The Persistence of Economic Factors in Shaping Regulation and Environmental Performance: The Limits of Regulation and Social License Pressures

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Many students of regulation, ourselves among them, have questioned models of regulation and business behavior that emphasize economic motives, finding instead that social norms (relating to environmentalism and law-abidingness) and social pressures play an important role in inducing businesses to comply with regulations and to go beyond compliance. This paper explores the *limits* of such "social license" pressures. Whereas our previous research focused on highly visible, closely regulated industries and on larger corporations, this paper explores the limits of "social license" pressures by examining regulation of dangerous diesel emissions from trucks and buses in the U.S., thus examining smaller companies that operate in highly competitive or unprofitable markets and find it extremely difficult to afford or pass on the cost of best available emission control technologies. We find that, economic variables, most prominently the sheer enormity of the economic cost of "greening" the national fleet of heavy-duty diesel vehicles, has (a) limited the coerciveness of direct regulation of vehicle owners and operators; (b) dwarfed the reach and effectiveness of the governmental programs that subsidize the purchase of new vehicles; and (c) elevated the importance of each company's "economic license" – as opposed to its "social license" – in shaping its environmental performance.

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In seeking to understand regulation and variations in compliance, many sociolegal scholars have questioned the explanatory power of traditional economic models, with their emphasis on short-term economic self-interest as the behavioral driver. The simplistic notion that regulatory law reflects well-organized interests' efforts to limit competition and capture economic rents (Stigler, 1971) has given way to more complex models that include the mobilization of diffuse interests by ideologically-motivated policy entrepreneurs (Wilson, 1980), social movements that generate 'norm cascades" (Keck & Sikkink, 1998), and disasters, scandals, or analyses that suddenly shift the politics of regulation (Bardach & Kagan, 2002: 22-25; D. Vogel, 2004; Levine, 2006: 217-223). At the level of policy implementation and compliance, sociolegal scholars have noted the importance of norms and social pressures in inducing businesses to comply with regulations and to go "beyond compliance" (Gunningham et al, 2003; May, 2005; Thornton, Gunningham & Kagan, 2005; Vandenberg, 2003; Vogel, 2005). Other scholars have written about the advent of "second generation" regulatory strategies that, building on business concerns about "reputational capital," seek to stimulate and harness corporate self-regulatory programs (Coglianese & Nash, 2006; Coglianese & Lazer, 2003; Gunningham & Rees, 1997).

This paper, while not challenging the validity of that prior literature, reports research that tests the *limits* of what we have called "social license" pressures in shaping regulation and compliance. Our own previous research concentrated on highly visible, closely-regulated industries and on larger corporations, or on medium-sized firms in distinctive markets (Gunningham et al, 2003; Gunningham et al, 2005; Thornton et al, 2005). But regulating the business equivalents of many impecunious field mice, we hypothesized, is inherently more challenging than regulating a smallish herd of well-financed elephants. To explore that hypothesis, we have studied the regulation of diesel emissions from heavy-duty trucks and buses in the U.S. -- a ubiquitous fleet of vehicles owned and operated by thousands of smaller trucking firms and a few large ones, and by bus companies that typically need government subsidies to survive.

In the following sections, we examine, in turn (1) the evolution and design of federal, California, and Texas regulations aimed at reducing nitrous oxide (NOx) and particulate (PM) emissions from trucks and buses; (2) *company-level variation* in environmental performance in California and Texas. Our findings suggest that in highly competitive or unprofitable markets, economic variables play a particularly salient role in structuring the politics that shape regulatory laws and programs *and* in explaining the environmental behavior of regulated firms. Most prominently, the sheer enormity of the economic cost of "greening" the national fleet of heavy-duty diesel vehicles has (a) limited the coerciveness of direct regulation of vehicle owners and operators; (b) dwarfed the reach and effectiveness of the governmental programs that subsidize the purchase of new vehicles; and (c) elevated the importance of each company's "economic license" – as opposed to its "social license" – in shaping its environmental performance.

I. Regulating Diesel Emissions: Roads Taken, Roads Not Taken

A. The Environmental Problem.

In 2005, there were 2.9 million diesel-powered tractors (heavy tandem conventional vehicles) involved in interstate commerce, undergirding the just-in-time delivery systems that have held consumer prices down. Millions of children travel to and from school in diesel-powered buses. Millions of urban dwellers rely on buses to get to and from work. Diesel powered vehicles collect our household wastes each week. Operators of all these kinds of vehicles favor diesel engines because of they are more fuel-efficient and durable than gasoline engines in moving heavy loads.[1]

Unfortunately, diesel engines also emit particulate matter (dPM) and nitrous oxides (NOx, a precursor to ground-level ozone).[2] In 1998, according California's Air Resources Board, a typical diesel-fueled bus emitted more NOx and particulate matter than would a whole load of bus riders had they

[1] There are additional, important sources of diesel emissions – e.g, agricultural and construction machinery, ocean-going ships docked at seaports, and electric power generators. The focus of our study, and of this paper, however, is limited to on-road trucks and buses.

[2] NOx is formed when temperature, pressures, and oxygen concentrations within an engine are sufficient to cause the naturally-present nitrogen in the atmosphere to combine with the oxygen. *Particulates* are formed primarily from the incomplete combustion of hydrocarbons. As combustion progresses, the fuel is reduced to extremely small ash and char particles. Of greatest concern to public health are the particles small enough to be inhaled into the deepest parts of the lung (PM10 – 10 microns or smaller and PM2.5 – 2.5 microns or smaller). Often (but not always) there can be engineering trade-offs between emissions rates of these two pollutants from diesel engines, so that controls measures aimed at NOx, for example, might *increase* PM emissions unless compensatory measures are adopted. Changing fuel from diesel to *natural gas* can improve emissions from heavy duty vehicles because natural gas burns at different temperatures and pressures than diesel and burns more completely, leading to less nitrous oxide emissions and less particulate formation. However, emissions of *ultra-fine* particulates from natural gas are not very different.

driven the same route in individual automobiles. U.S. EPA estimated in 2005 that 14% of nitrous oxide emissions and 7% of particulate matter emissions are from diesel vehicles, the majority of which are heavy duty trucks and buses. Exposure to ozone (for which NOx is a precursor) has been linked to inflammation and decreases in lung function, aggravation of lung diseases such as asthma, and increases in hospital admissions. Exposure to fine particulate matter is even worse. In a study of diesel exhaust, the California Office of Environmental Health Hazard Assessment found dPM posed the highest cancer risk of any air contaminant they had evaluated, accounting for some 70% of the risk the average Californian faced from breathing toxic air pollutants.[3] A large-scale study of post-menopausal women found that living in areas with high levels of fine particulates[4] in the air substantially increased the risk of death from cardiovascular problems.[5] Individual exposures to diesel exhaust are intensified where large numbers of trucks or buses sit idling their engines, such as near seaports' marine terminals, highway choke points, large truck stops, and (with respect to buses) outside schools or large sports events.[6]

All other things being equal, older trucks and buses emit more dPM and NOx per mile than newer vehicles. However, the durability of diesel engines creates incentives to keep them in operation for decades.[7] Older trucks are typically resold rather than scrapped. The old trucks can be bought for as little as $20,000,[8] enabling an individual to become a self-employed trucker, particularly in market niches in

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[3] In addition, in studies with human volunteers, dPM made people with allergies more susceptible to their allergens (e.g., dust and pollen). Like ozone, exposure to diesel exhaust also causes lung inflammation, aggravating chronic respiratory symptoms. Because children's lungs and respiratory systems are still developing, they are also more susceptible than healthy adults to fine particles, which are associated with increased frequency of childhood illnesses and can also reduce lung function in children.

[4] Diesel vehicle and engine emissions account for some 15% of ambient fine particulate (PM2.5) emissions.

[5] Miller et al, 2007 found that in 2000, levels of PM2.5 exposure varied from 3.4 to 28.3 μg per cubic meter (mean, 13.5). Each increase of 10 μg per cubic meter was associated with a 24% increase in the risk of a cardiovascular event and a 76% increase in the risk of death from cardiovascular disease.

