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# SPEED LEVEL REGULATION ON NORWEGIAN ROADS

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## Abstract

The paper presents an economic model of speed selection for risk neutral utility maximising drivers. The model is used to discuss briefly how the most relevant political means such as the speed limit statutes, the level of policing on the roads and the magnitudes of the penalty variables influence drivers' speed selection. The paper then reviews the development of the speed level and the speed limit statutes in Norway during the last twenty years. Thereafter it focuses on the Norwegian authorities' effort to deter speeding in the 1990's. Finally, it discusses the Norwegian regulation practice in the light of the suggestions derived from models aiming to minimise the total social costs of road traffic.

## INTRODUCTION

Drivers' behaviour influences safety as well as the economic efficiency or social costs of road traffic. Their behaviour over a certain stretch of road - which may also be described as their level of care, can be specified by a number of factors such as their selected speed, their chosen level of concentration, their distance to the car ahead, their awareness when driving through cross-roads and how considerate they are towards pedestrians. Among these variables, speed is undoubtedly regarded as the most important one, both from a safety and from an economic perspective. Consequently, the authorities use far more resources to decide speed limits and to enforce these statutes than they use to regulate other behavioural driving variables. The majority of economic models do also specify drivers' behaviour by their selected speed only, see for example Lee (1985), Janssen and Tenkink (1988), Graves *et al* (1989), Jørgensen (1991), Jørgensen (1993) and Jørgensen and Polak (1993).

The aim of this paper is to review and to discuss from an economic perspective the Norwegian speed regulation practice. The paper proceeds as follows: First we develop a simple model of a driver's speed selection enabling us to discuss how speed limits, the probability of being caught speeding, the penalty rules for speeding and moral campaigns influence his choice of speed. Second, we show the developments of the speed limit statutes and the actual speed level in Norway. Next, we review the enforcement effort of the speed limits during the 1990's by giving figures indicating the level of policing, the use of automatic speed controls and the magnitudes of the penalty variables for speeding. Here, we also shows some figures indicating how law-abiding Norwegian drivers are. Thereafter, we discuss the Norwegian speed regulation practice under the assumption that the authorities want to minimise total social costs of road traffic. Finally, we summarise the main conclusions.

## A DRIVER'S SPEED SELECTION

### The model

In the following we assume that the driver is a subjectively, norm-guided rational, risk neutral utility maximiser and that his perceived pecuniary cost per unit distance driven is constant. Under these assumptions, the driver selects a speed (s) that minimises his total cost of travel per distance (TC) where TC is defined as:

$$TC = T(s) + Q(s) + q(P) \cdot F(s_L, x) + M(s_L, x) \ , \ x = s - s_L. \qquad (1)$$

where T(s) is time cost per unit of distance driven, Q(s) is perceived expected private accident loss per distance driven, q is the perceived probability of being caught per distance travelled exceeding the speed limit ($s_L$), x is the magnitude of speeding ($x > 0$ when $s > s_L$), P is the level of policing per distance, $F(s_L,x)$ is the perceived magnitude of the penalty when caught speeding and $M(s_L,x)$ is the moral cost to the car driver per distance of exceeding the speed limit.

Before discussing how different speed regulation variables influence the driver's selected speed, we will offer some more comments on the model above: A driver's value of travel time per unit of time is among other things influenced by his income, by the purpose of the journey and by the quality aspects of the vehicles. Hence, the T(s) relationship is dependent on the same factors and it will,

thus, vary throughout the driving population and for different types of car. In the following we assume that $T_s < 0$ and $T_{ss} > 0$ where $T_s = \partial T / \partial s$, $T_{ss} = \partial^2 T / \partial s^2$. The Q(s) relationship is influenced by the technological characteristics of the car, the quality of the roads and the level of the car driver skills, implying that it varies according to the types of car and drivers. Further, it is important to note that the Q(s)-function denotes the driver's perceived estimate of the relationship between expected accident loss and speed; if he, for instance, overestimates his driving skills or underestimates the private consequences of an accident, the corresponding objective relationship ($Q^o(s)$) lies above the subjective one. For later use we assume that Q, $Q_s$, $Q_{ss} > 0$ when $s > 0$ and $Q = 0$ when $s = 0$.

The present enforcement technology for catching speedy drivers implies that the objective probability of being caught speeding ($q^o$) is the same for all individuals and for all types of car. Empirical Norwegian studies indicate, however, that the perceived value of being caught speeding (q) for the same stretch of road varies significantly throughout the Norwegian driving population (Glad *et al*, 1990) while it is independent of the type of car they drive. It is sensible to assume that q increases concavely with P; that is $q_P > 0$, $q_{PP} < 0$. The actual penalty for minor speeding offences in Norway, $F^o$, is the same for all types of vehicles and for all drivers. This is, however, not the case for serious speeding offences. Several empirical studies indicate that drivers' knowledge about the actual penalty function for speeding is limited (Østvik, 1988). Hence the perceived penalty function, $F(s_L,x)$ varies significantly throughout the driving population. For later use we employ the following restrictions regarding the perceived penalty function: $F = 0$ when $x \leq 0$, and the function $F(s_L,x)$ is nondecreasing in x and nonincreasing in $s_L$.

