

The role of point-to-point speed enforcement systems to prevent highway accidents: evidence from Italy

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1 Introduction

- Safety Tutor system
- Literature review
- Dataset & Descriptive trends

2 Model & Estimation results

- OLS estimation results
- IV estimation results

3 Final remarks

- Conclusions
- Drawbacks & To-Dos

Safety Tutor system

- Developed by Autostrade per l'Italia and the Traffic Police in 2004
- 320 point-to-point sites monitor 2900 km of highways (considering both carriageways)
- It allows to determine the average speed of vehicles passing through two camera sites

Figure 1: A Safety Tutor site



- Previous studies (within the Italian context) show encouraging positive findings on Safety Tutor effectiveness:
 - -27% injury rate, -50% mortality rate on Autostrade per l'Italia network after 12 months of operation (**ASPI, 2007; Falsi, 2009**)
 - -39% injury accidents on A56 Tangenzial di Napoli between 8 months pre and 8 months post installation in 2009 (**Cascetta and Punzo, 2009**)
 - -31% total accidents on an 80-km segment of A1 Milan-Naples motorway considering an analysis period from 2001 to 2009 (**Montella et al., 2012**)
 - -32% total accidents on A56 Tangenzial di Napoli analysing four weeks data between 2009 and 2011 (**Montella et al., 2015**)

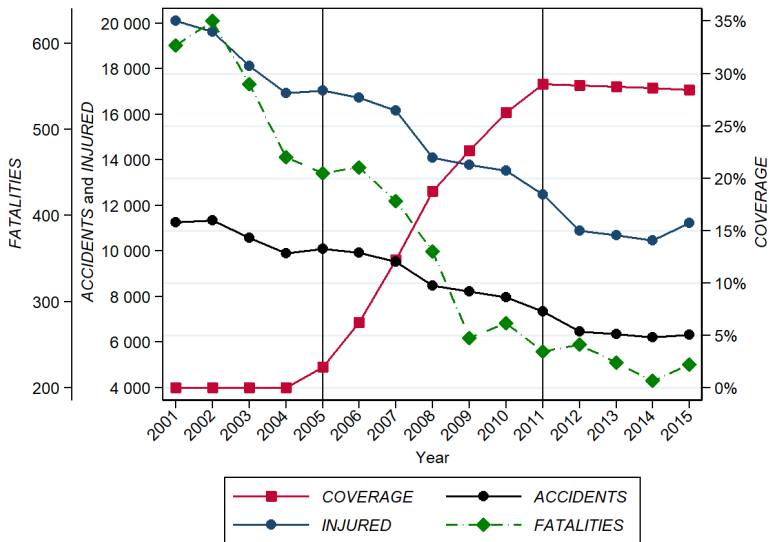
- To evaluate the effectiveness of Safety Tutor on reducing highway vehicle accidents on a substantial scale, we built a unique 15-year panel dataset (2001-2015) at motorway sectors level (56)

Table 1: Data and Sources

Variable	Variable definition	Source
<i>ACCIDENTS</i>	Number of total highway vehicle accidents that caused injuries or death to people	AISCAT
<i>INJURED</i>	Number of injured people caused by vehicle accidents	AISCAT
<i>FATALITIES</i>	Number of deaths caused by vehicle accidents	AISCAT
<i>DAILY_TRAFFIC</i>	Average daily number of vehicles	AISCAT
<i>HIGHWAY_LENGTH</i>	Number of kilometers of highways	AISCAT
<i>TUTOR_LENGTH</i>	Number of kilometers of highways covered by Safety Tutor sites	ASPI
<i>VEHICLES_AGE</i>	Average age of circulating vehicle fleet (in years)	ISPRA
<i>ALCOHOL_PC</i>	Per capita ethanol consumption (in liters)	GHO

