommended above, and the experiments now taking place with 50 mph and 60 mph speed limits on congested sections of the M25, should allow the TRL's model to be further developed. In addition to modelling, some simple trials with different drivers driving over the same routes at different speeds might be illuminating. According to one account,[13] experiments of this kind in the late 1960s and early 1970s showed that drivers driving as fast as possible within the speed limits took only a few minutes less over very long journeys than others driving in a much more sedate and leisurely fashion.

It has been seen that the calculation of the optimal speed limit gives very different results if different assumptions are made about what considerations influence travel decisions, in particular decisions connected with journey length. It is therefore very important to gain a better understanding of this point, which well designed market research should be able to provide. Car owners could be confronted with hypothetical but realistic choice situations and be asked to explore in discussions how they would make their decisions. For example, they could be asked to imagine that they were contemplating a winter break in a country pub. Descriptions of several pubs would be provided, of the kind one would expect to find in a brochure. The pubs would be similar in price and quality, but they would be at different distances from the respondent's home and therefore in different countrysides. The interview should bring out the importance of journey considerations vis-à-vis the attractiveness of the destination, and also how travel time and the various elements of travel cost rate against each other. Market research among hauliers might not have to rely on constructing hypothetical situations. Instead, the interviewer could observe and talk through with the haulier how he responded to and costed the real inquiries which he received over a given period.

Similar forms of market research might throw light on how people would adapt their travel behaviour if faced with a permanent reduction in speed limits. This is more difficult, however, both because it requires more imagination on the part of the respondent, and because the transport system, and therefore the options available to each individual traveller, would change in a way which is hard to predict. For example, take a family living in London who drive most weekends to a country cottage in the West Country. If the speed limit were very much reduced, they might decide to go by train instead, perhaps not quite so often, and to keep a car, perhaps a local runabout (see Chapter 11), at the country station. The attractiveness of this option would partly depend on how the rail system adapted to the more favourable situation created by lower speed limits on the road. But difficult though it would be, such exploratory market research should be well worthwhile.

9.7 Conclusions

It would be surprising if the present British speed limits were optimal, since they were not arrived at by a cost-benefit calculation or any other kind of rational assessment. The calculations in this chapter strongly suggest that the limits should be lower. It has not been possible to calculate precisely what they should be, but a range within which the limit for each class of road should be sought has been established.

There are three principal reasons why we incline to the view that the limits should be towards the bottom end of each range. The first is that we believe that the environmental and ecological effects which are not included in the calculations, but which, if they could be included, would produce lower estimates of the optimal speed limit, are very important. Secondly, although the calculations in this chapter of the loss to travellers, if they decided to reduce their road travel in response to lower speeds, rely on conventional economic theory based on the 'rule of half', the assumptions underlying this rule are invalid. We do not

believe that the great increase in travel, particularly in the length of journeys, both for people and goods, that has taken place over the years, in large part because of increases in speed, has been as valuable as the 'rule of half' would suggest. In fact, when all the consequences, environmental and social as well as economic, of longer travel are taken into account, it seems doubtful whether this trend has been desirable at all. If lower speeds now led to some reversal of the trend, and to more people seeking to satisfy their journey purposes locally, the benefits to travellers might well outweigh the losses, even without taking account of the environmental gains from reduced vehicle mileage. Thirdly, as was pointed out in Section 9.4, it is very desirable that the gap between the national speed limit and the urban speed limit should not be too large, so that vehicles designed with motorway use in mind should not consume too much fuel, or give rise to unnecessary noise, pollution and danger, when driven in towns or on minor rural roads.

No government could be expected to make a final decision about what the speed limits on main roads outside towns should be simply on the basis of the calculations and arguments in this chapter. That would be neither rational nor politically possible. The trials described in Section 9.6 will first have to be carried out, and much public discussion will also be necessary. But even though the precise limits cannot yet be determined, the arguments that they should be lower than at present are strong enough to count as proof. The Government should announce that it accepts these arguments, and that it will be pressing on with the work required to set precise limits as fast as possible. Such an announcement would be helpful to the motor trade and also to anyone, whether a firm or private individual, contemplating a major locational change such as moving house. It is important that such plans should not be based on the assumption that present speed limits will continue indefinitely.

The arguments for a lower limit on single carriageway 'A' roads are especially strong. We believe that there is a good case for immediately lowering the speed limit on these roads to 50 mph as an interim measure while further work is done to determine the final figure. But to do so before the automatic means of enforcement discussed in Chapter 11 have been introduced could be counterproductive unless the police were able to devote more resources to enforcing speed limits on these roads. We therefore recommend that the Department of Transport should discuss the question of resources with the Home Office and the police, and that, if the discussions are favourable, the 50 mph speed limit should be introduced as soon as possible.

Notes and references

1. Table 2.4 of *Transport Statistics Great Britain 1994* shows that in April 1993 VAT and fuel duty together accounted for 71 per cent of the pump price of four star leaded petrol and for 66 per cent of the pump price of unleaded petrol.
2. Table 2.3 of *Transport Statistics Great Britain 1993* shows that in April 1993 the pump price of derv was 49.3 pence per litre of which VAT accounted for 7.3 pence and fuel tax for 25.1 pence.
3. Department of Transport (1981) *COBA 9 Manual*, para 1.7.2.
4. Telephone conversation with the Department of Transport, 8 August 1994.
5. Telephone conversation with the TRL, 8 February 1995.
6. This research is described in M Salusjärvi (1981) *The speed limit experiments on public roads in Finland.* Technical Research Centre of Finland, Publications 7/1981, Sections 6.4.2 and 6.4.3.
7. Table VI.1 of the 1981 OECD publication *Methods for evaluating road safety measures* shows that in 1976 a fatality and a fatal accident were both valued 3.43 times as highly in Finland as in Britain and an injury was valued 4.46 times as highly. However, according to the British Department of Transport, the changes made in the methods of evaluating accidents since the 1970s mean that the values now recommended in Britain are higher in real terms than those used then by a factor of 3.65 for fatal accidents, 5.34 for serious accidents and 4.17 for slight accidents.
8. Personal communication from Technical Research Centre of Finland, September 1995. In the report mentioned in reference 6, a figure of 55 per cent is given, but this is for male industrial workers, as distinct from all male employees.
9. The average value of time for the occupant of a car can be calculated from the Department of Transport's *Highway Economics Note No.2* (1989) as 266.537 pence per hour at 1988 prices, which updated to 1993 prices comes to 394.48 pence per hour. The average annual wage for an employed male in 1993 is given in the August 1994 edition of the *Employment Gazette* as £8.4 per hour.
10. D B Kamerud (1988) 'Benefits and Costs of the 55 mph Speed Limit: New Estimates and their Implications', *Journal of Policy Analysis and Management*, Vol.7 No.2
11. T R Miller (1989) *65 mph: Does It Save Time?* Association for the Advancement of Automobile Medicine 33rd Annual Proceedings. Baltimore, 2-4 October 1989.

12. Mr Miller argues that years of lost life should be discounted since they lie in the future whereas travel time savings are in the present. This depends on one's view of the justification of discounting. In our view, the only valid reason for a public authority to discount the future is its inherent uncertainty. But the actuarial calculation of the years of life lost because of fatal or serious injuries on the roads is very exact. The only uncertainty would seem to be the possibility of a disaster such as a nuclear war or global epidemic which might cut short the lives of those people who were spared from death on the road by a road safety measure such as a lower speed limit.
13. This information was obtained in an interview with an official in the Department of Transport in 1972. We have not been able to verify it nor to trace the ultimate source during this study.

10

Speed limits in towns

The problem in towns, as outside them, is to find the speed limits which, if properly enforced, would strike the right balance between the time penalties of lower speeds and the gains in road safety, reduced fuel consumption and reduced pollution that they would bring. In one way the assessment is easier for towns, since it is less likely that increases in travel time would affect the origins and destinations of journeys. But in most respects it is harder. As will be explained below, it is very difficult to know what time penalties would actually be incurred if vehicles moved more slowly. The reduction in the non-accident costs of unsafe roads is much more important in towns than on main roads outside towns, but this effect is difficult both to predict and to evaluate. The effect of lower speeds on fuel consumption, air pollution and noise cannot be determined with precision.

Because of these difficulties, the formal calculations in this chapter are confined to time penalties and accident savings. Other effects of lower speeds have to be taken into account by judgement, but there is little doubt that at least in aggregate, if not in each individual case, they would be positive. Since also, as will be seen, the method of calculating the time penalties exaggerates them, it is likely that the calculations substantially understate the case for lower urban speed limits.

10.1 Time penalties

The time penalties from enforcing lower speed limits in towns were estimated with data from one of the Department of Transport's urban speed surveys, the one carried out in Norwich in 1993. In these surveys, the main road network of a town is divided into a number of routes, each of which is made up of a number of road sections. Each route is then driven over, at different times of day, by a specially equipped car

whose driver attempts to keep to the prevailing speed. The distance covered every two seconds is recorded to the nearest thousandth of a mile. Hence the speed at which the vehicle was travelling in each two-second interval can easily be calculated.

The extra time that would be required to drive the distance covered in any given two-second interval can then be calculated according to the method of the following example. Suppose that the observer's car was driving on a section of road with a 30 mph speed limit and that in a given two-second interval it travelled 0.015 miles. It was therefore moving at 27 mph. Although the speed limit is not now properly enforced, over this small length of road drivers were in fact complying with it, at least at that particular time of day, so no adjustment to their behaviour would have been necessary, and no time penalty would have been incurred, even if the 30 mph speed limit had been enforced. But if the speed limit had been reduced to 25 mph, and that speed limit had been enforced, it would have taken each vehicle 2.16 seconds to drive 0.015 miles, and with a well enforced 20 mph speed limit it would have taken 2.7 seconds.

By repeating similar calculations, the extra time required for each vehicle to traverse each section of road can be calculated. Since the hourly flow of vehicles on each section of road is also known from traffic counts which accompanied the speed survey, the time penalties arising from the enforcement of any given speed limit can be calculated both in terms of vehicle hours and in terms of seconds per vehicle kilometre.

These calculations, though simple, are too lengthy to be shown in full in this report. But Appendix L contains a worked example for one section of road in Norwich at one time of day. It also shows how the results for different sections of road and times of day were combined to calculate the time penalties that would have arisen from enforcing either a 25 mph, a 20 mph or a 15 mph speed limit throughout a 12-hour day (7 am to 7 pm) on roads in Norwich where the existing speed limit was either 30 mph or 40 mph. Table 10.1 shows the results of this calculation.

It should be noted that the increases shown in this table are not increases compared with the present situation of unenforced 30 mph or 40 mph speed limits. They represent increases over what the travel times would have been if the existing limits had been observed. It does not, in fact, make a great deal of difference which base is chosen, as can be seen from Appendix K. But the calculation of the time penalties

Table 10.1 The additional time that would have been required to drive the mileage driven in Norwich between 7 am and 7 pm on a typical weekday in 1993 on roads now subject either to a 30 mph or to a 40 mph speed limit if lower limits had been enforced

New speed limit	Increase in seconds per vehicle kilometre	% increase
25 mph	13	10.8
20 mph	31	25.7
15 mph	64	53.1

arising from lower and better enforced speed limits should not include time savings which people obtain by breaking the present laws.

The figures in Table 10.1 are certainly too high. They do not take account of the fact that very often when vehicles travel at relatively high speeds in towns they gain nothing from it. Especially in congested conditions, speeding between junctions often leads only to a longer wait at the next junction. Conversely, if people drove more slowly between junctions, they would have less time to wait at the next one. But the method of calculation assumes that any reduction in speed would always give rise to longer travel times.

Sometimes to travel at a relatively high speed does indeed produce a time saving for the driver concerned by allowing him to overtake other vehicles. But in congested conditions this is not a benefit to road users as a whole, since the gain to that driver is cancelled out by losses to others: the order of the vehicles in the queue is changed but the queue is not served any faster.

The calculations also ignore the connection between the speed of the traffic and the capacity of the road network. As with roads outside towns, though for a different reason, the capacity of the network can be increased by a reduction in speed. The capacity of an urban road network is governed by the capacity of the junctions, and the capacity of a junction tends to be higher when vehicles approach it at a low speed than at a higher one.

The importance of these points is borne out by experiments with lower speeds in Växjö, a Swedish town of 70,000 people.[1] The principal aim of these experiments was to reduce casualties to pedestrians and cyclists, especially to children and the elderly, and at the same time to

reduce feelings of unsafety. Since 75 per cent of accidents occur at junctions, special attention was paid to reducing speeds there. Small roundabouts were installed at 20 junctions previously subject to 'give way' regulations and at one which was previously signalised, and four-way stops were introduced at a further 11 junctions. Average speeds on the main roads (the roads which previously had priority) at the junctions where roundabouts were installed decreased by between 11 and 18 km/h and violations of the 50 km/h speed limit were virtually eliminated. Accidents affecting all road users were approximately halved, with larger gains to pedestrians and cyclists. But the travel time penalties were small. Drivers on the main roads experienced some extra delays, but these were almost entirely cancelled out by time savings to drivers entering the junctions from the side roads and to pedestrians and cyclists.

These results were used to simulate the likely effects of introducing similar measures on 111 junctions throughout the town. The simulation showed that there would probably be a small net time saving.

An experiment in west London with a stricter enforcement of the speed limit by means of speed cameras also showed time savings as well as very large accident savings. The time savings have been attributed to a reduction in the delays caused by accidents rather than to any beneficial effect on the capacity of the network, although in the absence of systematic studies the exact reasons must remain uncertain.[2] It should be possible to devise a micro-simulation traffic model which, by modelling the characteristics of each link and junction in detail, would predict with some accuracy the effect that reducing speeds in an urban road network would have on the time taken by a given volume and pattern of traffic. Although no such model now exists in Britain, we have been told of a Swedish one[3] and of a German one.[4] We recommend that such a model be applied in Britain to replace the simplistic calculations behind the figures shown in Table 10.1. If technically possible, the model should include pedestrians and cyclists as well as motor vehicles. If that is not possible, some other way of assessing the consequences for those travellers should be found. Meanwhile, Table 10.1 can be used to make some rough estimates of the extra travel time that would result from enforcing a lower speed limit on all roads in Britain where it is now either 30 mph or 40 mph, and of the money value of that extra time.[5]

The results are shown in Table 10.2. It will be noticed that the total money value of the time penalties has been calculated with and without

Table 10.2 Calculation of the time and cost penalties from enforcing lower speed limits on built-up roads in Great Britain in 1993

	Cars	Motor cycles	Buses	Light vans	HGVs	Total	Total less buses
Bn vehicle kms	151.9	2.3	2.9	15.8	6.7		
Value of time:							
£ per hour	6.95	3.95	47.63	12.73	9.23		
25 mph speed limit enforced							
Time penalty:							
seconds per km	13	13	(13)	13	13		
M. hours	549	8	(10)	57	24		
Value, £m	3,816	32	(476)	726	222	5,272	4,796
20 mph speed limit enforced							
Time penalty:							
seconds per km	31	31	(31)	31	31		
M. hours	1,308	20	(25)	136	58		
Value, £m	9,091	79	(1,191)	1,731	535	12,627	11,436
15 mph speed limit enforced							
Time penalty:							
seconds per km	64	64	(64)	64	64		
M. hours	2,700	41	(52)	281	119		
Value, £m	18,765	162	(2,477)	3,577	1,098	26,079	23,602

Sources: The vehicle kilometre figures are estimated from *Transport Statistics Great Britain 1994*, Table 4.9.[7] The figures for seconds per vehicle per kilometre, come from Table 10.1. For the cost per vehicle per hour, see Appendix E. For motorcycles, the cost per hour has been taken as that for cars divided by 1.76, which is the DoT's estimate of average car occupancy.

the figures for buses. It is likely that the speed of the buses in Norwich, as in other towns, was less than that of the other traffic recorded in the speed survey, so that buses would not have lost as much time as shown in the table. Also, it would be a reasonable policy, if lower speed limits were introduced generally in towns, to allow buses, especially if they were on segregated bus ways or bus lanes, to travel slightly faster.

The travel in billion vehicle kilometres recorded in the table must include some driven on roads other than those with a 30 mph or a 40 mph speed limit. In this way, the table exaggerates the penalties that would arise from reducing the 30 mph and 40 mph speed limits.

However, it must also include travel performed at night, when traffic moves faster than in the day, and when the delays from enforcing a lower speed limit would be correspondingly greater; by ignoring that fact, the calculations underestimate the time penalties. In addition, there are some grounds for thinking that traffic speeds are now lower in Norwich than in most other towns, other than London, in which case extra- polation from Norwich to urban roads generally would underestimate the time penalties.[6] But given the bias in the methods used to produce Table 10.1, it is safe to say that the penalties shown in Table 10.2 err on the high side, probably very substantially. They also take no account of the position of those road users who, the Växjö experiment suggests, should gain from lower speeds: pedestrians, cyclists, and drivers crossing or entering main roads from side roads.

10.2 Accident savings and other benefits from lower speeds

The value of the accidents occurring on built-up roads in Great Britain in 1993 is estimated in Appendix D as £15,510m. This figure allows for accidents on roads with a 20 mph speed limit, which, however, were so few as to make a negligible difference to the estimate, but not for any on roads with a speed limit of over 40 mph. In Section 4.1 it was argued, on the basis of experience with 20 mph zones in Britain and 30 km/h zones on the Continent, that strictly enforced 20 mph zones in towns should reduce accidents by at least 70 per cent. Since low speeds would be especially effective in reducing the number of the more severe accidents, the reduction in terms of value would be still higher, but this point can be ignored for the moment. Seventy per cent of £15,510m is £10,857m, and in Table 10.5 the time penalty of imposing a 20 mph speed limit in towns was estimated at £11,436m, assuming no increased delays to buses. So, according to this calculation, the accident saving from a 20 mph speed limit would be equivalent to 95 per cent of the time penalty. The exaggerations in the estimate of the time penalty are certainly enough to make up the difference.

If there were a straight choice between a 20 mph speed limit and the current 30 or 40 mph limits, this reasoning suggests that the limit should be 20 mph. But it is likely that most of the accident savings could be obtained, and most of the time penalties avoided, if the present speed limits were reduced to some intermediate level, such as 25 mph. In that case, the comparison between the 25 mph and the 20 mph limit would probably not, on this reasoning, be favourable to the 20 mph limit. It then becomes necessary to take account both of the crudities of the calculation and of the factors it omits.

As has been seen, the time penalties to those road users represented in the model are exaggerated, and those road users who are not represented stand to save time rather than to lose it by the enforcement of lower speeds. Nor can the safety benefits be measured only by the reduction in the number and severity of accidents. It was seen in Chapter 4 that the introduction of 20 mph zones in Britain and their equivalent on the Continent has not only reduced accidents but has transformed the way that streets are used. Conditions for walking and cycling have improved and street life generally has flourished, to the very great benefit of the people concerned. As was also mentioned in Chapter 4, the value of the time parents now spend in escorting children has been estimated at between £10 billion and £20 billion annually. Not all these trips can be thought of as unwanted consumption, forced on people by unsafe conditions and the other inadequacies of the transport system, but many of them probably are. These are not the only unwanted escort trips: other people, especially the old, now often have to be escorted, and some of these trips would also become unnecessary in improved conditions. The time and cost savings to the escorts would be substantial. In addition, the elimination of those unwanted escort trips that are now made by car would have a significant effect in relieving congestion, to the benefit of all other road users.

Comparisons between the proportion of journeys made by cycle in towns where cycling is well provided for and in other towns indicate a huge suppressed demand for cycling. A 20 mph speed limit, properly enforced, would go a long way to removing the present deterrents to cycling. There would be gains both to the cyclists who now brave the present unsatisfactory conditions and to the would-be cyclists, now frustrated, who would feel enabled to join them. In addition, once again, to the extent that the increase in cycling came from a transfer from cars, other road users would gain from reduced congestion.

The consequences of a 20 mph speed limit for energy consumption, noise and air pollution are less clear. Much depends on the particular vehicle and also on the driver's style. Sometimes a lower speed, especially if it is not adhered to steadily, but if the driver is constantly accelerating and braking, can make things worse. The Danish experiments with 30 km/h (19 mph) roads showed that they could change noise, fuel consumption and air pollution slightly in either direction.[8] This is a bit of a paradox, however, since the basic laws of physics suggest that both energy consumption and noise emissions should be reduced at low speeds. The reason that this does not always happen is because of the need to change into a lower gear. However, this would not be true, or would not have such a marked effect, if vehicles were designed for slower speeds. Some 57 per cent of car travel now takes place either on built-up roads or on minor rural roads,[9] but almost all cars are designed to be able to cruise at least at motorway speeds. The possibilities of changing vehicle design are discussed in the next chapter.

The idea that speed limits in towns should be reduced is gaining ground. The Department of Transport and even the motoring organisations have recently acknowledged[10] that it may be more appropriate to have a 10 mph rather than a 20 mph limit in some residential areas. In many Continental schemes vehicles are obliged to move only at walking pace in residential neighbourhoods, and this is perhaps more logical than a 10 mph limit. It is a way of saying to motorists: 'this is not your territory, you are here on sufferance, and if you come in you must conform to the speed of the pedestrians whose domain this is'.

Nevertheless, there is still a lingering idea that the arguments for lower speed limits in towns apply only to residential streets and to other unusually sensitive places rather than generally. In the Department of Transport's Circular Roads 4/90, which set out the guidelines for the introduction of 20 mph zones, it was said that '20 mph zones will be appropriate on access and local distributor roads. They will usually be in residential areas, but other areas, such as shopping streets, may be suitable'. Three years later, the Department's Traffic Advisory Leaflet 7/93, published to explain new traffic calming regulations, said that they would enable local authorities to achieve a range of objectives 'for example, objectives relating to conservation in historic town centres, improvement of safety and environmental conditions in residential areas, and the improvement of distributor roads which are also shopping centres'. But all town centres, whether historic or not, and all streets which serve shopping, commercial or recreational purposes deserve the same treatment. Towns are where people live, work and play. The exceptions, if there are any, are those urban roads which need *not* be regarded as sensitive.

Should the general urban limit be set lower than 20 mph? Not if the figures in Table 10.2 can be taken as a guide: the time losses of setting the speed limit at 15 mph would outweigh the gains even from a total cessation of accidents. It is true that the time losses are exaggerated, but even if they were estimated more accurately, and if allowance were also made for other benefits in addition to accident savings, it is unlikely that a comparison of this kind would show an advantage in moving from a 20 mph to a 15 mph speed limit. It might, however be possible to justify a 15 mph limit as part of a more radical approach to urban transport problems.

It has been pointed out that lower speeds would help to release the suppressed demand for cycling and to obviate the need for unwanted escort trips. But otherwise the analysis in this chapter takes the present pattern of travel in towns as given. But there are many grounds for questioning whether this pattern, and in particular the present division of personal travel between modes, is really desirable. It could be argued, on social, economic, health and environmental grounds, that the car now holds a much too dominant position, that the major modes should be walking, cycling and public transport, and that cars and taxis should play the subordinate, though still very important role of providing for those journeys which cannot conveniently be made by other means. For example, disabled people, or people accompanied by small children, or with heavy things to transport, might find a car essential, or at least especially convenient, even if all the alternatives were very substantially improved. It would be desirable, too, to be able to use a car, especially at night, for off-centre journeys not well served by public transport.

The problem, on this view, is to find ways of ensuring that a car can be used in appropriate circumstances while its use at other times is discouraged. There is no single solution to this problem. It is likely to require a package of measures, including, for example, some direct restraint on taking a car into town centres and the introduction of more cycleways and bus priority schemes. But a speed limit of about 15 mph might be part of the package. It would reduce the temptation to use a car even when another means of transport would serve the traveller almost as well and impose fewer costs on other people, just because at present travel by car tends to be faster. People would still be able to use a car when its advantages of providing shelter from the elements, door-to-door transport and the ability to carry passengers and luggage were of especial importance. In fact, it would become easier to use a car in such circumstances if, in part because of lower speeds, other car travel was reduced.

To explore the implications of an approach to urban transport based on this conception of the role of the car would be to go far beyond the

Table 10.3 The additional time that would have been required to drive the mileage driven in Norwich between 7.a.m and 7 p.m. on a typical weekday in 1993 on roads now subject to a 60 mph or to a 70 mph speed limit if lower limits had been enforced

	Present speed limit: 60 mph		Present speed limit: 70 mph	
	Increase in seconds per vehicle kilometre	% increase	Increase in seconds per vehicle kilometre	% increase
55 mph	0.2	0.2	1.6	2.8
50 mph	1.1	1.2	3.4	6.2
45 mph	2.8	3.6	6.0	10.9
40 mph	6.9	8.8	9.8	17.7
35 mph	14.4	18.3	15.7	28.3

Note: The times shown are additional to those actually taken in 1993, but there were virtually no violations of the existing speed limits on these roads.

bounds of this study. It has therefore been assumed in the remaining chapters of this report that the general urban speed limit should be 20 mph, or perhaps, in order to conform with Continental practice, 30 km/h (19 mph). But it is only for this practical reason that this assumption has been made. The more radical approach has not been dismissed; there is much to be said for it.