[6] UCLA researchers found "Children and adults who suffer from asthma and live near heavy vehicular traffic are nearly three times more likely to visit the emergency department or be hospitalized for their condition than those who live near low traffic density. For adults with asthma, medium to high traffic exposure increases the likelihood of chronic symptoms by approximately 40% to 80%. Moreover, living in areas of heavy traffic is a burden borne disproportionately by asthma sufferers who are ethnic/racial minorities or from low-income households. The issue is more pronounced among children than adults with asthma." (Meng et al, 2006)

[7] Modern diesel trucks may go 750,000 to 1,000,000 miles before their engines need to be rebuilt.

[8] In June 2006, www.truckpaper.com was advertising trucks for sale in Texas for between $7,000 and $65,000 for 1985 and earlier model years ($10,000 - $47,500 in California) as compared to $89,900 to $151,250 for 2007 model year trucks ($95,400 – $136,500 in California)

which goods are moved only short distances e.g., between a seaport and a railhead or a local warehouse during which they are less likely to break down.

B. The Federal Government's Regulatory Response

Since the late 1960s and even before (Morag-Levine, 2003) governments have relied heavily on "technology-forcing" regulations to reduce harmful emissions. Regulators specify progressively more stringent emissions standards, based on what they think can be achieved by the "best available technologies" – and sometimes by "not yet available technologies." Regulated enterprises are commanded to develop and deploy them, according to fixed deadlines. In our earlier research on regulation of water pollution from pulp mills, we found that regulators built increasingly demanding effluent limits into each mill's regulatory permit, yielding over three decades a 90 percent decline in harmful effluent (Gunningham et al 2003).[9]

Federal government regulation of emissions from motor vehicles, however, has taken a different course. Regulatory regimes have compelled vehicle *manufacturers* to meet progressively more stringent emission standards for new model-years. But owners and operators of *individual vehicles* have *not* been compelled by law to purchase and *use* the new, less-polluting, "best available technologies."[10] In effect, a "grandfather clause" has enabled households and businesses to continue to use older, dirtier vehicles, subject to periodic safety inspections to ensure that they are road worthy. Because new control technologies increase the capital cost of newer, less-polluting vehicles, the grandfather clause – as in

[9] More recently, governments have begun to use "cap and trade" regulatory systems, specifying the aggregate volume of particular pollutants that all producers in a region or state can expel into the environment. Enterprises are given flexibility in deciding what technologies to employ, and indeed can keep their old control technologies if they purchase "emission rights" from other enterprises that, by virtue of their mode of production, have been able to reduce emissions more efficiently. Cap and trade regulation has proved effective and efficient in reducing - emissions in a variety of industrial settings. (Nussbaum, 1991)
[10] The US Clean Air Act, as amended 1990, [42 U.S.C. 7521(a) (1)] provides that EPA can prescribe standards for emissions from "*new* motor vehicles or *new* motor vehicle engines." (emphasis added).

other regulatory situations in which it has been employed – gives owners of older vehicles additional incentives to keep using them as long as they can (Hsu, 2006).[11]

1. Regulating Engine Manufacturers: Cleaner Diesel Engines. Although Congress first enacted a statute concerning motor vehicle emissions in 1965, its first stringent action was a staggeringly ambitious provision of the 1970 Clean Air Act that mandated a 90% reduction of hydrocarbon and CO_2 emissions from new cars within five years, and of NOx within six (Tabb & Malone, 1997: 461). Motor vehicle manufacturers successfully argued in court that the requirement was technologically unfeasible, and also won a reprieve from Congress, delaying the deadline until 1980 (and even later for NOx). The legal dialogue led to statutes and regulations that more carefully calibrated the speed with which manufacturers could be compelled to adopt control technologies that had not yet been well-tested and introduced on a large-scale basis.[12]

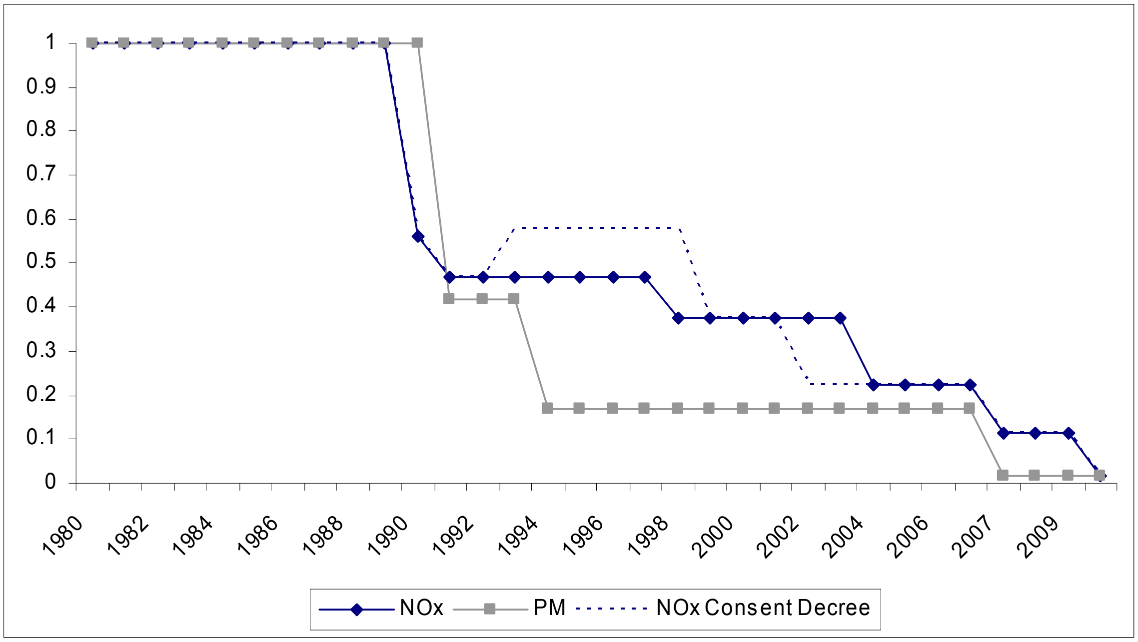
The Clean Air Act Amendments of 1990, for example, gave EPA the duty and authority to set maximum emissions for *heavy duty diesel engines*, taking both cost and best available technology trajectories into account.[13] The Act also authorized the agency to promulgate onboard diagnostic control requirements, designed to ensure that factory-set emissions limits are being met continuously (Walsh, 1991). Accordingly, EPA has periodically ratcheted down the maximum NOx and dPM standards for ***new*** heavy-duty diesel engines, as indicated in Figure 1, proceeding at a pace that seemed to provide adequate lead time.

[11] It is for that reason, among others, that academic economists have long favored pollution *taxes* or tradeable permits, since that gives users of older equipment an ongoing incentive to upgrade to newer, less-polluting equipment

[12] In *NRDC v Thomas*, 805 F.2d 410 (D.C. Cir. 1986), the court held that EPA could not simply order the whole industry to adopt technologies that had been tried by a single leader in environmental control effort, but must (1) respond to industry objections to the use of the proposed leading-edge technology, (2) identify the basic steps necessary for development and diffusion of the technology, and (3) offer a plausible basis for concluding that those steps could be taken by most firms within the deadline EPA had selected.

[13] California had already adopted Low Emission Vehicle standards for cars and light trucks that were considerably more stringent than then-existing EPA standards.

Figure 1: Proportional Declines in Federal NOx and PM Diesel Engine Emissions Limits (1980-2010) [14]



As noted earlier, truck *owners* were not required to *replace* their older vehicles or engines with new, lower-polluting models, nor required to retrofit them with pollution abatement technology. Nor are shippers required to hire trucking companies with newer vehicles to transport their goods. As noted, because diesel engines are extremely durable, companies that do buy new less-polluting trucks can and do re-sell older models to other companies. Neither Congress nor EPA adopted other regulatory strategies to increase incentives to abandon older, more-polluting diesels quickly – such as inducing state governments to impose substantial and progressively larger annual registration fees on owners of trucks and buses with higher-polluting engines.[15] Consequently, the federal policy mandating the design and production of

[14] NOx emissions in 1993 – 1998 model years are shown 24% higher than the legal emissions limit, because most truck manufacturers used software in the electronic engine control module of the truck engine to switch to a more fuel-efficient (but higher NOx) driving mode when the truck was not being operated under federal test conditions. This resulted in a lawsuit charging the manufacturers of using "defeat devices." The dispute was settled and manufacturers in the resulting consent decree agreed to introduce engines meeting the 2004 standard in 2002.