When the car driver is not amoral; that is he has conscience or scruples about committing speeding offences, the $M(s_L,x)$ function will be positive when $x > 0$. Since drivers' moral as far as exceeding the speed limit is concerned, probably varies considerably from driver to driver, so will the $M(s_L,x)$ relationship. A plausible assumption is that this function is dependent on the Q(s) - and the $F(s_L,x)$ functions. When the driver perceives that he drives safer (the Q(s) function shifts downwards), his moral cost of exceeding the speed limits are probably being reduced because he thinks that his speeding imposes lower risk on other drivers. Further, the formal sanctions for speeding give signals to the driver as to how serious society looks at such offences, Eide (1994). This suggests that the $M(s_L,x)$ function shifts upwards when the magnitudes of the formal sanctions for speeding increase. For later use we assume that $M = 0$ when $x \leq 0$ and $M_{s_L} < 0$, M, $M_x$, $M_{xx} > 0$ when $x > 0$.

## Regulating speed

The most relevant means for the authorities to regulate speed are: (1) setting the speed limit ($s_L$); (2) to influence drivers' perceived probability of being caught speeding (q) by changing the level of policing (P); and (3) to influence drivers' perceived sanction for speeding by changing the magnitudes of the actual penalty variables; that is the level of fine, the length of the suspension period of the driving licence and the length of imprisonment.

The first two means make it possible for the authorities to target speed regulation towards certain stretches of road. The regulators are also able to influence the speed level more indirectly by

informing about the hazards of speeding in the compulsory driving training courses and in traffic safety campaigns. Such information is supposed to get the Q(s) function as well as the $M(s_L,x)$ function to shift upwards. In the following discussion we will distinguish between the case when the drivers perceive that the relationship between penalty and speed is continuous for all speeds and the case when they perceive this function to be stepwise increasing.

*The perceived penalty function is continuous*

Even though the actual penalty function for speeding, $F^o(s_L,x)$, is stepwise increasing, it may be reasonable to assume a smooth relationship between perceived penalty and the magnitude of the speeding when the number of steps is rather large. For later use we also assume that $F = 0$ when $x \leq 0$, $F, F_x, F_{xx} > 0$ when $x > 0$ and $F_{s_L} < 0$ when $x > 0$. When assuming that the value of s that minimises TC is not where $s = s_L$, it follows from eqn (1) that the first order conditions for minimum of TC are:

$$T_s + Q_s = -q(P) \cdot F_x - M_x \text{ where } F(s_L, x) = M(s_L, x) = 0 \text{ when } s \leq s_L \text{ and } x = s - s_L. \quad (2)$$

Without loss of much generality, we will in the following specify T(s) in eqn (1) by T(s) = t/s where t is time cost per unit of time. The conditions under eqn (2) may then be written as:

$$\begin{aligned} &Y(s) = X(s_L, s) + Z(s_L, s) \text{ where } Y(s) = -t + Q_s \cdot s^2, \\ &X(s_L, s) = -q(P) \cdot F_x(s_L, x) \cdot s^2,\ Z(s_L, s) = -M_x(s_L, x) \cdot s^2,\ x = s - s_L. \end{aligned} \quad (3)$$

From previous restrictions imposed on the relevant functions it follows that $Y_s > 0$, and $X_s, Z_s < 0$. Further we assume that $Y_{ss} > 0$ and $X_{ss}, Z_{ss} < 0$. Sufficient but not necessary conditions for the latter are that $Q_{sss}, F_{xxx}, M_{xxx} > 0$, respectively. When the Y(s)-function climbs more steeply, the driver's private expected accident loss increases. Further, the higher the values of $F_x$ and $M_x$ and consequently, the steeper the $X(s_L,s)$ function and the $Z(s_L,s)$ function (with respect to s), the higher his perceptions about expected penalty costs of being caught speeding and the higher his moral cost of committing speeding offences become, respectively.

Using eqn (3), Figure 1 shows four different relevant cases of drivers' speed selection. In Case 1, driver A and B have the same time costs (t), but A has higher perceptions of the driving risk than B because $Q_s^A(s) > Q_s^B(s)$. Driver A will select a speed; $s_A$ which is lower than the speed limit, $s_L$. Hence, as long as $s_L > s_A$, neither his moral cost of exceeding the speed limit nor his perceptions of the expected penalty for speeding, will influence his selected speed. Driver B will, however, select a speed $s_B$ and thus exceed the speed limit by $(s_B - s_L)$. Without the speed limit, driver B's selected speed would have been $s_{B1}$ implying that speed regulation has decreased driver B's speed from $s_{B1}$ to $s_B$. The $s_{B2}$-value can be interpreted as driver B's selected speed when he perceives that the expected penalty of being caught speeding is zero. The differences $(s_{B1} - s_{B2})$ and $(s_{B2} - s_B)$ are, therefore, the "intrinsic" influence from the speed limit through the driver's moral and the effect through the enforcement system, respectively.

Case 2 shows a situation where driver A and B have the same driving risk perceptions, the same perceptions of the expected penalty from speeding and the same moral cost of committing speeding offences, but A has lower time costs than B. Both drivers exceed the speed limit, but B will always select a higher speed than A, no matter what their total inconvenience of driving too fast. The

relative positions of the curves in Case 2, imply too that $(s_{B1} - s_B) > (s_{A1} - s_A)$; that is the speed regulation has reduced driver B's speed more than driver A's speed, resulting in lower speed variance among them.