10.3 High-speed roads in towns

Table 10.3 shows the results of a calculation of the time penalties from imposing lower speed limits on roads in Norwich where they are now 60 mph or 70 mph. The table relates only to the mid-day off-peak period; at peak times the penalties would be smaller. The calculation rests on the same method as that used to produce Table 10.1 and therefore exaggerates the penalties. It seems that the penalties from adopting a 50 mph limit would be trivial and those from adopting lower limits also seem mild.

National traffic data for urban roads with speed limits of higher than 40 mph are not available, so a cost calculation comparable to that shown in Table 10.2 cannot be made. Even if such data existed, it may be that the characteristics of roads which now have high speed limits vary too much from town to town for an extrapolation from one town to others to be helpful. For example, the case for retaining high-speed roads may be stronger in conurbations than in a relatively small town such as Norwich. But since the Department of Transport now carries out speed surveys in each of the 20 largest urban areas in England, and in five smaller towns as well, it would be possible to produce results corresponding to those in Tables 10.1 and 10.3 for each of these 25 towns individually.

10.4 Conclusions and recommendations

A strong case has been made that the urban speed limit should normally be 20 mph, but further work is required to consolidate it. This should consist both of more realistic simulations and of comprehensive trials in selected towns. At the time of writing, the Department of Transport is about to announce which English town has been selected for its £5m 'Safe Town' scheme.[11] We recommend that a number of other such schemes should be conducted simultaneously.

Simulations and trials are also required to demonstrate the effects of a possible 15 mph speed limit as part of a wider policy, also including traffic restraint measures, to increase the share of personal journeys held by modes of transport other than the car. The trials should be conducted in towns where an especially strong case for traffic restraint and calming can be made out: for example, university towns and towns which attract large numbers of tourists or holidaymakers. It may be that even in the longer term a 15 mph limit could be justified in such towns though not in others.

The possibility of reducing the speed limits on urban roads where they are now 50mph, 60 mph or 70 mph should also be examined. The first step is to apply the crude techniques used in this chapter to the data for each of the 25 English towns where the Department of Transport has carried out speed surveys, in order to derive a maximum estimate of the possible time penalties. Similar surveys should be carried out in Wales, Scotland and Northern Ireland to allow the same calculations to be made there. Trials are also needed both to check these calculations and to ascertain the possible benefits of lower speeds. It may be that on segregated, motorway-style roads the accident savings would be comparatively small, while other benefits, such as a reduction in noise, could be much more important in a densely populated town than in the open country. Particular care should therefore be paid to monitoring all the environmental effects.

For the time being, the enforcement of lower speed limits in the towns or on the particular roads selected for the trials will have to be by conventional means: an enlarged police presence, speed cameras and traffic calming through physical alterations to the roads. However, trials of enforcing speed limits through the vehicle are also required. They are discussed in Chapter 12.

Notes and references

1. This account of the experiment in Växjö is taken from C Hydén, K Odelid and A Várhelyi (1992) *Effekten av Generell Hastighetsdämpning i Tätort*. Lund: Institutionen för Trafikteknik, supplemented by correspondence with Professor Hydén.
2. L N Swali (1993) *The Effect of Speed Cameras in West London*. Conference paper, supplemented by a telephone conversation with Mr Swali and by the Department of Transport's Press Notice LR 61/94 of 29 March 1994.
3. Contact with the Royal Technical University of Stockholm.
4. Contact with PTV System Software und Consulting GMBH of Karlsruhe.
5. The statisticians in the Department of Transport concerned with speed studies have criticised the use of the Norwich data to make these estimates on the grounds that, whereas many of the roads in Britain subject to a 30 mph limit are minor roads, very few minor roads were covered in the Norwich speed survey. They believe that minor roads are less likely to be congested than the roads surveyed, so that speeds on them will be higher at present, and the time penalties from enforcing lower speed limits will be correspondingly greater. In the absence of speed surveys on minor roads it is difficult to assess the force of this criticism. It may be that speeds on minor roads tend to be lower than those on major roads for reasons to do with their design, width and function, regardless of congestion. These uncertainties reinforce the need for further data collection and analysis, and in particular for the trials recommended later in this chapter.
6. The Norwich speed survey was chosen because it was the easiest to analyse of the surveys then available, but results published since (Department of Transport (1994) *Road Travel Speeds in English Urban Areas*. London: HMSO) show that speeds are relatively low in Norwich. It may be, however, that the difference is partly accounted for by a greater degree of illegal speeding in other towns than in Norwich. The degree of illegal speeding cannot be ascertained from the published results – a special analysis of the survey data would be required – but in our view any extra travel time which

people would incur if they reduced their speeds so as to comply with the existing limits should not be included in a cost-benefit calculation.

7. This table gives vehicle kilometres, by type of vehicle, for major built-up roads in Great Britain in 1993. It also gives vehicle kilometres, again by type of vehicle, for all minor roads in Great Britain but without distinguishing between built-up and non-built-up roads. But a special analysis was available for 1992 of the traffic on minor roads broken down between built-up and non-built-up. It was assumed that the vehicle kilometres for each type of vehicle on minor roads in 1993 could be divided between built-up and non-built-up roads in the same proportions as in 1992.
8. Danish Ministry of Transport (1993) *An Improved Traffic Environment – a Catalogue of Ideas*. Report 106.
9. *Transport Statistics Great Britain 1994*, Table 4.9.
10. *Local Transport Today*, 7 December 1995, p.4.
11. *Local Transport Today*, 7 December 1995, p.1.

11

Means of enforcement

Lower speed limits are pointless, and the calculations in Chapters 9 and 10 worthless, unless the limits can be enforced. How best to enforce them is therefore a crucial question. There have been three important developments in recent years: traffic calming, speed cameras and on-vehicle speed limiters.

11.1 Traffic calming

Traffic calming has been defined in various ways, but it usually involves changes either in the geometry of the road or in its surface to induce drivers to slow down. The vertical profile of the road may be altered by building humps, platforms and ramps. Drivers may be prevented from driving fast in a straight line by introducing bends into the road, by widening pavements to create pinch points, or by other means of creating horizontal deflections. Giving the road a rough surface, by paving it with cobbles, or by other means, is also a deterrent to speeding. The more ambitious traffic calming schemes may also involve planting trees and installing benches and other street furniture, even fountains and statues. Then traffic calming is no longer just a means of speed limitation, it becomes an instrument of urban design.

The very great improvements that traffic calming has brought to towns both on the continent and in Britain were described in Chapter 4. There is no doubt that the benefits amply justify the modest costs involved. The speed with which the very term 'traffic calming' has passed into the language is itself an indication that traffic calming is here to stay. It has proved so popular in Oxfordshire that the County Surveyor has said that 'it is impossible to do more than scratch the surface of the demand at present rates of expenditure'.[1]

Nevertheless, traffic calming has its limitations and even drawbacks. Although it does not apply only to residential roads and other access roads, as was once thought, but can sometimes be used on main roads as well,[2] it is not clear to how many main roads it can be applied. In particular, it is unlikely to be suitable on roads with a speed limit of more than 30 mph. Problems have also been experienced even on roads which would seem to be good candidates for such treatment. One common complaint is that speeds are not reduced enough, especially if drivers speed up between the humps or other speed-reducing measures. If drivers choose to slow down and speed up again, rather than driving at a steady speed, this can increase fuel consumption, and hence air pollution, and also noise, both from the engine and transmission and from the brakes. Noise is also caused when vehicles are driven over humps or other rough surfaces. Crossing a hump can be uncomfortable for the people in the vehicle and may possibly also do some damage to the vehicle itself. Although traffic calming can improve the look of a town, sometimes the visual effects are unpleasing. Drivers may respond to a traffic calming scheme by choosing another route. That may sometimes be desirable, if the alternative roads are less sensitive, but not always.[3]

For reasons such as these, although opinion surveys accompanying particular traffic calming schemes usually show a majority in support, they also show significant levels of dissatisfaction.[4] Some proposals have had to be substantially modified or even dropped; some schemes have had to be taken out after having been implemented.[5] No doubt, some of the problems can be attributed to poor design of a kind which more experience, further development of the techniques or more money could put right. But others are inherent in an approach to the enforcement of speed limits based on road engineering.

11.2 Speed cameras

Speed cameras automatically take photographs of vehicles exceeding any given speed and so allow drivers breaking the speed limit to be prosecuted. Their use was authorised by legislation which came into force on 1 July 1992. By March 1994, more than half the police forces in Britain were equipped with them.[6]

A big impetus to the use of speed cameras was given by a trial in west London launched in October 1992. Although some of the original estimates of the accident reductions achieved have had to be revised

downwards, there is no doubt that the scheme has been a huge success. After a year, accidents on those sections of main roads where cameras were installed were down by 14 per cent, relative to the reduction on the roads chosen as a statistical control, and fatal and serious accidents by 36 per cent.[7] The capital cost of the cameras was £360,000,[8] which in cost-benefit terms must have been covered several times over in the first year. The installation of the cameras not only reduced delays to travellers, as noted in Chapter 10, but also allowed the police who formerly patrolled those roads to be redeployed to other duties.[9]

Speed cameras have proved their worth and should be used much more extensively. They could be financed either by the revenue from fines or out of transport budgets, not just out of Home Office or police budgets. Nevertheless, there are limits to their use. Their impact seems to be very localised: hopes that there would be a 'halo' effect, such that drivers would slow down not only on the sections of road where the cameras are installed but on neighbouring sections as well, have not been borne out.[10] The TRL researcher concerned with the evaluation of the trials in west London and elsewhere has warned that speed cameras should be used to tackle particular blackspots, not as a general speed reduction measure, otherwise there is a risk of undermining public support for them and even of a possible 'backlash' from the public.[11]

11.3 Speed limiters

Modern speed limiters have a sensing device somewhere on the transmission of a vehicle connected to a control on the fuel input. When the vehicle exceeds a set speed, the supply of fuel is curtailed. For many years now, some vehicle operators have chosen to fit speed limiters to their vehicles in order to avoid the extra fuel and maintenance costs, as well as the increased risk of accidents, caused by excessive speeds. Starting with a Statutory Instrument which came into force on 18 March 1988, legislation, both British and European, has made it compulsory for speed limiters to be fitted to almost all coaches and to most heavy goods vehicles. Most coaches are limited to a top speed of 65 mph. Some lorries are limited to 56 mph and others to 60 mph, but lorries of 7.5 tonnes gross vehicle weight or less and some older lorries of over that weight do not have to be fitted with speed limiters.[12]

The progressive introduction of speed limiters has already had a noticeable effect on reducing speeding by lorries on motorways. The

Department of Transport's speed surveys show that the percentage of articulated lorries exceeding their 60 mph speed limit on motorways at any one moment went down year by year from 43 per cent in 1991 to 25 per cent in 1994. Over the same period, the percentage exceeding the 50 mph limit on dual carriageways at any one moment went up from 72 per cent in 1991 to 78 per cent in 1994.[13]

These figures illustrate an obvious limitation of the present type of speed limiters. They only limit the vehicle's top speed and therefore can only enforce the speed limit on motorways and on other roads to which the national speed limit applies. But there is a much greater need to control speeds on other types of road, where accident rates are higher and other kinds of nuisance from speeding vehicles more significant. What is needed is a variable speed limiter, which can be set to match the limit in force on the particular road on which the vehicle is being driven.

There is a further paradox about a top-speed limiter. Not only is it inadequate, in that it fails to address the most important part of the problem, it should also be unnecessary. The obvious way to enforce the national speed limit is to design vehicles whose top speed, even without a limiter, does not exceed the national limit, or exceeds it only by a small amount. To design vehicles to go much faster than the speed limit and then to prevent them from doing so by fitting a speed limiter seems perverse.

It is understandable that legislation should have tackled coaches and lorries before other types of vehicle. Although coaches are much safer than cars, in terms of casualties per passenger kilometre,[14] public transport operators have a special duty of care to their passengers. Accidents to coaches also tend to attract publicity because, although they are rarer, more people can be killed or hurt in one incident. Lorries have higher casualty rates than cars, especially for fatal and serious casualties, and when a lorry collides with another road user, the other road user is much more likely to be hurt.[15] But the need to limit the speed of vehicles of other types as well is shown by the results of the Department of Transport's 1994 speed surveys. At any one moment, 47 per cent of cars were breaking the 70 mph speed limit on motorways, 40 per cent were breaking the 70 mph speed limit on dual carriageway 'A' roads, 10 per cent were breaking the 60 mph speed limit on single carriageway 'A' roads, 31 per cent were breaking the speed limit on 40 mph roads and 69 per cent were breaking it on 30 mph roads.[16]

11.4 A comprehensive approach

This discussion suggests the following approach to the enforcement of speed limits. The national limit should be enforced by vehicle design: Construction and Use Regulations should prohibit the use of any vehicle on the public highway capable of breaking the national limit by more than a certain amount. Speed limits lower than the motorway limit but down to and including the new urban speed limit of 20 mph should be enforced by variable speed limiters. Vehicles of all types would have to be fitted with these speed limiters, except that there would be a new class of car and a new class of lorry, designed for local use, with top speeds of 20 mph or a little more. Limits lower than 20 mph, for example 10 mph or 5 mph limits in selected streets or outside schools etc, would continue to be enforced by conventional traffic calming measures, involving physical changes to the roads.

Before developing these proposals in detail, a widely held objection to speed limiters should be mentioned. Many people believe that speed limiters would be harmful rather than helpful to road safety, on the grounds that if they were fitted it would no longer be possible to accelerate out of a dangerous situation. There are several answers to this.

There are very few occasions even now when to accelerate is the right response to a dangerous situation; if all cars were speed-limited, such occasions would be rarer still. The speed limiter would still leave the driver free to accelerate over a range of speeds below the speed at which the limiter was set. Also, whether cars are fitted with speed limiters or not, there is a natural limit to their ability to accelerate which drivers take into account in their decisions. Perhaps the most plausible example of a situation when it may be appropriate to accelerate is in overtaking, when the car being overtaken speeds up, or when it turns out that an approaching vehicle is moving faster than was thought. Before deciding whether to overtake, a driver will take into account what reserves of power he has to deal with such contingencies. The driver of a fast car, not fitted with a limiter, will accept opportunities to overtake which the driver of a slow car, or of a car fitted with a limiter, would not accept. But both drivers will occasionally misjudge the situation and find that their reserves of power are not adequate. The faster one is driving, the more likely one is to misjudge the situation in the first place, the more difficult it is to take corrective action, such as abandoning the attempt to overtake, and the more serious any accident that may occur will be. Finally, if there were indeed any force in this objection to speed limiters, they can be designed in a way which allows them to be temporarily overridden.

11.5 The feasibility and cost of variable speed limiters

A variable speed limiter could either be operated by the driver or triggered off automatically by equipment buried under the road or installed at the roadside. There is no doubt about the technical feasibility of the driver-operated speed limiter. The technology is similar to that of the well-established cruise controls, and there has also been an extensive and successful trial with driver-operated speed limiters in Germany. Experiments with a variable speed limiter activated by equipment buried under the road were undertaken in the early 1970s by the Transport Research Laboratory at its research track, with completely successful results.[17] However, there must be some doubt whether this success could be repeated on the road network and with the vehicle population as a whole. Nor is it altogether clear whether it would be the better system even then. Sometimes a driver might pass a control point without realising it; the sudden and unexpected operation of his speed limiter could be dangerous. Speed limiters might also be more psychologically acceptable to drivers if they were left with some responsibility for operating them. Whichever system might prove to be preferable in the long term, more information is available on driver-operated limiters, and they could also be implemented more quickly and cheaply, so they are the ones discussed here.

With a speed limiter operated by the driver, there needs to be some way of indicating to the police and other road users that it had been set at the correct position. An external colour-coded light seems to be the best method. Such lights have not been included in the trials undertaken so far, but the technical problems and the expense would be trivial, at least in the case of speed limiters fitted to mass-produced new vehicles.

The German trials took place in the state of North-Rhine Westphalia with equipment developed by a research group from Munich and tested and approved by the appropriate official organisation.[18] Some 40 cars and 10 vans and lorries were retrofitted with a variable speed limiter which had two pre-set maximum speeds of 30km/h and 50 km/h, either of which could be selected by pressing the appropriate button; pressing another button enabled the driver to set the limiter to any other maximum speed that he wished. Hardly any technical problems were

experienced, and drivers found that with the limiters they felt under less pressure from other drivers to break the speed limit.

The research group which developed this speed limiter estimates that if one were included in the process of mass production, it would add less than DM 100 (roughly £40) to the cost of a car. The speed limiters would cost about DM 600 (roughly £250) each if supplied for retrofitting to existing cars, provided that at least 10,000 could be manufactured at a time, and each one would take a trained mechanic about four hours to fit. Although it is possible that the engine compartments of some cars would be too small or the bead chain to the carburettor too short for retrofitting to be possible, no such problem has been encountered so far. The limiters can be sealed in such a way as to be proof against tampering by anyone without advanced technical knowledge.

The small extra cost of a limiter on a new car is clearly justified and should be borne by the owner, just as owners have to bear the costs of exhausts, silencers, catalytic converters and other equipment designed to limit the nuisance their cars cause to third parties. Can the cost of retrofitting the existing fleet of cars and vans be justified? There are some 23 million of them,[19] so the total cost of retrofitting them all would be approaching £6 billion. If it is assumed that a vehicle would be on the road for five years after being retrofitted, so that the investment would have to be justified by the benefits achieved over that time, then, assuming also the 8 per cent discount rate used by the Government in the evaluation of road schemes, an annual benefit of £1.5 billion would be required to justify this investment. Since the annual cost of accidents is of the order of £24 billion,[20] if retrofit reduced accidents by only some 6 per cent, the cost would be justified on those grounds alone, even without reference to the non-accident benefits. If retrofit reduced accidents by one quarter, which is well within the bounds of possibility, the investment would pay for itself in a single year.

Under a strict application of 'the polluter pays principle', the cost of retrofitting existing cars would be borne by their owners, even though many of the benefits would accrue to other people. However, it seems unfair for society suddenly to change the rules in a way which imposes a heavy cost on people who have been conscientiously complying with the existing rules. It is true that over the years motorists would be able to recoup their costs, or a large part of them at least, out of lower insurance premiums; even so, it seems reasonable for the taxpayer to make some contribution to a cost which could be very burdensome for some poorer motorists.

It would, of course, be physically impossible to retrofit the entire vehicle fleet in one year. A programme extending over several years would be required. This would have to be worked out in detail with the manufacturers of speed limiters and the garage trade.

11.6 The wider benefits of vehicles with a low top speed

To design vehicles which cannot exceed the national speed limit, or can exceed it by only a small amount, is the obvious way of enforcing the speed limit on motorways and other roads to which the national speed limit applies. It might be expected that such vehicles would have other advantages too, in particular that they would achieve more miles to the gallon, and would consequently be less polluting, even when moving at speeds well below their natural limits. This is indeed true, although to achieve really large economies in fuel consumption requires acceleration to be limited as well as top speed. The relationship between acceleration and engine size is illustrated by the following table, derived from a report prepared in 1990 by Ricardo Consulting Engineers for the Dutch Ministry of the Environment.[21] The table is shown only to bring out the importance of acceleration, not as an indication of what economies in fuel consumption are possible. It will be seen below that much more economical cars can be built.

Table 11.1 Engine size, fuel consumption and acceleration of cars

	Fuel consumption at a steady 90 km/h		Fuel consumption over the ECE urban test cycle		Time(seconds) required to increase speed
Engine volume (cc)	litres 100 km	miles per gallon	litres 100 km	miles per gallon	from 50-80 km/h
750	4.3	66	5.7	50	26.1
1000	4.7	60	6.4	44	16.6
1400	5.1	55	7.7	37	10.2
1800	5.6	50	9.0	31	7.5
2200	6.1	46	10.4	27	5.9

Thus, according to this table, a motorist who insists on being able to accelerate from 50 km/h (31 mph) to 80 km/h (50 mph) in under six seconds will need a car which will only do 46 miles to the gallon at a steady 90 km/h (56 mph) and 27 miles to the gallon in urban conditions. But if he is prepared to take 26 seconds to achieve the same increase in speed, a car which would do 66 miles to the gallon at a steady 56 mph and 50 miles to the gallon in urban conditions would suffice.

Reducing acceleration should improve fuel consumption in other ways that are not reflected in the figures in this table or in other results from standard tests. The tests are undertaken by skilled drivers driving as carefully as they can. Few drivers will emulate that in real life. According to a recent paper by an official in the Dutch Ministry of the Environment, a 'racy' driving style with sudden accelerations and frequent braking can add 30 to 40 per cent to fuel consumption and can also cause 'sharp and even extreme' increases in the emissions of various air pollutants.[22] This style of driving should become much less frequent with cars of a lower performance. A reduced acceleration, especially at low speeds, would also make the roads safer for pedestrians. On empty roads, the time losses would be trivial. On crowded urban roads, a car with high acceleration gives its driver a competitive advantage – for example, he can pull away from the traffic lights faster than other people and so ensure that he is first in the queue at the next junction – but does little or nothing to maintain the speed of the traffic as a whole. But there are situations where reducing acceleration would produce a significant time loss. The most plausible example is on single carriageways in the country, where a slow driver can hold up others if they cannot overtake. This disadvantage could perhaps be mitigated by dualling some sections of these roads. In any event, it is unlikely to offset the various advantages of lower performance.

It is true that much can be done to make cars more fuel-efficient without affecting their performance in terms of speed and acceleration. Following an agreement between the American government and the big three American car manufacturers in 1993, the manufacturers launched a Partnership for the New Generation of Vehicles which has as one of its aims to develop a car with up to three times the fuel efficiency of the comparable 1994 vehicles, which achieve about 30 miles to the gallon. The means envisaged include advanced lightweight materials and structures, energy-efficient conversion systems, more efficient electrical systems, and waste heat recovery. No reduction in speed or acceleration seems to be envisaged: the goal is to be achieved 'while meeting the customers' needs for quality, performance and utility'.[23]

The most ambitious work on developing a fuel-efficient and non-polluting car without sacrificing performance has been undertaken by the Rocky Mountain Institute. The 'supercar' would be built of the synthetic lightweight materials now used in aeroplanes and some boats, rather than of steel. Any reduction in the weight of a vehicle automatically reduces its fuel consumption. It would be driven by electric motors on all or some of the four wheels, with the electricity generated on board the vehicle, perhaps by a conventional internal combustion engine, perhaps by a fuel cell. The elimination of the conventional gearbox and transmission system would further lighten the vehicle. In addition, these on-wheel motors would allow most of the energy now used in braking to be recovered. Energy consumption would be reduced still more by a body shape which minimised aerodynamic drag and by tyres which minimised rolling resistance. It is claimed that such cars could achieve some 300 miles to the gallon and could be one hundred times less polluting than today's cars; also that they would be very quiet.[24]

If cars of the existing type were replaced by supercars, one part of the case for lower speeds and acceleration would be weakened, since energy consumption and pollution would have become much smaller problems. The safety arguments would remain very strong, although the Rocky Mountain Institute's technologists claim that the materials and structure of the supercar would make it more energy-absorbent, and therefore safer in crashes, than a conventional car. Moreover, by reducing fuel costs so drastically, and perhaps other operating costs too, supercars would further encourage the trends to more and longer car journeys and the greater dispersion of activities, with all the adverse social and environmental effects, including pressure for more road building, that would follow from increased vehicle mileage.

Lower speeds are not the only possible way to counter these trends; road pricing would be another possibility. But lower speeds, besides being more equitable and easier to sell to the public than road pricing, would also be more effective. Road pricing reduces traffic costs by reducing traffic volumes, whereas lower speeds would reduce both traffic volumes and the costs associated with any given volume. Unless prices were set at unacceptably high levels, the lower speeds on main roads outside towns suggested in Chapter 9 would probably have a greater impact on traffic volumes than road pricing. It might be

desirable to supplement lower speeds with road pricing; the need for that would be easier to judge once the lower speeds were in operation. Whether or not it would still be needed, road pricing would certainly be easier to introduce if lower and better enforced speed limits were already in place. In particular, the risk that road pricing on motorways would divert traffic to other less suitable roads would be much reduced once lower speed limits had been enforced on those other roads.

The potential for designing a car that would be economical in energy, and in every way safe and environmentally friendly, would presumably be maximised if a low top speed and modest acceleration were combined with the light weight and other new features of the supercar. We know of no attempt to work out what could be achieved with such a design. The manufacturer that has gone furthest towards the production of a standard model car which would be highly energy efficient is probably Renault with its Vesta model.[25] The Vesta was developed in the 1980s with help from the French government and was presented for the first time publicly in 1987. Its petrol consumption was rated at 2.8 litres per 100 kilometres (just better than 100 mpg) on a composite test incorporating different driving conditions, and in June 1987 it achieved 1.94 litres per 100 kilometres, equivalent to 145 mpg, on a test run from Bordeaux to Paris. The car weighed less than 500 kilogrammes and it had a top speed of 120 km/h (75 mph). These figures can be compared with those of the Renault Clio, the smallest Renault model. Its weight varies between 830 and 1,000 kilogrammes, and its top speed between 155 km/h (96 mph) and 209 km/h (130 mph), depending on the particular version. The fuel consumption of the most economical petrol version, at a constant 90 km/h (56 mph), is 62.8 mpg.