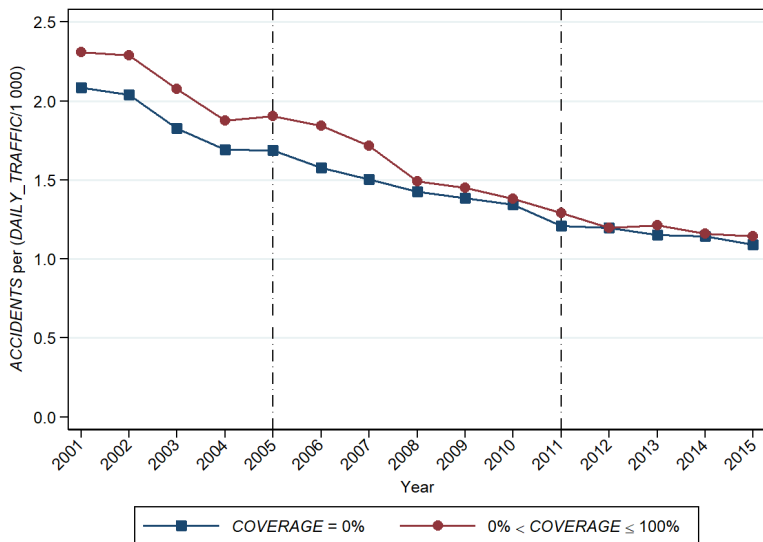
Descriptive trends

Figure 2: ACCIDENTS, INJURED, FATALITIES trends vs COVERAGE



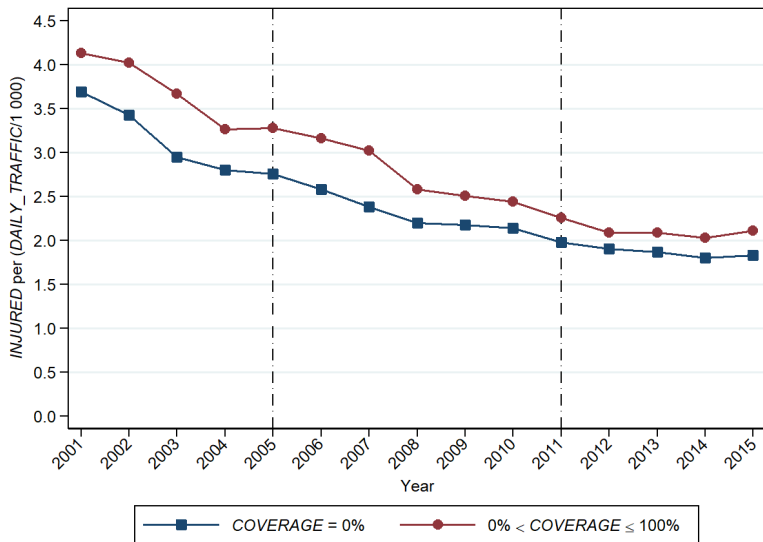
Descriptive trends

Figure 3: Patterns in ACCIDENTS rates by treated and non-treated groups



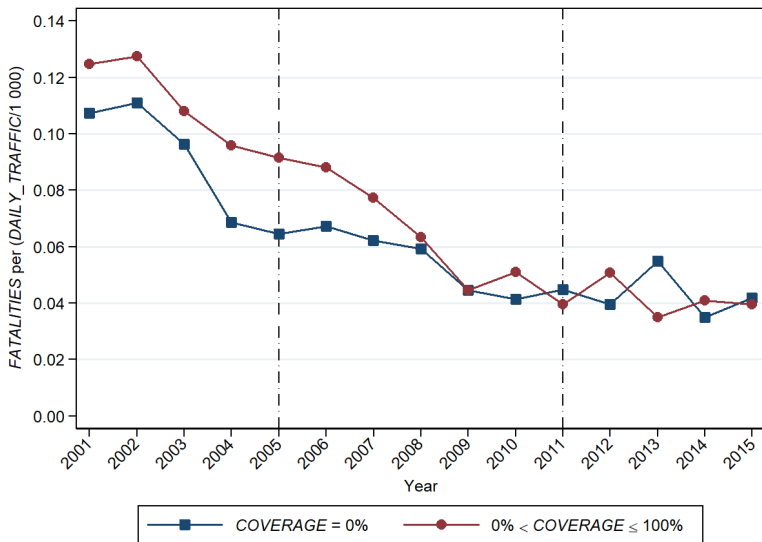
Descriptive trends

Figure 4: Patterns in *INJURED* rates by treated and non-treated groups



Descriptive trends

Figure 5: Patterns in *FATALITIES* rates by treated and non-treated groups



Model specification

- To test the effectiveness of Safety Tutor on reducing highway vehicle accidents we regressed the following panel equation:

$$\log\left(\frac{Y + 1}{DAILY_TRAFFIC} \times 10\,000\right)_{it} = \beta_0 + \beta_1 COVERAGE_{it-1} + BX + \alpha_j + \delta_t + \epsilon_{it} \quad (1)$$

