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Cars on crutches: How much abatement do smog check repairs actually provide?

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ABSTRACT

Not as much abatement as has been presumed. Smog check programs aim to curb tailpipe emissions from in-use vehicles by requiring repairs whenever emissions, measured at regular time intervals, exceed a certain threshold. Using data from California, we estimate that on average 41% of the initial emissions abatement from repairs is lost by the time of the subsequent inspection, normally two years later. Our estimates imply that the cost per pound of pollution avoided is an order of magnitude greater for smog check repairs than alternative policies such as new-vehicle standards or emissions trading among industrial point sources.

What's broken can always be fixed…What's fixed will always be broken.

—Jens Lekman

Introduction

Local air pollution arising from economic activity causes significant human health and environmental damage (Chay and Greenstone, 2005; Muller et al., 2011).[1] Motor vehicles represent the largest single source of nitrogen oxides (NOx), volatile organic compounds (including hydrocarbons, HC) and carbon monoxide (CO) in the United States (Environmental Protection Agency, 2008). NOx and volatile organic compounds react with sunlight to form ground-level ozone, leading to respiratory problems and damage to crops and sensitive vegetation and ecosystems. Human exposure to high concentrations of CO inhibits the blood's ability to transport oxygen and can result in nausea, angina, and even death (Environmental Protection Agency, 2011b).

Policy intervention can reduce the damages from local air pollution. A common view among economists, generally supported by empirical evidence, is that market-based mechanisms such as emissions trading or emissions taxes are preferable to command and control (CAC) approaches such as performance standards (Freeman, 2002; Fowlie, 2010; Fowlie et al., 2012a).

While taxes or caps represent a workable option for point sources, to this date actual tailpipe emissions from motor vehicles cannot reliably and economically be measured, as would be required to implement a market-based approach (Fullerton and West, 2002, 2010; Fowlie et al., 2012b). Gasoline taxes have been suggested as a second-best price instrument to control tailpipe emissions, but because emissions crucially depend on vehicle characteristics, including the condition of

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[1] For example, Muller et al. (2011) estimate that several industries, including solid waste combustion and oil and coal-fired power plants, entail air pollution costs larger than their value added.

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emissions control components, these taxes entail significant efficiency losses compared to a first-best emissions tax (Fullerton and West, 2010).[2]

Not surprisingly, then, current regulations aimed at curbing vehicles′ tailpipe emissions typically fall into the CAC category. Gasoline content regulations intended to reduce emissions of ozone precursors from mobile sources can, in principle, make gasoline burn more cleanly through changes in chemical composition (Aufhammer and Kellogg, 2011). However, such standards cannot address engine failures or defective emissions control components, hence the need for regulations pertaining to motor vehicles themselves. For new vehicles, regulations dictate maximum emissions rates and specific emissions control technologies to manufacturers.

For in-use vehicles, the focus of this paper, standards typically provide an emissions rate ceiling by vehicle class. In the United States, the 1977 Amendments to the Clean Air Act require all areas of the country that fail to meet National Ambient Air Quality Standards (NAAQS) to implement inspection and maintenance (I/M) programs to reduce tailpipe emissions from in-use cars and light duty trucks.[3] Vehicles must undergo emission-related repairs whenever their tailpipe emissions, measured at regular yet distant time intervals—typically two years—exceed established thresholds. I/M programs are ubiquitous across the U.S. and most developed countries, where they represent an essential lever to control emissions from mobile sources (Harrington et al., 2000).

The present paper seeks to document the emissions reductions attributable to I/M programs and to provide reasonable estimates of their cost effectiveness. Despite their prevalence and the empirical significance of the pollution they address, these programs have received little attention in the economics literature. Notably, it is not known whether they are cost effective relative to other policies targeting local air pollution.