[15] A progressive registration fee would give diesel engine manufacturers ongoing incentives to develop ever-less polluting vehicles, and give vehicle operators ongoing incentives to keep upgrading to cleaner engines. It also would be relatively simple to administer

progressively cleaner new engines can only very gradually reduce harmful NOx and PM from the national fleet of diesel engines.

2. Regulating Refineries: Cleaner Diesel Fuel. In order to meet the demanding reductions in NOx and PM required for 2007 model year vehicles, EPA expected that end-of-pipe emissions control devices would be needed, and that these devices would be disabled by high levels of sulfur in diesel fuel, just as lead in gasoline disabled catalytic converters. Therefore, in January 2001 EPA required diesel refiners and importers to formulate, produce and market by June, 2006 diesel fuel that reduced sulfur content by 97 percent.[16] What EPA did not do, however, was to require truck and bus operators to use only the new model vehicles that would benefit most from the new cleaner diesel fuel. Nor did EPA or Congress impose a high pay-at-the-pump tax on *conventional* diesel fuel, generating incentives to shift to alternative fuel vehicles or 2007 or later engines that use clean diesel fuel (which could be taxed only at current rates, or conceivably at reduced rates).

3. The Non-Regulation of Diesel Vehicle Operators*: *Economics and the Political Limits on Regulatory Policy. Why didn't regulatory policymakers require owners and operators of heavy-duty trucks and buses to use only the lowest-polluting new diesel engines, or vehicles powered by alternative fuels, such as natural gas or electricity? Why didn't regulators, as an alternative path to the same end, impose progressively higher annual license fees on older diesel engines, or higher taxes on the kind of fuel those older engines use? Or require shippers to employ only trucking firms with newer, greener vehicles? Why did regulators, in eschewing these policies, resign themselves to the consequence: that it

[16] EPA states that, in tandem with the 2007 model year limits on diesel engine emissions, the Clean Diesel Fuel rules will, by the time the current heavy-duty vehicle fleet has been completely replaced (2030 or before), result in more than $70 billion annually in environmental and health benefits, as a cost of $4 billion per year. (U.S. EPA, 2006). In addition, the newer fuel formulations can reduce dPM and NOx emissions in older vehicles. California Air Resources Board estimates that its diesel formulation reduces dPM emissions by 25% and NOx emissions by 7% in older vehicles.

will take *years* – perhaps 25[17] --before the worst-polluting (but long-lasting) diesel engines are taken off the roads?

The most immediate reason relates to the cost of the newest, greener engines. The least an urban transit system currently would to pay for a conventional diesel bus is approximately $280,000. A full-sized alternative-fuel bus costs 13%-18% more. In 2006, a new diesel *truck* (subject to the NOx emissions limits for 2004-06 model years, cost in the range of $150,000. Trucks meeting the tougher 2007 engine standards cost $7,000-$10,000 more than 2006 models,[18] and also entail higher operating costs for maintaining the new engines' particulate filter systems.[19]

Traditionally, regulatory policymakers have assumed that the polluting company would pass on the high capital costs of mandatory best-available-control -technology vehicles to their customers, who would in turn reflect those higher costs in charges to millions of ultimate customers. Thus in the case of trucking firms, Walmart customers would pay a little more for their purchases. The same logic would lead urban transit systems, compelled to buy cleaner buses, to increase fares. But when those cost-pass-though scenarios are economically unrealistic – as they seem to be in the case of heavy-duty trucks, urban transit systems, and local school bus systems – the capital costs of compulsory requirements (or powerful financial inducements) to adopt best control technologies can be financially devastating to many regulated entities. Regulators, not surprisingly are very reluctant to impose such economically disruptive, and hence politically unviable, policies.

The nature of the economic constraints on truckers, urban transit systems, and school bus systems are slightly different, and worth discussing briefly. But the regulatory outcome in each case – except for

[17] In 2004, trucks from the 1979 or older model year constituted 5.6% of the California truck population, accounting for 0.9% of vehicle miles (since older trucks generally are used for shorter-hauls). Using a 25 year lag-time as a guide, we can estimate that in 2030, vehicles from 2004 or earlier model years will still be around, accounting for a roughly similar proportion of trucks and miles driven. Indeed, the proportion may be higher, since engine models sold in the last decade are likely to last 1,000,000 miles without rehaul (up from 500,000 in earlier decades).

[18] Interview, Dec 5, 2006, with Allen Schaeffer, Executive Director, Diesel Technology Forum, Washington, DC, and formerly Vice President for Environmental Affairs, American Trucking Association.

[19] The ultra low sulfur diesel needed for the lowest-polluting diesel engines costs approximately 10c/gallon more than ordinary diesel

some recent initiatives by the State of California – has been to "grandfather in" older, more polluting heavy duty diesel engines

Small Firm Trucking Sector: the Constraints of Perfect Competition. There are many large trucking companies in the United States -- including FedEx, UPS, YRC Worldwide (which owns Yellow Transportation and Roadway Express), Schneider, and Con-way, Inc. – that own and operate thousands of heavy-duty diesel trucks. Some large companies that are not directly in the trucking business – such as Home Depot, Walmart, Dell, and the large petroleum companies – operate large truck fleets themselves. Nevertheless, owner-operators and small or medium-sized trucking companies with fleets of fewer than 70 trucks account for more than half the diesel trucks on the road. In 2005 in Texas alone, more than 80,000 trucks – 24 percent of the whole Texas fleet – were owned by 32,000 small trucking companies with 10 or fewer vehicles, and 38% of the Texas fleet belonged to firms with no more than 30 trucks.

Following the deregulation of the American trucking industry (1979-81),[20] governmental rate-setting ended, and small truckers flooded into market niches from which they had long been excluded by regulation. Competition intensified, the Teamsters' Union's ability to demand high wages for most drivers faded rapidly, and the rates charged by trucking companies fell dramatically. Pricing is extremely competitive, resulting in what New Deal regulators called "destructive competition" and sought to tame through competition-limiting regulation. Owner-operators and small trucking companies today work very long hours for the equivalent of blue-collar wages. Most cannot afford the capital cost of new engines or vehicles. And in such a populous, competitive market, collective action problems leave smaller trucking firms unable to pass on the costs of new lower-polluting vehicles to the shippers who hire them.[21]

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[20] For a concise account of the advent of competition-limiting regulation by the Interstate Commerce Commission, 1935-1980 and the advent of deregulation during the Carter Administration, see Moore (1986)

[21] According to the American Trucking Association's former Vice President for Environmental Affairs, Allen Schaeffer, low barriers to entry have driven freight rates down to the point that for every dollar earned, profit levels are about 2-3 cents, and that margin is easily eroded by jumps in fuel costs (since most carriers are too small to do anything about hedging price and are reluctant to add fuel surcharges).Moreover, small companies, Schaeffer thinks, probably do not charge the full costs of moving goods (e.g. failing to charge for such costs as drivers' waiting time). Interview, December 5, 2006

Consequently, any law or regulation that directly (by legal mandate) or indirectly (by imposing very high taxes or fees on older engines) compelled a rapid phase-out of older, more-polluting engines threatened to drive a great many firms out of business and destroy the resale value of their only capital asset. The gap in demand for trucking services would be filled, eventually, by a much smaller number of very large companies with cash and credit ratings that would enable them to buy new-model trucks. But that would result in higher shipping costs. Politicians and regulators, therefore, recognized that a mandatory rapid phase-out would be opposed by a wide range of major businesses -- shippers and customers alike. And the political storm that would stem from visiting unemployment and bankruptcy on thousands of small trucking companies, was apparently not what environmentally committed policymakers in Washington or state capitals were interested in encountering.[22]

Urban Transit Systems: The Constraints of Insufficient Demand. Urban bus systems have monopolies on their bus routes; unlike trucking firms, they don't worry about tough competition from other bus companies. But they are obligated, for reasons of social policy, to operate many routes and long hours, including many in which there is insufficient demand (in the financial sense). Thus urban bus systems typically operate at a loss, and are subsidized by local governments. If they tried to pass on the high cost of new, less-polluting buses to their generally low-income clientele in the form of higher fares, many urban transit systems would lose riders and their revenues would decline.[23] In other words, in many cities, consumer demand is not great enough to finance high-cost, very-low-polluting urban bus service.