- Y is our set of dependent variables: *ACCIDENTS*, *INJURED*, and *FATALITIES*.
- *COVERAGE* is the ratio between *TUTOR_LENGTH* and *HIGHWAY_LENGTH*
- X is a set of control variables: *VEHICLES_AGE* and *ALCOHOL_PC*

OLS: $\log(\text{ACCIDENTS})$

Table 2: OLS regressions with clustered standard errors. ***, **, and * denote significance at 1%, 5%, and 10% level

Dependent variable	$\log(\text{ACCIDENTS})$			
	(1)	(2)	(3)	(4)
$\text{lag}(\text{COVERAGE})$	0.0511 (0.149)	-0.617*** (0.0652)	-0.202*** (0.0583)	-0.138** (0.0586)
ALCOHOL_PC			0.125*** (0.0169)	
VEHICLES_AGE			-0.0535*** (0.0162)	
Motorway sector	No	Yes	Yes	Yes
Year	No	No	No	Yes
Constant	2.493*** (0.0943)	2.564*** (0.00695)	2.000*** (0.240)	2.843*** (0.0318)
Observations	777	777	777	777
R^2	0.000	0.165	0.412	0.463

OLS: $\log(\text{INJURED})$

Table 3: OLS regressions with clustered standard errors. ***, **, and * denote significance at 1%, 5%, and 10% level

Dependent variable	$\log(\text{INJURED})$			
	(1)	(2)	(3)	(4)
$\text{lag}(\text{COVERAGE})$	0.219 (0.175)	-0.609*** (0.0724)	-0.184*** (0.0630)	-0.108* (0.0597)
ALCOHOL_PC			0.125*** (0.0171)	
VEHICLES_AGE			-0.0583*** (0.0172)	
Motorway sector	No	Yes	Yes	Yes
Year	No	No	No	Yes
Constant	2.929*** (0.112)	3.017*** (0.00772)	2.491*** (0.254)	3.338*** (0.0400)
Observations	777	777	777	777
R^2	0.006	0.135	0.353	0.421

OLS: $\log(FATALITIES)$

Table 4: OLS regressions with clustered standard errors. ***, **, and * denote significance at 1%, 5%, and 10% level

Dependent variable	$\log(FATALITIES)$			
	(1)	(2)	(3)	(4)
$lag(COVERAGE)$	-0.534** (0.230)	-1.088*** (0.108)	-0.523*** (0.124)	-0.440*** (0.139)
$ALCOHOL_PC$			0.247*** (0.0341)	
$VEHICLES_AGE$			0.0144 (0.0361)	
Motorway sector	No	Yes	Yes	Yes
Year	No	No	No	Yes
Constant	-0.277*** (0.0940)	-0.218*** (0.0115)	-2.351*** (0.503)	0.238*** (0.0596)
Observations	777	777	777	777
R^2	0.025	0.127	0.254	0.289

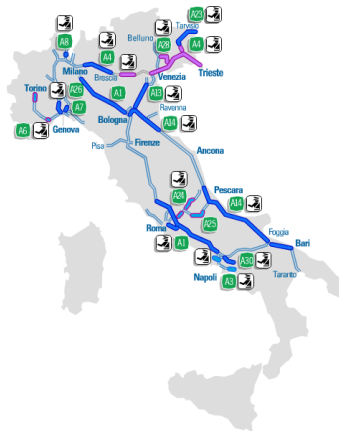
IV: Exclusion restriction & 1st Stage

- $Instrument = Dummy_{Year > 2004} \times Dummy_{ASPI_group}$

Figure 6: ASPI_group in 2011



Figure 7: Safety Tutor sites in 2011



IV: Exclusion restriction & 1st Stage

- $Instrument = Dummy_{Year > 2004} \times Dummy_{ASPI_group}$

Table 5: Progressive deployment of Safety Tutor sites by concessionaires

Concessionaires	TUTOR.LENGTH						
	2005	2006	2007	2008	2009	2010	2011
Autostrade per l'Italia S.p.A.	107.2	339.4	543.1	869.6	1072.0	1240.2	1276.8
Tangenziale di Napoli S.p.A.	0.0	0.0	0.0	0.0	9.4	9.4	9.4
Autostrada Torino-Savona S.p.A.	0.0	0.0	0.0	0.0	0.0	29.2	29.2
Soc. Autostrada Tirrenica S.p.A.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Strada dei Parchi S.p.A.	0.0	0.0	121.2	121.2	121.2	121.2	121.2
Autostrade Meridionali S.p.A.	0.0	0.0	0.0	0.0	0.0	13.7	13.7
Soc. Italiana Traforo Monte Bianco S.p.A.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Raccordo Autostradale Valle d'Aosta S.p.A.	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total <i>ASPI.GROUP</i> (A)	107.2	339.4	664.3	990.8	1202.6	1413.7	1450.3
Autovie Venete S.p.A.	0.0	0.0	0.0	0.0	0.0	0.0	104.1
Aut. Brescia-Verona-Vicenza-Padova S.p.A.	0.0	0.0	0.0	37.2	37.2	37.2	47.6
Total <i>OTHERS</i> (B)	0.0	0.0	0.0	37.2	37.2	37.2	151.7
Total (A+B)	107.2	339.4	664.3	1028.0	1239.8	1450.9	1602.0