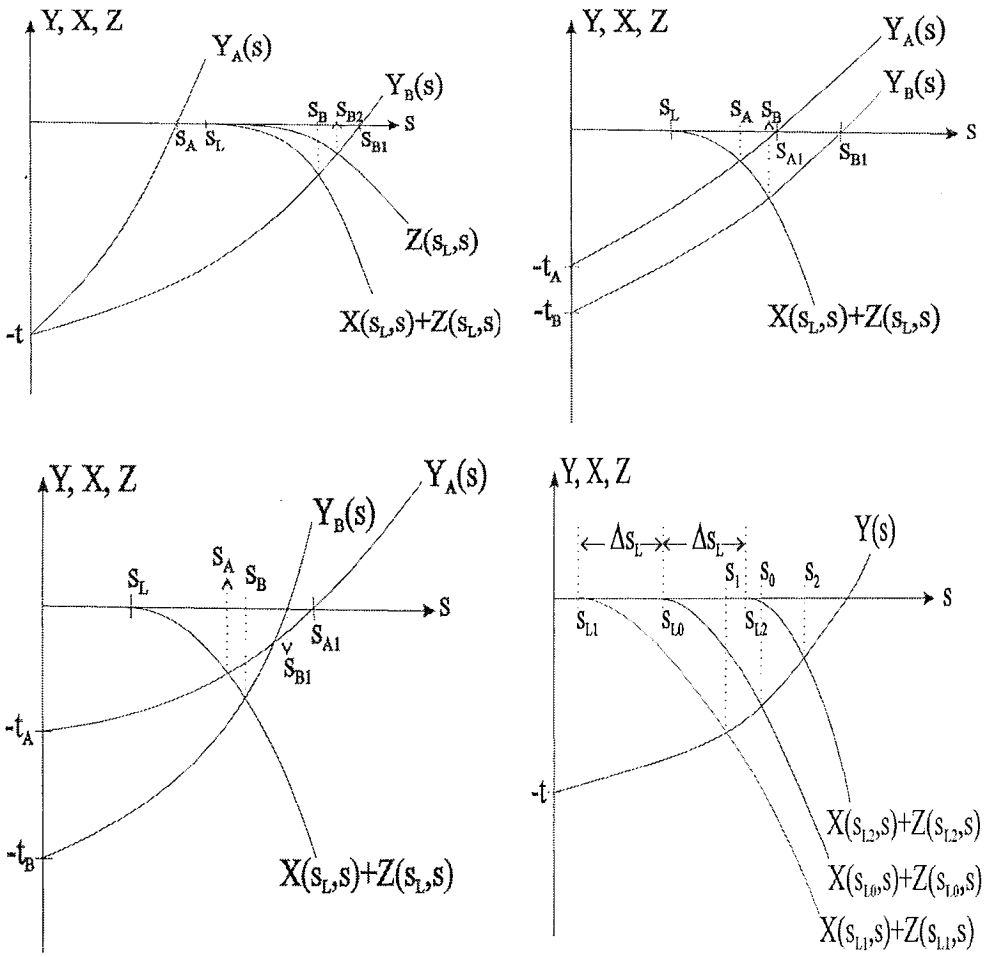


**Figure 1 - Driver A and B speed selection. Upper left: Case 1. Upper right: Case 2. Lower left: Case 3. Lower right: Case 4.**

Case 3 shows a situation where driver A has lower time cost and lower driving risk perceptions than driver B (because $Q_s^A(s) < Q_s^B(s)$), but we still assume that they have the same perceptions regarding the expected penalty from speeding and the same moral cost of committing speeding offences. Without the speed limit, Case 3 shows a situation where A will drive faster than B and he will still do so with speed limits as long as their total inconvenience from exceeding the speed limits are low enough to provide that the (X+Z) curve lies to the right of the point where the $Y_A$ curve and the $Y_B$ curve intersect. If their total inconvenience from exceeding the speed limit increases such that the (X+Z)-curve lies - as in Case 3, to the left of the intersection point mentioned above, driver B will,

however, drive faster than driver A. The latter situation illustrates that the drivers who commit the most serious speeding offences may not be the same drivers as those who will drive fastest without speed limits - even though their total perceived costs of exceeding the speed limit are the same.
Case 4 shows the influence of changing the speed limit when assuming that the driver's perceived total cost of exceeding the speed limit by x km is independent of the speed limit itself. With the restrictions we have imposed on the F-and the M-functions, it follows that the (X+Z) curve is steeper (for the same value of $x = (s-s_L)$) the higher the value of s. When the Y(s) curve increases, it then follows from Case 4 that reducing the speed limit, $s_L$, by $\Delta s_L$ will reduce the driver's selected speed from $s_0$ to $s_1$ while an increase in $s_L$ by $\Delta s_L$ will increase the driver's speed from $s_0$ to $s_2$ and such that:

$$\Delta s_L > (s_0 - s_1) \text{ and } \Delta s_L > (s_2 - s_0) \quad (4)$$

The changes in the driver's speed will, thus, always be lower than the changes in the speed limit. Without imposing more restrictions on the actual functions we are, however, not able to conclude whether $(s_0 - s_1) \leq(>) (s_2 - s_0)$. One important point to note from the discussions above is the mutual dependence between the most relevant means to regulate speed; the influence of changing the speed limit is dependent on the level of policing and the total magnitude of penalty for speeding and vice versa. Further, the influence on drivers' speed selection from safety campaigns and moral campaigns aiming to get the Y(s) function to shift upwards and the $Z(s_L,s)$ function to shift downwards, respectively, is dependent on the speed limits, the level of policing and the magnitude of the penalty variables for speeding.