Although more work is required on the feasibility of the more advanced technological ideas, there is no doubt that it would be both possible and desirable to produce slower, lighter cars which would be far more energy-efficient, less polluting, less noisy, less likely to be involved in a crash and less threatening to other road users than today's cars. But such a transformation will not happen voluntarily. The market trends are all in the opposite direction. Cars are becoming larger and heavier: the interior space and weight of the average car in each range is now at the same level as the average car in the range above of the 1960s. They are also becoming faster. Current small cars have the same performance as medium-range models 25 years ago, while medium-range models have the same performance as sports cars 25 years ago and sports cars have the same performance as racing cars 25 years ago.

Consequently, despite improvements in engine technology, in most OECD countries, the average fuel consumption of new petrol-engined cars has ceased to decline, after falling continuously since the first oil crisis.[26]

In terms of consumers' motivation, these trends are understandable and even, up to a point, rational, given the present regulatory framework. Even motorists not imbued with the competitive spirit may find it irksome always to be overtaken by or under pressure from other cars, so they will buy a faster car than they might otherwise choose in order to avoid this annoyance. Since in a collision between a heavy car and a light one the occupants of a heavy car are less likely to be hurt,[27] it makes sense for someone who can afford it to buy a heavy car. The less rational, and perhaps only partly conscious, motives may be more powerful. A Dutch psychologist has shown 'how the car fits in perfectly with the factors determining behaviour: territorial needs, the need for security, the need for physical power, social superiority (competition), the desire to be different and project an identity, and the need to experience risks (hunter instinct)'.[28] The sexual associations of a fast, powerful car are also well known.

Regulation is therefore required to bring about the required changes in the characteristics of the vehicle population. Any resistance to this idea on the grounds of interference with individual liberty is misplaced. No one has the right to cause more danger to others, to consume more of the world's finite supplies of fuel, nor to create more noise and pollution than is strictly necessary for the achievement of some legitimate purpose.

These thoughts are not new. At a meeting of a panel of experts convened by OECD and the IEA (International Energy Agency) in 1990, it was stated that action was required by national and international authorities to check the trend towards more powerful vehicles.[29] The panel said that '...the creation of regulatory and economic frameworks and incentives which are stable, equitable and harmonised internationally would enable the automobile industry to better plan for future requirements. As a consequence, the industry would be in a better position to commit the resources required to achieve continuously improved levels in fuel consumption and emissions, in pace with technological progress'.[30] In 1991, the European Conference of Ministers of Transport (ECMT) passed a resolution in favour of limiting the power and performance ratings for all categories of vehicles in the interests of road safety, environmental

protection and energy conservation.[31] In 1993, the ECMT again pointed out that progress towards achieving the Rio objectives required the political will to implement the necessary measures and that 'existing technology is not being put to best advantage because of the freedom of transport users to adapt their behaviour to convert potential environmental amelioration into more transport service. Controlling this adaptive behaviour should begin immediately by seriously addressing the issues of reducing the specific power, performance and speed of vehicles.'[32]

The Dutch government, which has always been in the forefront of transport thinking, has proposed as first steps for international action that CO_2 emission standards and fuel consumption standards should be formulated for different vehicle weights and regularly tightened up; that the cylinder capacity and specific power of cars, motorcycles and, to a more limited extent, goods vehicles and buses should be limited; and that speed limiters should be fitted to motorcycles, private cars, delivery vans, goods vehicles and buses as a transitional measure towards the limitation of power ratings in all vehicles.[33] It is possible to take these ideas a little further. Instead of setting standards for emissions and fuel consumption within each weight class, it seems more appropriate to set standards for emissions, fuel consumption and weight within classes of vehicle defined in terms of their carrying capacity. The amount of internal space they need, whether for carrying people, luggage or other goods, is a matter for individual consumers to decide, but a vehicle should not be permitted to be heavier than its capacity requires. Also, although in the longer term it is certainly better to limit the maximum speed of vehicles by restricting their power rating rather than by fitting a speed limiter, it was argued above that variable speed limiters, rather than top speed limiters, will always be necessary to enforce speed limits lower than the motorway or national limits.

The power to set vehicle standards has now almost entirely passed from the member states of the European Union to the European Union itself. The EU has been criticised both by the Dutch[34] and by the ECMT[35] for not giving enough attention to environmental objectives in transport policy, and there is little sign at present of its formulating vehicle regulations of the kind suggested here. The European dimension is discussed further in the next chapter.

Member states do, however, retain control over taxation, which can have an important influence on the type of car people choose to buy.

Company cars present the best immediate opportunity, especially in Britain, the country where they are most prevalent.

Company cars account for about 12 per cent of cars on the road but over half the new cars bought each year are company cars. The difference in these percentages is accounted for by the facts that most company cars (about 70 per cent) are bought new, whereas most privately owned cars (about 75 per cent) are bought secondhand, and that company cars are replaced after a much shorter interval than privately owned cars.[36]

The effect of company cars on the level of car ownership is uncertain. It is probable that the great majority of owners of company cars would buy a car of their own if the company car were not available.[37] But without company cars, the number of cars on the secondhand car market would be much smaller and prices significantly higher; the impact on the level of private car ownership might therefore be substantial. Company cars certainly have an effect on the size of cars in the vehicle population; privately bought new cars tend to be smaller.[38] Company cars do more mileage than privately run cars, not only on business but for other purposes too. On average, company car drivers who are provided with free fuel commute over two and a half times as far as non-company car drivers, and those without free fuel commute over twice as far. Leisure and other non-business, non-commuting mileage is a third higher for company than for non-company cars.[39] Company car drivers admit to more speeding than other drivers[40] and are involved in more accidents.[41]

Eighty per cent of people with a company car claim that it is essential for carrying out their jobs and a further nine per cent say that it is helpful; only nine per cent say that it is simply part of their remuneration package.[42] These claims are hard to reconcile with the fact that other countries manage with a far lower level of company cars. In France, according to the Ministère de l'Equipement, there are few company cars, although businesses do reimburse their employees when they use their cars for business purposes, which can sometimes include commuting.[43] In the United States, where company cars account for only 14 per cent of new registrations, the company car is regarded as 'an anti-status symbol – a testament to your lowly status as a salesman or rep'.[44] Company cars can have a bad effect on personal relations within a company, and Sir John Harvey-Jones has recommended, for this reason, that they should be phased out.[45]

Company cars should indeed be phased out, but that will take time. Meanwhile, changes in the rules could encourage slower, better driving and perhaps simultaneously reduce mileage as well. A change that could be brought in immediately is that tax concessions would not be available for cars over a certain size and engine capacity without a signed statement from a senior company official certifying that a larger, more powerful car was really necessary for that employee's job. Next, it could be made a rule that only cars fitted with variable speed limiters would be eligible for tax concessions. This change could be introduced as soon as it was established that industry could cope with the work of supplying and fitting the limiters. Finally, tax concessions on company cars could be used to expedite the general introduction of the less powerful, more environmentally friendly cars discussed above. This would mean that for a car to be available for tax concessions, it would have to meet not only the current standards required by domestic or European legislation, but the more stringent standards to be introduced in the next round.

Tax concessions on company cars are not the only way in which the present fiscal arrangements distort travel behaviour. The rates at which people can claim for using their cars on their employer's business vary widely from company to company, but some employers at least reimburse their employees at rates far above marginal costs.[46] In France, the Ministry of Finance sets the rates at which car mileage can be claimed;[47] it would seem appropriate for the central government in Britain to do likewise. It is reasonable that the rate should be set at a little above marginal cost, but not much.

In addition, to encourage the acquisition and use of environmentally friendly cars, the rates could be set by reference to a medium-range family car which met the new criteria for weight and fuel consumption. Anyone who wanted to use a larger car on business could still do so, but the rates might not fully compensate him. As with company cars, higher rates could be paid only if the employer made a formal statement that a larger car was required for that particular purpose. People using a car smaller or otherwise more economical than the standard car would be in pocket. It would be unfair to bring in such a rule immediately, since that would penalise people who had taken their decisions in the light of the existing rules, but the Government could announce that it was going to introduce it at a specified date in the future.

11.7 The local runabout

Policy on speed should include the recognition of new categories of vehicle designed for local use with a top speed of some 20 to 30 mph. An appropriate name for the car might be the local runabout.

The local runabout would be subject to its own driver licensing regulations and fiscal regime, less stringent than those applying to conventional cars. For a car to count as a runabout, in addition to the low top speed, it would have to be very economical in fuel; quiet; as far as possible, non-polluting; simple to drive; and so designed, with respect to its shape and materials, as to minimise the injury to pedestrians in the event of a collision with one.

The runabout would not be allowed on motorways, therefore the driving test for a runabout need not include any motorway driving. But the driving test for conventional cars could, in future, include motorway driving. This would remove an unfortunate anomaly of the present situation, that people can acquire a full licence which covers motorway driving without having been tested on a motorway or even, perhaps, ever having driven on one. The objection to including motorway driving in the present test is that many candidates might quite truthfully say that they have no intention of driving on one. Such people would be restricted to runabouts. The physical conditions, with respect to eyesight, speed of reaction and so on, could be less stringent for eligibility to drive a runabout than for eligibility to drive a conventional car. This could be important for old people, by postponing the time they have to give up driving, with the loss of independence that that implies. Given the option of the runabout, doctors and magistrates would find it easier to take a tough line with people who, because of age or some infirmity, should not be allowed to drive a conventional car but often now do.

It is probable that many runabouts would be small, but that would not be part of the legal definition. Some people who only need a car for local purposes might nevertheless require it to be roomy, perhaps because they need to transport several children, for example. A runabout in the form of a van would suit the needs of many workers, such as plumbers and electricians, who need to carry the tools of their trade, and they too would need a vehicle of a substantial carrying capacity. The runabout should not be confused with another concept, the city car. The inspiration of the city car, an idea which has been around at least since the late 1960s,[48] is the supposed need to accommodate cars in city centres. The smaller the vehicle, the more of

them that can be fitted in. A more reasonable objective for city centres would be to minimise the use of cars there. It may even be possible for city centres to be completely free of cars, but if some have to be allowed, they should be few enough for their size not to be a problem.

Many runabouts might be electric. The problem about making a conventional electric car is that there is a direct trade-off between the range of the car – the distance it can go on a single charge of the battery – and its speed. The low top speed of an electric runabout would help to ensure that its range was adequate. Electric cars should also have little difficulty in meeting the stringent environmental requirements of the runabout. But it would be wrong to insist that runabouts must be electric. Hybrid electric vehicles and vehicles with conventional internal combustion engines might also be able to meet all the requirements. The specifications should relate only to the desired ends, leaving manufacturers as free as possible to decide how to achieve them.

Runabouts should be cheaper both to buy and to run than conventional cars. They would also be simpler, both to drive and to look after, more reliable and longer lasting. They would therefore be available to many people who might have an especial need for a car, because they find difficulty in using the alternatives of public transport or a bicycle,[49] but who cannot cope with a conventional car. The deterrent might be expense, not just the predictable expense of buying and running a car, but perhaps the fear of suddenly being faced with a very large bill if something went wrong. Or some people may have insufficient mechanical aptitude to pass the driving test for a conventional car or to take on the responsibility of looking after one. It has already been mentioned that some old or infirm people might be able to manage a runabout but not a conventional car. Others in the same position, though for a different reason, might include mothers bringing up a young family on a limited income. Runabouts could be a substitute for motorcycles for some young people.[50]

Runabouts would not only extend the market for cars, they would be a preferable alternative for many people who do now own a conventional car. Some cars are now used only for short local travel; cars used exclusively for that purpose may as well be specially designed for it. There must be many other people who decide to buy a car for their daily local purposes but who also use it occasionally on longer journeys. The runabout should be substantially cheaper and easier for the primary local use, and its natural advantage in that respect could be enhanced by fiscal policy. So some of these people would be better off owning a runabout rather than a conventional car and making other arrangements for the occasional longer journey. The other arrangements could include hiring a conventional car for the whole journey or going by public transport for the longer part of the journey and hiring a car for the final stage. The introduction of the runabout should make the fly/drive, rail/drive, coach/drive option much more attractive, since if the hired car were a runabout, the cost should be much less than at present. One can envisage a future in which runabouts could be hired at every railway station. The enforcement of lower speed limits on motorways and other main roads would also add to the appeal of this option. The demand for motor-rail services might also be boosted.

Any extension of car ownership would be disadvantageous to other road users and to the environment, but given the stringent specifications of the runabout and its limited use, those disbenefits should be minor and easily outweighed by the enrichment of life of the new owners. The substitution of runabouts for conventional cars or motorcycles would be wholly beneficial. For local travel, the cost, in the widest sense of that word, would be much less, mile for mile, than at present. The change in long-distance travel behaviour would both ease conditions on the roads and give a boost to long-distance public transport. Instead of the familiar vicious circle of decline – a loss of patronage leading to reduced services, higher fares and a further loss of patronage – the local runabout, coupled with lower speeds on motorways and 'A' roads, could introduce a virtuous circle of renewal.

Market research[51] could help to quantify the potential market for runabouts, but meanwhile the National Travel Survey throws some light on the extent to which conventional cars are now being used only as runabouts. The 1991/93 survey shows that 16 per cent of household cars were driven fewer than 3,500 miles a year, and 9 per cent fewer than 2,500 miles a year. The corresponding figures for the second and subsequent cars in the household, which account for 29 per cent of all household cars, were 26 per cent and 18 per cent.[52] Presumably most cars with such low mileages, and perhaps a significant number of others, were being used only for short local journeys.

Britain, or any other state, could recognise the runabout as a separate legal category without the involvement of the European Union. This would cost very little and could usefully be done straight away. But the main deterrent to buying and using runabouts is likely to be the insecurity or disadvantage which their drivers would feel vis-à-vis

drivers of conventional cars. In towns, the enforcement of the 20 mph limit should go a long way towards dispelling such feelings. In the country, a new class of slow roads, consisting of country lanes and minor roads, could be recognised, intended primarily for pedestrians, cyclists and runabouts. Conventional vehicles would also be allowed on these roads, in order to preserve access to premises, but their speed limiters would have to be set at 20 mph, which would discourage through traffic. But runabouts would have to be allowed on other roads as well, even though not on motorways, otherwise certain destinations would be inaccessible to them. This poses a problem of mixing runabouts with faster, heavier vehicles. One partial solution might be to allow runabouts a top speed of 30 or even 35 mph, in which case, however, they would also have to be fitted with a speed limiter set at 20 mph to be switched on in towns and on rural slow roads. Alternatively, or in addition, slow lanes might be added to certain rural roads.

Appendix M gives short descriptions of some relevant foreign experience.

11.8 Local goods vehicles

Heavy lorries have been a major source of concern and complaint since the end of the 1960s. Part of the response has been that local highway authorities have been given extensive powers to ban unsuitable lorries from particular roads or zones, but there are problems about using these powers. The more ambitious schemes may need the cooperation of several neighbouring authorities and also the permission of the Secretary of State. The lorries to be banned can be defined by reference to their weight, length, width, height or any other easily recognised feature, but these features may be only loosely correlated with the nuisances which the ban is intended to mitigate. For example, it is common to ban lorries over 16.5 tonnes, yet lorries of that weight, because they need only two axles, cause more road damage than much larger and heavier ones. The proliferation of types of ban is confusing for operators and vehicle manufacturers and also makes enforcement more difficult.

All this suggests the need to introduce a new category of 'green' lorry designed in such a way as to minimise the various nuisances of lorry operation – danger, noise, vibration, emissions, physical damage – while at the same time providing the maximum capacity compatible with such environmental constraints. Unless there were special exemptions which initially might be numerous, but most of which would be phased out over the years, lorries not meeting these new criteria, such as the 38-tonners which are the maximum now permitted in Britain or the 44-tonners shortly to be introduced, would be confined to a restricted network of motorways and certain other dual carriageway 'A' roads.

There could be two types of green lorry. One, which would be intended both for long-distance and for local use, would have a top speed and acceleration similar to the larger lorries operating only on the restricted network. Such lorries would need a variable speed limiter. Others would be intended only for local work and would therefore be designed with a low top speed of 20 mph or thereabouts. The introduction of the new regime would encourage area-based rather than firm- or product-based distribution in towns, for which such local lorries would be admirably suited.[53]

Although such ideas have been around for a long time in Britain, they have not so far been tried out on the ground. Other countries are more advanced. A scheme of area-based distribution was introduced in Bremen originally without any government intervention; the pedestrianisation of a zone of small retailers and workshops is expected to give it a further boost. Many other German cities are looking at the possibilities.[54] The Bremen scheme seems to use lorries of the most suitable existing type rather than specially designed ones, but in Sweden Volvo is developing a 15-tonne hybrid electric city distribution vehicle, and from April 1996 there will be restrictions on the movement of large diesel powered lorries in the cities of Stockholm, Gothenburg and Malmö.[55]

11.9 Motorcycles

The case for controls on the speed and other characteristics of motorcycles is especially strong. In 1994, the casualty rate, per million vehicle kilometres, of users of two-wheeled motor vehicles was more than ten times that of car occupants; motorcycles are also more than three times as dangerous to pedestrians.[56] Noise from motorcycles is also a serious problem. In a survey of the adult population of Great Britain conducted in 1980 (there has been nothing comparable since), 21 per cent of respondents said that the noise of motorcycles was 'particularly bothersome' to them when they were indoors at home.[57]

A study by the Road Research Laboratory based on fieldwork carried out in 1958 showed a very strong correlation between motorcycle accident rates and engine size, within each separate riders' age group and after taking account of the effect of their experience.[58] More recent studies, however, do not show this correlation, except perhaps for fatalities. If anything, the casualty rate seems to be inversely correlated with engine size.[59] The most obvious explanation of this change over the years is that engine size is no longer a good indicator of the dangerous characteristics of a motorcycle, such as (presumably) top speed and acceleration; but there could be other explanations.

The permitted noise level of new motorcycles depends on engine size. For the least powerful motorcycles, the permitted noise level is the same as for cars (77dB(A)); motorcycles of medium power are permitted to make more noise (80dB(A)) than cars and the permitted noise level of the most powerful motorcycles (82dB(A)) is only a little less than that of the heaviest lorries (84dB(A)).[60] This great range reflects the fact that to design a quiet, heavy, powerful motorcycle is a very difficult technical problem. The permitted noise levels are not always a good guide to actual noise emissions, especially if the machine is poorly maintained or the silencer is deliberately tampered with.

The European Commission tried for several years to limit the power of motorcycles but met opposition in the European Parliament and in particular, presumably because of the British manufacturing interest, from Britain.[61] Consequently, the attempt was abandoned in January 1995.[62] Any further attempt is likely to require very thorough research into the relationship between a motorcycle's power, speed and other characteristics and its accident rate. The research would have to be on a large scale in order to take account of the other non-vehicle variables, including, at least: driver's age, gender, experience and training; type of road; time of day. Difficult though it would be, this research should be undertaken urgently. The expense should not be a deterrent, since the cost is still tiny in relation to the number and cost of casualties in accidents involving motorcycles.

If there is still room for doubt about the desirability of limiting the power of motorcycles, there should be none about the need for them to be fitted with speed limiters. The Department of Transport's 1994 speed surveys showed that at any one moment 12 per cent of motorcycles but only one per cent of cars were exceeding 90 mph on motorways; 25 per cent of motorcycles but only nine per cent of cars were exceeding 80 mph on non-urban dual carriageway 'A' roads and 22 per cent of motorcycles but only two per cent of cars were exceeding 70 mph on non-urban single carriageway 'A' roads.[63] These figures very considerably understate the tendency of riders of powerful motorcycles to exceed the speed limits, since many of the motorcycles on these roads would have been light machines incapable of doing so. As an indication of this, in 1994, 44 per cent of motorcycles but only four per cent of cars on dual carriageway 'A' roads were travelling at less than 50 mph at any given moment.[64]

The technical feasibility of fitting variable speed limiters to motorcycles should be investigated urgently (unfortunately, the resources available for this study did not allow us to do so). Meanwhile, the Dutch proposal for top speed limiters on motorcycles, mentioned above in Section 11.6, should be adopted.

11.10 Other countries

As the law stands at present, many of the actions recommended in this chapter could only be taken at an international level. Even if the law were changed, as recommended in the next chapter, to allow more autonomy to the member countries of the European Union, international cooperation and coordination of regulations concerning vehicle design would still be very desirable, not only within Europe but worldwide. But do the arguments put forward in this report also apply to other countries?

The arguments in this chapter that speed limits, except the very lowest ones, are best enforced through vehicle design are technical arguments, relatively little influenced by cultural or geographical factors, and would seem to apply generally. It is not so clear that the speed limits that are optimal in any one country would also be optimal in others. It would be useful to repeat the calculations in Chapters 9 and 10 with data from different countries, but in the absence of such studies certain broad points can be made.

In Europe, at least, where most towns retain the compact form and strong centres that they acquired before the motor age, it would be surprising if the optimal urban speed limits varied very much from country to country or town to town. If anything, the case for lower speed limits may be stronger in continental cities than in British ones. Densities tend to be higher, and many continental cities have done more than British ones to safeguard their public transport systems and to preserve or restore good conditions for pedestrians and cyclists. This means that the alternatives to cars are often of a better quality than in Britain and therefore that any penalties imposed on car use – if indeed,

lower and better enforced speed limits really would constitute a penalty – would be less serious. But it is hard to see any reason why the gains in reduced danger and pollution should be substantially less. The situation might be different in those north American cities which have grown up with motor cars in a form which depends on them.

Each edition of the annual publication *Road Accidents Great Britain* contains a table of international comparisons of road deaths in developed countries. Britain always comes out either the best or one of the best, despite a relatively poor record for pedestrian deaths. Since pedestrian casualties tend to be concentrated in built-up areas, this suggests that Britain's record outside those areas must be outstanding. It follows that other developed countries would have even more to gain than Britain, with respect to reduced accidents and casualties, from lower and better enforced speed limits on rural roads. It is possible, however, that the time penalties of lower speeds would be higher in some relatively sparsely populated countries, such as the Scandinavian countries, Canada, the United States and parts of France, than in Britain. Be that as it may, in the more densely populated countries, such as Italy, the Netherlands and Belgium, the case for lower speed limits outside towns should be at least as strong as it is in Britain.

Powerful though the arguments for lower and better enforced speed limits are in developed countries, in developing countries they are far stronger. Road accidents are a much more severe problem there, especially in Africa. In Nigeria, the fatality rate, calculated in terms of deaths per 10,000 vehicles, is 85 times the rate in Great Britain; the corresponding ratio for Ghana is 53 and for Kenya 29. The country with the lowest accident rate in the Indian sub-continent is Sri Lanka, but even there the rate is ten times that in Great Britain.[65] Although this rate tends to fall as the vehicle population increases, both the absolute numbers of deaths and deaths per head of the population are increasing in African and Asian countries.[66] The problem of road safety in developing countries must, of course, be tackled in a variety of ways, but speed control is certainly one of them.

The arguments for speed control as a way of conserving energy are also stronger in developing countries, which cannot afford any waste of resources. The need to conserve resources and to reduce the import bill also strengthens the case for enforcing speed limits through the vehicle. Indeed, developing countries might be well advised to consider whether any cars other than runabouts should be allowed, except for the police and the army. Among other advantages, this would make local vehicle manufacture more feasible. To the extent that cars were still imported, the drain on foreign exchange would be reduced.

Notes and references

1. *Local Transport Today*, 21 January 1993.
2. In January 1994, it was reported that Kent County Council was looking for other possible sites on main roads where traffic calming could be implemented following its success in calming 'A' roads through the villages of Sarre and Brasted (*Local Transport Today*, 20 January 1994). In addition to the scheme in Thorney (see Reference 5), there has been at least one other traffic calming scheme on a trunk road, on a section of the A1079 in Yorkshire including the village of Dunnington (*Local Transport Today*, 18 August 1994).
3. These examples are taken from various sources, including R Windle and A M Mackie (1992) *Survey on public acceptability of traffic calming schemes*, TRL Contractor Report 298; Oxfordshire County Council (1992) *Kennington Traffic Calming Scheme*; 'York poll uncovers cool response to traffic calming', *Local Transport Today*, 15 September 1994.
4. As Reference 3; also the TRL's leaflet, published in 1994, containing the executive summary of Project Report 85: A Wheeler, M Taylor and J Barker *Speed Reduction in 24 Villages: Details from the VISP study*.
5. The use of humps on a trunk road through the village of Thorney in Cambridgeshire was ruled out 'mainly on aesthetic grounds'. Local people objected to speed tables in the centre of the village, intended to supplement gateways and other traffic calming measures at the outskirts, 'both on visual and noise grounds, as there is a high proportion of lorries in the daily traffic flow' (*Local Transport Today*, 18 August 1994). A scheme in Cobham in Kent was abandoned because, although it reduced vehicle speeds at the outskirts of the village, it did not do so in the centre, since drivers speeded up again. The scheme was also thought to be dangerous in other ways. But other measures were being contemplated, which may by now have been introduced (Kent County Council (1992) *Review of Traffic Calming Schemes in Kent*). A scheme involving pinchpoints in the village of Brantham, on a main road in Suffolk, slowed down the traffic considerably but residents claimed that it led to more pollution, as traffic queued at the pinch points, and to an increase in traffic noise because of gear changing and braking. The scheme was withdrawn in favour of speed cameras (*Local Transport Today*, 11 May 1995).
6. Department of Transport Press Release LR 61/94, 29 March 1994.