In the 2011, the 90.5% of Safety Tutor sites were installed within *ASPI_group*

IV: 1st Stage & Reduced Form

Table 6: 1st Stage and Reduced Form regressions with clustered standard errors. ***, **, and * denote significance at 1%, 5%, and 10% level

<i>1st Stage</i>	Dependent variable	<i>lag</i> (<i>COVERAGE</i>)	<i>lag</i> (<i>COVERAGE</i>)	<i>lag</i> (<i>COVERAGE</i>)
	<i>lag</i> (<i>INSTRUMENT</i>)	0.211*** (0.042)	0.211*** (0.042)	0.211*** (0.042)
	<i>R</i> ²	0.342	0.342	0.342
<i>Reduced Form</i>	Dependent variable	<i>log</i> (<i>ACCIDENTS</i>)	<i>log</i> (<i>INJURED</i>)	<i>log</i> (<i>FATALITIES</i>)
	<i>lag</i> (<i>INSTRUMENT</i>)	-0.0783 (0.0512)	-0.0718 (0.0498)	-0.0274 (0.109)
	<i>R</i> ²	0.461	0.420	0.274
	1 st Stage F-statistic	25.06	25.06	25.06
	Motorway sector	Yes	Yes	Yes
	Year	Yes	Yes	Yes
	Observations	777	777	777

IV: 2nd Stage & OLS

Table 7: 2nd Stage and OLS regressions with clustered standard errors. ***, **, and * denote significance at 1%, 5%, and 10% level

2 nd Stage	Dependent variable	<i>log</i> (ACCIDENTS)	<i>log</i> (INJURED)	<i>log</i> (FATALITIES)
	<i>lag</i> (COVERAGE)	-0.371 (0.239)	-0.340 (0.237)	-0.130 (0.501)
	R^2	0.446	0.406	0.281
OLS	Dependent variable	<i>log</i> (ACCIDENTS)	<i>log</i> (INJURED)	<i>log</i> (FATALITIES)
	<i>lag</i> (COVERAGE)	-0.138** (0.0586)	-0.108* (0.0597)	-0.440*** (0.139)
	R^2	0.463	0.421	0.289
	1 st Stage F-statistic	25.06	25.06	25.06
	Motorway sector	Yes	Yes	Yes
	Year	Yes	Yes	Yes
	Observations	777	777	777

● Conclusions

- OLS estimates suggest a positive correlation between Safety Tutor and highway accidents reduction (but much lower with respect to previous studies).
- By controlling for additional endogeneity issues through an IV strategy, 2SLS estimates show no evidence of a significant causal effect of Safety Tutor on preventing none of the accident categories analyzed (informative only for the subsample of "complier" motorway sectors).

● Limitations

- Possible measurement error
- Possible spillover effect
- IV exclusion restriction

● To-Dos

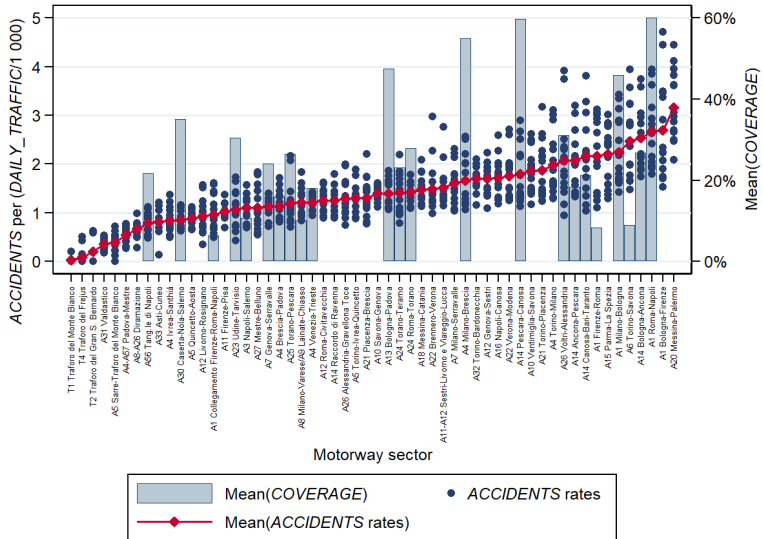
- Add controls (Roadway capacity, Average age of drivers)
- Add spatial information
- Add robustness checks (DID, Poisson regressions)