Broadly speaking, the conclusions which can be drawn from the figure discussions above, are in accordance with empirical results dealing with drivers' speed selection, see for example Glad *et al* (1990) and Jørgensen and Polak (1993).

*The perceived penalty function for speeding is stepwise increasing*

The Norwegian penalty rules for speeding imply that the actual penalty function, $F^o(s_L,x)$, is a stepwise increasing function with x when $0 < x \leq x_M$ where $x_M$ thus, denotes the threshold level of speeding resulting in suspension of the driving licence. When $x > x_M$, the relationship between $F(s_L,x)$ and x is probably continuous, but shifts upwards at the level of speeding, $x_N$ when the question of imprisonment arises.

Assuming the driver knows the actual penalty function, the $TC(s_L,s)$-function is depicted in Figure 2 below; it will be a stepwise function when $s_L < s < s_M$ ($s_M = s_L + x_M$) and otherwise continuous except at the threshold level of speed, $s_N$, resulting in imprisonment. It reaches a minimum when $s = s_0$ implying that the driver will exceed the speed limit by $(s_0 - s_L)$. The A-B curve shows the relationship between TC and s if no speed limit existed while the A-C curve shows the same relationship when the driver perceives that the expected penalty for speeding is zero. Hence, the influence of the speed limit because of the driver's moral and because of the penalty system is $(s_2 - s_1)$ and $(s_1 - s_0)$, respectively.

It is worth noting that the magnitudes of the steps in Figure 2 are not only dependent on the penalty function but also on the level of policing; all other things equal the higher the level of policing and thus the probability of being detected for speeding, the larger the steps. It is also reasonable to conclude from Figure 2 that the driver will normally select speeds close up to one of the break

points. Neither significant changes of the driver's risk perceptions nor in his time costs (the position of the A-B curve) will necessary change his selected speed. If all drivers have the same perceptions concerning the penalty function, a stepwise penalty function will, therefore, lead to their speeds being close up to the break points. This will reduce speed variance among drivers which in turn will have a positive influence on accident rate (Lave, 1985). The larger the steps of the penalty function, the more important these factors become. These views are confirmed by simulations, see Jørgensen (1991).

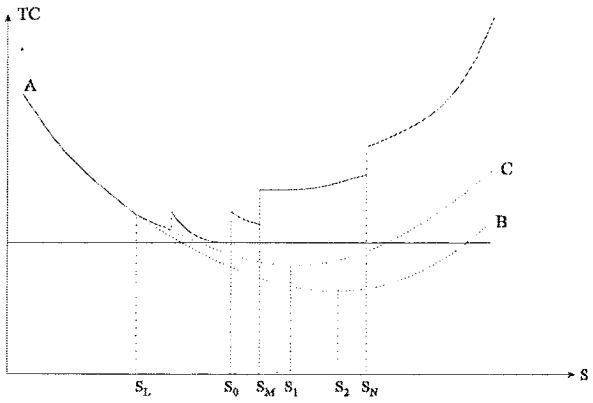


**Figure 2 - A driver's selected speed when assuming that he perceives the penalty function to be stepwise increasing.**

## THE SPEED LIMITS AND THE SPEED LEVEL IN NORWAY

Since 1970, the speed limit issue has been thoroughly discussed in two official reports (Ministry of Transport, 1977 and Directorate of Roads, 1995). The general speed limit policy is decided by Parliament and is administered by the Directorate of Roads.

Apart from the majority of other industrialised countries, the long term trend in Norway has, so far, gone in the direction of higher speed limits. One major reason for this is probably that the quality of the Norwegian roads has improved significantly during the last three decades. The last significant change of the speed limit statutes took place in 1965; the general speed limit in urban areas was increased from 40 km/h to 50 km/h and in rural areas from 70 km/h to 80 km/h. The changes of the speed limit rules in 1965, also opened for the possibility to use speed limits other than the general ones (50km/h and 80km/h). The speed limit statutes on Norwegian main roads and on county roads for 1996 are shown in Table 1 below. Unfortunately, data is not available enabling us to show, quantitatively, the development of the use of different speed limits in Norway. The proportion of roads with general speed limits (50 km/h and 80 km/h) has probably been reduced over time; in urban areas in particular 60 km/h and 30 km/h speed limits have become more common.

Information from the Directorate of Roads reveals that the average level of speed in Norway has not shown a smooth time pattern since 1980 but the long term trend is positive. Today, the speed level is about 5% higher than in 1980. The average speed levels during the winter season and the summer

season are about the same for stretches of road with speed limits below 60 km/h, but 1 - 3 km/h lower during the winter season on roads with higher speed limits.