For urban transit systems, the only feasible alternative is to pass the high cost of new, green vehicles on to the cities and counties that are already subsidizing mass transit. This would require even

[22] One might imagine that large trucking firms would have been a powerful political lobby for regulatory mandates requiring rapid phase-out of old trucks. The largest firms would be better able to afford the new trucks and raise rates as thousands of small firms dropped out of the industry. But such a lobby did not materialize because many large trucking firms rely primarily on subcontracts with small truckers – and those large firms' costs could be expected to increase sharply if their subcontractors were required to buy new green trucks (and their ranks were sharply depleted). Put another way, the American Trucking Association, dominated by large firms, was divided between members who profited from the intense competition among smaller trucking firms with cheaper,older trucks, and those that didn't. See generally Levine (2006) (noting that deregulation typically makes firms in an industry more *diverse,* and hence likely to have different policy goals).

[23] Note, this is probably not the case for bus systems or bus routes that serve white collar and professional commuters from middle class suburbs, commuting to and from the city at rush hours only.

larger subsidies, the cost of which presumably would be passed on to property-owners in higher taxes, or in user-fees to clients of other governmental services. In some cities, where political demand for less pollution is very strong, or where middle class demand for bus service remains high (e.g, Manhattan), local politicians may be willing to increase subsidies for new, less-polluting buses. In a great many, they probably are not. Or at least, the prospect of disrupting bus service for millions of urban voters, or saddling them with higher fares, or arousing opposition from already hard-pressed local governments, was enough to deter Washington policymakers from requiring cities to scrap old buses and shift to new, least-polluting vehicles within a short transition period.

School Buses: Regulating without Market Demand. For related but somewhat different reasons, public school bus transportation services – sometimes operated directly by public school districts, sometimes contracted out to private companies for a price certain – could not be expected to pass the costs of greener vehicles on to their customers in the form of higher "prices." Most school districts do not charge for transporting children to and from school. The school districts – and the local property-tax payers and state-wide tax payers who finance the schools – bear the cost of the bus systems. The issue facing environmental policymakers, therefore, was how school district officials and taxpayers would react to regulatory demands to spend more on cleaner buses, given the insistent demands they face for better and more teachers, special educational services, better teaching materials, and better facilities. Again, in some districts, popular demand for cleaner buses is high (particularly where parent groups are especially aware of the health risks to children from PM emissions) and voters presumably would support new school bond issues or slight tax increases. In many districts they might not, or at least that is what a rational policymaker in Washington might expect. As in many other situations, it is more difficult for government to impose stringent environmental regulations on government bodies, which cannot easily raise taxes to fund compliance, than it is to regulate private industry, which often can pass those costs on in the form of higher prices (Wilson & Rachal, 1979; Ackerman, et al, 1973).

4. Battling Economic Constraints: The Clean Air Act's Health-Based Air Quality Standards. Once the federal government declined, for the economic and political reasons just discussed, to prohibit the use of older, high-polluting diesel engines by a sequence of dates certain (or to use high fees or taxes to bring about similar result), environmental advocates' hopes of accelerating the gradual greening of the nation's diesel fleet rested on a key provision of the federal Clean Air Act of 1970 – a provision that was structured to make regulation impervious to economic constraints. The 1970 Clean Air Act required EPA to set National Ambient Air Quality Standards (NAAQS) for particular pollutants found to endanger public health – and do so on the basis of health considerations alone, erring on the side of safety.[24] The current criteria pollutants are sulfur dioxide, carbon monoxide, nitrogen dioxide, ozone, particulates, and lead.[25]

In enacting the Clean Air Act, Congress and the President were happy to take the moral high ground of writing health-based regulation, but not to assume responsibility for dealing with the economic impacts of compliance. Hence, the federal laws assigned *state governments* the primary responsibility for attaining and maintaining the EPA-selected "safe" levels of pollution. Each state must devise a state implementation plan (SIP) designed to achieve the NAAQSs by prescribing and enforcing limitations on individual sources and "such other measures as may be necessary' (Tabb & Malone, 1997:368).[26] The 1977 Clean Air Act Amendments required EPA, using the NAAQSs as the standard, to classify regions throughout the states as either "attainment" or "non-attainment" areas, imposing tighter deadlines for reduction of harmful emissions in the former.[27] To enforce those obligations, states face legal deadlines

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[24] The NAAQS, the Act said, should be set at the levels "that allowing an adequate margin of safety, are requisite to protect public health." Clean Air Act Sec. 109(b), 42.U.S.C. 7409 (b) (1) (2000)
[25] Note 2007 Sup Ct ruling requiring EPA to set NAAQS for carbon emissions, to deal with long term global warming.
[26] This regulatory strategy – environmental standard-setting by central governments and implementation by states or local regional governments – is common to all economically advanced federal democracies (Kelemen,2004).
[27] For the nonattainment areas, the deadline for attaining the primary NAAQSs was extended to 1982; for ozone, NO_2 and carbon monoxide (all closely associated with motor vehicle emissions), the deadline was extended to 1987, provided the states implemented a vehicle emission inspection and maintenance program (Tabb & Malone, 1997: 380-81)

for periodic submission of SIPs, which must meet standards prescribed by EPA reviewers. (Tabb & Malone, 997: 370).

Now, back to the diesel emissions issue. Beginning in the 1990s, environmental organizations, public health advocates, and some states (most notably, California and from the Northeast) lobbied EPA to tighten NAAQS for ozone and fine particulate matter – which, as noted, are the worrisome pollutants in diesel engine emissions. Industry (including the trucking industry) and after 1994, a Republican Congress, petitioned EPA to go slow and gather more data (Oren, 2006). But the Clean Air Act gave the environmentalists leverage. In 1997, following two major lawsuits demanding action, EPA substantially tightened the NAAQSs for ozone and fine particulate matter. Although the American Trucking Association and other industry groups then challenged the regulations in court, they were upheld after a lengthy legal battle,[28] and the new tighter ambient air standards for ozone and PM finally took effect in 2002.

Since then, the EPA has classified 474 counties around the country as non-attainment areas with respect to the new ozone NAAQS, and 208 counties as failing to meet the PM standard. The Clean Air Act requires states to submit to EPA inventories of emissions every 3 years, until NAAQS are met. To do so, state environmental and transportation planning agencies must establish emissions budgets for point, area and mobile sources, assigning specific emissions reduction levels to each source category.[29] State officials must ensure that anticipated emissions remain within the SIP's emissions budget, thus demonstrating what is called "transportation conformity." If the state fails, EPA can withhold hundreds of millions of dollars of federal transportation funding. Although this does not happen often, the threat is

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[28] The industry argued that existing health data didn't support the limits chosen by the EPA and that the aggregate costs of compliance, according to the EPA's own analysis, exceeded the expected social benefits. The U.S. Court of Appeals invalidated the regulations, stating that the EPA had acted arbitrarily. Neither Congress nor the agency, the court's opinion held, had stated any "intelligible principle" that would justify its choice. The U.S. Supreme Court reversed, holding that the regulations were not arbitrary and emphasizing that under the Clean Air Act and prior court precedents, only health considerations, not costs of compliance, were to be considered in setting NAAQSs. *Whitman v. American Trucking Associations*, 531 U.S. 457 (2001)

[29] Ozone non-attainment regions must have a specific "motor vehicle emissions budget" (MVEB) tied to their SIP. The motor vehicle budget calculations are based on the number of vehicles in the region, their age, the rate of fleet turnover to newer and cleaner vehicles, seasonal temperatures in the region, vehicle miles traveled, and population growth. www.fhwa.dot.gov/environment/conformity/ref_guide/partiii.htm

severe enough, and the adverse headlines politically important enough, that state agency officials and transportation planners take "transportation conformity" very seriously (Eisinger & Niemeier, 2004).[30] The threat of losing the highway funds, therefore, it gives states an incentive to devise imaginative ways to reduce emissions, promote use of mass transit, and accelerate diesel fleet turnover.

