TØI report 573/2002
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Summary:

Speed cameras
Effects on speed

Background and method

Insufficient information about the effect of speed cameras on speed

Speed cameras have been used to record speeding in Norway since 1988. In 2002, some 250 cameras are in use around the country.

Research has shown clear effects of speed cameras on accidents. In the Traffic Safety Handbook, the studies are summarised, and it has been concluded that there has been a total reduction in injury accidents of 17 %. However, information about the effects of speed cameras on driving speeds is insufficient.

On this basis, TØI was in 1999 commissioned by the Ministry of Transport and Communications and the Police Directorate to carry out a study to evaluate the effect of speed cameras on driving speeds.

The project consisted of two parts:

1. Before and after analyses on road sections with speed cameras based on automatic measurements
2. Measuring speed at the speed camera site using a laser pistol

Before and after analyses (with comparison sites) on road sections with speed cameras, based on automatic measurements

The main objective of this part of the project has been to study the effect of speed cameras on driving speeds at, between and after speed camera sites. The effect is measured by changes in the driving speed (measured as the hourly average) and the within-hour standard deviation of speeds . This is done by comparing results from the Road Department's automatic recording sites over a period of approximately 1 year before speed cameras are installed, with a corresponding data set from a period of approximately 1 year after speed cameras are installed. The recording sites in the before and after periods are identical - apart from the cameras. Driving speeds are also measured in the before and after period at sites placed between speed camera sites and after the final speed camera on road sections where several speed cameras are installed.

Automatic recording of driving speeds produces an average speed which is stored for all vehicles which have passed by within a period of one hour. The number of vehicles which have passed by are counted and stored, while at the same time the dispersion of driving speeds is calculated (as the standard deviation).

In order to deal with possible changes in driving speed from the before to the after situation which may be due to elements other than speed cameras, comparison sites are used. These are sites which are located on the same type of road and in the same area as the speed camera sites, but where no particular changes have occurred from the before situation to the after situation.

In order to control specifically for the effects of any changes in the number of stationary police controls, these have been recorded in both the before and the after period.

In consultation with the Norwegian Public Roads Administration, which was responsible for collecting the data, three road sections were selected where speed cameras had been installed at the end of 1999/2000. The before measurements were taken in 1999, and the after measurements in 2000. In order to study the effects of speed cameras over a longer period, data was also collected for some of 2001 at two sites.

The following road sections were selected:

1. E6 Østfold.

8400m road section between Ingedal (near Skjeberg) and Molteberg. Two lane road with a speed limit of 90 km/h and an annual average daily traffic of around 10,000 vehicles per day. 10 speed

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camera sites distributed with 5 in each direction of travel. (At two sites, the data is insufficient and cannot be used.)

2. E18 Østfold
10 800 m road section on a two-lane road between Rom in the east and Fosshellinga (both places lie west of Askim). A total of 10 speed camerasites, of which six were on a road section with an 80 km/h speed limit. (At one of the sites with an 80 km/h speed limit, the data is inadequate and cannot be used.) The speed limit was 70 km/h along the rest of theroad section . The annual average daily traffic is around 10,000 vehicles per day. Speed was also measured in both directions of travel at one site between the speed camera sites.

3. E6 Hedmark
26 000 m road section along Mjøsa from Espa in the south to Basterud (just north of the turn- off to Rv3). 4 speed camerasites, in 3 of which the speed of traffic from Oslo was measured. (At one of sites measuring traffic from Oslo, the data is insufficient and cannot be used). The annual average daily traffic is around 10,000 vehicles per day, on a two-lane road with a speed limit of 90 km/h. Speed has also been measured between the speed cameras, as well as at 4 sites between 7 and 19 km further on (in the direction of traffic) after the speed cameras have been passed.

Records of police activity shows that there were no significant changes in the amount of stationary surveillance on any of the three road sections. Adjusted for changes in the comparison sites , this means that the results of the before and after measurements can be regarded as net effects of speed cameras.

Measuring speed at speed camera sites using a laser pistol

In this part of the project, speed measurements were carried out using a laser pistol. The purpose is to demonstrate possible speed adjustments of individual vehicles in the immediate vicinity (+/- 200 m) of a speed camera installation, the so-called kangaroo effect. The laser pistol is particularly suited for this because the result from the measurements is the vehicle's speed and position (given as distance). The studies have been carried out in three different situations on the speed camera road section of the E6 in Østfold where there are 5 speed cameras in each direction:

1. Before and after the first speed camera post
2. Before and after the final speed camera post
3. Before and after a speed camera post between two subsequent posts

Results

4-6 km/h reduction in speed at speed camera sites on each of the road sections

Table S1 shows the weighted results of the effect of speed cameras on threeroad section , by direction of traffic and speed limit. (Corresponding results at each individual measurement site and traffic direction are shown in table V5 in appendix 1).