**Table 1 - The percentage km of the Norwegian roads in 1996 with different speed limits.**

| | 30 km/h | 40 km/h | 50 km/h | 60 km/h | 70 km/h | 80 km/h | 90 km/h |
|---|---|---|---|---|---|---|---|
| Main roads | 0.0 | 0.1 | 6.4 | 13.1 | 2.6 | 72.1 | 5.7 |
| County roads | 0.3 | 0.3 | 10.8 | 11.3 | 0.5 | 76.8 | 0.0 |
| Total | 0.1 | 0.1 | 8.4 | 12.3 | 1.7 | 74.2 | 2.8 |

Source: Directorate of Roads

There are three main reasons why the speed level in Norway has increased since 1980. Firstly, a substantial improvement of the quality of the roads has taken place. Secondly, the cars have become safer and easier to drive at higher speeds. Both these factors point in the direction that drivers' perceived expected accident loss has been reduced and thereby induce higher speeds. Thirdly, drivers' level of income has increased, implying higher time cost per unit of time. This will also - as previous discussion shows, lead to higher speed levels.

## THE ENFORCEMENT OF THE SPEED LIMITS RULES

### The level of speed control

Table 2 below shows some figures indicating the development of the Norwegian authorities' effort to detect speeding during the last five years. It shows no clear trend as far as the level of policing on roads to detect speeding is concerned; it dropped significantly from 1992 to 1993. Since then it is has increased steadily, but was still about 9% lower in 1996 than in 1992. The number of points with automatic speed control has increased significantly and the boxes are now spread throughout the whole Norwegian network of roads. Their total hours of operating time shows, however, no clear time pattern implying that their average utilisation has been reduced to 4.7% in 1996, measured by the percentage of time they are switched on. Neither does the total number of vehicles controlled show any clear trend. Broadly speaking, Table 2, thus indicates that the authorities' effort to detect speeding offences has been fairly stable the last five years.

**Table 2 - The Norwegian authorities' effort to detect speeding offences.**

| | 1992 | 1993 | 1994 | 1995 | 1996 |
|---|---|---|---|---|---|
| Total man-hours of police control. 1000 | 254 | 134 | 152 | 192 | 231 |
| Number of speed boxes installed | 108 | 120 | 122 | 132 | 159 |
| Total hours of automatic control. 1000 | 63 | 60 | 61 | 69 | 65 |
| Total number of vehicles controlled. Mill. | 11.4 | 10.9 | 11.1 | 12.9 | 12.5 |

Sources: Mobile Police Force and Directorate of Roads.

The responsibility for police speed controls is divided between the national "Mobile Police Force" and the local police stations. Today, about half of the total man-hours of police controls aiming to

regulate speed, are carried out by the local police. The speed boxes are managed by the Directorate of Roads in collaboration with the local police stations.

## The penalty rules for speeding

The punishment variables for speeding offences consist of a fine, suspension of driving licence for a certain period of time and additionally, imprisonment in cases of extreme speeding. A review of the Norwegian penalty system for speeding is given in Table 3.

Table 3 - The Norwegian penalty system for speeding offences in the 1990's.

| Speed limit: $s_L \leq 60$ km/h | | Speed limit: $s_L > 60$ km/h | |
|---|---|---|---|
| **Penalty variable(s)** | **Level of speeding (x)** | **Penalty variable(s)** | **Level of speeding (x)** |
| Fixed fine only | $x \leq 25$ | Fixed fine only | $x \leq 35$ |
| (minor speeding offences) | | (minor speeding offences) | |
| Fine and suspension | $25 < x \leq (\approx 45)$ | Fine and suspension | $25 < x \leq (\approx 50)$ |
| of driving licence | | of driving licence | |
| Fine, suspension of driving | $x > (\approx 45)$ | Fine, suspension of driving | $x > (\approx 50)$ |
| licence and imprisonment | | licence and imprisonment | |

Source: Ministry of Justice.

Minor speeding offences are punished by fixed monetary penalties alone which are stepwise increasing according to the level of speeding. The driver having being caught speeding, has to pay a fixed fine within a certain period of time. The nominal values of fines for minor speeding have been constant during the 1990's and up to Nov. 1997. Then they increased by about 25% and are now about 8% higher, in real terms, than in 1990. The threshold levels for minor speeding has been constant during the 1990's. About 93% of detected speeding offences in Norway belong to this category. According to the Norwegian Automobile Federation, the magnitude of the fines for minor speeding offences is far higher in Norway than in other Nordic countries.

The remaining number of offences (serious speedings) require formal prosecutions. Today, these cases are managed by the local police stations. The Ministry of Justice has drawn up rather detailed lines for reasonable relationships between the magnitude of the penalty variables and the level of speeding under so-called "normal driving conditions". The lawyers at the local police stations claim that the penalty level for each particular offence seldom differs greatly from the general guidelines. This indicates that the actual driving conditions when the offence took place, the personal characteristics of the driver and the characteristics of the vehicle, in practice, have limited influence on the levels of the different form of penalties.

The general guidelines indicate a linear relationship between the suspension period of the driving licence and the level of speeding; the period ranging from 3 months to 36 months. These guidelines have been the same for the last five years. Also the guidelines regarding the level of fines for serious speeding have been the same during the 1990's and show approximately a linear relationship between the magnitude of fine and the level of speeding; the actual level of fine for each particular offence normally ranging from 4000 Nkr to 15000 Nkr (10 Nkr ≈ 1 English pound). The length of a possible imprisonment period for speeding is normally two or three weeks.