7. M A Winnett (1994) *A Review of Speed Camera Operations in the UK*, paper given to the PTRC summer annual meeting, 1994.
8. Telephone conversation with Mr Lax Swali, the Department of Transport official concerned with the West London experiment, April 1994.
9. Telephone conversation with Sergeant Reynolds of the Metropolitan Police, April 1994.
10. M A Winnett (1994) op.cit.
11. A talk by Mr Winnett reported in *Local Transport Today*, 11 May 1995.
12. The first legislation on speed limiters was domestic; the more recent is European. Regulations have been introduced in stages, with the later ones being generally more stringent than the earlier. The result is a changing and complex set of rules. The following summary of the rules applying from 1 January 1996 is derived from a document supplied by the Department of Transport. Coaches of over 10 tonnes gross vehicle weight first used on or after 1 January 1988 have to be fitted with a limiter set at 100 km/h (62 mph), but the permitted performance tolerance allows a maximum speed for these coaches of 65 mph. Coaches first used between 1 April 1974 and 1 August 1988 have to be fitted with limiters set at 70 mph. Heavy goods vehicles of over 12 tonnes gross vehicle weight first used on or after 1 January 1988 have to be fitted with a limiter set at 86 km/h (53 mph), but the permitted performance tolerance allows a maximum speed for these lorries of 56 mph. Heavy goods vehicles of over 7.5 tonnes, but not over 12 tonnes, gross vehicle weight first used on or after 1 August 1992 have to be fitted with limiters set at 60 mph.
13. Department of Transport (1995) *Vehicle speeds in Great Britain 1994*, Department of Transport Statistics Bulletin (95)32.
14. *Road Accidents Great Britain 1994 The Casualty Report*, Table 26, shows that on non-built-up 'A' roads the casualty rate per 100 million vehicle kilometres was 1.9 times as high for buses and coaches as for cars; for motorways the corresponding ratio was 2.9. The exact occupancy rates are not known, but those assumed for the travel time calculations in Chapter 9 can be taken as a rough guide. They are 1.76 for cars, 13.2 for buses and coaches on roads other than motorways and 26.4 for buses and coaches on motorways (see Appendix E). It follows that per person kilometre the casualty rate for buses and coaches was roughly a quarter of that for cars on non-built-up 'A' roads and roughly a fifth of that for cars on motorways.
15. S Plowden and K Buchan (1994) *A New Framework for Freight Transport*, London: the Civic Trust, Tables 4.2 and 4.4.
16. Department of Transport (1995) op.cit.

17. R C Moore (1972/73) *A System for Transmitting Speed Commands to Vehicles: Part 1 Road Installation, Part 2 Vehicle Receiver*, TRRL Technical Notes TN 706 and TN 775.

18. The information in this paragraph and the next has been provided partly by the Wuppertal Institute and partly by Dr-Ing H-H von Winning, a partner in the research organisation which produced the TempoMASTER TM 20 speed limiter.

19. *Transport Statistics Great Britain 1995*, Table 3.1, shows that there were 22,671,000 cars and light vans currently licensed at the end of 1994.

20. In Table D2 of Appendix D it is estimated that the cost of accidents in 1993, at 1993 prices, on motorways, built-up roads and non-built-up 'A' roads, was £21,119 million. The cost of accidents on non-built-up 'B' and minor roads can be roughly estimated on the same basis at a little less than £3bn.

21. This report was confidential to the client. It is quoted here with the permission both of Ricardo Consulting Engineers and of the Dutch Ministry of the Environment.

22. M C Kroon (1994) 'Engine Downsizing – the Key to Fuel Efficiency and Road Safety'. Paper for the OECD/IEA conference *Towards Clean Transport: Fuel Efficient and Clean Motor Vehicles.*

23. Personal communication from the American Automobile Manufacturers Association, December 1994, incorporating the Executive Summary of the PNGV Program Plan.

24. Supercars are described in a number of publications of the Rocky Mountain Institute. This account draws particularly on A B Lovins and L H Lovins (1994) 'Reinventing the Wheels' in *The Atlantic Quarterly*, December 1994 and on A B Lovins, J W Barnett and L H Lovins (1993) *Supercars: The Next Industrial Revolution* (obtainable from Rocky Mountain Institute, 1739 Snowmass Creek Road, Colorado 81654-9199 USA).

25. All the information on the Renault Vesta in this paragraph comes from two documents issued by the Greenpeace Hamburg office in September 1993: a press release entitled *Greenpeace not returning Renault Vesta, action to place orders for a fuel-efficient car* and *The car that supposedly was no more: how Greenpeace came into the possession of the Renault Vesta.* Neither document states the acceleration of the Vesta. The information about the Renault Clio comes from the current Renault brochures.

26. M C Kroon (1994) op.cit.

27. The extent to which the occupants of the heavier car are better protected than those of the lighter one when the two collide is a matter of some dispute among experts. Early studies suggesting that the occupants of the heavier car enjoyed a very substantial advantage have been questioned on the grounds that the differences shown were largely due to vehicle design rather than vehicle mass, or at least that they could be reduced by vehicle design. Nevertheless, it is a fundamental fact of physics that if two objects with a different mass collide more energy is absorbed by the object with less mass. From the point of view of public policy, however, the important point is that any advantage enjoyed by the occupants of the heavier vehicle is obtained only at the expense of the occupants of the lighter one. If two heavy cars travelling at a given speed collide, the risk of injury to their occupants is not less than if two light cars travelling at that speed collide. Downsizing of some vehicles only would not, other things being equal, result in a reduction of deaths and injuries in road accidents, but the risk to the occupants of the downsized vehicles would increase, while the risk to the occupants of the other vehicles would be reduced (C Tingvall (1993), 'Vehicle Downsizing and Safety – the Influence of Mass and Stiffness' in *Safety, Mobility and the Environment: Striking the Balance*. London: Parliamentary Advisory Committee for Transport Safety. The rules should not allow a road user to protect himself against danger simply by transferring the risk he runs to someone else, especially if, as is very likely to happen, his increased feelings of security then encourage him to drive less carefully and so to become still more dangerous to other people. The severity of the injury to a pedestrian or cyclist struck by a car also increases with the weight of the car, at least when the car is travelling at low speeds.

28. This extract is quoted from M C Kroon (1994) op.cit. Mr Kroon was drawing on R F W Diekstra (1993a) 'Saying goodbye to the car' and 'The car jungle' in *Verkeer en Milieu*, Delft: PAO, and on R F W Diekstra (1993b) 'The car as the last territory', *Verkeerskunde* No 2.

29. OECD and IEA (1990) *Low consumption / low emission automobile*, Proceedings of an expert panel, Rome, February 1990, p.xviii. These sentiments were not necessarily held by all the members of the panel.

30. Ibid, p.xxvi. This view seems to have been that of the panel as a whole.

31. Quoted in M C Kroon (1994) op.cit.

32. ECMT (1993) *Transport Policy and Global Warming*. Summary and Conclusions on page 237.

33. M C Kroon (1994), op.cit.

34. Ibid, p.8: 'In the EC's White Paper on Transport and the Commission's proposal for a road safety action programme, little can be found of the above analysis. Policy makers in Brussels follow the car culture ... We should not harbour any illusions about the resistance which limiting the power rating of cars will provoke. I believe that the "car-industrial-cultural"

complex will ensure that this approach will not be embodied in directives until far into the next century.'

35. ECMT (1993) op.cit, p.236 'If that [the ability to indulge in adaptive behaviour which nullifies the potential environmental benefits of the technological instruments] is to be overcome it would seem necessary for transport ministries to recognise the whole range of complicated interactions, and particularly to grasp the nettle of redirecting transport policy to incorporate the environmental objectives. The EC attempts to do this were considered to be very feeble.'

36. Estimates of the number of company cars differ between different sources for reasons which have to do with differences in definition as well as problems of sample design and size. Figures supplied by the Driver and Vehicle Licensing Agency for the period August 1993 to July 1994 show that 51 per cent of newly registered cars were registered by companies. Some of these cars would have been kept in a company car pool and would not have been available for private use, but the figure excludes cars registered by private people but paid for, wholly or in part, by their company, as well as cars bought by self-employed people under tax concessions similar to those applying to employees. The highest estimate that we have seen for the number of cars bought new each year 'run on the business' is 73 to 75 per cent (telephone conversation, 29/7/94, with Peter Cooke, Director of the Centre for Automotive Management at Henley Management College). A special breakdown provided to us by Lex Service plc of a MORI survey carried in October 1993 shows that 12 per cent of cars in the vehicle population were provided by employers or bought as a business expense. According to the 1989/91 National Travel Survey, ten per cent of household cars were bought wholly or partly by an employer; this does not include any business cars run by self-employed people. The estimate that 70 per cent of company cars but only 25 per cent of privately owned cars in the vehicle population were bought new comes from *1993 Lex Report on Motoring 'The Company View'*, published by Lex Vehicle Leasing Ltd in June 1993.

37. 85 per cent of 498 holders of company cars interviewed by MORI in October/November 1992 said that if they no longer had a company car they would buy a car themselves. *1993 Lex Report on Motoring 'The Company View'*, op.cit.

38. The special breakdown of the October 1993 MORI survey mentioned in Reference 36 shows that 52 per cent of privately bought cars but only 34 per cent of company cars had engines of under 1401 cc. The general point that privately owned cars are smaller is confirmed by a number of surveys.

39. A Hanton (1994) *Company Cars, Summary of the Main Environmental Impacts*. The mileage figures in this paper are derived from the National Travel Survey.

40. In the 1994 MORI survey for Lex, 44 per cent of private car drivers admitted to having exceeded the speed limit on motorways and 59 per cent to having exceeded it on a normal main road in the preceding 12 months; the corresponding figures for people driving cars provided by their employers were 79 per cent and 78 per cent. These differences presumably reflect the greater mileage driven by company car drivers, especially on motorways, as well as different driving behaviour. This survey was reported in *The Independent* of 10 March 1994.

41. A survey of 1,000 drivers carried out by the motor warranty firm Car Care Plan in 1989 found that 27 per cent of company car drivers but only 9 per cent of private car owners had been involved in a crash of some kind in the preceding year (*Transnet Newsletter*, December 1989). This difference must also reflect different mileages as well as different driving behaviour.

42. 1993 Lex Report on Motoring 'The Company View', op.cit.

43. *Company Cars: An International Perspective*, National Economic Development Office, 1991, p.23.

44. Ibid, pp.1, 35-37.

45. 'Company cars are a source of constant administrative difficulty and complaint on the part of the staff. I have, for many years, believed that it would be easier for the companies and would eliminate the source of jealousy and contention, if their use could be phased out and replaced by an increase in basic salary'. Letter from Sir John Harvey-Jones, 16 August 1994.

46. Parliament sets a bad example in this respect. For mileages of up to 20,000 miles a year, MPs get 72.2 pence per mile for a car of over 2,300 cc, 46 pence per mile for a car of 1300 to 2300cc and 30.5 pence per mile for a smaller car. The AA recommends a rate of 51.2 pence per mile for a car of between two and three litres driven 20,000 miles a year on business. 'MPs use car mileage to clock up expenses', *The Independent*, 12 June 1995.

47. *Company Cars: An International Perspective*, op.cit, p.23.

48. An early and very thorough study was the report Cars for Cities produced by the Ministry of Transport in 1967. This was in a sense a response to the Buchanan Report, *Traffic in Towns*, published in 1963, which explored the possibility of accommodating more cars in towns by redesigning the towns. The approach of *Cars in Cities* was to make cars smaller, more uniform in size and more manoeuvrable as well as quieter and less polluting. There have been many ideas for city cars since that time, including some developed

by major manufacturers. Although the roles envisaged for the two cases are very different, it is possible that some of the design features of a city car might also apply to a local runabout.

49. The question is sometimes asked why a local runabout is necessary when a bicycle, if properly segregated from motor traffic, would fill the same function. What the local runabout offers which the bicycle does not is protection from the elements, the ability to carry people and luggage, and the avoidance of physical effort. There will always be people, especially the elderly and parents of young children, for whom these advantages are important.

50. Apart from people, such as the police and couriers, who use motorcycles in their work, motorcycle users fall into two categories: the enthusiasts, to whom the runabout would not appeal, and people who simply want a cheap form of personal motor transport. According to an AA survey, many motorcyclists would prefer to have a car. 'Motorcyclists would prefer cars, survey finds', *Local Transport Today*, 18 August 1994.

51. Market research on the potential market for runabouts, and the nature of the consumer resistance to be overcome, would require detailed planning, which is beyond the scope of this report. But one part of it might take the following form. Owners of conventional cars, excluding those with very high annual mileages, could be asked to imagine that they owned runabouts instead. They would then be taken through the long-distance car journeys they had made in the preceding twelve months and asked for each one how they would have performed it, or whether they would have forgone it altogether or substituted another journey for it. Two assumptions could be made about the alternative facilities: that they would remain as they are now, or that they would be improved by better and cheaper car hire and in the other ways suggested above. Then estimates would be made of the respondent's annual expenditure on transport both at present and if (s)he gave up a conventional car in favour of a runabout. In the light of all this, respondents would be asked to say whether they would choose a conventional car or a runabout.

52. Special breakdowns of the 1991/93 NTS supplied by the Department of Transport. The annual mileage figures are based on respondents' estimates.

53. For an elaboration of these ideas see S Plowden and K Buchan (1995) *A New Framework for Freight Transport*. London: the Civic Trust.

54. A Stricker (1993) 'An environmentally friendly solution to urban goods distribution', *Transport Retort*, September/October 1993.

55. F Worsford (1995) *The Trend towards Distribution and Lorry Parks: Meeting Industry Needs for a New Millennium*. Manchester: the Burford Group.

56. *Road Accidents Great Britain 1994, The Casualty Report*, Table 26.

57. C J Baughan, B Hedges and J Field (1983) *A National Survey of Lorry Nuisance*, TRRL Supplementary Report 774, Table 4. It should be noted, however, that motorcycle mileage has almost halved since 1980 and the machines themselves are quieter, at least in test conditions, so it is unlikely that if this survey were repeated today it would reveal the same degree of dissatisfaction.

58. J M Munden (1964) 'The Variation of Motorcycle Accident Rates with Age of Rider and Size and Age of Machine', *International Road Safety and Traffic Review*, Vol XII No 1, Figure 2. This is quoted in detail in Table II.7 of S Plowden and M Hillman (1994) *Danger on the Road, the Needless Scourge*. London: PSI.

59. J Broughton (1988) *The Relation between Motorcycle Size and Accident Risk*, TRRL Research Report 169 and M C Taylor and C R Lockwood (1990) *Factors Affecting the Accident Liability of Motorcyclists – A Multivariate Analysis of Survey Data*, TRRL Research Report 270.

60. Personal communication from the Department of the Environment, 8 January 1996.

61. Commission of the European Communities COM(94) 321 final – COD 371.

62. *Financial Times*, 19 January 1995.

63. Department of Transport (1995) *Vehicle Speeds in Great Britain 1994*, Department of Transport Statistics Bulletin (95)32. Since this chapter was drafted, the Department of Transport has discovered that problems with the equipment used in its speed surveys make the speeds recorded for motorcycles unreliable. The problems affect only two-wheeled vehicles; there is no reason to doubt the accuracy of the results for vehicles of any other type. It is, however, a matter of common observation that motorcycles are often driven faster than other vehicles, and it would be surprising if more reliable figures, when they become available, were to invalidate the conclusion that motorcycles should be fitted with speed limiters.

64. Ibid. The rest of footnote 63 also applies.

65. From figures for the years 1988 to 1990 supplied by the Overseas Centre of the Transport Research Laboratory.

66. A Ross, C Baguley, B Hills, M McDonald and D Silcock (1994) *Towards Safer Roads in Developing Countries*, Transport Research Laboratory and Overseas Development Administration, p.2.

12

Politics and public opinion

12.1 The European Union and member states

In the absence of special derogations, once the European Union has legislated on a certain topic, individual member states lose their powers to do so.

The first move towards having speed limits treated as a European issue was made in March 1984, when the European Parliament asked for 'a uniform but practicable system of speed limits throughout the Community which relates to the actual traffic situation and is suitably differentiated according to the type of road, the specific category of vehicle and the surroundings (country, built-up areas, conurbations, residential districts etc)'.[1] In a further resolution of the European Parliament passed in February 1986, a Community regulation on speed limits was considered 'an indispensable measure in promoting road safety'.[2] In December 1984, the European Commission informed the Council, in its first Communication on European Road Safety Year 1986, that it intended to present a proposal for harmonisation of speed limits in the Community.[3] At the Environmental Council of June 1985, the Commission undertook to present an appropriate proposal on speed limits. The 'influence of speed on pollutant emissions from cars' seems to have been the principal consideration leading to this undertaking.[4]

The Commission presented its Communication to the Council *Speed Limits in the Community* in January 1987.[5] This document discussed the influence of speed on accidents, energy consumption and air pollution. Intimidation, the other non-accident costs of unsafe roads and noise were not mentioned. Neither was the influence of speed on journey lengths and modal choice, although the point was made that relatively high speed limits on motorways helped to attract vehicles to them from other, less safe, roads. It was said that as long as speed limits

were not fixed at levels far below speeds practised by the majority of motorists, there would be no harmful effects on transport efficiency or motor car manufacture.

In this document, the Commission suggested that the 'normal' speed limit for cars on motorways might be 120 km/h, with the possibility of a higher limit on motorways with relatively low volumes of traffic sited well clear of urban areas, and of a lower one on those in or close to urban areas or carrying large volumes of traffic. The Commission also recommended that limits for cars on roads other than motorways should be lower than their normal limit on motorways, and that on each kind of road limits for coaches and heavy lorries should always be lower than those for cars.

The reason for the choice of 120 km/h was not made clear. No attempt was made to balance those speed-related costs that the document recognised against travel time, nor was any other rationale for this figure given. The impression the document gives is that the authors were trying to produce a harmonised speed limit which would involve the least amount of change for member countries: four countries already had a 120 km/h speed limit; three had higher limits and four had lower ones. The need for limits to be 'realistic' in the sense of being accepted by drivers was stressed, so perhaps it was also felt that a significant number of drivers would not have accepted a lower limit.

In the event, the Commission proposed a Directive for speed limits, by type of road, for coaches, heavy lorries and vehicles towing other vehicles but not for cars.[6] Although the Directive was not passed, the regulations for speed limiters on coaches and certain heavy lorries mentioned in the last chapter mean that there is now, in effect, a European speed limit for those vehicles on motorways.

The European Union, or Community as it then was, has been involved with vehicle regulation for a long time. For example, European Directives have been the means of ensuring that vehicles are manufactured to progressively higher standards with respect to emissions of noise and fumes. Although the legal position is not completely clear, it seems to be agreed both by the Commission[7] and by the British Department of Transport[8] that the power to set Construction and Use Regulations has now passed almost entirely to the European Union. So far, the only Directives bearing on speed are those that have already been described requiring lorries and coaches to be fitted with top-speed limiters. The Commission has no plans for variable speed limiters on these vehicles or for speed limiters of any kind on cars. Nor, as was seen in the last chapter, is there any immediate prospect of European legislation to prevent the construction of vehicles capable of exceeding a given speed.

The present situation is unsatisfactory in various ways. Although powers to determine speed limits remain, for the most part, with member countries, who also have the responsibility of enforcing them, the most effective means of enforcement, through the vehicle itself, have been taken away from them. Those countries who wish to progress more quickly than the rest, whether with respect to speed control or any other aspect of vehicle design, are prevented from doing so. This deprivation affects other countries too, in that they lose the chance of learning from the experience of the avant-garde. It is possible for harmonisation not only to delay progress, but to reverse it. For example, if the idea of a Europe-wide speed limit of 120 km/h were put into effect, several countries, including the United Kingdom, would have to raise their existing national limits.

Some of the present defects can perhaps be blamed on excessive caution or wrong priorities on the part of the Commission or the Council of Ministers. As was seen in the last chapter, the attitude of Brussels has been criticised both by the Dutch and in an experts' report for the ECMT. But whether or not these criticisms are deserved, a fundamental flaw in the present system is the fact that either Brussels or the member countries have the exclusive responsibility in any given field of action. In the United States, both the federal government and state governments can be involved with the same subject. A state's laws may be more stringent than the federal government's but not less. For example, when in 1987 the federal government raised the national speed limit from 55 mph to 65 mph, some states chose to retain the 55 mph limit. Similarly, with respect to vehicle standards, some states, notably California, have always set especially stringent requirements, some of which have later been adopted by the federal government.

In effect, the federal government sets minimum standards, whereas the European Union's standards are both minima and maxima. There is a paradox here, since advocates of greater European integration have always said that it was not intended for the union to be closer, or the central institutions more powerful, than in the United States. We believe that, in this area of policy at least, the present division of powers between the European Union and its members is inappropriate. The European Union's regulations, like those of the federal government in the United States, should be minima only. Any country wishing to set

more stringent standards should be free to do so. As far as speed limits are concerned, this recommendation is in line with the views of the European Transport Safety Council, which in a report published in 1995[9] recommended that each member country should be required to impose its own limit of 120 km/h *or less* (emphasis added).

It is possible that countries would feel some reluctance to set higher standards in environmental matters than their neighbours for fear of an adverse competitive effect on their industries. It is not clear that there would be any such effect in relation to lower and better enforced speed limits, but in any case it would be up to the countries concerned to decide whether they were prepared to take that risk. If different countries had very different Construction and Use Regulations for cars, there could also be problems about cars registered in a country where the standards were relatively low being driven in a country where they were higher. A solution might be for countries with high standards to allow a car which met the European standards but not their own to enter for a stay of a defined length. Or possibly this anomaly might just have to be accepted. If the United States can live with such problems, so can Europe.

Some countries are now opposed to speed limits being set by Brussels because they fear that their own would have to be raised. Their opposition would presumably cease if they had the power to continue with their own lower limits. Germany is opposed to a European speed limit because at present it has no mandatory speed limit on motorways, although it does have an advisory speed limit of 130 km/h. If the opposition of the countries who now resist the introduction of European limits for quite different reasons were removed, Germany might find it increasingly difficult to maintain its position, especially as it is out of line with German public opinion.[10]

But is there in fact any advantage to be gained from a European approach to speed limits? The argument put forward by the Commission in 1987 was that:[11]

> ...since an increasing number of motorists travel from one country to another within the Community, which is working towards a complete internal market in 1992, it is unreasonable to have different speed limits for the same type of infrastructure. Different speed limits within the Community should only be authorized on a local basis.

This is not very convincing. Those motorists who drive from one country to another are presumably quite capable of adapting to different speed limits. But if it is accepted that the best way to enforce speed limits is through the vehicle, then a much stronger case for action at the European level can be made. Vehicle manufacture and marketing is an international business; it would be very convenient if all new cars sold in Europe had a top speed not greater, or greater by only a specified small margin, than the European speed limit for motorways. In addition, if all vehicles sold in Europe had to be fitted with variable speed limiters, this would enable the speed limits on roads other than motorways to be enforced and, indeed, the limits on motorways in those countries which chose to adopt limits lower than the European ones.

If the calculations in Chapter 9 apply to other European countries as well as to Britain, then the European motorway speed limit should be less than 100 km/h. But however strong the arguments, it is politically unrealistic to think that such a limit would command enough support to be accepted as a Europe-wide standard in the near future. But even if European regulations limited the top speed of new cars sold in Europe to 130 km/h (81 mph), which is the highest limit now found in Europe (albeit in Germany it is advisory rather than mandatory), that would be a great advance.

One of the advantages in letting member countries set more stringent regulations than those set by Brussels is to allow other countries and the Commission to learn from them. But to exploit this advantage fully, it is important that there should be reliable and comparable statistics in each country. The speeds at which different types of vehicles are driven on different types of road should be monitored by surveys similar to the British ones used for the analyses in Chapters 9 and 10. Comparable statistics on speed-related nuisances are also necessary. The Commission has already worked on the creation of a Union-wide data bank for accidents.[12] Because of the under-reporting of accidents in the police records, surveys of various kinds, for example, among hospitals, doctors, households and insurance companies, are required to supplement the police statistics, and these surveys too should have a common design. Air quality and noise should also be monitored in a standardised way. A review is required of how all these aspects are monitored at present in each member country, and of what needs to be done to produce statistics which would allow inter-country comparisons to be made. In the light of this review, the Commission should encourage the necessary data collection and analysis to be set up in each country. A possible method of encouragement might be to make various kinds of aid from Brussels dependent on this work going ahead.

12.2 Public attitudes to speed limits and their enforcement

The objective case for lower and better enforced speed limits is very strong, and better enforcement presents no great technical difficulty. The main obstacle is political: politicians fear that motorists, who now constitute a majority of the electorate, would not stand for such a policy. It was only for this political reason that the Transport Research Laboratory's successful experiments with variable speed limiters on cars in the early 1970s, mentioned in Chapter 11, were discontinued. It is true that democratic governments cannot move too far in advance of public opinion, but are politicians' views about what the public wants well founded?

