Institute of Transport Economics
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Summary:

Evaluation of the crash effects of section control

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A before-after empirical Bayes evaluation of section control at 14 sites in Norway found a reduction of the number of injury crashes by between 12 and 22% and a statistically significant reduction of the number of killed or severely injured road users (KSI) by between 49 and 54%. The results refer to the section of road between the two cameras. Downstream of the section control sites (3 km in each direction) injury crashes were found to be significantly reduced by 46%. The number of KSI downstream of the section control sites is too small for drawing any conclusions. The study has controlled for trend, volumes, speed limit changes at some of the sites and speed cameras at some of the sites in the before period. Regression to the mean is controlled for by using the empirical Bayes method which takes into account that exceptionally high crash numbers in the before period usually are associated with a reduction of the number of crashes in the after period, even without any effective safety measure. Eight of the section control sites are in tunnels. The results indicate that the crash reductions in tunnels are at least of the same magnitude as on open roads. Most tunnel sites have section control in only one direction. These are for the most part steep downhill sections in subsea tunnels. At such sites the number of injury crashes may be reduced by up to 25% and the number of KSI may be reduced by up to 59%.

The effects of section control on injury crashes and on the number of KSI was investigated in a before-after empirical Bayes (EB) evaluation. Each section control site consists of a stretch or road between two speed cameras (four speed cameras at sites with bidirectional section control), both of which take pictures of all passing vehicles in one direction with automatic license plate recognition. Average speed is calculated from the times at which the first and second camera is passed. Drivers of vehicles with an average speed above the speed limit may be prosecuted.

The study has controlled for trend, volumes, speed limit changes at some of the sites, speed cameras at some of the sites in the before period, and regression to the mean (RTM). Additionally, the effects of section control were estimated without control for RTM. Figure S.1 shows the results from the EB-evaluation and additionally maximum estimates of the crash effects that are based on findings indicating that some of the crash reductions that were found in the EB-evaluation may be underestimated. Effects of RTM may be underestimated in tunnels, the results for injury crashes may be more representative when one of the open road sites (Finstad) is omitted and one of the tunnel sites had an exceptionally high number of KSI in the before period (Eiksund S) which was adjusted to one in a sensitivity test.

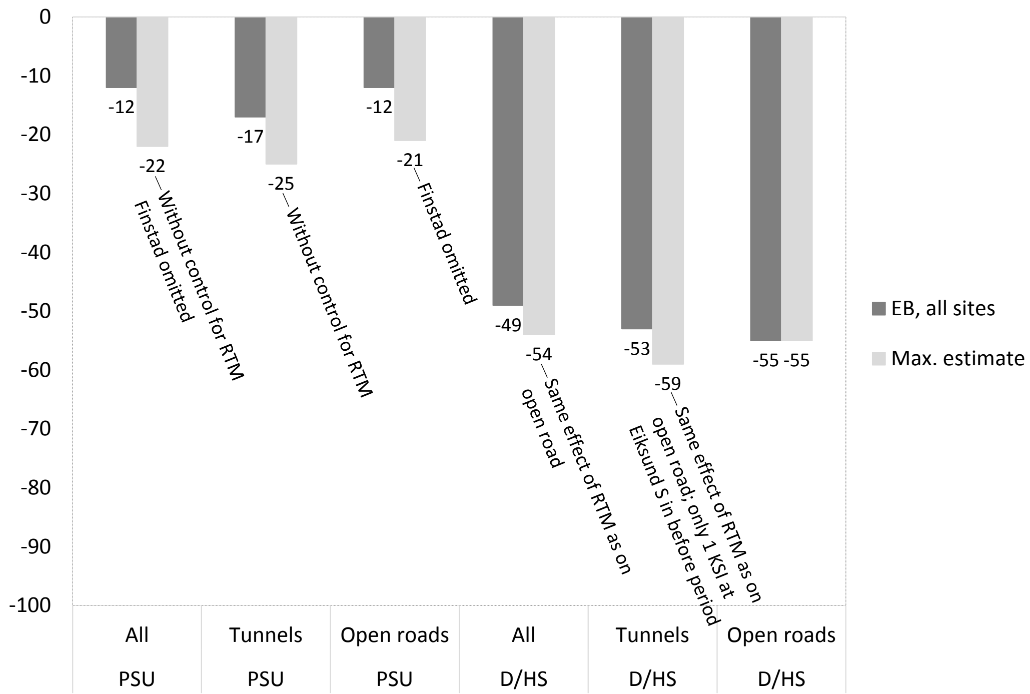

Figure S.1: Effects of section control on injury crashes and KSI, results from the EB evaluation, based on all sites, and maximum estimates, based on assumptions that some of the EB effects may be underestimated.

Description of sites and study design

The evaluation is based on 14 section control sites in Norway, eight of which are in tunnels. Seven of the tunnel sites are in subsea tunnels. Only sites where section control was installed in 2012 or earlier are included in the evaluation. Most sites have an 80 km/t speed limit, two lanes and volumes between an AADT of 1800 and 14000 (mean AADT = 6400) in the before period. At eight of the sites there were speed cameras in the before period. The evaluation takes into account the assumed crash effects of the speed cameras. The results refer therefore to the effects of section control at sites without camera enforcement in the before period. The length of the before period is three years at all sites. The length of the after period varies, depending on the date of installation. All after periods start in the third month after installation and end at the latest in the end of 2013. The average length of the after periods is 1.8 years.