## The number of clear-ups, crime rate and clear up rate

Table 4 reveals that neither the number of minor speeding offences nor the number of serious offences have shown any clear trend during the last five years. The radar and laser controls indicate that the proportion of speedy drivers has been below 5% and shows no clear trend. Since the drivers are being informed when driving into a zone with automatic speed control the crime rate is, as expected, low on these stretches of road.

The proportion of drivers punished due to radar-and laser controls ($R_1$), is often regarded as a measure of their general law-abidingness as far as respecting the speed limits is concerned. A more thorough analysis of drivers' law-abidingness should, of course, go more into depth as regards the magnitude of the speed violations than we have done. As illustrated in Table 3, the range of speeding within the category defined as minor speeding offences, is rather large. Despite these caveats, the values of $R_1$ in Table 4, nevertheless indicate that Norwegian drivers have not become less law-abiding the last years. Our impression is that this conclusion is in conflict with general public opinion in Norway.

The average detection rate ($q_1$) pr km on the stretches of road outside the automatic speed control zones, is in Table 4 defined as $q_1=C_1/TD$, where $C_1$ is the number of drivers caught from speeding by laser-and radar controls (by the police) and TD is the total yearly number of kms driven by all types of vehicles on Norwegian roads outside the automatic control zones. Table 4 indicates no clear time pattern in the value of $q_1$ during the 1990's. It is, however, worth emphasising that the value of this detection rate varies significantly between different stretches of road; it is probably higher in urban areas than in rural areas and on roads with a high accident rate. The probability of punishment when passing a speed box is estimated on the basis of Table 2 and is, simply, the average proportion of time the speed boxes are switched on.

**Table 4 - Number of clear-ups, crime rate and detection rate for speeding offences in Norway 1992-1996.**

| | Number of clear-ups | | | Crime rate ®, % | | Probability of punishment, % | |
|---|---|---|---|---|---|---|---|
| Year | Minor speeding ($C_1$)* | Serious speeding ($C_2$)** | Total (C) | Radar and laser ($R_1$) | Automatic control ($R_2$) | Radar and laser ($q_1$)*** | Automatic control ($q_2$)**** |
| 1992 | 90973 | 7779 | 98752 | 4.5 | 0.3 | $7.7 \cdot 10^{-3}$ | 6.7 |
| 1993 | 107094 | 7211 | 114305 | 4.7 | 0.3 | $8.0 \cdot 10^{-3}$ | 5.7 |
| 1994 | 101079 | 6907 | 107986 | 5.0 | 0.3 | $6.7 \cdot 10^{-3}$ | 5.7 |
| 1995 | 100868 | 7268 | 108136 | 4.7 | 0.3 | $6.8 \cdot 10^{-3}$ | 6.0 |
| 1996 | 97423 | 6800 | 104223 | 4.0 | 0.3 | $7.0 \cdot 10^{-3}$ | 4.7 |

*Number of detected speeding offences punished by fine only, **Number of detected speeding offences implying suspension of driving licence and/or imprisonment, ***Probability of being punished per km driven, **** Probability of being punished when passing a speed box.

Sources: Ministry of Justice, Mobile Police Force, Directorate of Roads, State Agency for the Recovery of Fines, Damages and Costs and Central Bureau of Statistics of Norway.

In summary, Table 4 does not indicate any clear trend regarding the probability of being caught speeding. Consequently, since the penalty level for speed violations has been reduced during the

1990's, so has the expected penalty for speeding. These findings in combination with the fact that the proportion of speedy drivers has been slightly reduced, point in the direction that drivers' moral costs for driving to fast have increased during the last five years. This is probably also in conflict with general public opinion in Norway.

## SOME COMMENTS ON THE NORWEGIAN REGULATION POLICY

In the following we assume that the purpose of the speed regulation is to minimise the total social costs of road traffic; i.e. to minimise the sum of:

- The drivers' private costs (pecuniary costs + time costs + accident costs born by themselves)
- The external costs; that is the sum of the cost each driver imposes on third parties such as noise, atmospheric pollution and accidents.
- The cost of policing the roads.

Formal models taking the above starting point have been developed by Lee (1985) and Graves *et al* (1989). These studies do not explicitly consider drivers' morals but assume that the authorities possess two means to influence the average speed level; the level of policing and the speed limit statutes. Both studies take the penalty structure as exogenous and assume that increasing policing and lowering the speed limit will reduce average speed. Another implicit essential assumption in these studies is that over the relevant ranges of speed limits, average speed without formal sanctions would be greater than the average speed that is socially optimal; drivers' moral cost of exceeding the speed limits are, thus, not sufficiently high to secure low enough level of average speed. We will not discuss these studies in detail, but use some of their main results when discussing the Norwegian speed limit statutes and the penalty system for speed violations.

### The speed limits

One important conclusion from the studies carried out by Lee (1985) and Graves *et al* (1989) is that the speed limit on a certain stretch of road should be set as low as it is "politically possible". This result holds no matter what the quality of the roads, the characteristics of the vehicles, the drivers' skills and the magnitude of the penalty variables. The plausibility of this result comes from the fact that it costs less, on the margin, to reduce average speed levels by lowering the speed limit rather than raising the level of policing. The general public opinion about speed limits offers guidelines as to what changes are "politically acceptable"; if, for example, a great majority of the Norwegian population is against reducing the general speed limits in rural areas, the politicians will probably not lower them. A survey carried out by the Directorate of Roads in 1993/94, is interesting in that respect. Some of its results are shown in Table 5 below.