Evidence from various social surveys suggests that most people would welcome the stricter enforcement of speed limits. An international survey of motorists' attitudes to various issues of road safety and transport policy was carried out in 1991 and 1992; the British fieldwork was carried out in December 1991. Seventy-three per cent of the British motorists questioned were in favour (27 per cent strongly in favour) of the Government's devoting more effort to the enforcement of traffic laws, with only ten per cent against (one per cent strongly against). Seventy per cent were in favour (32 per cent strongly in favour) of much more severe penalties for driving offences with only ten per cent against (one per cent strongly against). Speeding was not distinguished from other driving offences in this question, but other questions were concerned specifically with methods of controlling speeds. Only 42 per cent supported, while 50 per cent were against, speed limiters on cars which would make it impossible to exceed a certain limit at any time, but 61 per cent supported and 33 per cent were against speed limiters on cars of a kind which would allow drivers free to decide whether or not they wanted it to operate. Fifty-five per cent supported and 38 per cent were against a requirement that manufacturers throughout European countries should be required to modify their vehicles to restrict maximum speeds.[13] Among those opposed to these particular methods, there must have been some who would, nevertheless, have approved of better enforcement by some other means, such as speed cameras.

A survey of adults in Northern Ireland conducted in 1990 found that 49 per cent thought that speed cameras should definitely be allowed and a further 30 per cent thought that they should probably be allowed.[14] A Gallup poll in Great Britain in December 1992 found that 69 per cent of all adults and 63 per cent of those in car-owning households approved of speed limiters on cars of a kind which would automatically prevent a given speed being exceeded.[15] This finding suggests that a considerable strengthening of opinion against speed had taken place in the two years following the international survey. There is other evidence of that, in particular from surveys among Scottish motorists carried out in 1991 and 1994.[16] The number of motorists who took a serious view of speeding increased over that time and so did support for most forms of enforcement. The percentage of motorists strongly in favour of speed cameras rose from 37 per cent in 1991 to 45 per cent in 1994 (a further 44 per cent in 1991 and 35 per cent in 1994 were also in favour). The percentage in favour of more speed humps in residential areas rose from 48 per cent to 61 per cent. The fact that people who were doubtful about these particular measures might still wish to see stricter enforcement is shown by the fact that in 1994, 86 per cent of Scottish motorists were in favour of more enforcement of speed limits in built-up areas and 71 per cent were in favour of stricter enforcement of motorway speed limits.

When asked what the speed limit should be on any particular type of road, there is a strong tendency for people to say that the existing speed limit is the right one.[17] This may explain the contradictory findings in the 1994 Scottish motorists' survey that 71 per cent thought that the present 30 mph limit in residential areas was about right, but 69 per cent were in favour of reducing the speed limit in built-up areas.

One finding which is very clear is that people would like to see lower speeds in the more sensitive parts of towns. Ninety-four per cent of Scottish motorists in 1994 were in favour of reduced speed limits outside schools. A customer survey carried out by Autoglass in 1995 found that 90 per cent would support 20 mph limits 'at places like schools and busy town centres, where there are vulnerable pedestrians'.[18] In surveys conducted by the TRL accompanying traffic calming schemes in four different towns, 64 per cent thought that cars travelling too fast was a serious problem even after the introduction of the schemes.[19] Similarly, opinion surveys accompanying the introduction of traffic calming in villages 'indicated that the changes in the five villages studied had been generally strongly welcomed but were often not considered to be effective enough. Many improvements were suggested to reduce speeds more'.[20] A survey by Colin Buchanan and Partners in the Lothian Region found that four-fifths of residents were in favour of the principle of traffic calming, but that there was a high degree of dissatisfaction with chicanes, which were felt to encourage

Table 12.1 Scottish motorists' views on what speed limits are appropriate on main roads outside built-up areas

On motorways / dual carriageways / unrestricted single carriage-ways, the speed limit is 70 mph / 70 mph / 60 mph. Do you think this is too fast, about right, too slow?

Percentages

	Motorways 70 mph limit	Dual carriageways 70 mph limit	Unrestricted single carriageways 60 mph limit
Too fast	8	36	37
About right	70	60	58
Too slow	22	3	3
Don't know	-	1	1

Base: 1,079

Source: See the text and footnote 16.

bad driving and to be ineffective in reducing speed. Almost 80 per cent of the 425 people interviewed were in favour of a mandatory 20 mph speed limit in residential areas.[21]

Outside towns, the tendency to believe that the existing speed limits are right predominates, but there is significant minority support for the view that speed limits should be lower than they are at present on roads other than motorways, but higher than they are at present on motorways. This is shown in Table 12.1, derived from the 1994 Scottish survey. The British part of the 1991/92 international survey confirms this finding.[22]

The results of the international survey, taken as a whole, suggest that British motorists tend to be more concerned about road safety and more in favour of controls on speeds than their continental counterparts, although 33 per cent of all the motorists surveyed were strongly in favour of more enforcement of traffic laws, as compared with 27 per cent in Britain.[23]

What can be said, in the light of these findings, about the political feasibility of adopting the lower speed limits and the more effective methods of enforcing them that have been recommended in this report? Much needs to be done to 'sell' these ideas to the public, but there are some very hopeful signs. The degree of acceptance both of speed limiters and of the idea of limiting the maximum speed of vehicles through vehicle design is already high enough for the EU and national governments to start working on the technical and legal specifications. The idea that the speed limit in towns should normally be 20 mph rather than 30 mph, with some higher and lower limits on special kinds of road, may already be the majority view. Although most people think that the present speed limits on roads outside towns are the right ones, there is a strong undercurrent of feeling that they are too high on non-motorway roads. If it is true that the majority view is not so much a positive endorsement of the present limits as a reflection of the tendency to accept whatever limits happen to exist, the task of obtaining acceptance for lower limits on these roads may not be too difficult. But for motorways, where a substantial minority of drivers would like to see the present speed limits raised, the task may be much harder.

The first essential is to make sure that people know the facts about the relationship between speed and the various nuisances of traffic. In recent years, the Department of Transport has put a great deal of effort into campaigns, using the mass media, to inform people about how the probability that a child will be killed when hit by a car increases with the car's speed. This has been very successful in terms of knowledge,[24] and it is reasonable to suppose that the public's better understanding of this point has helped to bring about the changes in attitude to speed that have been noted. In particular, it may well help to account for the fact that the great majority of people would like to see a 20 mph speed limit in sensitive parts of towns.

It may be that a better understanding of the relationship between speed and accidents would suffice to dispel even the present opposition to lower speeds on motorways. It is not long since the AA, the RAC and even the police were advocating raising the motorway speed limits, so it is hardly surprising that many motorists still hold that view. The facts about speed causing accidents were instrumental in changing the minds of the motoring organisations and the police; if the public also knew these facts, they might change their minds as well. But it would be wrong for attempts to educate the public to concentrate exclusively on accidents. The Departments of Transport and the Environment should mount campaigns to inform the public about the contribution of speed to all the adverse effects of traffic. The campaigns should also stress the connection between speed and traffic growth. Opposition to road construction is becoming intense; if people realised that lower speeds would check and, in time, even reverse traffic growth, and so eliminate

the need for major new road building, the present hostility to lower speeds on motorways might turn into support. But for the Department of Transport to emphasise this point would require a volte-face, since it continues to argue that traffic growth is mainly due to growth in incomes,[25] a development which is outside its control and which few people would wish to see checked.

Any attempts to educate public opinion should be accompanied by monitoring, by means of social surveys, to see what success has been achieved. These surveys should include both questions on the facts about the effects of speed and also questions about people's attitudes to speed limits and methods of enforcement. It will then be possible to see to what extent knowledge influences attitudes.

Large-scale trials of the strict enforcement of lower speed limits are also required. On the principle that seeing is believing, trials may be more effective than statistical analyses, often based on foreign experience, in convincing the public of the connections between speed and the danger and environmental impact of traffic, even when the existing evidence is in fact compelling. In addition, some of the relationships have been established only approximately; trials will help to make them more precise. They will also enable much better estimates to be made of the time penalties of lower speeds, and will give people the chance to experience the more subjective effects of driving in a traffic stream where everybody is driving more slowly, such as, it is to be hoped, a reduction in stress. Finally, they will bring to light any practical problems, especially concerning the means of enforcement, which may not be evident now.

Such trials would have to cover different types of road: urban, minor country roads, main roads between towns, and motorways. Most trials will have to rely on an enhanced police presence and the greater use of existing means of enforcement such as speed cameras. But it is important to try out the use of speed limiters too. The problem is to find an area which is reasonably self-contained in traffic terms, in the sense that relatively little mileage is accounted for by vehicles from outside which could not be fitted with the limiters, and which is also both small enough to enable the experiment to be mounted without excessive expense and large enough to yield enough data for analysis in a fairly short time.

Islands like the Isle of Wight and the Isle of Man might be suitable. But the best choice within the United Kingdom may be Northern Ireland, especially seeing that its accident problem is worse than Great

Britain's,[26] that to tackle it is already recognised as a priority,[27] and that a recent study suggests that speed is a principal cause of road accidents there.[28] In addition, the selection of Northern Ireland for an experiment of potential importance not only to the United Kingdom but to Europe and the world as a whole could boost both its image abroad and the peace process. Possibly an experiment there could be extended to the Republic as well, where the accident problem is still more severe.[29] If that were done with the willing consent of people from both sides of the border, with no element of coercion, that might further assist the peace process. Whether the experiment was confined to the north or extended to the south, its wider relevance should enable it to attract European as well as national funds. (This paragraph was first drafted before the ending of the IRA's ceasefire in February 1996. Trials in Northern Ireland will be more difficult, and may not be feasible at all, until the ceasefire is restored, although planning for them could still go ahead.)

References

1. This statement is quoted in COM(88) 706 final *Proposal for a Council Directive on speed limits for certain categories of motor vehicles in the Community*, published 11 January 1989, where the source is given as Official Journal No C 104, 27.04.1984.
2. This statement is also quoted in COM(88) 706, where the source is given as Official Journal No C 68, 24.03.1986.
3. This statement is also quoted in COM(88) 706, where the source is given as COM (84)704 final of 13 December 1984.
4. COM(86) 735 final *Communication from the Commission to the Council, Speed limits in the Community*, published 26 January 1987.
5. Ibid.
6. *Proposal for a Council Directive on speed limits for certain categories of motor vehicle in the Community*, Official Journal No C 33/9, 9.2.1989.
7. Personal communication from DG VII, 14/10/94. Also, on page 11 of the Appendix to COM(93) 246 final *Communication from the Commission to the Council for an action programme on road safety*, vehicle construction is mentioned as one example of a field where action at EC level is required because 'it cannot be taken by Member States because of the provisions of the Treaty'.

8. House of Commons Select Committee on European Legislation (1995) *The United Kingdom and the Community: Who Makes the Law on Road Safety?*, London: HMSO. See especially the evidence given by the Department of Transport's witnesses on p. 55.
9. European Transport Safety Council (1995) *Reducing Traffic Injuries Resulting from Excess and Inappropriate Speed*, pp. 25 and 28. It is noteworthy, however, that, like the European Commission, this Council did not attempt to show that the harmonised motorway speed limit that it recommended would be optimal. Instead, again like the Commission, it seems to have selected the limit of 120 km/h as the one that would have involved least change from the existing limits in the various member countries, although it did also appeal to a public opinion survey among motorists in EU countries (see next reference) in which 57 per cent approved of a harmonised 120 km/h limit.
10. A survey of active drivers in a number of European countries carried out in 1991/92 included interviews with 1,022 drivers in west Germany and 1,067 in east Germany. Only 30 per cent of drivers in west Germany and 10 per cent of those in east Germany thought that there should be no speed limits on motorways. Barjonet P (1993) *Sartre: Social Attitudes to Road Traffic Risks in Europe, Report on Principal Aspects*, Figure 3.16. This report was published by INRETS.
11. COM(86) 735 final, op.cit., p. 7.
12. COM(93) 246 final, op.cit., p. 18.
13. The findings from the British part of the international survey in this paragraph are taken from A Quimby, C Downing and C Callahan (1991) *Road users' attitudes to some road safety and transportation issues*, TRRL Contractor Report 227, and from Social Surveys (Gallup Poll) Ltd (1992) *Final Analysis Pan European Survey on GB Social Attitudes to Road Risks*.
14. P Stringer and G Robinson (eds) (1992) *Social Attitudes in Northern Ireland, the Second Report*. Belfast: Blackstaff Press.
15. These figures come from questions inserted in a Gallup omnibus survey on behalf of RoSPA, who have kindly provided us with the tabulated results.
16. This survey was carried out by Market Research Scotland Ltd on behalf of the Scottish Office. The results quoted here come from the published report *Attitudes of Scottish Drivers Towards Speeding – 1994 Survey*, published by the Scottish Office in 1994, and from extra tabulations kindly supplied by the Scottish Office.
17. This tendency is not confined to Britain. It was mentioned in the report of the 1991/92 international survey of motorists' opinions, P Barjonet op.cit., p. 44, and has also been found in Finland. Professor Salusjärvi, who has

been responsible for a large programme of research on speed in Finland, believes that more than 50 per cent of drivers support the speed limit that exists, whatever it happens to be. If a new limit is introduced, they will defend it after a short time, even though they previously opposed it (personal communication with Professor Salusjärvi, May 1994).

18. This survey was based on a sample of 412. The tabulations were kindly supplied to us by Autoglass.

19. R Windle and A M Mackie (1992) *Survey on public acceptability of traffic calming schemes*. TRL Contractor Report 298.

20. *Executive Summary of Project Report 85*, TRL leaflet published in 1994. The full report is A Wheeler, M Taylor and J Barker (1994) *Speed Reduction in 24 Villages: Details from the VISP Study*.

21. 'Lothian sets calming agenda for new councils as public backs 20 mph zones', *Local Transport Today*, 9 November 1995, p.4.

22. P Barjonet, op.cit., p.143.

23. When asked what the speed limit should be on main roads between towns, 32 per cent mentioned a speed of 40 mph or less, 30 per cent said 50 mph, 27 per cent said 60 mph, 9 per cent said 70 mph and one per cent said 80 mph. For motorways, 9 per cent mentioned a speed of less than 70 mph, 43 said 70 mph, 36 per cent said 80 mph and 11 per cent mentioned a higher speed. Social Surveys (Gallup Poll) Ltd, op.cit.

24. Questions placed by the Central Office of Information on an omnibus survey conducted by the British Market Research Bureau showed that in October 1991, 53 per cent of drivers thought (incorrectly) that if a car travelling at 20 mph hit a child, the child would be extremely likely or very likely to be killed. By October 1993, only 19 per cent thought so. In the spring of 1994, the focus of the Department of Transport's advertising campaign switched from child pedestrians to all pedestrians. This may help to account for the fact that in May 1994 the percentage of drivers giving this answer had risen again to 24 per cent. Letter from the Central Office of Information 20 December 1994, with tabulations attached.

25. That this view seems still to prevail in the Department of Transport, despite its somewhat grudging acceptance of the SACTRA report on traffic generation, is shown by a letter from John Watts, Minister for Railways and Roads, in *Local Transport Today*, 26 October 1995.

26. Table 48 of *Road Accidents Great Britain 1994* shows that in Northern Ireland in 1993 there were 8.8 road deaths per 100,000 population and 2.4 road deaths per 10,000 motor vehicles, as compared with 6.7 and 1.5 for Great Britain and 12 and 3.7 for the Irish Republic.

27. Between 1969 and 1994, more people in Northern Ireland were killed or seriously injured in road accidents than in the 'troubles'. In March 1995, the Chief Constable of the RUC, Sir Hugh Annesley, in launching 'Operation Roadsafe', said that road safety was to be given the highest priority. Vidya Borooah 'Fast Lanes', *Fortnight*, May 1995.

28. 'TRL blames speed and drink for NI road safety problem', *Local Transport Today*, 18 January 1996.

29. See Reference 26.

Appendix A

The derivation of the 'rule of half' and the assumptions on which it depends

1. If the cost of making a certain journey, as defined by origin and destination and mode of travel, were to fall, say because of an investment in infrastructure, it is likely that more of those journeys would be made. The rule of half states that the value of this extra travel, to the people who make it, is given by the number of additional journeys multiplied by half the difference between the cost of making each journey without the investment and the cost of making it with it. This is a very economical rule in terms of its data requirements, since apparently it is not necessary to know anything about what the travellers concerned would do if the investment did not take place. The purpose of this appendix is to show the derivation of this rule and to discuss its underlying assumptions.

2. Let us take the example of a particular traveller who has to choose between two shopping centres: N, which is near to him, and D, which is more distant but also more attractive. At present, the traveller goes by bus to N, but if a proposed road widening scheme between his village and D went ahead, he would go by car to D instead. In order to express his choices in mathematical terms, it is necessary to adopt the Utilitarian assumptions that people act to maximise their satisfaction and that satisfactions can be measured in some common unit such as money. If Vn is the value the traveller attaches to shopping in N, Vd is the value he attaches to shopping in D, Cn is the cost of the bus journey to N, Cd1 is the cost of the journey to D by car without the road widening, and Cd2 is the cost of the journey to D by car with the road widening, then the following expressions can be written:

   Vn - Cn is the satisfaction which the traveller gets from his shopping expedition in the 'without' situation;

Vd - Cd2 is the satisfaction which the traveller gets from his shopping expedition in the 'with' situation.

3. The increase in his satisfaction that would result from the road widening is therefore (Vd - Cd2) - (Vn - Cn). Let this expression be G (for gain); the problem is to evaluate G.

4. It is clear that G is more than 0, since otherwise the traveller would still travel by bus to shop in N even when the cost of the car journey to D was reduced by the road widening. Also, Vn - Cn must be more than Vd - Cd1, since otherwise the traveller would choose to drive to D to shop even if the road were not widened. Hence G must be less than (Vd - Cd2) - (Vd - Cd1); that is, less than Cd1 - Cd2. So G lies between 0 and Cd1 - Cd2. If the number of people in the same position as the one traveller considered in this example is fairly large, and if the difference between Cd1 and Cd2 is not too great, it is reasonable to suppose that the average gain per traveller will lie halfway between these two extremes, with a value of ½(Cd1 - Cd2).

5. What setting out the proof in this algebraic way brings out is that the rule of half is valid only on the assumption that the values of the terms Vn, Cn and Vd remain the same in the 'with' and 'without' situations. But that assumption is highly implausible. If a number of people desert the local shopping centre, it may have to reduce its range of choice or increase its prices. Perhaps it will be put out of business altogether, as many village shops have been. The local bus service may also have to withdraw services or put up prices if patrons desert it; that, too, is a familiar story. Shopping in the larger shopping centre may become less agreeable as it becomes more crowded. (If the example concerned beauty spots rather than shopping centres, the negative effects of an increase in the number of visitors might be particularly severe.) In all these cases, the gain to the people whose changed travel behaviour triggers off the other changes is likely to be less than the rule of half suggests. But, in addition, some other travellers would actually be worse off if the road widening went ahead, for reasons quite apart from the delaying effect or the extra accidents of the additional car miles driven. They include those people who rely on the local shops or bus service, and at least some of those who would choose to go to the more distant attraction (which may not be more distant for all of them, but may indeed be the local facility for some people) even if the road widening did not take place.

Appendix B

Accident statistics

1. The purpose of this appendix is to explain the derivation of the accident statistics used in Chapters 9 and 10. The starting point is Table B1, derived from official statistics based on police reports. However, the police reports do not constitute a complete record of casualties in road accidents and the police classification of the severity of injuries often differs from that of hospitals: sometimes the police record a casualty as serious which hospitals record as slight, but more often they record as slight casualties which hospitals consider serious. The figures in Table B1 therefore have to be adjusted to correct for these shortcomings. In addition, since statistics based on police records relate only to injury accidents, estimates are required of the number of damage-only accidents.

Table B1 Injury accidents in Great Britain in 1993 by type of road and severity as stated in the national statistics based on police reports

	Type of road			
Severity	Motor-ways	'A' roads with a limit of 70 mph	'A' roads with a limit of 60 mph	Built-up roads
Fatal	159	248	893	1,646
Serious	979	1,249	5,306	25,497
Slight	5,725	4,937	17,497	141,339

Source: *Road Accidents Great Britain 1993*, Tables 13 and 15.

Underestimation of casualties

2. As has been mentioned, the figures in Table B1 are based on police reports. Comparisons between police reports and hospital records show that although all fatal casualties from road accidents appear in the police reports, there is considerable under-reporting of other casualties. Table B2 shows the results of three studies, carried out at different dates and in different parts of Britain, comparing police and hospital statistics. Each cell of the table shows the number of casualties from road accidents treated in hospital and also appearing in the police reports expressed as a percentage of the total number of road casualties of that severity treated in hospital.

Table B2 Coverage of casualties in the police records

Percentages

	Hospital classification of casualties		
	Serious	Slight	Serious or slight
Casualties also recorded in the police records either as serious or slight			
1970 Birmingham	82	65	70
1974-6 Berkshire	79	66	72
1990 Manchester	74	42	49

Sources: Birmingham - J P Bull and B J Roberts[1]
Berkshire - L A Hobbs, E Grattan and J A Hobbs[2]
Manchester - J M Hopkin et al,[3] Figure 10.

3. The reasons for the large discrepancies in coverage between the Birmingham and Berkshire studies on the one hand and the Manchester study on the other are not known. It is possible that there has been some decline in the completeness of the police records over the years. In the Netherlands[4] the completeness of police records for in-patients was approximately 85 per cent and stable during the late 1970s but declined to 70 per cent by 1988 (all in-patients are classified as seriously injured in the British statistics, but the seriously injured category also includes a number of other casualties). It could be that the growing pressure of other work has led to the police having less time to devote to attending accident sites or filling in accident reports. But differences in the practices of different police forces may be a more important explanation than any changes over time.

4. It is possible that hospital records understate the number of road accident casualties treated in hospital. One can imagine that in a busy casualty department the circumstances of an injury are not always reported. However, an omission arising from this reason would not necessarily affect the percentages shown in Table B2, since the police might have recorded the same proportion of the road casualties not identified as such by the hospital as of the identified ones. Another possibility is that someone who is treated in hospital for an injury which only becomes apparent some time after the accident might not be identified as a road accident victim in the hospital records. It is very likely that such a person would not figure in the police records either, since they are completed at the scene of the accident or shortly afterwards. If there were a significant number of such cases, the figures in Table B2 would overstate the degree to which the numbers of road accident casualties treated in hospital are recorded in the police reports on which the national accident statistics are based.

5. The Birmingham and Manchester studies also revealed a tendency for the police to understate the severity of a road accident casualty. This is shown in Table B3; the data from the Berkshire study do not allow a similar comparison to be made.

Table B3 Comparison of police and hospital classifications for non-fatal casualties

Percentages

	Birmingham		Manchester	
	Casualties classified by the hospital as:			
Police classification	Serious	Slight	Serious	Slight
Serious	86	1	48	2
Slight	14	99	52	98
Total hospital	100	100	100	100

Only casualties recorded as either serious or slight both by the police and by the hospital are included in this table.

Sources: See Table B2.

6. It also possible that some road accident casualties recorded by the police will not appear in the hospital records. It has already been seen that some people injured in road accidents might be treated in hospital without being identified in the hospital records as road accident casualties; some of them will be covered in the police statistics. Another, and probably much more important, possibility is that some injured people who figure in the police records are treated away from a hospital, for example by their GP, or are not treated at all. The only one of the three hospital studies which allows an estimate to be made of the number of casualties appearing in the police records but not in the hospital records is Manchester. A comparison of the hospital and police statistics from the Manchester study is set out in Table B4.

Table B4 Hospital and police records of non-fatal road casualties compared

Hospital classification	Police classification	
A. Serious	Serious	180
B. Serious	Slight	195
C. Serious	Not recorded/reported	130
D. Slight	Serious	17
E. Slight	Slight	718
F. Slight	Not recorded/reported	1,030
G. Not in hospital records	Serious	10
H. Not in hospital records	Slight	652
I. Dismissed as trivial	Serious	3
J. Dismissed as trivial	Slight	123

Source: See Table B2.

7. If these Manchester figures could be taken as representative of Britain as a whole, and if also all road accident casualties appeared either in the police records or in the hospital records or in both, then these figures could be used to calculate correction factors to be applied to the police figures in order to arrive at the true figures. The number of serious casualties recorded by the police is given by

A + D + G + I = 210. The number which, on these assumptions, should have been recorded as serious is given by A + B + C + G = 515. Therefore the correction ratio is 515/210 = 2.45. The number of slight casualties recorded by the police was B + E + H + J = 1688; the number that should have been recorded is D + E + F + H = 2417; the correction factor is therefore 1.43.

8. These correction factors still do not allow for those casualties which figure neither in the police nor in the hospital records. There is no British source from which to estimate what the number of such casualties might be. In the Netherlands, a large household survey was undertaken in 1986/87 on injuries from road accidents.[4] This survey showed that for every 100 casualties which could have been included in the police records, since they fell within the police definition of a road accident casualty, 42 per cent were neither treated in hospital nor recorded by the police (according to the respondents in the survey, the police were not present at the scene of the accident). If the same percentage applied in Britain, a further correction factor of 1.72 would have to be applied to the number of casualties appearing either in the police or in the hospital records in order to arrive at the true figure.