4. Subsidizing Compliance. The tightened NAAQS for ozone and PM, plus the SIP process, gave states the obligation and incentive to accelerate the adoption of newer, less-polluting trucks and buses. But the regulations didn't give state governments any escape from the basic economic (and hence political) problem: how to get thousands of smaller trucking companies and non-money-making urban transit and school bus systems to scrap old vehicles and purchase the expensive newer, greener ones. De-licensing (or heavily taxing) older vehicles and throwing thousands of truckers out of business has been no more appealing to most state legislatures than it had been to Congress. Federal regulators, therefore, offered a set of *subsidies:* (1) monetary grants to help diesel vehicle operators retrofit, rebuild or replace old vehicles, and (2) funding of demonstration projects that help determine the cost-effectiveness of different modes of dispensing subsidies and/or test the feasibility of new control measures.

The U.S. EPA's budget, however, has been limited; it has concentrated on offering relatively small carrots -- funding for demonstration projects – and on the hope that its pressure on non-attainment areas will force state governments to subsidize diesel fleet replacement from state funds. More substantial funding comes from the U.S. Department of Transportation (DOT). In addition, the Department of Energy provides funds for alternative fuel vehicles through its Clean Cities program. Between 1998 and 2003, the DOT's Congestion Mitigation and Air Quality (CMAQ) program spent \$1.2 - \$1.4 billion dollars each year (slightly more than in the 1991-1997 period) on state and local projects designed to reduce pollution

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[30] Between 1990 and 1997, EPA gave states formal notice of disapproval 855 times and imposed sanctions 14 times. Highway fund sanctions were applied twice. In all 14, EPA imposed a 2:1 offset sanction for non-attainment areas in the state in question; that is, to authorize a new or expanded enterprise that will increase pollution of a criterion pollutant, the state must ensure that emissions from *existing* sources in the non-attainment area will be reduced by twice the amount of pollutants that the new or modified source will generate.

from transportation-related sources.[31] In addition, although it is less closely targeted on air quality problems, DOT's Surface Transportation Program (STP) was authorized to spend $4 billion in 1997, rising to $5.9 billion in 2003, allocated to states and localities for intra-city and intercity bus terminals and facilities and capital projects for mass transit, as well as (and primarily) for highway projects.

Yet the federal subsidies, plus state-level subsidy programs funded by state revenues, are not nearly large enough to finance more than a very small percentage of new or rebuilt heavy-duty trucks and buses. There are approximately 3 million heavy-duty diesel trucks on the road, and if a new best-pollution technology model currently costs approximately $150,000, then replacing all these trucks would cost $450 billion. By the end of 2006, Texas's TERP program had spent $57 million dollars replacing 1,283 on-road vehicles with more up to date vehicles, at an average cost of $45,000 per vehicle.[32] In California, state and combined federal-state-local subsidy programs together have funded replacements of 812 trucks. But in 2006, there were approximately 40,000 trucks in Texas with 1990 or earlier model years, and 76,000 in California. With the cost of replacing 100,000 vehicles likely to range between $4.5 and $6.0 *billion,* it is clear that governmental subsidy programs will not result in a *quick* turnover heavy-duty diesel truck fleet – although by a combination of direct mandates and concentrating funding on school buses and urban transit fleets (a much smaller population of vehicles), California has made substantial progress in shifting them to "greener" vehicles.[33]

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[31] The CMAQ funds are apportioned annually to each region largely according to the severity of the air quality problem and the number of people exposed to low air quality. The highest priority for funding under the CMAQ program is for implementation of SIP measures – and as noted earlier, states that fail to ensure timely implementation of SIP requirements can trigger the cut-off of these funds by the EPA. To provide an indication of the scope and allocation of these funds: in FY2000, $589 million in CMAQ funds were spent in California on 293 projects, of which 63 (22%) funded alternative vehicle purchases, repowering, or infrastructure. Alternative fuel projects accounted for 39% of all California's expenditures of CMAQ funds, including the purchase of at least 1,210 alternative fuel buses and the building and/or upgrading of seven alternative fueling stations.

[32] Costs of vehicle replacements have risen steadily. Average cost was $29,364 in 2004, $43,371 in 2005, and $59,424 in 2006. Original data taken from Appendix 5, Texas Emissions Reduction Plan (TERP) Biennial Report to the Texas Legislature, December 2006.

[33] According to 2004 data, for example, alternative fuel vehicles constituted 43% of the 10,000+ urban bus fleet in California, Moreover, because California regulations have impelled transit agencies to install retrofit technologies that reduce PM emissions by 85%, 17% of the entire *diesel* bus fleet has had a diesel emissions control system installed

5. State Regulation of Diesel Emissions: California and Texas

The huge economic costs of "greening" the national fleet of diesel-powered trucks has also inhibited state governments' efforts to accelerate reduction of NOx and PM emissions via direct regulation of individual vehicle owners and operators. One rough indicator of progress in that regard would be the age distribution of each state's fleet of diesel vehicles, along with the percentage of vehicles that use alternative fuels. But since state motor vehicle registration data bases are not readily available in formats useful for that purpose, we decided to concentrate on just two states – California and Texas -- working closely with state officials to get the best quantitative data possible. Both California and Texas are large states with large volumes of import-export traffic. Politically, however, Texas generally is more conservative and less "green" than California, whose air pollution problems are worse and more politically salient.[34] Comparing Texas to California, therefore, promised to reveal the relative importance of state political environment and "social license pressures" in reducing NOx and PM emissions from heavy-duty vehicles.

Not surprisingly, the two states' *regulatory regimes* differ significantly. California has developed independent regulatory programs that often parallel and sometimes exceed equivalent federal programs.[35] Moreover, independent of any federal requirement and pursuant to its own toxics law, California identified diesel particulate matter as a toxic air contaminant, pursuant to which, the California Air Resources Board (CARB) imposed restrictions on idling of heavy-duty diesel vehicles, first for school buses, and in 2005 for commercial trucks. In September 2000, CARB designated certain populations of vehicles -- first transit buses, then garbage trucks, then public fleet trucks, and most recently, private

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[34] California has particularly severe air pollution problems, with large swaths of the state in non-attainment; the South Coast Air Basin (Los Angeles and surrounds) and the San Joaquin Valley are anticipated to be held in "extreme" non-attainment for the 8-hour ozone standard as well as in non-attainment for the PM2.5 standard. Air quality in Texas is far better: only two areas in moderate non-attainment for the 8-hour ozone standard and no area is currently designated in non-attainment for PM2.5.

[35] For example, California regulators, pursuant to California law, have developed their own ambient air quality standards covering a slightly larger number of criteria pollutants than the federal regulations. California 'clean diesel fuel' regulations, in contrast to EPA's, cap not only sulfur content but also the aromatic component of the fuel sold. California regulations require truck fleet owners to perform annual smoke tests on their own vehicles (to prevent smoking vehicles) and periodically inspect fleets to see that this is done. The California Air Resources Board (CARB) deploys roadside "strike teams" of inspectors who move from locality to locality to pull over diesel-powered trucks to check for excessive smoke.

trucks for mandatory phased retrofitting or replacement of older diesel vehicles[36]. Currently, the Ports of Los Angeles and Long Beach have proposed to ban "dirty" diesel trucks from cargo terminals within five years.[37] Texas, in contrast, has been more a regulatory follower than a leader, dutifully copying federal standards and sometimes adopting requirements pioneered by California regulators. Lacking California-style toxic air contaminant legislation, Texas regulators have focused primarily on NOx to meet federal SIP requirements for ozone (in contrast to California's intense focus on particulate matter as well). And in implementing federal standards, Texas has relied primarily on carrots – subsidy programs – rather than emulating California's use of mandates and the stick of legal sanctions.

The results of these different policy choices are most evident in aggregate data on the California and Texas bus fleets. As noted earlier, the California bus fleet has made a much more dramatic move towards alternatively-fueled vehicles than is the case in Texas – and we suspect, than in almost all other states. On the other hand, in the much larger (and hence larger aggregate emissions) heavy-duty truck arena, California's regulatory mandates directed at vehicle owners and operators have been applied only to the solid waste collection vehicle sector. For the large on-road trucking sector, California regulations have not significantly accelerated the shift to newer, potentially lower-emission engines.[38] Using 2005 figures, of California's 234,000 registered heavy-duty vehicles (GVW greater than 33,000 lbs), 66% were pre-1998 models (compared to 39% of Texas's 335,885 trucks GVW greater than 26,000 lbs).[39] Only

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[36] However, only the transit bus and garbage truck portion of these California regulations had been formally promulgated and implemented at the time of our truck data collection, and the truck portion – the biggest sector by far, is still only a CARB proposal.