In order to control for effects of RTM and other potential confounding factors the main part of the evaluation has been conducted with the empirical Bayes (EB) method. This method compares the observed crash numbers in the after period with the expected crash numbers. Expected crash numbers in the after period are those that are most likely when taking into account the observed crash numbers in the before period, RTM and general changes from the before- to the after period. RTM occurs in before-after studies when the observed number of crashes in the before period has been exceptionally high (or low). Crash numbers in the after period are then most likely to be closer to the long term average crash number, i.e. smaller than in the before period, even without any effective safety measures. Other factors that are controlled for are period length, trend effects, volume changes (including the general relationship between volumes and crashes), speed limit changes at some of the sites, and speed cameras at some of the sites in the before period. In order to estimate the size of the effects of RTM the results of the EB evaluation are compared to the results from a before-after study that has controlled for the same factors as the EB-evaluation, except RTM.

Section control reduces injury crashes and, even more, KSI

Injury crashes were found to be reduced by 12% in the EB-evaluation. They may be reduced by up to 22% when taking into account that effects of RTM in tunnels may be overestimated and that one of the open road sites (Finstad) had exceptionally few injury crashes (or, rather, an overestimated predicted number of injury crashes) in the before period, and that the results therefore may be more representative when this site is omitted. The results are not statistically significant at the 5 percent level. In order to become statistically significant, data from at least five times as many sites would have had to be available.

KSI were found to be reduced by 49% in the EB evaluation. The result is statistically significant. KSI may be reduced by up to 54% when taking into account that one of the tunnel sites (Eiksund S) had an exceptionally high number of KSI in the before period (five fatalities in one crash) and that the effects of RTM at the remaining tunnel sites may be overestimated.

The effects of RTM in tunnels may be overestimated, and the estimated crash reductions in tunnels therefore underestimated in the EB-evaluation, because the predicted crash numbers in the before period (which are the base of comparison for estimating effects of RTM) most likely are underestimated. Most tunnel sites are on steep downhill grades and the crash prediction models that have been used to calculate the predicted crash numbers in the before period do not include the degree of vertical grade as a predictor variable. Steep downhill grades were in other studies found to be strongly associated with a high risk for crashes, especially serious crashes.

As shown in the discussion of the effects of RTM in tunnels and the effects of two sites with especially high / low crash numbers in the before period, there are several factors that indicate that the crash reductions that were found in the EB-evaluation may be underestimated, but no specific factors could be identified that indicate that the crash effects are likely to be overestimated. A sensitivity analysis that has investigated the effects of several choices that were made when calculating predicted crash numbers in the before period did not indicate that the results are affected by such choices to a large degree.

The estimated effects of section control on injury crashes and, even more, those on KSI, are larger than one would have expected based on the effects of section control on speed that were found at several of the sites included in this evaluation. This indicates that it is unlikely that the positive effects of section control on speed are counteracted by unfavourable side effects, such as drivers getting distracted by the task of monitoring their speed.

The effects of section control in tunnels are of about the same magnitude or larger in tunnels compared to open roads

The results indicate that section control has greater effects on injury crashes in tunnels than on open roads. Injury crashes were found to be reduced by 17% in tunnels and by 12% on open roads. In tunnels, injury crashes may be reduced by up to 25% when taking into account that effects of RTM in tunnels may be overestimated. However, on open roads injury crashes may be reduced by up to 21% when Finstad is omitted, which is the site with exceptionally few injury crashes (or an overestimated predicted number of injury crashes) in the before period.

For KSI the effects that were found in tunnels are similar to those found on open roads. The maximum estimate in tunnels (-59%) in figure S.1 is based on the assumption that the effect of RTM is the same in tunnels as on open roads. The maximum estimate is calculated as the effect without control for RTM on all sites (with the number of KSI at Eiksund S set equal to one instead of five), minus the effect of RTM on open roads, which is 11 percentage points.

Although most results indicate some difference between the effects of section control in tunnels and on open roads, the results are not quite consistent and all effects are within each other's confidence intervals and the differences may therefore be due to chance. The speed reductions that were found by Ragnøy (2011, 2013) are also of about the same magnitude in tunnels and on open roads. It is therefore not possible to conclude that section control has greater effects in tunnels than on open roads.

Most sites have section control in only one direction, while most sites on open roads have section control in both directions. One might expect that bidirectional section control has greater effects than unidirectional section control. However, most tunnel sites are on steep downhill grades and it is unlikely that section control may have a considerable effect on steep uphill sections. It is therefore not possible to conclude that section control might have greater effects in tunnels when installed in both directions.

Section control reduces injury crashes downstream of the section control sites

The effects of section control on stretches of road 3 km downstream of the section control sites were evaluated with the same methods as at the section control sites. Injury crashes were found to be significantly reduced by 46%. The number of KSI on the downstream sites is too small for drawing any conclusions. The results indicate that section control has a crash reducing effect even downstream of the enforcement sites and that it is unlikely that (many) drivers compensate for the speed reductions on the section control sites by speeding up more than they otherwise would have done afterwards.