The existence of I/M programs is predicated upon the expectation that repairs conducted on non-compliant vehicles durably reduce tailpipe emissions. An assumption commonly made in calculating benefits from I/M programs is that the initial repair-induced abatement is *persistent* throughout the I/M cycle (Harrington et al., 2000; Ando et al., 2000; California Air Resources Board, 2009; Environmental Protection Agency, 2012). Under the *persistence* assumption, the cumulative reduction in emissions is computed by multiplying the drop in a vehicle′s emissions rate per mile attributable to repairs by the expected number of miles driven during the cycle. However, if the benefits from emission-related repairs in terms of avoided emissions decrease over vehicle use, that is, if the abatement lacks persistence, benefits calculated based on the persistence assumption will clearly be overstated (Harrington and McConnell, 1994; Hubbard, 1997; Singer and Wenzel, 2003). Empirical evidence regarding the actual degree of abatement persistence is lacking (Environmental Protection Agency, 2002; Singer and Wenzel, 2003). As a result, attempts to relax the persistence assumption in the evaluation of I/M benefits have been rare and have relied on *ad hoc* assumptions.[4]

This study is the first to provide econometric evidence of the lack of persistence of repair-induced emissions abatement throughout an I/M cycle. Our inference is based on a large cross section of vehicles from California for which we have detailed and reliable information on tailpipe emissions and emission-related repairs performed at high-quality stations over the course of the past decade. California is a particularly well-suited setting to investigate the effect of repairs on the emissions deterioration of in-use vehicles due to its relatively old fleet and the extensiveness of its I/M program, known as the California Smog Check Program. We find that on average, 41% of the abatement observed at the time of repair is lost by the subsequent inspection. The magnitude of this loss is shown to be robust to various model specifications and various ways to aggregate targeted pollutants.

Two sources of lack of abatement persistence should be distinguished. First, because the emissions control components of vehicles deteriorate with use, their tailpipe emissions rates tend to increase secularly. We refer to this increase in a vehicle′s emissions rate over use as its *emissions trajectory*. To the extent that this trajectory is concave—we provide empirical evidence that it is—successful repairs will bring vehicles back to a portion of their emissions trajectory where their emissions accrual rate with use is higher (their emissions trajectory is steeper). Consequently, the gap in emissions intensity between a repaired vehicle and a counterfactual vehicle that did not receive repairs will decrease over vehicle use, i.e., the repair-induced abatement will not be persistent. Unless vehicles can be repaired to perform better than they historically did, this type of abatement deterioration with use is technically unavoidable.

The second source of lack of abatement persistence is poor repair durability. Only durable repairs can bring back vehicles to an earlier point in their emissions trajectory, in the sense that the vehicle will follow its historical path of emissions accumulation once again. Non-durable repairs, by contrast, will decrease the emissions rate of a vehicle while increasing its emissions accrual rate relative to its historical trajectory, further eroding the persistence of repair-induced abatement. Arguably, I/M programs can be improved to increase the durability of repairs, for instance by improving technician training, increasing the performance standards of stations, or mandating centralized testing and repairs. As such, it is important from a policy perspective to distinguish between the two aforementioned sources of abatement deterioration.[5]

[2] Several authors have investigated the merits of more complicated tax schemes to replicate or approximate the first-best tax on emissions. See for instance Innes (1996) and Fullerton and West (2002, 2010).

[3] Six pollutants are covered by NAAQS: CO, lead, NOx, ozone (a secondary pollutant formed by the interaction of NOx and volatile organic compounds in the presence of sunlight), particle pollution, and sulfur dioxide (Environmental Protection Agency, 2010b).

[4] The only instances we are aware of are the newer iteration of California′s mobile emissions model EMFAC (California Air Resources Board, 2001b) and the study of Singer and Wenzel (2003).

[5] California′s EMFAC model currently accounts for the first source of abatement loss—but not for the second one—when deriving the emissions trajectories of vehicle groups subject to I/M over time. Even so, abatement persistence may still be assumed by the California Air Resource Board when performing cost–benefit analysis (California Air Resources Board, 2004, 2009).