9. But there are reasons for thinking that the police records of road accidents and casualties are more complete in Great Britain than in the Netherlands. One is that in 1986/87, only some 70 per cent of hospital in-patients and some 26 per cent of all hospital patients (in-patients and out-patients combined) in the Netherlands were recorded in the police statistics;[4] these ratios are very much lower than those for Britain shown in Table B2. Another is that the ratio of injuries to deaths in road accidents, as recorded by the police, is always lower in the Netherlands than in Britain. In 1993, this ratio was only 38:1 in the Netherlands but 79:1 in Britain (in both countries the police records provide a complete coverage of road deaths). The true ratio of injuries to fatalities on the road is unlikely to be identical in any two countries, but one would expect the ratios to be broadly similar in two countries as much alike as Britain and the Netherlands.[5]

10. One possible reason for the injury/fatality ratio to be genuinely higher in Britain than in the Netherlands is that children account for a higher proportion of road casualties in Britain, and both sets

of statistics show a considerably higher ratio of injuries to fatalities for children than for adults. However, for adults, the Dutch ratio for 1993, according to police statistics, was 37:1, whereas the British was 73:1, so this explanation does not account for much. It is difficult to think of any other reason why the Dutch injury/fatality ratio should really be so much lower than the British. Since also the comparisons between police and hospital records in the two countries suggest that a lower level of reporting by the Dutch police could easily account for the apparent difference, it has been assumed for the purpose of this calculation that this is indeed the explanation. In order to estimate a correction factor for Britain, the number of casualties appearing in the Dutch police records has therefore been doubled, and the number of casualties not recorded has been adjusted accordingly. This is shown in Table B5, from which it can be seen that as a result of the adjustments the correction factor falls from 1.72 to 1.41.

Table B5 Calculation of the correction factors needed to convert casualty figures as recorded by the police and/or hospitals to the total figures

Units: percentages

	Netherlands unadjusted	Netherlands adjusted to allow for British levels of police accident reporting
Recorded by police (some of which also recorded by hospitals)	24	48
Recorded by hospitals but not by police	34	23
Recorded neither by police nor by hospitals	42	29
Total from household survey	100	100
Correction factor	100/58 = 1.72	100/71 = 1.41

Source: S Harris, reference 4.

11. It can be seen from paragraph 7 above that the 'true' number of casualties in the Manchester study, *before* allowing for those not recorded either by the police or by the hospitals, was 2932 (515 serious plus 2417 slight). The application of the correction factor of 1.41 raises this total to 4134. Since the coverage of casualties in the police statistics rises with the severity of the casualty, the great majority of the extra 1202 unreported casualties are likely to be slight. In order to err on the low side, let it be assumed that they are all slight. Hence the true number of slight casualties in the Manchester study, *after* allowing for those reported neither by police nor by the hospitals, can be estimated at 3619. So the correction factor to be applied to the number of slight casualties recorded by the police in order to arrive at the number that actually occurred rises from 1.43 (2417/1688) to 2.14 (3619/1688). But the correction factor to convert the number of serious casualties recorded by the police to the number that actually occurred remains unchanged at 2.45.

12. These correction factors should be applied to the national statistics only if the Manchester situation is typical of Britain. It may be, but the earlier Birmingham and Berkshire studies suggest that it may not. It is therefore prudent to modify the Manchester results to bring them more into line with the other studies.

13. Although both the Berkshire and the Manchester studies showed that the police were inclined to underestimate the gravity of road casualties, Table B3 showed that that tendency was much more pronounced in Manchester. There the police classified as slight 52 per cent of the injuries classified by the hospital as serious (ignoring those casualties recorded by the hospital but not by the police), whereas the corresponding figure in Birmingham was only 14 per cent. Had the police estimation of the severity of injuries been as accurate in Manchester as in Birmingham, the number in row A in Table B4 would have been 322 and the number in Row B would have been 53.

14. As Table B2 shows, in Manchester the police also recorded a lower proportion of road accident victims treated in hospital than they recorded either in Birmingham or in Berkshire. Had the proportion of slight hospital casualties recorded by the police in Manchester been as high as it was in Birmingham, the figure in Row F of Table B4 would have read 618 rather than 1030. If the extra 412

casualties are divided proportionately between rows D and E, the numbers in those rows become respectively 27 and 1120. Similar corrections can be made to the figures in Rows A, B and C, after those in Rows A and B have been adjusted as described in paragraph 13. Table B4 adjusted in these ways becomes Table B6.

Table B6 Hospital and police records of non-fatal road casualties compared: Manchester figures adjusted to allow for the same levels of completeness and accuracy in the police records as were achieved in Birmingham

Hospital classification	Police classification	
A. Serious	Serious	355
B. Serious	Slight	59
C. Serious	Not recorded/reported	91
D. Slight	Serious	27
E. Slight	Slight	1,120
F. Slight	Not recorded/reported	618
G. Not in hospital records	Serious	10
H. Not in hospital records	Slight	652
I. Dismissed as trivial	Serious	3
J. Dismissed as trivial	Slight	123

15. Correction factors corresponding to those calculated in paragraph 7, not allowing for casualties excluded from both the police and the hospital records, can be calculated from this table. For serious casualties, the correction factor is 1.3, and for slight it is 1.24. If the same reasoning as in paragraphs 10 and 11 is followed, then the correction factor which does allow for those unrecorded either by the police or by the hospitals remains at 1.3 for serious casualties but rises to 1.85 for slight casualties. In order not to exaggerate the number of casualties now occurring, and therefore the number which might be saved by a reduction in vehicle speeds, these lower factors have been retained rather than the unadjusted Manchester ones.

Establishing correction factors to be applied to Table B1

16. There are two problems about using the correction factors for serious and slight casualties calculated above to adjust the accident figures by type of road set out in Table B1. The degree of under-reporting by the police is likely to vary significantly by type of road, and even on a national basis, taking the road network as a whole, the correction factor for accidents will not be the same as for casualties.

17. If the reason why the police failed to record a casualty is that they were not present at the scene of the accident, or, being present, failed to fill out an accident report, then the correction factors for casualties and accidents would be identical or nearly so. But it could also be that an accident report was filled out but was not complete. For example, if there was an accident in which two people were seriously injured but the police recorded only one, the number of serious casualties recorded by the police should be doubled but the number of serious accidents would be correct.

18. It seems probable that more of the shortfall in the number of casualties recorded by the police comes from missing records than from incomplete ones; even so, the correction factors for accidents must be less than those for casualties. However, it is shown in Appendix C that the error from neglecting this fact is almost entirely corrected at the stage in the calculation when money values are assigned to accidents. In the context of this study, therefore, there is very little error in applying the correction factors for casualties to accidents.

19. The degree of under-reporting by police is unlikely to be the same for all types of road. Motorways are more heavily policed than other roads, and the hospital studies have also shown that under-reporting is more prevalent for casualties to cyclists and pedestrians, which very rarely occur on motorways, than for casualties to occupants of cars and lorries. It has therefore been assumed that on motorways the number of unreported accidents per 100 reported ones will be half that for the road network as a whole, so that there will be 15 unreported serious accidents for every reported one and 42 unreported slight accidents for every reported one. For other roads, it has been assumed that the correction factors shown in paragraph 15 of 1.3 for serious casualties and 1.85 for slight ones can be applied to the accident figures. On these assumptions, the figures in Table B1 can be revised

upwards to produce those in Table B7, which have been used in Chapter 9.

Table B7 Injury accidents in Great Britain in 1993 by type of road and severity adjusted to allow for under-reporting and misclassification of casualties in the police records

	Type of road			
Severity	Motorways	'A' roads with a limit of 70 mph	'A' roads with a limit of 60 mph	Built-up roads
Fatal	159	248	893	1,646
Serious	1,126	1,624	6,898	33,146
Slight	8,130	9,133	32,369	261,477
Total	9,415	11,005	40,160	296,269

Estimating the number of damage-only accidents

20. Ratios of damage-only accidents to injury accidents for urban and rural roads have been calculated by the Transport Research Laboratory from information supplied by a major insurance company. For urban roads the ratio is 10.5 to one and for rural it is 4.6 to one. The data are for the year 1990 but it is assumed that these ratios apply also to 1993. There were not enough data from this source to calculate the ratio for motorways, but earlier work by the TRL produced a ratio of 4.5 to one for motorways, so it is assumed that this ratio also still holds good.[6] But these ratios cannot be applied to the numbers of accidents shown in the total row of Table B7 since those numbers are known to be too high and in this case there is no automatic mechanism whereby an overestimate of the number of accidents will be corrected at the stage when money values are applied. For this purpose, therefore, the numbers of extra accidents calculated in paragraph 19 have been reduced by one third. It is therefore assumed that the true number of severe accidents exceeds the number given in Table B1 only by 10 per cent on motorways and by 20 per cent on other roads, and that the true number of slight accidents exceeds the number given in Table B1 only by 28 per cent on motorways and by 57 per cent on other

roads. Hence the estimates of injury accidents given in the first row of Table B8 are derived.

21. The ratios of damage-only accidents to injury accidents given in the last paragraph relate only to the damage-only accidents for which a claim was made to an insurance company. According to a survey of 30,000 car and van drivers carried out by the Transport Research Laboratory in 1988, there are 0.69 damage-only accidents with no claim for each one with a claim.[7] The survey did not provide inform...n by type of road, so it has been assumed that the ratio of 0.69 to one applies to every type of road. However, the damage-only accidents reported to insurance companies are known to be more serious than those not reported, so it is important to keep them as separate categories, as has been done in Table B8.

Table B8 Estimates of the number of damage-only accidents in 1993 by type of road

	Type of road			
	Motorways	'A' roads with a limit of 70 mph	'A' roads with a limit of 60 mph	Built-up roads
Estimated number of injury accidents	8,564	9,498	34,730	254,144
Ratio of damage-only accidents reported to insurance companies to injury accidents	4.5	4.6	4.6	10.5
Estimated number of damage-only accidents reported to insurance companies	38,538	43,691	159,758	2,668,512
Ratio of damage-only accidents not reported to insurance companies to those reported	0.69	0.69	0.69	0.69
Estimated number of damage-only accidents not reported to insurance companies	26,591	30,147	110,233	1,841,273

Recommendations for the production of better accident statistics

22. It is clearly unsatisfactory that the estimates of the true number of road accidents and casualties should start with such an incomplete record and should therefore require so many assumptions and approximations. Obviously, the more that can be done to improve the police records, from which the annual report *Road Accidents Great Britain* and almost all other official statistics on road accidents are derived, the better. The differences between the Birmingham, Berkshire and Manchester studies suggest that the coverage of road accidents in the police statistics varies widely in different parts of the country. A study is required to ascertain why this is so and to see what could be done, without excessive expense, to obtain a fuller record.

23. Even after all reasonable improvements have been made to the police records, many accidents and casualties, perhaps still the majority of the slight ones, will continue to escape them. Other sources of information to supplement the police records will therefore always be required. The Department of Transport is now funding a three-year research project to collect information on casualties from road accidents from a national sample of hospitals. We recommend that this survey should either be made continuous or at least should be repeated at regular intervals. It would be helpful if the information gathered from hospitals included the location of the accident, especially the type of road.

24. Hospital records should allow the great majority of serious injuries from road accidents to be recorded, but many slight injuries will be treated elsewhere, especially by GPs. A continuous sample survey of GPs is therefore required to provide the same type of information as that given by the hospital surveys.

25. The Dutch survey mentioned above[4] found that almost all slight injuries, except those that were very slight indeed, were treated either by a hospital or by a GP. But a continuous, or regularly repeated, household survey is needed in Britain too to check on the completeness of the information from hospitals and GPs. This survey could also collect information from a sub-sample about the consequences of an accident, and the disruptions caused to the lives of the victims, their families and other people connected with them, in order to improve the costing of accidents.

26. It would never make sense to ask the police to collect information on damage-only accidents, except on the rare occasions when a prosecution might be contemplated. The approach adopted by the TRL, of a study based on insurance records supplemented by a questionnaire survey among drivers, is clearly the right one, but the work needs to be undertaken more frequently and possibly on a larger scale. It would be useful if a sub-sample of respondents in the drivers' survey were to be asked about the time that was involved in dealing with the insurance company, the garage and so on, and about any other difficulty or expense arising from being deprived of their vehicle for a time so that some allowance for these losses can be made in the cost estimates.

27. It is also important for more attention to be paid to the problems of incomplete statistics in *Road Accidents Great Britain*. For the most part, it will not be possible to adjust the information given in the detailed tables to allow for the data missing from the police records, although some of the tables might be adjusted. But estimates, making allowance for the missing data, of the number of accidents and casualties, by severity, including damage-only accidents, should be given, preferably within each type of road. The calculation of the annual cost of road accidents should also include an allowance for gaps or errors in the police records.

References

1. J P Bull and B J Roberts (1973) 'Road Accident Statistics – A Comparison of Police and Hospital Information', *Accident Analysis and Prevention*, Vol.5.
2. L A Hobbs, E Grattan and J A Hobbs (1979) *Classification of Injury Severity by Length of Stay in Hospital*. TRRL Laboratory Report 871.
3. J M Hopkin, P A Murray, M Pitcher and C S B Galasko with C Jordan, M J Madden, S Mansfield, J Sunter, A Kinsella and B Towers (1993) *Police and Hospital Recording of Non-Fatal Road Accidents*. TRL Project Report PR/SRC/1/93.
4. S Harris (1990) 'The Real Number of Road Traffic Accidents in the Netherlands: a Year-long Survey', *Accident Analysis and Prevention*, Vol.22, No.4.
5. The British statistics come from *Road Accidents Great Britain 1993* and the Dutch statistics from a breakdown supplied by SWOV, the Dutch Institute for Road Safety Research.

6. H F Simpson and D M O'Reilly (1994) *Revaluation of the Accident Related Costs of Road Accidents*. TRL Project Report 56.

7. M C Taylor (1990) *The Cost of Vehicle Damage Resulting from Road Accidents*. TRRL Research Report RR 256, reported in Reference 6.

Appendix C

The justification of applying correction factors based on casualties to accidents

1. It was stated in paragraph 18 of Appendix B that it was legitimate, for the purpose of evaluating the savings in injury accidents to be expected from reduced speeds, to apply the correction factors required to take account of the under-reporting of casualties also to accidents, since any error in that procedure would be almost entirely compensated for at the stage when money values were attached to casualties and accidents. The justification of this statement follows.

2. The following table is taken from Table 12 of *Road Accidents Great Britain 1993*. These are national figures and include casualties and accidents on roads with 50 mph speed limits and on minor country roads, neither of which was covered in Appendix B.

	Type of accident			
	Fatal	Serious	Slight	All
Number of accidents	3,470	38,031	187,364	228,865
Number of casualties:				
Fatal	3,814		-	3,814
Serious	1,452	43,557	-	45,009
Slight	1,913	15,638	239,646	257,197

3. The money values, in pounds sterling, to be attached to casualties and accidents, at June 1993 prices, are given in the following table, taken from the Department of Transport's Highways Economics Note 1, September 1994. The cost figure given for an accident

includes the costs of all the casualties which occur in the accident as well as the non-casualty costs.

	Fatal	Serious	Slight
Cost per accident	863,370	101,990	9,970
Cost per casualty	(not relevant)	84,260	6,540

4. The cost of the accidents reported in *Road Accidents Great Britain 1993* can be calculated from the top rows of these two tables. The total comes to £8,743 million.

5. All fatal accidents and casualties are included in the police records on which *Road Accidents Great Britain* is based, but it was calculated that, to allow for under-reporting of casualties, a correction factor of 1.3 was needed for serious casualties and of 1.85 for slight casualties. If these correction factors were applied to the number of accidents shown above, then, assuming the same costs per accident, the new total would come to £11,494 million.

6. If, alternatively, it is assumed, as an extreme case, that the number of accidents recorded by the police is correct, so that the shortfall in the number of casualties recorded is entirely accounted for by the failure to record the casualties in those accidents fully and correctly, then a different procedure applies. A further 13,503 serious casualties have to be allowed for, at an extra cost of £1,138 million, and a further 218,617 slight casualties, at an extra cost of £1,430 million. So the corrected total according to this method would be £11,311 million.

7. The difference between the two methods is less than two per cent. The real error in adopting the first method must be even smaller.

Appendix D

The estimation of costs per accident by severity and type of road

1. Appendix B drew on various sources to estimate the number of injury accidents, including those not reported to the police, and also of damage-only accidents, by type of road, in 1993. To arrive at the total accident costs by type of road in the present situation of the existing speed limits unenforced, it is necessary to apply cost-per-accident figures to these numbers. However, as was pointed out in Chapter 4, the Department of Transport's figures for the cost of a casualty (and consequently for the cost of an accident) are too low. In particular, that part of the cost of a casualty which is estimated by the 'willingness-to-pay' method is about half, or perhaps less than half, of what it should be.

2. In Table D1 of this Appendix, the Department's cost-per-accident figures for injury accidents are revised upwards by doubling the 'willingness-to-pay' component. In Table D2 the revised figures are applied to the numbers of reported accidents. It is assumed that the value to be placed on unreported serious and slight accidents should on average be two-thirds that of the value placed on the reported ones. For damage-only accidents, the Department's values have been updated to 1993 prices by applying a factor of 1.13.

Table D1 Revised estimates of the cost per accident of reported injury accidents in 1993 assuming that the 'willingness to pay' component of the cost is doubled

Units: £, 1993 prices

	Motorways	Rural roads	Urban roads
Fatal accidents			
1 Unadjusted cost per accident	990,880	908,910	805,090
2 Accident related component	9,579	8,007	5,189
3 Casualty related component	981,301	900,903	799,901
4 Human costs, incl. consumption, as % of (3)	99.6	99.6	99.6
5 Human costs, incl. consumption	977,376	897,299	796,701
6 Revised estimate (1) + (5)	1,968,256	1,806,209	1,601,791
Serious accidents			
1 Unadjusted cost per accident	122,850	114,330	95,600
2 Accident related component	7,689	3,367	2,363
3 Casualty related component	115,161	110,963	93,237
4 Human costs, excl. production, as % of (3)	79.8	79.8	79.8
5 Human costs, excl. production	91,898	88,548	74,403
6 Revised estimate (1) + (5)	214,748	202,878	170,003
Slight accidents			
1 Unadjusted cost per accident	13,570	11,520	9,380
2 Accident related component	3,860	2,166	1,371
3 Casualty related component	9,710	9,354	8,009
4 Human costs, excl. production, as % of (3)	75.3	75.3	75.3
5 Human costs, excl. production	7,312	7,044	6,031
6 Revised estimate (1) + (5)	20,882	18,564	15,411

Sources:

1. The unadjusted figures in Row 1 are from *Highways Economics Note No. 1*, Department of Transport, September 1994.
2. The accident related components in Row 2 are from Helen F Simpson and Deirdre O'Reilly (1994) *Revaluation of the accident related costs of road accidents*, TRL Project Report 56, Tables 6 and 14. These costs have been updated to 1993 prices.
3. Percentages in Row 4 are from *Highways Economics Note No. 1*, op. cit. Table 3.

Table D2 Calculation of total accident costs in 1993 by severity of accident and class of road

	Motorways	'A' roads with a limit of 70 mph	'A' roads with a limit of 60 mph	Built-up roads
Fatal accidents				
Number of accidents	159	248	893	1,646
Cost per accident (£)	1,968,256	1,887,233	1,806,209	1,601,791
Total cost (£m)	313	468	1,613	2,637
Serious accidents recorded in 'Road Accidents Great Britain'				
Number of accidents	979	1,249	5,306	25,497
Cost per accident (£)	214,748	208,813	202,878	170,003
Total cost (£m)	210	261	1,076	4,335
Additional unrecorded serious accidents				
Number of accidents	147	375	1,592	7,649
Cost per accident (£)	143,165	139,209	135,252	113,335
Total cost (£m)	21	52	215	867
Slight accidents recorded in 'Road Accidents Great Britain'				
Number of accidents	5,725	4,937	17,497	141,339
Cost per accident (£)	13,921	13,149	12,376	10,274
Total cost (£m)	120	97	325	2,178
Additional unrecorded slight accidents				
Number of accidents	2,405	4,196	14,872	120,138
Cost per accident (£)	13,921	13,149	12,376	10,274
Total cost (£m)	33	55	184	1,234
Damage-only accidents reported to an insurance company				
Number of accidents	38,538	43,691	159,758	2,668,512
Cost per accident (£)	1,942	1,987	2,033	1,271
Total cost (£m)	75	87	325	3,392

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Table D2 continued

	Motor-ways	'A' roads with a limit of 70 mph	'A' roads with a limit of 60 mph	Built-up roads
	Additional unreported damage-only accidents			
Number of accidents	26,591	30,147	110,233	1,841,273
Cost per accident (£)	471	471	471	471
Total cost (£m)	13	14	52	867
Grand total (£m)	785	1,034	3,790	15,510

Notes:

1. For accident numbers see Appendix B; for the cost-per-accident values of injury accidents see Table D1. The values for rural roads have been used for the recorded accidents on 'A' roads with a 60 mph limit. For the recorded accidents on 'A' roads with a 70 mph speed limit, the average between the figures for motorways and those for rural roads has been taken. The cost-per-accident figures for unrecorded injury accidents have been taken as two-thirds those of the corresponding recorded accidents.
2. The values for damage-only accidents are derived from Helen F Simpson and Deirdre O'Reilly (1994) *Revaluation of the accident related costs of road accidents*, TRL Project Report 56, Tables 6 and 14 and page 9 updated to 1993 prices.

Appendix E

Data and procedures for the calculation of the vehicle operating costs and travel time costs of Chapter 9

Traffic volumes

Traffic on motorways by type of vehicle is shown in Table 4.9 of *Transport Statistics Great Britain 1994*. This table also shows traffic on non-built-up 'A' roads, but the table divides these roads into trunk and principal roads, not into dual carriageway and single carriageway roads, which are the categories used in the speed surveys. The Department of Transport made a special estimate for us of how the traffic on non-built-up 'A' roads is divided between dual and single carriageway roads. These estimates, shown below, were used in the calculations in Chapter 9.

Units: billion vehicle kms

	Motor-ways	Dual carriageways	Single carriageways
Cars	48.7	41.77	53.66
Light goods vehicles	5.1	4.33	6.34
Buses and coaches	0.5	0.27	0.6
2-axle rigid heavy goods vehicles	3.6	2.27	3.16
Other rigid heavy goods vehicles	0.7	0.4	0.77
Articulated heavy goods vehicles	4.4	2.21	1.77

Speed distributions

The speed distributions, taken from the Department of Transport's Statistics Bulletin (94)30 *Vehicle Speeds in Great Britain 1993*, were as shown below. In the calculations the mid-point of each range was taken as the average for the range. For vehicles driving on motorways at under 40 mph, the figure of 35 mph was used, and for those driving at over

90 mph the figure of 95 mph was used. Similarly, 25 mph and 85 mph were used for the slowest and fastest vehicles on dual carriageways and 15 mph and 75 mph for the slowest and fastest vehicles on single carriageways. In order to convert mph into km/h, which is necessary in order for the cost formulae shown later in this appendix to be applied, the ratio of 1.6094 kilometres to a mile was used.

The Department's bulletin also gives the speed distributions for rigid heavy goods vehicles with more than two axles, but it was decided not to use them. One reason was a doubt about the representativeness of the observations for dual carriageways, where more rigid heavy goods vehicles with more than two axles were observed in the speed survey than two-axle rigids and artics combined. As the table above shows, this is completely contrary to the national position and suggests that there must have been some exceptional factors at work. Rigid heavy goods vehicles with more than two axles were therefore combined with artics. These two types of vehicle are subject to the same speed limits (60 mph on motorways, 50 mph on dual carriageways and 40 mph speed limits on single carriageways) and their speed distributions shown in the bulletin were similar.

Column percentages

Speed in mph	Cars	Light goods	Buses/ coaches	2-axle rigids	Artics
			Motorways		
Under 50	4	6	5	10	10
50 to 60	12	21	18	44	56
60 to 65	11	16	18	23	25
65 to 70	17	20	38	14	7
70 to 75	25	22	19	7	2
75 to 80	13	8	1	1	-
80 to 90	16	7	1	1	-
90 and over	2	1	-	-	-

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Column percentages

Speed in mph	Cars	Light goods	Buses/ coaches	2-axle rigids	Artics
			Dual carriageways		
Under 30	-	-	-	1	-
30 to 40	1	1	10	4	3
40 to 50	6	11	30	24	23
50 to 60	22	30	31	48	58
60 to 65	15	16	14	13	11
65 to 70	17	16	11	7	3
70 to 80	30	20	4	4	1
80 and over	10	5	-	1	-
			Single carriageways		
Under 20	1	1	1	1	2
20 to 30	3	4	9	7	8
30 to 40	27	31	42	35	28
40 to 50	41	41	34	40	47
50 to 60	21	18	12	14	15
60 to 65	4	3	1	2	1
65 to 70	2	2	-	1	-
70 and over	1	1	-	-	-

Vehicle operating costs as a function of speed

These costs are calculated according to the formulae given in the Department of Transport's Highways Economics Note No. 2 (1989), updated by the methods recommended by the Department. Vehicle operating costs are divided into two parts, fuel and all other. 'All other' comprises oil, tyres, maintenance, depreciation and an allowance for administration. Items, such as garaging, which do not vary with mileage driven are excluded; so are all indirect taxes. Both fuel cost and other costs are calculated according to a formula of the form $p = a + b/v + cv^2$, where p is the cost in pence per kilometre and v is the speed in km/h. The values of a, b, and c for 1988 given in Table 5 of Highways Economics Note No. 2 (1989) are as follows:

	a	b	c
Cars			
*Fuel	0.461	24.019	0.000059
Non fuel	4.432	27.762	0.000055
Light goods vehicles			
*Fuel	0.718	30.760	0.000079
Non fuel	10.052	52.223	0.000094
Other goods vehicles			
Fuel	2.528	35.695	0.000157
Non-fuel	23.397	96.329	0.000166
Buses and coaches			
Fuel	2.832	45.688	0.000134
Non-fuel	35.476	174.270	0.000175

* The fuel costs for cars and light goods vehicles should be reduced by 15 per cent when these vehicles are driven on motorways.