Thank you

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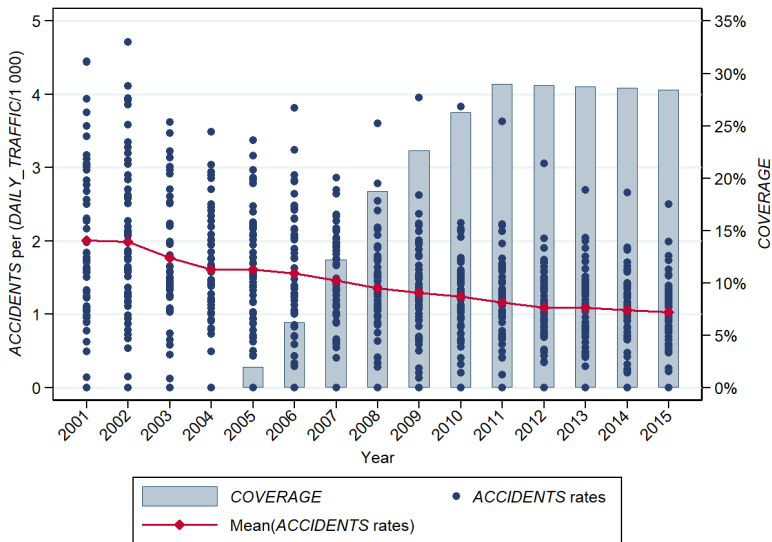
Descriptive trends

Figure 8: Heterogeneity of ACCIDENTS rates across motorway sectors



Descriptive trends

Figure 9: Heterogeneity of *ACCIDENTS* rates across years



IV Robustness (no outliers): 1st Stage & Reduced Form

Table 8: 1st Stage and Reduced Form regressions with clustered standard errors. ***, **, and * denote significance at 1%, 5%, and 10% level

<i>1st Stage</i>	Dependent variable	<i>lag</i> (<i>COVERAGE</i>)	<i>lag</i> (<i>COVERAGE</i>)	<i>lag</i> (<i>COVERAGE</i>)
	<i>lag</i> (<i>INSTRUMENT</i>)	0.194*** 0.0397	0.194*** 0.0397	0.194*** 0.0397
	R^2	0.338	0.338	0.338
<i>Reduced Form</i>	Dependent variable	<i>log</i> (<i>ACCIDENTS</i>)	<i>log</i> (<i>INJURED</i>)	<i>log</i> (<i>FATALITIES</i>)
	<i>lag</i> (<i>INSTRUMENT</i>)	-0.0717 (0.0528)	-0.0732 (0.0523)	0.0340 (0.107)
	R^2	0.529	0.459	0.282
	1 st Stage F-statistic	23.84	23.84	23.84
	Motorway sector	Yes	Yes	Yes
	Year	Yes	Yes	Yes
	Observations	700	700	700

IV Robustness (no outliers): 2nd Stage & OLS

Table 9: 2nd Stage and OLS regressions with clustered standard errors. ***, **, and * denote significance at 1%, 5%, and 10% level

2 nd Stage	Dependent variable	<i>log</i> (ACCIDENTS)	<i>log</i> (INJURED)	<i>log</i> (FATALITIES)
	<i>lag</i> (COVERAGE)	-0.370 (0.283)	-0.377 (0.283)	0.176 (0.539)
	R^2	0.511	0.440	0.269
OLS	Dependent variable	<i>log</i> (ACCIDENTS)	<i>log</i> (INJURED)	<i>log</i> (FATALITIES)
	<i>lag</i> (COVERAGE)	-0.123* (0.0666)	-0.108 (0.0719)	-0.456*** (0.154)
	R^2	0.530	0.459	0.295
	1 st Stage F-statistic	23.84	23.84	23.84
	Motorway sector	Yes	Yes	Yes
	Year	Yes	Yes	Yes
	Observations	700	700	700