Table S1 shows that the net effect of speed cameras at speed camera sites varies between the road sections from -6,16 km/h on the E6 in Hedmark to -4,18 km/h on the E6 in Østfold. The change is clear and negative (speed reduction) at all speed camera sites covered by the table. On 80 km/h road sections, the effect is estimated to -5,72 km/h and at 70 km/h stretches to -5.04 km/h.

On each road section there is a some variation in the effects in the different directions of traffic.

The relationship between speed in the before situation and the net effect of speed cameras

Corresponding calculations of the net effect of speed cameras at each of the 20 individual speed camera sites where there are speed measurements, showed reductions in speed at all sites, varying from -1.38 km/h to -7.10 km/h.

	Speed limit	Traffic direction	Number of sites	Number of vehicles BEFORE	Average speed BEFORE	Number of vehicles AFTER	Average speed AFTER	Before - after **Difference**	Difference comparison sites	Calculated net effect of cameras
	km/h	from			km/h		km/h	km/h	km/h	km/h
E6	90	Oslo	4	1 586 944	85,72	3 070 893	80,61	-5,11	-1,28	-3,83
Østfold		Sverige	4	1 544 490	89,37	3 411 744	83,32	-6,05	-1,31	-4,74
	Sum		8	3 131 434	**87,52**	6 482 637	**82,04**	**-5,48**	-1,30	**-4,18**
E18	80	Oslo	2	327 624	74,24	169 530	68,88	-5,36	0,26	-5,62
Østfold		Sverige	3	517 687	75,58	314 234	69,87	-5,71	0,11	-5,82
	Sum 80		5	845 311	**75,06**	483 764	**69,52**	**-5,54**	0,19	**-5,72**
	70	Oslo	2	386 804	65,11	291 593	60,65	-4,46	0,26	-4,72
		Sverige	2	384 790	66,97	292 922	61,72	-5,25	0,11	-5,36
	Sum 70		4	771 594	**66,04**	584 515	**61,19**	**-4,85**	0,19	**-5,04**
E6	90	Oslo	2	1 524 431	89,06	1 447 722	84,28	-4,78	1,10	-5,88
Hedmark		Hamar	1	525 196	90,18	479 849	85,66	-4,52	1,76	-6,28
	Sum		3	2 049 627	**89,35**	1 927 571	**84,62**	**-4,73**	1,43	**-6,16**

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Table S1: Measured and calculated changes before and after speed cameras according to speed limit and direction of traffic at the three sites.

For each speed limit there is a relationship between the calculated net effect of speed cameras at a speed camera site and the average speed at this site before the speed camera was introduced. If the speed in the before situation is high, the effect is greater than where the speed in the before situation is lower. The association is demonstrated by regression analysis, shown in figure S1.

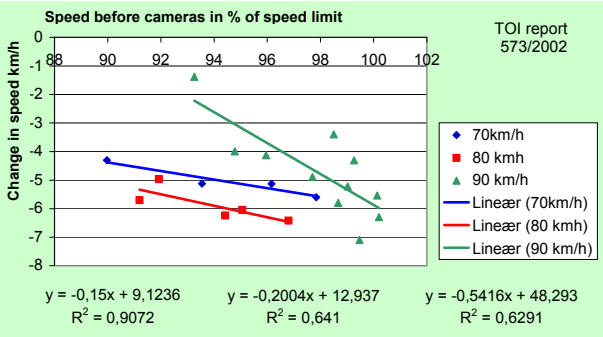

Figure S1: Effect of speed cameras in km/h v. average speed in the before situation in % of the speed limit, for roads with speed limits of 70, 80 and 90 km/h.

On the vertical axis the change in speed is shown in km/h from before to after speed cameras (net effect). The horizontal axis shows the speed in the before situation given in % of the speed limit on the road section.

The diamonds represent each of the 4 speed cameras where the speed limit is 70 km/h. The associated black line is the result of a linear regression analysis with the correlation coefficient R^2=0,91 based on the 4 sites. The line is the result of the equation Y(70)=-0,15X + 9,1 where Y= the calculated effect of speed cameras in km/h and X= the before speed in % of the speed limit.

Similarly, roads with speed limits of 80 km/h are shown with squares and roads with a 90 km/h speed limit with triangles.

The figure shows that the slope of the three curves varies. This is ”controlled” by the coefficient in front of the X in the equation. For roads with a 70 km/h speed limit this entails that, when the speed is reduced by 1%, the effect of the speed camera changes by -0.15 km/h. Similarly, for roads with speed limits of 80 km/h and 90 km/h, the change will be -0.20 km/h and -0.54 km/h respectively.