The Department of Transport recommends that for the fuel costs of cars and light goods vehicles the values of a, b and c should be reduced by one per cent per year to allow for increases in vehicle efficiency, so, other things being equal, their 1993 values would be 95 per cent of their 1988 values. It also recommends that both fuel and non-fuel costs for all types of vehicle are updated in line with the Retail Price Index. Table 6.4 of the August 1994 edition of the *Employment Gazette* gives the annual average values of the RPI between 1987 and 1993. It can be shown from this table that the factor required to convert 1988 prices to 1993 prices is 1.316. (For fuel, this up-date factor can be checked from the annual fuel prices given in *Transport Statistics Great Britain*; after excluding taxation, agreement is very close).

The values of a, b and c used for the calculations in Chapter 9, after updating as described above, were as follows:

	a	b	c
Fuel costs			
Cars on motorways	.490	25.524	.000063
Light goods vehicles on motorways	.763	32.688	.000084
Cars on all other roads	.576	30.028	.000072
LGVs on all other roads	.898	38.456	.000099
HGVs (both 2-axle rigid and artics)	3.327	46.975	.000207
Buses and coaches	3.727	60.125	.000176
Non-fuel vehicle operating costs			
Cars	5.833	36.535	.000072
Light goods vehicles	13.228	68.725	.000124
HGVs (both 2-axle rigid and artics)	30.790	126.769	.000218
Buses and coaches	46.686	229.340	.000231

Values of travel time

Table 3 of Highways Economics Note No. 2 (1989) gives the resource values of time for each type of vehicle in average 1988 prices. These figures assume certain vehicle occupancies as stated in the document, and also that mileage can be split between journeys undertaken for business and for pleasure in the proportions also stated there. According to the Department of Transport, these occupancies and proportions still broadly apply. The only problem, therefore, is to update the time values from 1988 to 1993 prices. The Department recommends that they should be increased in line with the increase in average earnings that took place over that period. It can be seen from the figures given in Table 5.6 of the August 1994 edition of the *Employment Gazette* that annual average earnings in 1993 were 1.48 times those of 1988. Applying this factor to the figures in Table 3 of Highways Economics Note No. 2 (1989) gives the following values in pence per hour at 1993 prices:

Cars	694.8
Light goods vehicles	1273.0
Buses and coaches	4762.7
Heavy goods vehicles	922.5

According to Highways Economics Note No. 2 (1989), the occupancy figures for cars and for buses and coaches 'were derived from the 1985/86 NTS (National Travel Survey) and Departmental sources'. However, the occupancy figure of 13.2, including the driver, given in the Note is implausibly low for long-distance express coaches. Figures supplied to us by National Express for the last six months of 1994 suggest an occupancy of roughly double that. To allow for this, the cost of 4762.7 pence per hour shown above for buses and coaches was doubled before being included in the motorway calculations in Chapter 9. This adjustment applies only to motorways.

Heavy goods vehicles

As described above, heavy goods vehicles were divided into two categories, effectively two-axle rigids and all others, for the purpose of working out their costs at each speed. These costs were then added to produce the results for the single heavy goods vehicle category shown in Chapter 9.

Appendix F

The calculation of accident reduction ratios for different speed limits by class of road assuming no change in traffice volumes

1. For each class of road, the average spot speed if different speed limits were enforced was first calculated. The types of vehicle considered for this purpose were cars, light goods vehicles, two-axle rigid heavy goods vehicles and articulated heavy goods vehicles. The types of motor vehicle left out of account – motorcycles, buses and coaches, and rigid heavy goods vehicles with more than two axles – account for about 2.5 per cent of vehicle mileage on major roads in non-built-up areas.

2. The distribution of spot speeds at present, for each type of vehicle on each class of road, was taken from the Department of Transport's Statistics Bulletin (94)30 *Vehicle Speeds in Great Britain 1993*. Then the present average spot speed for a given type of vehicle on a given class of road was calculated as in the following example for cars on motorways.

(1) Present speed (mph)	(2) Per cent of vehicles travelling at that speed	(3) (1) x (2)
Under 50 (taken as 45)	4	180
50 to 60 (taken as 55)	12	660
60 to 65 (taken as 62.5)	11	687.5
65 to 70 (taken as 67.5)	17	1147.5
70 to 75 (taken as 72.5)	25	1812.5
75 to 80 (taken as 77.5)	13	1007.5
80 to 90 (taken as 85)	16	1360
Over 90 (taken as 95)	2	190
Total	100	7045
Average		70.45

3. The same procedure was followed for the other three classes of vehicles. This gave the following result for motorways at present.

Type of vehicle	Average spot speed
Car	70.45
Light goods	66.14
Two-axle rigid heavy goods	59.225
Articulated heavy goods	57.1

4. The average spot speed over all types of vehicle was found by weighting each of these averages by the proportion of the vehicle flow accounted for by vehicles of each type. For motorways, the weights were as follows:

Car	.79
Light goods	.08
Two-axle rigid heavy goods	.06
Articulated heavy goods	.07

The weighted average spot speed for motorways at present therefore comes to 68.4972, which can be rounded to 68.50.

5. The calculation of the average spot speed if existing speed limits on motorways were enforced assumed that all cars, light goods vehicles and two-axle rigid heavy goods vehicles now driving at over 70 mph would drive exactly at that speed, and that all artics now exceeding their motorway speed limit of 60 mph would drive exactly at 60 mph. The speed distributions were adjusted in accordance with these rules and the calculations were then repeated using the new distributions. As an illustration, the calculation of the new average spot speeds for cars on motorways if existing speed limits were enforced is as follows:

(1) Present speed (mph)	(2) Per cent of vehicles travelling at that speed	(3) (1) x (2)
Under 50 (taken as 45)	4	180
50 to 60 (taken as 55)	12	660
60 to 65 (taken as 62.5)	11	687.5
65 to 70 (taken as 67.5)	17	1147.5
70	56	3920
Total	100	6595
Average		65.95

6. The application of these rules gives the following results if the present speed limits on motorways were enforced:

Type of vehicle	Average spot speed
Car	65.95
Light goods	63.71
Two-axle rigid heavy goods	58.83
Articulated heavy goods	55.70
Weighted average	64.63

7. The calculations for other motorway speed limits, and also those for other major non-built-up roads, proceeded in a similar way. The following table of average spot speeds, in mph, shows the results:

	Motorways	Major non-built-up dual carriageways	Major non-built-up single carriageways
Present	68.50	64.94	44.60
70 mph limit enforced	64.63	62.28	N/A
65 mph limit enforced	61.84	59.92	N/A
60 mph limit enforced	58.37	57.03	44.10
55 mph limit enforced	54.51	53.79	43.78
50 mph limit enforced	49.75	49.40	42.46
45 mph limit enforced	45.00	44.87	41.15
40 mph limit enforced	40.00	39.93	37.84
35 mph limit enforced	N/A	N/A	34.45

8. These speeds were used, in conjunction with the relationships between speed and accidents discussed in Chapter 4, to derive the following accident reduction ratios. They do not take account of the likelihood that flows would be reduced if speeds fell, but relate to the 'constant flow' assumptions of Chapter 9.

	Motorways	Major non-built up dual carriageways	Major non-built-up single carriageways
Present	1.00	1.00	1.00
70 mph limit enforced	.84	.87	N/A
65 mph limit enforced	.71	.75	N/A
60 mph limit enforced	.62	.65	.975
55 mph limit enforced	.55	.58	.96
50 mph limit enforced	.50	.55	.89
45 mph limit enforced	.47	.52	.84
40 mph limit enforced	.45	.50	.80
35 mph limit enforced	N/A	N/A	.76

9. If the rule discussed in Chapter 4 were applied strictly, that for every one mph reduction in average speed there would be a 5 per cent reduction in accidents, then the enforcement of the existing 70 mph limit on motorways would reduce accidents by 19.4 per cent and the enforcement of a 65 mph limit would reduce them by 33.3 per

cent. But it is likely that with the large reductions in average speed shown above, that rule would already start to weaken; for this reason, smaller accident savings should be assumed. It was seen in Chapter 4 that at one point while the 50 mph speed limit imposed because of the 1993 oil crisis was in operation, the daytime motorway accident fell to half the rate that would have been expected if that limit had not been imposed, even though very few cars observed it. It seems very modest, therefore, to assume that if a 50 mph speed limit were enforced now, the accident rate on motorways would be halved. The reduction ratios for the 60 mph and the 55 mph motorway speed limits were found by interpolation. It was assumed that if the motorway limit were reduced to below 50 mph, accidents would continue to decrease but by very modest amounts. To go from an enforced motorway speed limit of 50 mph to one of 45 mph would reduce the average speed by 4.75 mph. It has been assumed that this would result in a reduction of only 6 per cent in the number of accidents, or 1.26 per cent for every one mph decrease. To go from an enforced motorway speed limit of 45 mph would reduce the average speed by 5 mph, but only a 4.25 per cent reduction in accidents is assumed, less than one per cent for each one mph reduction in speed.

10. There is less breaking of the speed limit on dual carriageways than on motorways. The enforcement of the existing limits would reduce the average speed by 2.66 mph; to enforce a 65 mph limit would reduce it by a further 2.36 mph. It is assumed that in these two cases the rule that a reduction in average speed of one mph would produce a reduction in accidents of 5 per cent would hold, but that further reductions in average speed would produce progressively smaller accident savings, and that to reduce accidents by 50 per cent would require an enforced speed limit as low as 40 mph.

11. The 60 mph speed limit on single carriageways is much better observed than the 70 mph limit on dual carriageways: to enforce it would reduce the average speed by only half of one mph. Even to enforce a 50 mph limit would reduce the present average speed by only 2.14 mph. It is assumed that the rule that a one mph reduction in average speed produces a 5 per cent saving in accidents would hold over that interval, but not if speed limits were reduced to below 50 mph. Although the enforcement of a 35 mph speed

limit would reduce the average speed by just over 20 mph, it is conservatively assumed that it would result in only a 24 per cent fall in accidents.

12. It was noted in Chapter 4 that the variation about the average speed of vehicles in a stream of traffic has an important effect on the accident rate additional to that of the average itself. It is not known how well speed limits were enforced in those situations on which the rule that a one mph reduction in average speed produces a 5 per cent saving in accidents was based, but, given the present means of enforcement, it can safely be assumed that compliance was imperfect. With modern technology, enforcement of the speed limit could be virtually 100 per cent, so the variation of speeds about any given average would be much less than at present. For this reason, the accident reduction ratios shown above are likely to be too modest. Also, in the calculations in Chapter 9 these ratios are applied to accident costs as a whole, without taking account of the fact that speed reductions should produce a greater saving in the more severe accidents, and in fatal accidents in particular, than in others. Since fatal accidents are many times more costly, in cost-benefit terms, than serious or slight ones, the fact that they have not been treated separately also results in an underestimate of the value of the accident savings. In the later calculations in Chapter 9, which make allowance for the reduction in traffic flow that would result from a reduction in speeds, it is assumed that accidents would be reduced in the same proportion as flows. In fact, the reductions in traffic densities and the general easing of traffic conditions resulting from a reduction in flow should produce a more than proportional decrease in accidents. All these reasons suggest that the estimates of the reductions in accident costs in Chapter 9 are likely to be conservative.

Appendix G

Taxation and the constant flow hypothesis

1. This appendix explains in algebraic terms how the introduction of taxation on vehicle operating costs affects the evaluation of the vehicle cost savings brought about by lower speed limits. It then sets out the working for two particular cases. For the purposes of the algebraic exposition, travel time costs are ignored, but they are included in the worked examples.

2. Vb is the amount spent on vehicle operating costs, without any taxes, in the before situation, i.e. the present situation where the existing speed limit on a given class of road is not enforced; Va is the amount spent on vehicle operating costs, without any taxes, in the after situation, i.e. the situation where the existing speed limit or some lower limit is enforced; r is the proportion of road users' expenditure on vehicle operating costs accounted for by tax; z is the proportion of road users' expenditure on alternative items of consumption accounted for by tax.

3. Before the reduction in speeds, road users spend Vb/(1-r) on vehicle operating costs including taxes and after they spend Va/(1-r). So the gain to road users is (Vb-Va)/(1-r).

4. Before the reduction in speeds, the Inland Revenue gets rVb/(1-r) in taxes. After the reduction, it gets rVa/(1-r) + z(Vb-Va)/(1-r). So its loss is rVb/(1-r) - rVa/(1-r) - z(Vb-Va)/(1-r). This simplifies to (Vb-Va)(r-z)/(1-r).

5. The combined net gain to road users and the Inland Revenue is (Vb-Va-(Vb-Va)(r-z))/(1-r), which simplifies to (Vb-Va)(1-r+z)/(1-r).

6. Some implications and special cases are given below.

6.1 If r = z = 0 (an economy run without taxation), the expression for the gain to road users and the expression for net gain both come to Vb-Va.

6.2 If z = 0, the expression for net gain also comes to Vb-Va whatever the value of r. In this case, the tax component of the gain to road users is exactly cancelled out by the loss to the Inland Revenue. The tax component of the gain to road users is (Vb-Va)/(1-r) - (Vb-Va) = (Vb-Va)r/(1-r). If z = 0, the expression for the loss to the Inland Revenue, shown above to be (Vb-Va)(r-z)/(1-r), also comes to (Vb-Va)r/(1-r). It is therefore only the existence of taxation on items of alternative expenditure that makes the result of a calculation with taxation any different from the results of a calculation which ignores it. Since for vehicles other than cars it is assumed that money saved on vehicle operating costs will be spent on items which in effect are untaxed (operators pay VAT but can reclaim it), it follows that for those vehicles the introduction of taxation does not affect the result. But for any value of z other than 0, the net gain must be more than Vb-Va. This is because the fraction (1-r+z)/(1-r) must be more than one if z is more than 0. Therefore for cars, where we assume that money saved on vehicle operating costs will be spent on items which attract the standard rate of VAT, a calculation allowing for taxation always gives a larger net gain than one not allowing for it.

6.3 If r = z, then there is no change in the position of the Inland Revenue and the gain to road users and the net gain both come to (Vb-Va)/(1-r). This is the situation for cars with respect to non-fuel items of vehicle operating costs, since it is assumed that both those costs and the items on which motorists would spend the money saved by driving at lower speeds would alike be taxed at the standard rate of VAT.

7. Tables G1 and G2 give two worked examples showing how, given the assumptions in Chapter 9, Section 9.2, the introduction of taxation affects the assessment of the losses and gains from lower speeds under the constant flow hypothesis. Both examples are concerned with the better enforcement of the existing speed limit on motorways. Both for cars (Table G1) and for light goods vehicles (Table G2), lowering speeds has a more beneficial (or less adverse) effect on users when taxation is allowed for. In the case of light goods vehicles, however, this improvement in the position of users is entirely wiped out by a deterioration in the position of the Inland Revenue, so that the assessment gives the same result with and without taxation. The same would be true for buses and coaches

and for heavy goods vehicles, for which the assumptions about taxation are the same as for light goods vehicles. For cars, however, the improvement in the position of motorists when taxation is taken into account is only partly offset, not entirely wiped out, by the deterioration in the Inland Revenue's position.

Table G1 How the calculation of the gains from enforcing the 70 mph speed limit on cars on motorways is affected, under the constant flow hypothesis, by the inclusion of tax

Units: £m

	Tax not included			*Tax included*		
	Present speeds	70 mph limit enforced	Gain	Present speeds	70 mph limit enforced	Gain
Travel time	3,063	3,228	-165	3,063	3,228	-165
Fuel	755	706	49	2,435	2,277	158
Non-fuel	3,463	3,409	54	4,069	4,006	63
Total user costs	**7,281**	**7,343**	**-62**	**9,567**	**9,511**	**56**
Tax on fuel				1,680	1,571	-109
Tax on alternatives to fuel				0	24	24
Tax on non-fuel items of vehicle operating cost				606	597	-9
Tax on alternatives to non-fuel items of vehicle operating cost				0	9	9
Total tax take				**2,286**	**2,201**	**-85**
Net gain			**-62**			**-29**

Note: It is assumed, in conformity with the assumptions in Chapter 9, that tax accounts for 69 per cent of the price motorists pay for fuel and for 14.89 per cent of the price they pay for all other items.

Table G2 How the calculation of the gains from enforcing the 70 mph speed limit on light goods vehicles on motorways is affected, under the constant flow hypothesis, by the inclusion of tax

Units: £m

	Tax not included			*Tax included*		
	Present speeds	70 mph limit enforced	Gain	Present speeds	70 mph limit enforced	Gain
Travel time	626	643	-17	626	643	-17
Fuel	105	101	4	263	253	10
Non-fuel	782	777	5	782	777	5
Total user costs	**1,513**	**1,521**	**-8**	**1,671**	**1,673**	**-2**
Tax on fuel				158	152	-6
Tax on alternatives to fuel				0	0	0
Tax on non-fuel items of vehicle operating cost				0	0	0
Tax on alternatives to non-fuel items of vehicle operating cost				0	0	0
Total tax take				**158**	**152**	**6**
Net gain			-8			-8

Note: It is assumed, in conformity with the assumptions in Chapter 9, that tax accounts for 60 per cent of the price vehicle operators pay for fuel and that they can recover in full any tax paid on all other items.

Appendix H

Formulae for calculating the losses to road users and the Inland Revenue arising from lower speed limits assuming that traffic volumes would be reduced

1. The terms used in these formulae are as follows:

- Tb stands for travel time costs in the present situation of the existing speed limits unenforced;
- Ta stands for what travel time costs would be if the existing speed limit or some lower limit was enforced according to the constant flow hypothesis;
- Fb stands for fuel costs without taxation in the present situation of the existing speed limits unenforced;
- Fa stands for what fuel costs without taxation would be if the existing speed limit or some lower limit was enforced according to the constant flow hypothesis;
- Nb stands for non-fuel items of vehicle operating costs without taxation in the present situation of the existing speed limits unenforced;
- Na stands for what non-fuel items of vehicle operating costs without taxation would be if the existing speed limit or some lower limit was enforced according to the constant flow hypothesis;
- Cb stands for road users' perceived costs in the present situation of the existing speed limits unenforced;
- Ca stands for road users' perceived costs if the existing speed limit or some lower limit was enforced according to the constant flow hypothesis;

- x = Ca/Cb. However, in a few cases it was found that Ca was less than Cb, although only by a very small amount. In these cases x was taken as one;
- e is the price elasticity of demand for vehicle kilometres, where price is defined in terms of perceived costs;
- y is the ratio of the number of vehicle kilometres in the after situation (with the existing or some lower speed limit enforced) to the number in the present situation of the existing speed limits unenforced; y = 1-e(x-1);
- r is the proportion of road users' expenditure on fuel which is accounted for by tax. For cars, the value of r is 0.69 (including VAT); for other vehicles it is 0.6 (excluding VAT).

2. It is assumed that car users pay VAT at the standard rate of 17.5 per cent on non-fuel items of motoring expenditure and also on the goods they would buy with the money saved from driving less and/or at lower speeds. Users of other vehicles are assumed in effect to pay no VAT, either on vehicle operating costs of any kind or on the goods they would buy with the money saved by driving less and/or at lower speeds (they would pay VAT but would be able to reclaim it).
3. Alternative assumptions have been made about which of their costs car users perceive and base their travel decisions on. If they perceive all their costs, then Cb = Tb + Fb/(1-r) + 1.175Nb, which comes to Tb + Fb/.31 + 1.175Nb, and Ca = Ta + Fa/.31 + 1.175Na. If they perceive only their time and fuel costs, then Cb = Tb + Fb/.31 and Ca = Ta + Fa/.31. If they perceive time costs only, then Cb = Tb and Ca = Ta. It is assumed that operators of vehicles other than cars always perceive their full costs, so that for them, Cb = Tb + Fb/(1-r) + Nb, which comes to Tb + 2.5Fb + Nb, and Ca = Ta + 2.5Fa + Na.
4. The perceived loss to users of changing from the present situation of the existing unenforced speed limits to a situation in which either the existing speed limit or some lower one is enforced is given by the expression Ca - Cb - ½(x-1)(1-y)Cb (for the proof of this see Appendix I). For car users who perceive only their travel time costs and fuel costs, there is also an unperceived gain of 1.175(Nb-yNa).

For car users who perceive only their travel time costs, there is a further unperceived gain of (Fb-yFa)/.31.

5. The loss to the Inland Revenue is given by (r-.1489)(Fb-yFa)/(1-r), which comes to 1.7454(Fb-yFa), for cars; and by r(Fb-yFa)/(1-r), which comes to 1.5(Fb-yFa), for other vehicles.
6. The travel time increase factor does not enter into the cost-benefit expression but is needed to help interpret it. It is given by yTa/Tb.
7. The following examples illustrate these formulae. They all relate to cars on motorways and to the comparison between the present situation and the situation that would arise if a 55 mph limit were enforced. The elasticity, e, is 0.5. The values of the cost inputs, in £m, as given in Chapter 9, Table 9.3, are as follows: Tb = 3063, Ta = 3858, Fb = 755, Fa = 618, Nb = 3463, Na = 3314.

Car users perceive all their costs

- Cb = 3063 + 755/.31 + 1.175 x 3463 = 9567.5
- Ca = 3858 + 618/.31 + 1.175 x 3314 = 9745.5
- x = Ca/Cb = 1.0186; therefore y = .9907
- Loss to users = Ca - Cb - ½(x-1)(1-y)Cb
  = 178 - .5 x .0186 x .0093 x 9567.5 = 177.17
- Loss to Inland Revenue = 1.7454(Fb-yFa)
  = 1.7454(755 - .9907 x 618) = 249.15
- Travel time increase factor = yTa/Tb = .9907 x 3858 ÷3063 = 1.25

Car users perceive only their travel time costs and fuel costs

- Cb = 3063 + 755/.31 = 5498.5
- Ca = 3858 + 618/.31 = 5851.5
- x = Ca/Cb = 1.0642; therefore y = .9679
- Perceived loss to users = Ca - Cb - ½(x-1)(1-y)Cb
  = 353 - .5 x .0642 x .0321 x 9567.5 = 347.33
- Unperceived gain in non-fuel costs to users = 1.175(Nb-yNa)
  = 1.175(3463 - .9679 x 3314) = 300.07
- Net loss to users = 347.33 - 300.07 = 47.26

- Loss to Inland Revenue = 1.7454(Fb-yFa) = 1.7454(755 - .9679 x 618) = 273.74
- Travel time increase factor = yTa/Tb. = .9679 x 3858 ÷ 3063 = 1.22

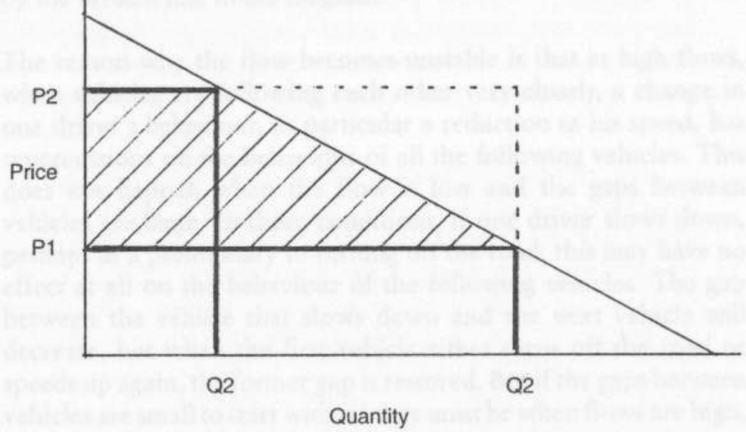
Car users perceive only their travel time costs

- Cb = 3063
- Ca = 3858
- x = Ca/Cb = 1.26; therefore y = .87
- Perceived loss to users = Ca - Cb - ½(x-1)(1-y)Cb = 795 - .5 x .26 x .13 x 3063 = 743.24
- Unperceived gain in fuel costs to users = (Fb-yFa)/.31 = (755 - .87 x 618)/.31 = 701.1
- Unperceived gain in non-fuel costs to users = 1.175(Nb-yNa) = 1.175(3463- 3314 x .87)= 681.29
- Net loss to users = 743.24 - 701.1 - 681.29 = -639.15
- Loss to Inland Revenue = 1.7454(Fb-yFa) = 1.7454 (755 - .87 x 618) = 379.35
- Travel time increase factor = yTa/Tb = .87 x 3858 ÷ 3063 = 1.10

Appendix I

The proof of the formula for the loss to road users arising from lower speeds given in Appendix H

1. In Appendix H it was stated that the cost to road users when speeds fall because of a lower or better enforced speed limit is given by the formula Ca - Cb -½(x-1)(1-y)Cb, where Cb is the generalised cost of travel in the present situation, with the existing speed limits unenforced; Ca is the generalised cost of travel in the after situation, with the existing or some lower speed limit enforced, but assuming constant flows, x = Ca/Cb; and y is the ratio of the number of vehicle kilometres in the after situation to the number in the present situation. The aim of this appendix is to show that this formula is simply a special case of the conventional formula for calculating the loss to consumers when the price of any given product is raised.