[37] The ports will join with the state and local agencies to finance programs to replace trucks with a new generation of clean or retrofitted vehicles. They propose to allocate more than $200 million over five years to assist with this massive truck replacement initiative. The program would only allow port-licensed concessionaires, operating "clean trucks," to enter port terminals without having to pay an "impact" gate fee. "Clean trucks" are defined as 2007 or newer trucks, retrofitted trucks manufactured in 1994 or newer, or trucks that have been replaced through the Gateway Cities truck modernization program.

[38] We characterize newer vehicles as "potentially" lower-polluting, since emissions are also affected by company maintenance practices, speeds, loads carried, distance traveled, idling time, etc. Other things equal, younger fleets mean lower emissions.

[39] Texas and California collected data for different categories of vehicles by gross vehicle weight. Texas' Department of Transportation collected data on all trucks in excess of 26,000 lbs. California provided aggregate data on heavy heavy-duty vehicles (greater than 33,000 lbs) and medium heavy duty vehicles (14,000 lbs to 33,000 lbs). While we describe comparisons of California's heavy-heavy duty fleet compared to Texas' heavy duty fleet, it is

10% of California diesel trucks were 2003 or newer models, compared to 24% in Texas. In this important sector, it appears, environmental outcomes have been shaped less by regulations and more by the sheer cost of replacing tens of thousands of old trucks in a densely-populated, highly-competitive industry.

II Company-Level Variation in Environmental Performance

Progress in reducing harmful emissions from heavy-duty diesel-powered trucks and buses ultimately depends on the behavior or the thousands of companies that purchase and operate the vehicles. Yet as we have seen, with the exception of urban transit fleets in California, those companies are not legally *obligated* to buy the newest, "greenest" engines. With rare exceptions, trucking firms are not obligated to reduce idling or adopt other measures (including fuel-efficiency measures) that incrementally reduce emissions. Any rapid improvement of air quality in this sector, therefore, depends on individual firms' willingness to engage in what regulatory scholars have labeled "beyond compliance" behavior.

Another, and major, part of our research, accordingly, focused on trucking companies. We sought to determine why some firms, but not others, had purchased newer, less-polluting engines and why some, but not others, had adopted day- to-day operating practices that reduce emissions (such as introducing controls on idling time, better engine maintenance). To that end, we conducted detailed interviews with a sample of eight trucking companies headquartered in California and eight headquartered in Texas.

In our prior research on company or facility-level regulatory compliance and environmental performance, we found it useful, as well as consonant with the way the company personnel thought about the challenges they faced, to think of firms as having a multi-faceted "license to operate" – a concept that refers not only to (a) the company's *legal and regulatory obligations* but also to (b) its *economic license* (its managers' conception of a minimally adequate rate of return on investment or level of profitability) and (c) its *social license* (the demands it faces from neighbors, employees, community groups, and environmental NGOs, both directly and indirectly, e.g., through the threat to engender political obstacles

clear that the same basic relationships hold true if we do the less restrictive comparison (compare TX 26,000 lbs and over vehicles to CA 14,000 lbs and over vehicles).

to firm operations or expansion) (Gunningham et al, 2003). In a 1999 study of 16 mills that manufactured paper pulp from wood chips, we found that *inter-facility variation in environmental performance* was explained more fully by variations in the "tightness" of the particular firms' *social license* than by their regulatory or economic licenses (Ibid).[40]

Our current study of trucking firms is designed to test the limits of our pulp mill study findings. Pulp mills are large, capital and chemical-intensive facilities, very much in the public eye (and nose). When we studied their environmental performance in 1999, pulp mills had been subjected to detailed and demanding regulatory permits and official scrutiny for two or three decades. Their chlorine emissions had been the subject of a world wide campaign by Greenpeace. Most trucking companies, conversely, are small. Their polluting "facilities" are relatively small and mobile, and hence subject to much less intense social license pressures from local communities and environmental activists. And while trucking companies have been subjected to tight legal and regulatory license pressures relating to *safety,* in most states, they are not subject to demanding environmental regulations or subjected to tight scrutiny from environmental regulators. Unlike manufacturing companies that emit pollutants, truckers are not currently subject to national legal obligations to use the best available control technology for their polluting 'facilities'. So the trucking industry, we speculated, would provide a very hard test for the proposition that firm level environmental performance is influenced by social license pressures, by increasingly entrenched norms concerning environmental protection, and by corporate concerns about building and preserving reputational capital.

We indeed have found that *in an extremely competitive market like trucking, dominated numerically by small companies, social license pressures are weak and environmental consciousness is minimal. Variation in environmental performance, we found, flows primarily from economic variables.* Primary in this regard in the trucking industry is the extent to which a firm has developed a *market niche* that emphasizes long distance delivery of goods and highly reliable service. Trucking companies who seek to operate in that market niche have strong incentives to purchase newer trucks, primarily for economic

[40] This finding reflects the considerable *convergence* we found in regulatory license requirements across firms.

reasons. Highly competitive markets have also impelled trucking companies to emphasize fuel economy in their operations, not to reduce emissions but in order to control costs. In sum, we found that trucking companies that had better environmental performance most often did so as a byproduct of actions undertaken primarily for economic reasons, such as the cost of external repair services, late delivery penalties, customer demands for reliability and rising prices for fuel.

A. Sampling Companies for Intensive Study.

To obtain adequate data on environmental actions and motivations by individual companies, we were compelled to adopt a study design based on in-depth interviews with trucking company officials, conducted in their offices. Due to this labor intensive (and somewhat expensive) research strategy, our sample of firms to be interviewed necessarily was limited to 16, eight headquartered in California and eight in Texas, which we hypothesized would provide some variation in "social license pressures" and in regulatory environment.

Further, to ensure variation in company size and performance, we constructed a stratified sampling frame, based on two variables: (a) company size (as measured by number of trucks) and (b) a rough proxy for company environmental performance. We defined "small" firms as having 7 to 27 trucks, and "large" as having 60 to 450 (although in the trucking industry context, firms with 60-450 trucks could more accurately be characterized as "medium-size enterprises). In Texas, we used average fleet age as an indicator for environmental performance, as the Texas Department of Motor Vehicles was able to provide us with company-level information of truck model year distributions for all firms registered in the state. In California, this state-wide information was not available. Instead, for sampling purposes, we used company safety record as a proxy for environmental performance. We reasoned that safety performance was a reasonable indicator of company *management style* -- a variable that we had found significant, in our prior research, in explaining company-level environmental performance (Gunningham et al, 2003).

In order to ensure that we had variation in environmental performance and size in our sixteen participating companies, we grouped all trucking companies about whom we had data[41] in California and Texas into four types: small/good environmental record; large/good environmental; small/mediocre environmental; large/mediocre environmental). We then identified companies in each group based on location[42] and a name that suggested the company's primary business was transportation. Refusals to cooperate were invariably based on the claim that the relevant company official simply couldn't afford to take time for an interview. [43] Interviews ranged from 1 to 2.5 hours, typically lasting about an hour.

B. Information Sought

Because so many trucking firm choices that affect environmental performance also affect fuel economy, we asked participants how important fuel efficiency was to their company, and asked them to describe specific policies or practices they had put in place in order to improve fuel economy. We asked participants how the company went about buying trucks – what criteria did they consider in making truck purchases? In order to assess general awareness of the trucking industries' environmental and health impacts, we asked participants what they saw as the industry's environmental and health impacts and how they had changed over time. We asked companies about the most important *environmental* regulations they operated under, and the *government regulations* that had the biggest impact on their company. We

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[41] In California, we had limited information on company size, and used federal safety data and or participation in EPA's Smartway program as a proxy for environmental performance. Average performers had safety rankings in the lowest quintile and/or received Carl Moyer funding, or were classified as 'non-compliant' in the Vehicle Complaint and Roadside Inspection dataset. In Texas, we had company-level information for all TX registered fleets, and used information regarding their vehicle age distribution as a proxy for fleet environmental performance.

[42] In California the locations were the Los Angeles Basin and the Central Valley. In Texas, the Houston-Galveston area and the Rio Grande Valley area.

