Cars on crutches: How Much Abatement Do Smog Check Repairs Actually Provide?

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ARE 50th Anniversary celebration

Motivation

- motor vehicles represent a large share of emissions of VOC, NOx and CO in the US
- inspection and maintenance (I/M) programs are ubiquitous
- over half of California's registered fleet subject to I/M
- California Smog Check Program cost (ARB/BAR): $1.1bn/cycle
- previous studies suggest I/M is a relatively costly way to reduce emissions (Harrington et al., 2000; Mérel and Wimberger, 2012)

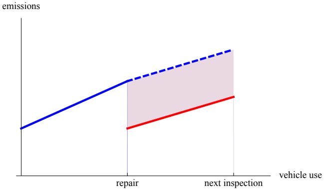
Challenges to measuring repair benefits

- cumulative emissions saved are not observed
- we observe initial abatement in emissions intensity (A)
- in previous studies:

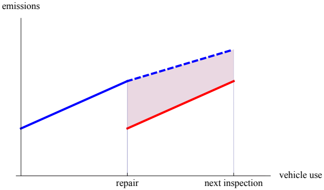
$$\text{Benefits} = A \times \text{Expected VMT}$$

- this calculation implicitly assumes abatement persistence
- here we relax abatement persistence assumption

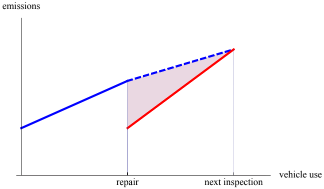
Why should we care?



(a) Persistent abatement

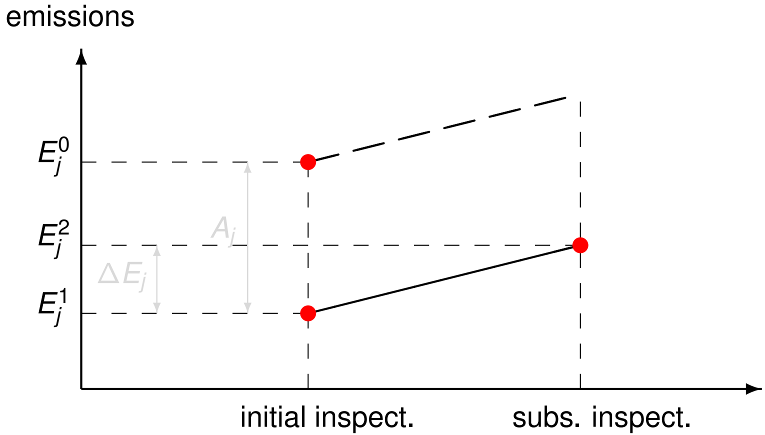


(b) As good as new repairs

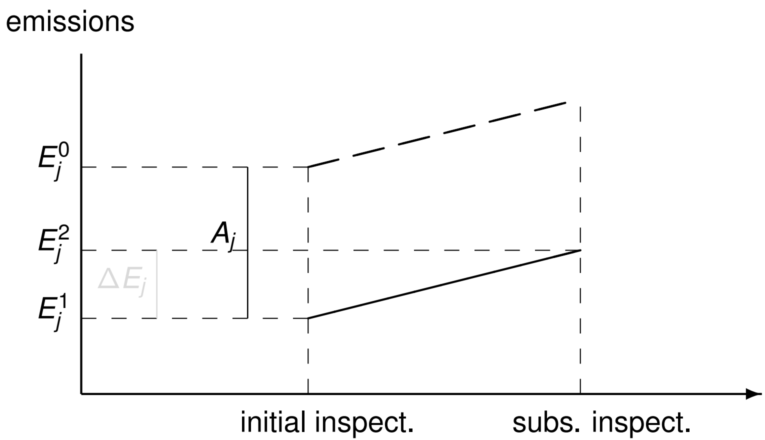


(c) Not as good as new repairs

Definitions



Definitions



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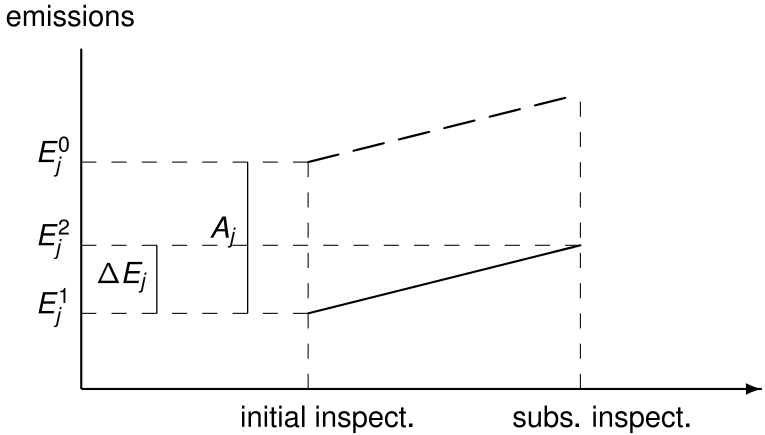

Econometric model

$$\Delta E_j = \alpha + \beta_0 E_j^0 + \beta_1 A_j + \mathbf{X}_j \gamma + \mathbf{Z}_j \delta + \epsilon_j$$

- $\beta_0 < 0$ (concavity of emissions trajectory)
- $\beta_1 = 0$ (persistence of abatement)
- $\beta_0 + \beta_1 = 0$ (repairs as good as new)
  vs. $\beta_0 + \beta_1 > 0$ (repairs not as good as new)
- Identification assumptions
  - ϵ_j is uncorrelated with $A_j \Rightarrow$ choice of data set
  - ϵ_j is uncorrelated with $E_j^0 \Rightarrow$ controls in $\mathbf{X}_j$ and $\mathbf{Z}_j$ + robustness checks

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One of 5 results tables:

Table 3
Results for the full sample of 209,603 repairs.