2. If p1 is the price of the product before the price rise, q1 is the quantity bought at price p1, p2 is the price of the product after the price rise and q2 is the quantity bought at price p2, then the loss to the consumer is given by the area of the shaded region in the diagram. The area of the rectangular part of the shaded region is q2(p2 - p1), which represents the loss (that is, the extra expense) to the people who buy the product both before and after the price rise. The area of the triangular part of the shaded region is given by ½(p2 - p1)(q1 - q2), which represents the loss to the people who buy the product before the price rise but not after. However, the area of the shaded region can also be written as p2q1 - p1q1 - ½(p2 - p1)(q1 - q2), where p2q1 represents the amount that would have been spent on the product after the price rise if everyone had continued to buy the same quantity of it as before, and is therefore equivalent to Ca, and p1q1 represents the expenditure on the product before the price rise and is therefore equivalent to Cb.
3. Let p2/p1 = m and q2/q1 = n. Then ½(p2 - p1)(q1 - q2) can also be written as ½(m-1)(1-n)p1q1, where p1q1 is again the equivalent to Cb. But since m = p2/p1 and p2/p1 = p2q1/p1q1, which is equivalent to Ca/Cb, m = x. Also n = y. Thus, the area of the shaded region can be written in the notation of this report as Ca - Cb - ½(x-1)(1-y)Cb.

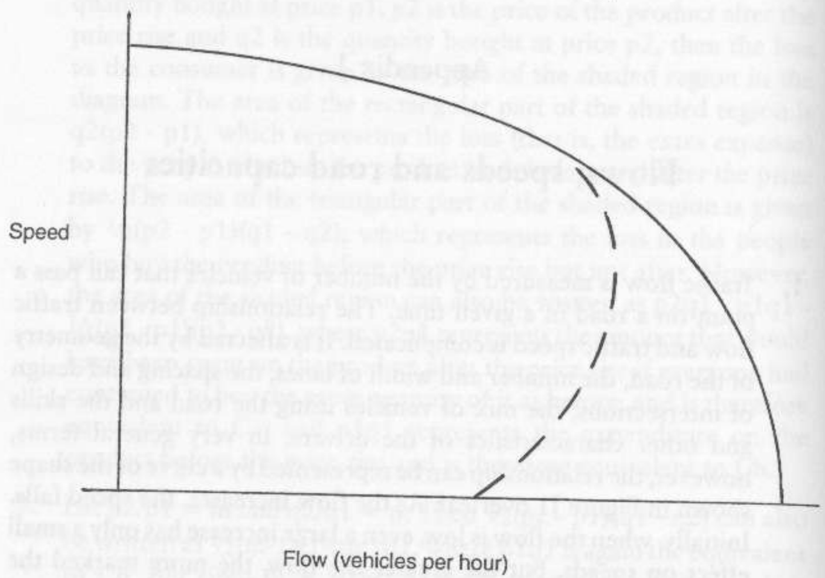
Appendix J

Flows, speeds and road capacities

1. Traffic flow is measured by the number of vehicles that can pass a point on a road in a given time. The relationship between traffic flow and traffic speed is complicated. It is affected by the geometry of the road, the number and width of lanes, the spacing and design of intersections, the mix of vehicles using the road and the skills and other characteristics of the drivers. In very general terms, however, the relationship can be represented by a curve of the shape shown in Figure J1 overleaf. As the flow increases, the speed falls. Initially, when the flow is low, even a large increase has only a small effect on speeds, but the greater the flow, the more marked the effect of an increase. If traffic always flowed smoothly, the vertical section of the unbroken curve would represent the absolute capacity of the road. But as capacity approaches, the smooth flow of traffic breaks down. Conditions become unstable and the full potential capacity cannot be obtained. This situation is represented by the broken line in the diagram.

2. The reason why the flow becomes unstable is that at high flows, when vehicles are following each other very closely, a change in one driver's behaviour, in particular a reduction in his speed, has repercussions on the behaviour of all the following vehicles. This does not happen when the flow is low and the gaps between vehicles are large. In those conditions, if one driver slows down, perhaps as a preliminary to turning off the road, this may have no effect at all on the behaviour of the following vehicles. The gap between the vehicle that slows down and the next vehicle will decrease, but when the first vehicle either turns off the road or speeds up again, the former gap is restored. But if the gaps between vehicles are small to start with, as they must be when flows are high, then if one driver brakes, the driver of the following vehicle is obliged to brake as well. In practice, he brakes a moment later, and

Figure J1 The general form of the speed-flow relationship



the driver behind him brakes a moment after that, and so on. In the extreme case, this can lead to a collision or even a pile-up, but even if there is no collision, experience shows that it takes longer for normal conditions to be restored after such an incident than for the situation to break down in the first place. On a two- or three-lane road, this cascade effect can be triggered off by a vehicle changing lanes. Even if that vehicle does not have to reduce its own speed, its action may force the vehicles in the lane which it joins to reduce theirs.

3. It is believed that the point at which the smooth speed-flow curve breaks down, and unstable conditions begin to occur, depends on the variability of the speeds of the vehicles in the traffic stream. If vehicles are all travelling at the same speed in the first place, it is thought that incidents triggering off the cascade effect would be less likely to occur. On motorways, the uniform speed should also presumably be low enough for drivers turning off not to have to brake before turning. This belief is supported by Continental experience and by the initial results of the experiments now taking place on certain sections of the M25. On these sections, 50 mph and 60 mph speed limits are being imposed at congested times in the hope that this will delay the onset of stop-start conditions and so increase the capacity of the motorway. In terms of the diagram, the broken line would move closer to the unbroken one.

4. The nature of the speed-flow relationship also explains why the calculations of time losses from lower speeds in Chapter 9 are exaggerated even when flows are well within the capacity of the roads. Table J1 is derived from the speed flow-curve for two-lane motorways in the COBA 9 manual. It shows how as flows build up and speeds fall, vehicles are driven closer to each other. For example, with a flow of 1,000 vehicles per lane per hour, average speed is 96 km/h or 60 mph and the headway is 96 metres or 3.6 seconds, but with a flow of 1800 vehicles per lane per hour, speeds drop to 80 km/h or 50 mph and headways become 44 metres or two seconds. If lower speeds were imposed on a given stream of traffic, there would also be a reduction in headways, which would reduce the time penalty resulting from lower speeds. There is no simple way of calculating this effect. For motorways, it could be calculated using a micro-simulation model which would take into account not only general traffic volumes but also the numbers of vehicles entering and leaving the motorway at each junction at particular times. We understand that the TRL has such a model, and we recommend that it should be used, suitably modified if necessary, to throw further light on what increases in travel time would result from lowering the speed limit on motorways or enforcing the existing limit. But in Chapter 9 we have simply ignored the fact that if speeds fell headways would be reduced. Thus our estimates of the increases in travel time costs are exaggerated.

Table J1 Flows, speeds and headways on 2-lane motorways

Vehicles per lane per hour	Speed km/h	Speed mph	Headway metres	Headway seconds
200	100	62.5	500	18
1000	96	60	96	3.6
1480	88	55	59	2.4
1800	80	50	44	2.0
2120	72	45	34	1.7

Appendix K

Some further results of the calculations on which the figures in Table 9.10 were based

Table 9.10 showed what elasticities were required to change the apparent optimal speed limits on each class of road from those calculated for zero elasticity. As an aid in deciding whether these elasticities were reasonable, it also showed for each one the corresponding value of the increase in travel time for cars. As a further aid to the interpretation of Table 9.10, some more results of the calculations on which it is based may be useful.

In the following tables, all the increases, losses and gains are calculated by reference to the present (1993) situation of the existing speed limits unenforced, except that the index of the increase in travel time for cars is calculated in the way explained in the note to each table.

Table K1 Details for motorways for those elasticity values which are the lowest necessary to produce a change in the apparent optimal speed limit, assuming that motorists perceive only travel time costs and fuel costs

	Apparent optimal speed limit changes to: 60 mph	55 mph
Elasticity	1.68	2.00
Percentage increase in (perceived) costs for:		
- Cars	3%	6%
- Light goods vehicles	2%	4%
- Buses and coaches	5%	9%
- Heavy goods vehicles	0%	0%
Percentage increase in travel time for cars	10.9%	9.8%
Percentage increase in travel time for cars if elasticity was zero	17.2%	26.0%
Index of the increase in travel time for cars	63%	38%
Perceived loss to motorists, £m	171	330
Unperceived gain to motorists in reduced non-fuel vehicle operating costs, £m	349	675
Loss to light goods vehicles, £m	31	61
Loss to buses and coaches, £m	38	64
Loss to heavy goods vehicles, £m	-13	-12
Loss to Inland Revenue, £m	293	450
Saving in costs of accidents, £m	320	399
Net gain, £m	149	181

The index of the increase in travel time for cars is the increase in car travel time after allowing for the reduction in flow due to the elasticity of demand expressed as a percentage of the increase in travel time at the same speed limit with zero elasticity.

Table K2 Details for dual carriageway 'A' roads for those elasticity values which are the lowest necessary to produce a change in the apparent optimal speed limit, assuming that motorists perceive only travel time costs and fuel costs

	Apparent optimal speed limit changes to: 55 mph
Elasticity	1.37
Percentage increase in (perceived) costs for:	
- Cars	4%
- Light goods vehicles	3%
- Buses and coaches	1%
- Heavy goods vehicles	0%
Percentage increase in travel time for cars	12.2%
Percentage increase in travel time for cars if elasticity was zero	19.1%
Index of the increase in travel time for cars	64%
Perceived loss to motorists, £m	209
Unperceived gain to motorists in reduced non-fuel vehicle operating costs, £m	309
Loss to light goods vehicles, £m	37
Loss to buses and coaches, £m	4
Loss to heavy goods vehicles, £m	2
Loss to Inland Revenue, £m	273
Saving in costs of accidents, £m	464
Net gain, £m	248

The index of the increase in travel time for cars is the increase in car travel time after allowing for the reduction in flow due to the elasticity of demand expressed as a percentage of the increase in travel time at the same speed limit with zero elasticity.

Table K3 Details for single carriageway 'A' roads for those elasticity values which are the lowest necessary to produce a change in the apparent optimal speed limit, assuming that motorists perceive only travel time costs and fuel costs

	Apparent optimal speed limit changes to: 40 mph
Elasticity	1.33
Percentage increase in (perceived) costs for:	
- Cars	8%
- Light goods vehicles	5%
- Buses and coaches	4%
- Heavy goods vehicles	1%
Percentage increase in travel time for cars	1.5%
Percentage increase in travel time for cars if elasticity was zero	13.8%
Index of the increase in travel time for cars	11%
Perceived loss to motorists, £m	607
Unperceived gain to motorists in reduced non-fuel vehicle operating costs, £m	491
Loss to light goods vehicles, £m	126
Loss to buses and coaches, £m	30
Loss to heavy goods vehicles, £m	49
Loss to Inland Revenue, £m	241
Saving in costs of accidents, £m	1,049
Net gain, £m	487

The index of the increase in travel time for cars is the increase in car travel time after allowing for the reduction in flow due to the elasticity of demand expressed as a percentage of the increase in travel time at the same speed limit with zero elasticity.

Table K4 Details for motorways for those elasticity values which are the lowest necessary to produce a change in the apparent optimal speed limit, assuming that motorists perceive only travel time costs

	Apparent optimal speed limit changes to:		
	60 mph	55 mph	50 mph
Elasticity	0.31	0.45	0.61
Percentage increase in (perceived) costs for:			
- Cars	17%	26%	38%
- Light goods vehicles	2%	4%	7%
- Buses and coaches	5%	9%	15%
- Heavy goods vehicles	0%	0%	0%
Percentage increase in travel time for cars	11.2%	11.2%	6.0%
Percentage increase in travel time for cars if elasticity was zero	17.2%	26.6%	37.9%
Index of the increase in travel time for cars	65%	43%	16%
Perceived loss to motorists, £m	513	749	1,028
Unperceived gain to motorists in reduced fuel costs, £m	459	675	970
Unperceived gain to motorists in reduced non-fuel vehicle operating costs, £m	342	630	1,100
Loss to light goods vehicles, £m	31	62	115
Loss to buses and coaches, £m	39	69	113
Loss to heavy goods vehicles, £m	-13	-12	12
Loss to Inland Revenue, £m	284	423	624
Saving in costs of accidents, £m	318	393	464
Net gain, £m	265	407	642

The index of the increase in travel time for cars is the increase in car travel time after allowing for the reduction in flow due to the elasticity of demand expressed as a percentage of the increase in travel time at the same speed limit with zero elasticity.

Table K5 Details for dual carriageway 'A' roads for those elasticity values which are the lowest necessary to produce a change in the apparent optimal speed limit, assuming that motorists perceive only travel time costs

	Apparent optimal speed limit changes to:			
	55 mph	50 mph	45 mph	40 mph
Elasticity	0.27	0.50	0.56	0.61
Percentage increase in (perceived) costs for:				
- Cars	19%	30%	43%	61%
- Light goods vehicles	3%	5%	9%	15%
- Buses and coaches	1%	4%	7%	13%
- Heavy goods vehicles	0%	0%	1%	3%
Percentage increase in travel time for cars	12.9%	10.5%	8.6%	1.2%
Percentage increase in travel time for cars if elasticity was zero	19.1%	29.9%	43.2%	60.1%
Index of the increase in travel time for cars	68%	35%	20%	2%
Perceived loss to motorists, £m	521	777	1,066	1,390
Unperceived gain to motorists in reduced fuel costs, £m	421	685	907	1,167
Unperceived gain to motorists in reduced non-fuel vehicle operating costs, £m	287	639	959	1,391
Loss to light goods vehicles, £m	37	80	134	217
Loss to buses and coaches, £m	5	13	24	43
Loss to heavy goods vehicles, £m	2	7	31	88
Loss to Inland Revenue, £m	262	419	559	721
Saving in costs of accidents, £m	460	536	605	679
Net gain, £m	341	564	657	778

The index of the increase in travel time for cars is the increase in car travel time after allowing for the reduction in flow due to the elasticity of demand expressed as a percentage of the increase in travel time at the same speed limit with zero elasticity.

Table K6 Details for single carriageway 'A' roads for those elasticity values which are the lowest necessary to produce a change in the apparent optimal speed limit, assuming that motorists perceive only travel time costs and fuel costs

	Apparent optimal speed limit changes to: 40 mph	35 mph
Elasticity	0.61	0.71
Percentage increase in (perceived) costs for:		
- Cars	14%	24%
- Light goods vehicles	5%	10%
- Buses and coaches	7%	7%
- Heavy goods vehicles	1%	3%
Percentage increase in travel time for cars	4.2%	2.9%
Percentage increase in travel time for cars if elasticity was zero	13.8%	24.2%
Index of the increase in travel time for cars	30%	12%
Perceived loss to motorists, £m	720	1,208
Unperceived gain to motorists in reduced fuel costs, £m	305	513
Unperceived gain to motorists in reduced non-fuel vehicle operating costs, £m	389	759
Loss to light goods vehicles, £m	128	239
Loss to buses and coaches, £m	30	61
Loss to heavy goods vehicles, £m	49	111
Loss to Inland Revenue, £m	198	331
Saving in costs of accidents, £m	976	1,337
Net gain, £m	545	659

The index of the increase in travel time for cars is the increase in car travel time after allowing for the reduction in flow due to the elasticity of demand expressed as a percentage of the increase in travel time at the same speed limit with zero elasticity.

Appendix L

Calculation of the additional travel times that might arise from enforcing the existing or lower speed limits in Norwich

The speed survey on which this calculation was based was described in Chapter 10, where a brief example of the method was also given. Table L1 shows the use of this method to calculate the time that would have been needed to traverse one section of road during the morning off-peak period (10 a.m. to 1 p.m.) if the existing 30 mph speed limit had always been respected. The observer's car traversed this section of road in 92 seconds. The distances covered in each of the 46 two-second intervals are shown in the table as a frequency distribution. In 11 of the 46 two-second intervals, the traffic was moving at a speed greater than the speed limit of 30 mph. For each such interval, the time that would have been required to drive the same distance if the speed of the traffic had been reduced to exactly 30 mph was calculated. Hence the extra time to drive over the whole road section can be calculated. It will be seen that the time required rises from 92 seconds, when the speed limit was not complied with, to 93.52 seconds if it had been complied with, a difference of 1.52 seconds.

It can also be seen from the table that the observer's car exceeded 25 mph in 30 of the 46 two-second intervals. The reader can easily check that if the car's speed had been constrained to exactly 25 mph for each of those intervals, the time required to traverse this section of road would have risen to 101.55 seconds. Similarly, if a 20 mph limit had been enforced, 121.1 seconds would have been required, and if a 15 mph limit had been enforced, 154.64 seconds would have been required.

Similar calculations were made for each section of road covered in the speed survey for each time of day. Since the length of each section of road was known, and also the hourly flow of vehicles along each section at each time of day, it was possible to calculate both the vehicle miles along each section of road at each time of day and the vehicle hours required to perform that travel, both in the existing situation of unenforced speed limits and if the present speed limit or some lower one had been enforced. These calculations were made, for each time of day, for each section of road now subject to a 30 mph speed limit, and the results were then summed to show the position for all 30 mph roads. Similar calculations were then made for 40 mph roads. The results were then aggregated as shown in Table L2, from which Table 10.1 in Chapter 10 is derived.

Tables L3 and L4 give slightly more detailed information about the effects of enforcing the 30 mph and the 40 mph speed limit respectively. A particularly interesting result in Table L4 is that to have enforced a 30 mph speed limit on roads where it is now 40 mph would have added only eight per cent to the time required if the 40 mph limit had been observed.

Table L1 Calculation of the time that would have been required to have driven along a section of road in Norwich (link 13 - 61) in the morning off-peak period if the 30 mph speed limit had always been observed

Miles now driven in two seconds	No. of 2-second intervals	Present speed (mph)	Speed if the present limit was observed (mph)	New time interval (seconds)	New total time (seconds)
.002	3	3.6	3.6	2	6
.006	1	10.8	10.8	2	2
.007	2	12.6	12.6	2	4
.010	1	18.0	18.0	2	2
.012	5	21.6	21.6	2	10
.013	4	23.4	23.4	2	8
.014	4	25.2	25.2	2	8
.015	9	27.0	27.0	2	18
.016	6	28.8	28.8	2	12
.017	3	30.6	30.0	2.04	6.12
.018	7	32.4	30.0	2.16	15.12
.019	1	34.2	30.0	2.28	2.28
Total	46				93.52

Table L2 The final stage of aggregation in the calculation of the results shown in Table 10.1

Type of road and time of day	Vehicle miles	Vehicle hours: Actual	Existing 30/40 mph limit enforced	25 mph limit enforced	20 mph limit enforced	15 mph limit enforced
30 mph (1)	31,848	1,786	1,850	1,977	2,220	2,677
30 mph (2)	60,636	2,884	3,010	3,274	3,762	4,678
30 mph (3)	35,692	2,454	2,501	2,598	2,864	3,349
40 mph (1)	21,377	1,019	1,024	1,210	1,389	1,711
40 mph (2)	38,898	1,724	1,744	2,121	2,458	3,060
40 mph (3)	23,718	1,309	1,312	1,493	1,687	2,038
Total	212,169	11,176	11,441	12,673	14,380	17,513
Extra time, in vehicle hours as compared with the enforcement of the present speed limits				1,232	2,939	6,072
Extra time in seconds per vehicle mile				20.9	49.9	103.0
Extra time in seconds per vehicle kilometre				13.0	31.0	64.0

The times of day shown in this table are (1) 7 a.m. to 10 a.m. (2) 10 a.m. to 4 p.m. and (3) 4 p.m. to 7 p.m.

Table L3 The additional time that would have been required to drive the mileage driven in Norwich on a typical weekday in 1993 on roads now subject to a 30 mph speed limit if lower limits had been enforced

New speed limit	Morning peak 7 am to 10 am	Between peaks 10 am to 4 pm	Evening peak 4 pm to 7 pm	12-hour total	% increase (12 hours)
		seconds per vehicle per mile			
25 mph	14.4	15.6	9.7	14.1	6.6%
20 mph	41.8	44.7	36.6	41.7	20.2%
15 mph	93.5	99.0	85.5	93.9	45.4%

The times shown are additional to those that would have been required if the present speed limit had been observed.

Table L4 The additional time that would have been required to drive the mileage driven in Norwich on a typical weekday in 1993 on roads now subject to a 40 mph speed limit if lower limits had been enforced

New speed limit	Morning peak 7 am to 10 am	Between peaks 10 am to 4 pm	Evening peak 4 pm to 7 pm	12-hour total	% increase (12 hours)
		seconds per vehicle per mile			
35 mph	3.8	5.2	3.0	4.3	2.4%
30 mph	13.6	16.1	11.2	14.1	8.0%
25 mph	31.3	34.8	27.5	31.9	18.2%
20 mph	61.4	66.1	57.0	62.3	35.6%
15 mph	115.7	121.8	110.2	117.0	66.9%

The times shown are additional to those that would have been required if the present speed limit had been observed.

Appendix M

Some foreign experience relevant to the concept of a local runabout

Although local runabouts of the kind described in Chapter 11 do not exist in any country, there are cars in some countries, especially France and Japan, which are similar enough for lessons to be learnt from them. Among other things, this experience demonstrates how market behaviour can be influenced by the fiscal and legal framework imposed by the government.

In France, there are two categories of car akin to a runabout.[1] The rules for a voiturette are similar to those for a moped. The engine has to be less than 50cc or 4 kw and the permitted maximum speed is 45 km/h (28 mph); there are also certain restrictions on the car's weight and dimensions. The car can be driven at the age of 14 without a driving licence and it does not need a vehicle licence either. Only one passenger, who may be either a child or an adult, is allowed. There are also mini-truck versions of the voiturette. Voiturettes are not allowed on motorways.

The rules for a quadricyle are similar to those for a light motorcycle. The engine has to be less than 125 cc or 9.6 kw and the permitted maximum speed is 75 km/h (47 mph). There are certain restrictions on the car's weight but not on its dimensions. The car can be driven at the age of 16; a driving licence is required, the acquisition of which depends on passing a theoretical examination about the Code de la Route. A vehicle licence is also required. Some models of quadricycle are permitted to carry more than one passenger. Quadricycles are allowed on motorways.

Production and sales figures for these cars are not available because they are included with motorcycles in the statistics, but annual production has been estimated by the Comité des Constructeurs Français d'Automobiles at between 15,000 and 20,000. There are at least a dozen manufacturers. There is no systematic information on the kinds of people who buy voiturettes, but according to a press release from one of the manufacturers, Ligier, in 1980, the main potential market was seen to be among people aged over fifty, probably retired, living either in the country or on the outskirts of small towns without much public transport.

In Japan,[2] the purchase of microcars is encouraged by favourable tax and insurance rates. In addition, in most cities the rule applying to regular cars, that their owners have to prove that they have an off-street parking space, is waived for microcars. The maximum length of a microcar is 3.3 metres, maximum width 1.4 metres and maximum engine size 660cc.

There has always been a market for these low-cost low-upkeep vehicles in rural areas in Japan, where incomes are low and people need their own transport, but in the 1980s a new market for microcars was opened up as the second car in urban households, used for shopping, taking children to school and so on. In 1990, microcars accounted for about a quarter of new vehicles registered in Japan.

Studies of Japanese accident rates in the years 1980 to 1982 suggested that microcars were not only less of a danger to other road users than regular cars, as would be expected, but were safer for their users as well. This finding, which is contrary to the experience of small cars in other countries, has been attributed to the lower top speed of microcars, which at that time was 80 km/h (50 mph) as opposed to 100 km/h (62 mph) for regular cars.[3] It seems that both these limits have since been lifted or increased[4] but we know of no studies of the effects on accident rates.

Japanese microcars have been exported to Peru 'and other markets where there is a special tax bracket as in Japan for small-engined cars'.[5]

References

1. All the information given here about the French cars, except for Ligier's account of its target market, has been supplied by the Comité des Constructeurs Français d'Automobiles.

2. The information in this paragraph and the next comes from K Radley (1991) 'Good Things in Small Packages', *Sunday Times Magazine*, 26 May 1991.

3. F T Sparrow (1985) 'Accident Involvement and Injury Rates for Small Cars in Japan', *Accident Analysis and Prevention*, Vol.17, No.5.

4. Mr Radley mentions that there are now microcars which are also sports cars capable of 130 km/H (81 mph).

5. K Radley, op.cit.