[43] Contacted companies with good safety/environmental records were more likely to agree to participate. For example, in California we were unable to reach 1 of 4 larger and 8 of 15 smaller companies with very good records.. However, the remaining 3 larger companies and 3 of 7 smaller companies agreed to participate. One large and one small company were dropped from the study, the first because we were unable to schedule an interview, and the second because they never provided us with a description of the vehicle fleet. Of 10 larger companies with safety rankings in the *bottom quintile*, 5 could not be reached, 4 refused to participate and 1 agreed to participate. We then turned to California's Vehicle Complaint and Roadside Inspection dataset and generated a list of companies classed as 'non-compliant' during site inspections, or having received Carl Moyer funds. One company could not be reached but the second large company contacted agreed to participate. Of the 11 smaller average performers we tried to recruit, we were unable to reach 4, 5 refused to participate and 2 agreed to participate.

asked about the most important constraints they experienced in improving their environmental performance, and the role (if any) that government subsidies had played in their company. Finally, we asked what role environmental agencies, community groups, and environmental groups had played in the life of the company.

In order to create a more precise estimate of company-level environmental performance, during our interviews with trucking company representatives we obtained data on the age distribution of their truck fleet, the fuel they used (diesel vs. alternative), their maintenance practices, the amount of time their trucks idled, the policies the company had in place to decrease idling times, the miles per years their trucks traveled, the speed at which their trucks were governed (or other policies the company had in place to influence truck speed), and the fuel economy of the fleet.

We also asked companies to rate their own environmental and economic performance on a scale of 1 (worse than average) to 5 (excellent).[44] We asked companies about their prior experience with environmental and safety regulators. We asked for relatively detailed information about the maintenance practices at the company, and technologies the company had considered and/or adopted that would impact fuel efficiency and idling.

***C. Measuring Company-Level Environmental Performance*.**

A trucking firm's NOx and PM emissions are affected not only by the age-distribution of the fleet but also by deterioration in its trucks' emissions systems over time; the quality of its maintenance program; type of fuel used (diesel versus natural gas), the formulation of the diesel fuel it regularly has access to; the average speed at which its trucks travel; the average time its fleet spends cruising the highway versus battling traffic on city streets; the amount of time its trucks, on average, spend idling; and the number of miles its trucks travel. The relationships among these factors are complex. For example, for some model

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[44] All the firms we interviewed were privately-held companies whose financial statements are not available. Hence self-assessment, stated in rough categories, was the best available indicator of firms' financial condition and profitability.

years, a cruising speed of 65 miles per hour will result in increased NOx emissions, and for other model years, a decrease.

Using data obtained from interviews and from California's EMFAC 2007 model[45] , we calculated seven measures of each company's NOx and PM emissions, as described in Appendix A. It became clear that the environmental performance of a company varies tremendously depending on which outcome measure is used. One firm, for example, ranked last on five of the seven measures, yet it ranked third best in terms of on-road NOx emissions (because of its ultra-modern fleet, i.e., vehicles model year 2005 or newer). Since we could not find a rational way of *weighting* each outcome measure in order to create an aggregate scale, we concluded any summary measure of firm-level environmental performance would be misleading. Instead, we decided to focus on the underlying technological and operational "drivers" of better environmental performance in heavy-duty diesel trucks and the extent to which those factors explained variation in the environmental performance of our study participants (using a variety of measures of environmental performance).

D. Drivers of Company-Level Environmental Performance

In broad terms, a trucking company confronts five basic "drivers" of environmental performance:

a. The type of *fuel* used. Heavy-duty trucks fueled by liquid or compressed natural gas have lower emissions than their diesel-fueled counterparts. Specially formulated diesel fuels, while more costly, can lower emissions in diesel trucks. In California, these special formulations of diesel fuel have been available statewide. In Texas, special formulations are available in some limited areas, but most truck companies avoid paying for the more expensive fuel.

b. The *age-distribution* of the vehicle fleet. Due to increasingly demanding emissions standards for new engines, the more modern a company's fleet (all other things being equal), the lower its emissions.

c. Careful *maintenance* of both engine and emissions control systems. Parts wear over time and distance and start to perform less well unless adequately maintained.

d. Management of the *speed* at which fleet vehicles travel on the highway. For most model years, speeds in excess of 60 mph increase emissions, while speeds between 20 mph and 60 miles per

[45] EMFAC is the EMission FACtors model developed by California's Air Resources Board and used to calculate emissiosn rates from on-road heavy duty trucks that operate on highways, freeways and local roads in California. EMFAC 2007 is the most recent version of this model.

hour decrease emissions. A company can control its trucks' speed by electronically governing the engine, or through effective policies that influence driver behavior.

e. The amount of time a company's truck spends *idling*, either in traffic, waiting to load or unload, or when the driver is resting or sleeping. A firm can decrease idling emissions several ways: through use of alternative power units (that is, not using the truck's large diesel engine to run the radio and air conditioning); by connecting to electrical units at truck stops where they are available (no retrofit required); by retrofitting the truck so that it uses electric power from the truck stop; by paying truck-drivers to use motels rather than sleeper carriages; by setting engine controls to automatically turn off the engine after a set amount of time idling; or by having effective policies in place to encourage drivers to decrease idling.

Table 1: Factors Affecting NOx and PM emissions and Environmental Performance

Company ID and nickname	Avg Rank for Env Per	Environmental Performance Drivers								Company Characteristics	
		Alte Fuel	Exc Maint	State	Pct 1997-	Pct 2003+	Hwy Speed	Idle Time	Miles per year	Fleet Size	Company Econ Perf
10 Tulane	3.38	NO	Exc	CA	1%	56%	58	Low	Avg	363	I: Excellent
13 Nurse	5.88	NO	Avg	CA	0%	93%	60	Low	Low	44	2: Doing Well
02 Police	6.25	NO	Avg	TX	0%	50%	***70***	Low	Low	193	I: Excellent
16 Alternative*	6.50	YES	Exc	CA	***17%***	60%	***65***	***High***	Low	65	3: Managing
01 Computer	6.75	NO	Avg	TX	***76%***	24%	***65***	Low	V. low	85	4: Strained
05 Buttoned	7.63	NO	Exc	TX	***49%***	28%	62	Low	Avg	134	I: Excellent
06 Security	8.75	NO	Avg	TX	0%	100%	***65***	***High***	Avg	150	I: Excellent
15 Fairgrav	8.75	NO	Avg	CA	***42%***	8%	***65***	Low	V.Low	24	5: Bad
04 Weekly	9.63	NO	Exc	TX	0%	27%	***72***	***High***	Avg	70	I: Excellent
14 OBM	9.88	NO	Avg	CA	***71%***	***0%***	35	***High***	Low	266	I: Excellent
11 Acombo	10.13	NO	Avg	CA	***14%***	***0%***	***65***	Low	Low	7	I: Excellent
07 Almost	10.63	NO	Avg	TX	9%	43%	***70***	***High***	Avg	112	2: Doing Well
09 Lunch	10.63	NO	Exc	CA	***29%***	***0%***	60	***High***	Avg	27	3: Managing
03 Cross	11.00	NO	Exc	TX	0%	100%	***70***	***High***	***High***	11	2: Doing Well
17 Phone	12.00	NO	Avg	CA	***30%***	***0%***	***65***	Low	Avg	10	3: Managing
08 Struggling	13.13	NO	Avg	TX	0%	100%	***70***	***High***	***High***	10	5: Bad

*Numbers reported reflect diesel portion of fleet only

Table 1 shows each participating company's rank for environmental performance, averaging its rank on the seven measures described in Appendix A. The table also shows each company's score with respect to each of the "drivers" of environmental performance mentioned above. "Driver" ratings associated with lower emissions are shaded. "Driver" ratings associated with worse environmental performance are written in ***bold and italic***. Company fleet size and economic performance self-ratings are also provided.

Only one participating company (16, nicknamed Alternative) used any alternatively fueled heavy duty trucks. The *maintenance* program of a company was rated excellent or average. A company's maintenance program was rated excellent if preventative maintenance programs were highly emphasized, if maintenance procedures above and beyond those required for warranty purposes were described, and if companies saw excellent maintenance as an integral part of doing business. The *state* in which the company is registered is shown as California or Texas. All miles for a California company were assumed to use California fuel formulations, and hence entail lower emissions. The *speed* trucks are governed, or the speed at which they cruise on the highways, is also reported. The percent of time spent at highway speeds was assumed to differ for the long haul and short haul portion of the business. Long haul trips were assumed to spend 80% of their miles at highway speed, while short haul vehicles were assumed to spend 50% of their miles at highway speed. *Idling* is described as low (10 hours per week or less) or high (25 hours per week or more). The number of miles traveled per truck per year is described as average (100,000 miles), low or high.