Speed cameras reduce speed at measurement sites between and after speed camera posts

A speed profile is is defined as a figure where speed is shown as a continuous function over a given road section. In order to portray a speed profile, continuous speed measurements are necessary. Our automatic average measurements are therefore strictly speaking not adequate to portray this, since we do not know the speed between the measurement sites. Nonetheless, in order to illustrate the longitudinal speed variation in the two directions of traffic we have done this, with some reservations.

Figure S2 shows the results from all measurement sites on the E18 Østfold. The upper part of the figure concerns the traffic direction from Sweden and the lower from Oslo. The horizontal axis shows the names of the measurement sites (the axis is not to scale). The vertical axis shows the

average speed in km/hh. The black curve shows the average speed after the speed cameras, while the grey curve shows the average speed before speed cameras, adjusted for changes in the comparison sites. The distance between the curves in each site represents the calculated net effect of speed cameras.

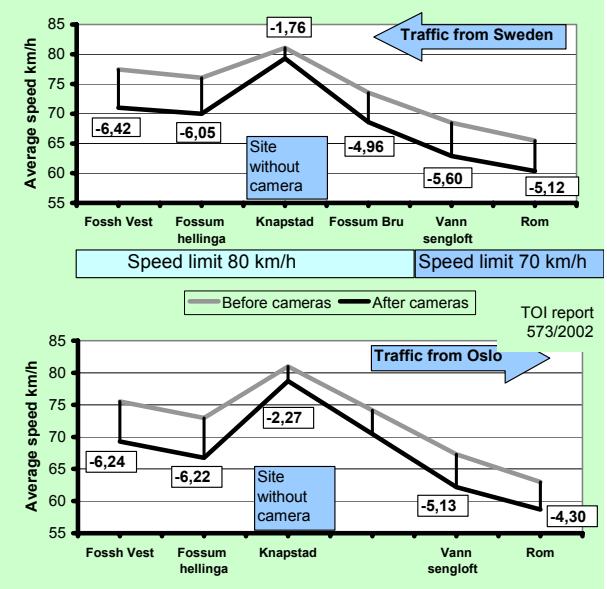

Figure S2: Longitudinal speed profile E18 Østfold. (Speed limit shown in figure) Average speed before and after speed cameras in km/h. (Adjusted for changes in comparison sites) Changes in average speed in km/h.

All sites in the figure have speed cameras, apart from Knapstad. The changes in speed where speed cameras are installed are estimated to be between -4.30 km/h and -6.42 km/h. In Knapstad, between consecutive speed cameras, the change in speed is estimated to be 1.76 km/h in the direction from Sweden and -2.27 km/h in the direction from Oslo. The distances from the speed cameras and the measurement site at Knapstad are 4750 m and 3250 m measured in the direction of traffic.

Figure S3 shows the results from the E6 Hedmark in a similar way.

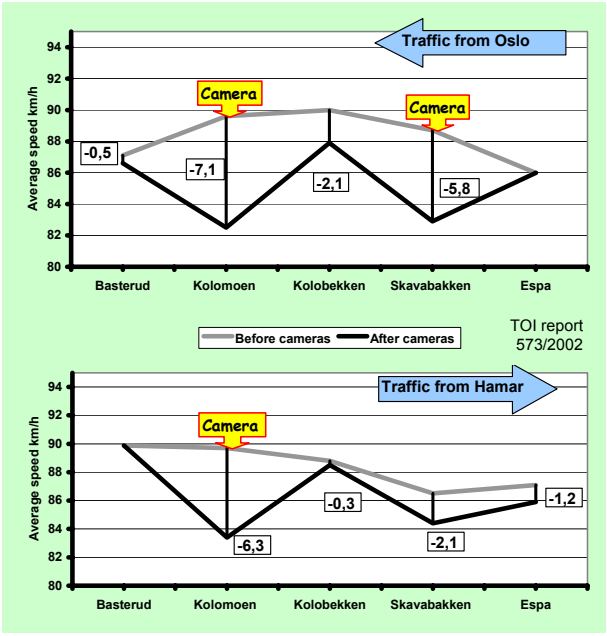

Figure S3: Longitudinal speed profile E6 Hedmark. Speed limit 90km/h. Relative average speed before and after speed cameras in km/h. (Adjusted for changes in comparison sites). Change in average speed in km/h.