Table 5 in combination with the results of the models mentioned above, indicate that there should be no reasons to increase general speed limits in Norway. It seems, however, politically impossible to lower them, in particular on motorways and in rural areas. Another interesting result from the above survey is that 37% of the Norwegians supported lower speed limits in rural areas during the winter season. It is interesting to note that despite the significant improvements of the Norwegian roads in rural areas and of the improved driving characteristics of the vehicles since the present general speed

limit rules were established in 1965, the majority of Norwegians will not change them. This indicates that improvements in these factors should not, necessarily, lead to higher speed limits.

**Table 5 - The Norwegian population's attitudes about the speed limits in 1993/94.**

| | Lowering it by 10 km/h(%) | Keeping it unchanged (%) | Increasing it by 10 km/h (%) |
|---|---|---|---|
| General speed limit in rural areas | 7 | 58 | 35 |
| General speed limit in urban areas | 17 | 79 | 4 |
| General speed limit on motor ways | 4 | 54 | 42 |

Source: Directorate of Roads.

## The penalty system for speeding

In general, monetary sanctions are preferable to non-monetary sanctions because imposition of the former is cheaper than imposition of the latter; having established a system to exact money sanctions, the operating costs are fairly independent of the magnitude of the fines. Imprisonment requires, however, use of resources, since building and operating prisons are expensive. The social costs of suspension of a driver's licence for a certain period of time is approximately, his maximum willingness to pay for not losing his driving licence

Assuming the drivers are risk neutral, it is most effective in theory to set the money sanctions as "high as possible" because it is cheaper to increase the expected penalty by increasing the magnitude of the fine than increasing the probability of being caught through increased policing, see for example Shavell (1993). The natural upper limit of the magnitude of the fine is the wealth of the offender because his wealth is equivalent with the maximum amount that it is realistic to exact. This result can also easily be deduced from the models developed by Lee (1985) and Graves *et al* (1989) by introducing the magnitude of the penalty as an endogenous variable.

Another plausible result from the models above is that the higher the expected harm or the external costs of speeding offences, the more important it is to deter them and consequently, the higher the expected penalty costs or the deterrence should be. The external costs of a speeding offence are, in particular dependent on: (1) the level of speeding; (2) the weight of the vehicle involved; (3) the car driver's skills; and, finally, (4) the driving conditions on the stretch of road on which the offence takes place.

Since the probability of being caught speeding is the same at all speeds and for all types of vehicle and driver, a different expected total magnitude of penalty for different categories of drivers and vehicles, must be captured through the penalty function alone. The penalty level for speeding is, however, approximately the same on all roads; at least for minor speeding offences. The magnitude of the expected penalty for speeding on different stretches of road must, therefore, be allowed for due to different levels of policing. Let us, briefly discuss the Norwegian penalty system for speeding in the light of the above conclusions:

*The relationship between the magnitude of the penalty variables and speed*

Even though the level of fine increased significantly in Nov. 1997, the state agency that recovers the fines claims that it so far, has few problems to exact them. This suggests that their levels could have been even higher. Another thing to note is, however, that the magnitude of the fines for speeding must be reasonable compared to the magnitude of the fines for other types of offences.

Under reasonable assumptions concerning drivers' reaction time and from physical rules it can be deduced that an increase in a driver's speed by 1% will increase the expected accident costs which he imposes on other drivers by about 4% (Jørgensen, 1991), given that his speed is above the average speed level. When assuming that the sum of other form external costs such as noise and atmospheric pollution are fairly independent of the level of speed, the above facts thus, indicate that the magnitude of the total penalty should increase convexly and substantially with the level of speeding . This justifies the use of non-monetary penalty variables for serious speeding; using monetary sanctions alone demands that their magnitude would be so high that quite a few of the offenders would probably be unable to pay. The stepwise increasing penalty function for minor speeding implies that the marginal deterrence for speeding is zero within certain intervals of speeds. This is obviously in conflict with theory, but the increased social costs of this penalty structure must be balanced with the additional administrative costs of implementing a more continuous penalty function.

A survey carried out by the Institute of Marketing Research in 1997 and based on a sample of about 2000 Norwegian car owners shows large variations of their reported maximum willingness to pay (WP) for not losing their driving licence. Their average value of WP for not losing it for 6 months, 12 months and 24 months was 4700 Nkr, 8500 Nkr and 13400 Nkr, respectively. Hence, WP seems to increase concavely with the length of the suspension period. From our previous discussion of the penalty rules it thus, follows that the marginal deterrence of serious speeding is positive but probably decreasing with the level of speeding. This weakness of the penalty structure can be corrected without extra enforcement cost; it merely infers that the authorities change the general guidelines about the relationships between the level of speeding and the length of the suspension period of the driving licence from being linearly to being convexly increasing.

*The weight of the vehicle*

A driver's reaction time and the necessary stopping distance of a vehicle are both independent of the weight of the vehicle. This suggests that the probability of being involved in an accident is independent of the vehicle's weight. The negative consequences for third parties of an eventual accident increase, however with its weight. The latter may be explained by the fact that a vehicle's kinetic energy increases proportionally with its weight. Other forms of external costs (noise, atmospheric pollution etc.) also increase with the weight of the vehicle.