Dep. var. ΔE_j Obs. 209,603	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
E_j^0	0.081*** (0.007)	−0.135*** (0.011)	−0.229*** (0.012)	−0.244*** (0.012)	−0.265*** (0.011)	−0.278*** (0.012)	−0.279*** (0.012)	−0.282*** (0.013)	−0.252*** (0.014)
$(E_j^0)^2$	–	–	–	–	–	–	–	–	−3.01e−04** (8.76e−05)
$A_j = E_j^0 - E_j^1$	0.143*** (0.009)	0.315*** (0.010)	0.392*** (0.012)	0.394*** (0.011)	0.404*** (0.011)	0.408*** (0.012)	0.408*** (0.012)	0.428*** (0.014)	0.408*** (0.012)
Odometer	3.50e−06*** (4.64e−07)	4.54e−06*** (4.65e−07)	4.95e−06*** (4.63e−07)	6.14e−06*** (4.98e−07)	6.81e−06*** (5.04e−07)	7.03e−06*** (5.28e−07)	6.00e−06*** (5.43e−07)	6.14e−06*** (5.45e−07)	5.81e−06*** (5.45e−07)
MY f. e.	No	Yes	–	–	–	–	–	–	–
MY/Class f. e.	No	No	Yes	–	–	–	–	–	–
MY/Class/Make f. e.	No	No	No	Yes	–	–	–	–	–
MY/Cl./Mk./Eng. f. e.	No	No	No	No	Yes	–	–	–	–
VIN Prefix f. e.	No	No	No	No	No	Yes	Yes	Yes	Yes
Distance traveled							3.17e−05*** (2.54e−06)	3.13e−05*** (2.55e−06)	3.12e−05*** (2.54e−06)
Time elapsed							0.002*** (1.82e−04)	0.002*** (1.82e−04)	0.002*** (1.82e−04)
A_j × Oxygen Sensor								−0.029*** (0.007)	
A_j × Catalytic Conv.								−0.018* (0.008)	
A_j × Fuel Evap. Syst.								−0.044** (0.017)	
A_j × Ignition Syst.								0.020* (0.009)	
A_j × Other Compon.								−0.024* (0.010)	
R-squared	0.125	0.148	0.157	0.176	0.209	0.289	0.291	0.292	0.291

Reported standard errors are heteroskedasticity-robust. In column (9), E_j^0 is demeaned, so that $\hat{\beta}_0$ represents the marginal effect of pre-repair emissions evaluated at the sample mean of E_j^0.
* Statistical significance at the 5% level.
** Statistical significance at the 1% level.
*** Statistical significance at the 0.1% level.

Main results

Dep. var. ΔE_j **Obs. 209,603**	(7)
E_j^0	-0.279*** (0.012)
$A_j = E_j^0 - E_j^1$	0.408*** (0.012)
Odometer	6.00e-06*** (5.43e-07)
VIN Prefix f. e.	Yes
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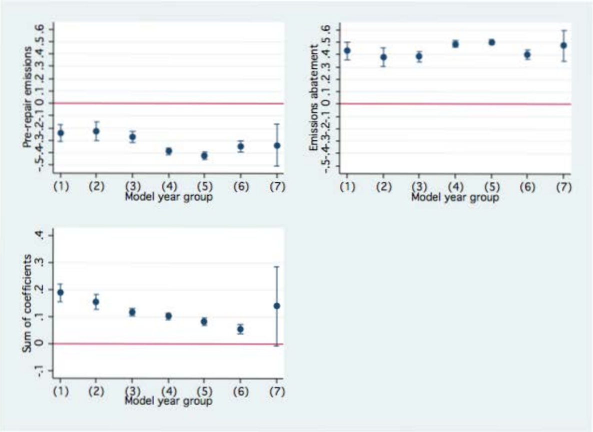
Model year groupings



Cost effectiveness of emissions-related repairs

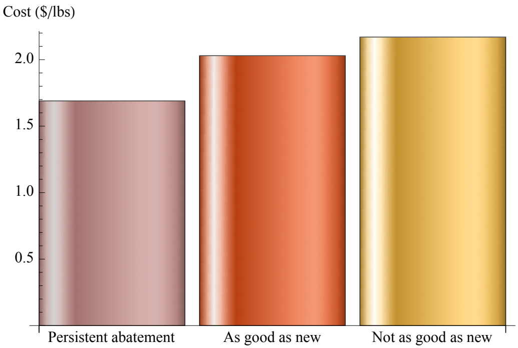


Figure: Repair cost per lb of HC-NOx-CO abated.

Conclusion

- we find no support for persistence hypothesis or even “as good as new” effect
- on average, 41% of abatement lost by next inspection
- 28% due to non-linearity in emissions trajectory
- Smog Check repairs on CAP vehicles are not cost effective relative to other efforts to reduce criteria pollutants