In the direction of traffic from Oslo, shown in the upper part of the figure, the changes in speed from the before to after speed cameras are respectively -5.8 km/h and -7.1 km/h at the speed camera sites. At the measurement site (Kolobekken) located between the speed cameras, a change in speed of -2.1 km/h. has been estimated. The site is located 3100 m beyond the speed camera (Skavabakken).

In this direction of traffic, it also appears that changes in speed of -0.5 km/h can be detected at one measurement site (Basterud) located beyond the end of the speed camera section. (Road users have passed three speed camera sites, but since we do not have the data, only two are shown on the figure). The distance from the final speed camera to the measurement site is 8642 m.

In the direction of traffic from Hamar, there is only one speed camera. Here the effect is estimated to -6.3 km/h. At measurement sites at distances of 3,933 m, 7,043 m, and 17,956 m from the speed cameras (in the direction of traffic) the changes in speed areestimated to -0.3 km/h, -2.1 km/h and -1.2 km/h. When the change is estimated to be greater at Skavabakken than at Kolobekken, in spite of the fact that the distance from the speed camera is greater, this may be have to do with the fact that the measurement site at Skavabakken works like a speed camera in the *opposite direction of traffic* , and that the "backside" of the camera box may have

some effect. This may also be significant for the effect at the measurement site at Espa.

Speed cameras can contribute to greater longitudinal speed variation, but speed is reduced

As shown in figures S2 and S3, the calculated changes in speed longitudinally are greater at the speed camera sites than at the measurement sites between and after speed camera sites. It can therefore be claimed that speed cameras contribute to increased longitudinal variation in speed on the road sections studied. In the figures, this is most clearly expressed on the E6, Hedmark (Figure S3).

Even though speed cameras contribute to increased variation in driving speeds on the E6 Hedmark and E18 Østfold, it can **not** be concluded that road users compensate for the reduction in speed at speed camera sites by increasing driving speed between or after the speed cameras. Speed cameras have led to reductions in speed at all sites where measurements have been taken.

Speed cameras have a lasting effect

At the speed camera site at Skavabakken E6, Hedmark, a clear effect of speed cameras has been demonstrated both 0.5 years and 1.5 years after speed cameras were installed. The effect (net effect, adjusted for changes in comparison sites) is estimated for the actual periods to-8.30 km/h (after 0.5 years) and -8.10 km/h (after 1.5 years) respectively. This indicates that the effect is relatively stable over time.

Between speed camera sites, the effect is also relatively stable, but not as stable as at the speed camera sites. This may indicate that the tendency to increased longitudinal variation in speed along a road section as a result of speed cameras, increases with time.

Road users adjust their speed in the direct vicinity of a speed camera

Using a laser pistol connected to a laptop PC, measurements have been taken of the speed and position of vehicles in the direct vicinity of speed cameras. In order to accumulate the measurements of vehicles, special software has been developed as part of this project, which calculates average driving speeds within 10 metre intervals on the actual road section. Figure 4 shows the results of this type of calculation made for the first speed camera of a series of 5. (The figure is based on 4000 "laser shots" at 302 vehicles.)

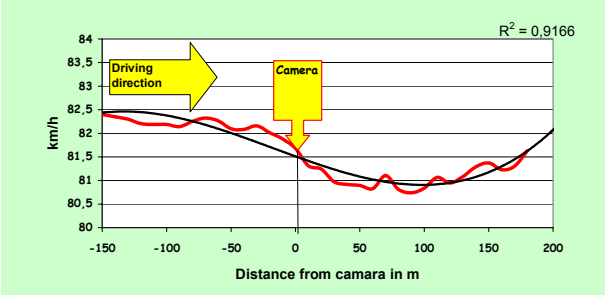

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Figure S4. Speed profile on at speed camera installations, Ingedal, E6 Østfold, traffic direction from Sweden. Driving speed in km/h v distance between speed camera posts and vehicles in m. First speed camera of a series of five.

The horizontal axis shows the distance in m from the vehicle to the speed camera (negative distance is in front of the speed camera), and the vertical axis shows driving speed in km/h in the actual position. The grey line shows the actual measurement results, while the black line shows a mathematical "smoothing" of the measured speed profile.

The measurements in the three different situations described above show that road-users on average reduced their speed from a position about 100 - 150 metres before a speed camera installation and up to the speed camera installation itself by 1 – 2 km/h, before then increasing their speed again.

The speed towards the first post in a series of several speed cameras (figure S4) is lowest at a point around 50 metres after passing the speed camera. Similarly, for the final post and the central post in a series, the speed is lowest at a point around 0 - 20 metres before the camera itself.

Beyond the last camera in a series, speed is higher at a point 120 metres beyond the camera than it was 20 metres before the installation. Unfortunately it has not been possible to take measurements which show where speed stabilises again after passing the speed camera.