Broadly speaking, the Norwegian penalty system disregards these matters. The penalty for minor speeding offences - which accounts for about 93% of the total number of speedings (see Table 4), is the same irrespective of the weight of the vehicle. For serious speedings the penalty will probably be moderately higher if one drives a lorry rather than a small car, in particular if the offence takes place in an urban area. Whether the weight of the vehicle should influence the level of the penalty

variables more systematically than today, depends, of course, on the costs of implementing a more complicated penalty system compared to the improved efficiency of road traffic.

*The car drivers' skills*

All other things equal, the external safety costs of speeding are lower the better the car drivers' skills are. This implies that the deterrent effect of the penalty system should be higher for bad drivers than for good drivers. The monetary cost of minor speeding offences is the same for all drivers. Consequently, if they are risk neutral these penalties will deter equally. If the drivers, however, are risk averters, the deterrent effect of the sanctions will be higher the poorer the drivers are, see for example Eide (1994). Assuming that young drivers, on average, have lower disposable income, but not significantly lower degree of risk aversion than the older drivers, the present penalty system will deter younger and thereby less skilled drivers strongest.

This seems, however, not to be the case for the penalty levels for serious speedings. Regressions based on the previously mentioned survey from the Institute of Marketing Research in 1997, indicate that a driver's willingness to pay (WP) for not losing his driving licence for 6, 12 and 24 months is, among other things, significantly dependent on (except for the last point below, the influences on WP are broadly the same for all these three suspension periods):

- The yearly distance which he drives himself; an increase in the yearly driving distance by 1% will increase WP by about 0.1%.
- How long he has held his driving licence; drivers who have held their driving licence for more that 10 years, have about 25% higher WP than the others.
- Gender; female drivers have about 28% lower WP than male drivers.
- Where the driver lives; drivers living in rural areas have about 25% and 9% higher WP than those living in Oslo and in other Norwegian towns, respectively.
- His income; drivers with a yearly income between 200000-399000 Nkr have, for example, about 30% higher WP than those with lower income.
- His dependence of the driving licence at work; when the suspension period in question was 6 months, drivers who answered that they were to some extent and to a large extent dependent in that respect, had about 14% and 25% higher WP, respectively, than those who answered that their dependence on the licence at work was minimal. These percentages seem to increase with the length of the suspension period.

The first two of the above driver characteristics indicate his driving experience; the longer he drives per year and the longer he has held his driving licence, the more experienced driver he is. According to current Norwegian practice, the factors mentioned above seem to have minimal influence on the magnitude of the penalty variables. Consequently, the deterrent effect of the penalty system is - all other things equal, higher for experienced drivers than for inexperienced ones, higher for male than for female drivers etc.

Several investigations have concluded that driving experience positively influences a car driver's skills (Jørgensen, 1993). The present Norwegian penalty practice thus implies that the best drivers; that is those who impose the lowest external costs at certain speeds, are most deterred. This is obviously in conflict with the general economic principles of optimal law enforcement. Further, as

far as we know, no serious analyses have concluded that gender influences individuals' driving skills. Neither will probably the other factors mentioned above. These facts suggest that these different categories of drivers should be equally deterred by the penalty system. This implies - taking estimations of WP into account, that the length of the suspension period should differ between these groups.

The above points to the weaknesses of using suspension of the driving licence as a penalty variable for speeding. If this form of sanction should deter effectively from a social costs' point of view, the lawyers must, in practise, have some reliable and easily attainable information about each offender that signals correctly his welfare loss of losing his driving licence. The studies of WP which we have done above are important in that respect; it is for example acceptable both from a political and a juridical point of view to let the length of the suspension period be dependent on how important the driving licence is for the offender at work. The above analysis reveals, however, too the conflict between effective penalty structure from an economic perspective and what structure that is politically and juridical acceptable. It is probably impossible from the latter perspective to have general guidelines recommending that the length of the suspension period of the driving licence should be lower for male drivers than for female drivers, lowest for those drivers living in rural areas and lower the higher the driver's income is.

## CLOSING REMARKS

Based on the conclusions drawn in our analysis, it is tempting to summarise the following political implications:

- There should be no reason to increase the general speed limits in Norway. On the other hand, the present strategy from the road authorities to gradually reduce them during the winter season on stretches of road with high accident rates is sensible. Present practise resulting in a greater proportion of the roads in urban areas getting lower speed limit than 50 km/h also makes sense.
- One should use monetary sanctions alone for a rather wide range of speedings and these sanctions should be changed more frequently than in the 1990's to secure that their levels are as "high as possible". It is sensible to keep quite a few steps of the penalty functions and to keep the break points for the magnitude for speeding unchanged. The latter is because a greater proportion of drivers will know the break points. This in turn leads to lower speed variance. Besides that, when keeping the break point unchanged, drivers will notice more quickly when the fines increase.
- The length of the suspension period of the driving licence should increase convexly with the level of speeding and it should, principally, decrease more systematically than today with drivers' dependence on the driving licence.
- In order to provide maximum deterrent on those vehicles that cause most harm, one should consider whether the magnitude of the penalty variables should increase with the weight of the vehicle.

Another interesting result from the analysis is that even though the expected penalty of being caught speeding has been reduced on Norwegian roads outside the automatic speed control zones during the

last five years, the proportion of speedy drivers has not increased. This fact contradicts with the views of more reckless driving and that Norwegian drivers have become more amoral.

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