As already mentioned, because of the complex interaction between these factors, no single factor is clearly related to the average environmental rank of a company, and average environmental rank is a dubious measure of overall environmental performance. However, it is clear that as we move down the average rankings, more negative scores and fewer positive scores can be seen in the table.

In the remainder of this paper we will show that state level policies impact all drivers of environmental performance, but less profoundly than does the firms' economic license. That is, economic incentives drive the choice of alternative vs. diesel fuel,[46] the age-distribution of the fleet, maintenance practices (to a limited extent), highway speed, and idling (again to a limited

[46] The choice of diesel fuel formulation is both a regulatory license and economic license issue.

extent). Each company employs a complex mix of technologies and policies that influence its environmental performance, and economic factors are front and center in making those choices. But state-level policies also have some impact.

E. The impact of States on company-level environmental performance.

State policies can impact all the drivers of environmental performance described above. State law determines the availability and environmental characteristics of both alternative fuels and specialty diesel formulations. California's low sulfur diesel formulation was available earlier and more widely, and has a greater environmental impact than the federal low sulfur diesel formulation used in Texas. Trucking companies also are impacted by state laws unrelated to environmental protection: labor laws, workers compensation costs and requirements, vehicle registration fees, etc –all of which are more demanding in California. The resulting higher cost of doing business in California might have slowed down turnover of the California fleet, which, as noted above, is older than the Texas-registered truck fleet. California also has more restrictive speed limits than Texas.[47] This as well as economic considerations (e.g. higher fuel costs) may help explain why the average governing speed of the California firms in our sample is considerably lower than for our Texas companies – which should have an emission-reducing

[47] The maximum speed limit on most California highways for passengers vehicles is 65 mph, and for trucks is 55 mph. Trucks are also restricted to the rightmost lane(s) of a highway. Texas highway speed limits are the same for trucks and passenger vehicles, but vary by time of day 70 mph daytime and 65 mph nighttime. In counties with population densities of less than 10 people per square mile, daytime speed limits are 75 miles per hour.This may have affected the choice of governing speed. Similarly, California, unlike Texas, requires all truck fleets in California to perform an annual check of each truck's smoke emissions (visible PM) and conducts periodic roadside inspections of smoke emissions. While this program identifies *badly* maintained trucks, it does not require the kind of excellent maintenance that reduces deterioration in truck engine performance, and we find in our participating sample that half the companies with excellent performance are located in California and half in Texas.

effect for California firms. Finally, the state of California also has anti-idling regulations in place but their impact thus far appears limited.[48]

All in all, however,our interviews and company-level data suggest that state of registration and the aggressiveness of state environmental regulation have a relatively small effect – compared to the market-based factors discussed below – in shaping the environmental performance of the firms in our sample.

F. Economic License and the Drivers of Environmental Performance

Economic license pressures appear to operate on three levels: (a) the general market – how well the economy is doing, the price of fuel, the price of labor where the company operates; (b) the particular firm's market niche – the kinds of goods are being hauled, how far they are being hauled, day-to-day decisions designed to decrease costs and meet specific customer demands and (c) company-level financial condition. The choices made by a company regarding drivers of environmental performance are a mixture of these, but different choices tend to be dominated by one level.

1. Economic License Pressures and Fuel Choice. Only one company participating in our study (nicknamed "Alternative") used alternatively fueled heavy duty trucks. Another (Tulane) had seriously looked into the idea,[49] but all other companies had quickly dismissed the prospect as economically infeasible. Alternative's owner, however, had been approached by a

[48] For example, trucks in California may not idle for more than 5 minutes. However, until November 2006 (after our data collection ended) there was an exemption from this requirement for sleeper trucks when drivers were resting or sleeping, as long as the truck was not idling near a school or residences. This exemption has meant that companies in our sample with longer hauls in California have high levels of idling, despite the regulation.

[49] Tulane decided not to purchase alternative fuel trucks because of problems with the availability of fueling stations and the weight they could haul for longer distances if they had to carry more fuel. They also felt there would be issues with the longevity of the alternative trucks.

government/environment consortium that was trying to increase the number of alternative fueling stations available in California. The owner's environmental beliefs and the venture's potential profitability led him to invest not only in alternatively fueled trucks but also to build an on-site fueling station, since the consortium funded 50% of the station. After the initial investment, however, natural gas prices have increased more than diesel fuel prices. In addition, truck manufacturing companies have stopped making heavy duty alternative-fuel truck engines, as their engineering resources have gone towards meeting the new diesel engine standards and towards the larger alternative-fuel bus market, Hence "Alternative" has been unable to update its alternative fleet of trucks, although it remains committed to the technology.

In terms of diesel fuel formulation, all companies bought the cheapest fuel it was legal for them to purchase. Thus California companies bought California diesel and Texas companies bought Texas diesel. Companies made use of software that allowed them to identify fuel stations with the cheapest fuel and required their drivers to purchase fuel at these stations. So the limited distribution of cleaner diesel fuel formulations in Texas meant that for our participating companies, the use of California fuel formulations was minimal. None of our participating Texas companies had made use of Texas' incentive program to subsidize the cost of buying diesel fuel. Thus whereas regulatory factors determined the distribution of cleaner diesel fuel formulations -- statewide in California and in very limited distribution in Texas -- .economic license pressures led companies to avoid the more expensive, cleaner diesel whenever it was feasible and legal to do so.

2. Economic License Pressures (Market Niche) and Fleet Age Distribution. The age distribution of trucking companies' fleets is dominated by the market niche in which the company operates. Most important, in that regard, is whether it regularly participates in the long-haul market, in which its trucks have long absences from home terminals, or whether the firm is engaged in transportation of particularly delicate goods which would deteriorate if the trucks experienced en-route breakdowns. Off-site breakdowns are extremely expensive for trucking companies, because the load still has to be taken care of, the truck hauled, and non-contract (and therefore expensive) maintenance services employed. Consequently, if its trucks are off-site 95% of its operating time, a company has strong economic incentives to buy new trucks. Table 2 shows the relationship between market niche (percent long-haul, delicate goods or not) and average age of fleet for the 16 companies we studied. The table below is sorted by percent of the fleet model year 2003 or newer.

Table 2: Fleet Age Distribution and Company Market Niche

ID	Fleet Age Distribution			Pct trips long haul	Length of long trips (days)	Delicate Load	Idle	Explanation of Fleet Age Distribution
	Pct 1997-	Pct 98-02	Pct 2003+					
03 Cross	0%	0%	100%	99	14	No	High	Trip length
06 Security	0%	0%	100%	97	14	No	High	Trip length
08 Struggling	0%	0%	100%	100	14	No	High	Trip length
13 Nurse	0%	7%	93%	30	1	Yes	Low	**Delicate** Goods
16 Alternative	17%	29%	60%	25	1	Yes	High	Mostly short haul for older vehicles. **Delicate** goods for longer hauls.
10 Tulane	1%	44%	56%	25	1	Yes	Low	**Delicate** goods. Extremely vigilant maintenance to extend reliable life of trucks.
02 Police	0%	50%	50%	50	14	No	Low	Long haul portion is new vehicles.
07 Almost	9%	50%	43%	100	7	No	High	Shorter trips, trucks don't need to be as new.
05 Buttoned	49%	28%	28%	0	0	No	Low	Short haul only
04 Weekly	0%	73%	27%	90	7	No	High	Shorter trips, trucks don't need to be as new.
01 Computer	76%	0%	24%	6	1	No	Low	New trucks purchased with government **incentive funds**.
15 Fairgrav	42%	58%	8%	0	0	No	Low	Short haul only
09 lunch	29%	71%	0%	80	3	Yes	High	Shorter trips, very careful maintenance.
11 Acombo	14%	86%	0%	25	1	No	Low	Trips short
14 OBM	71%	36%	0%	15	1	No	High	Short haul (port work)
17 Phone	30%	70%	0%	10	1	No	Low	Short haul, short trip lengths

For example, companies “Cross” and “Struggling” deliver goods all over the 48 contiguous states. Annual average mileage per truck for both companies is well over 100,000 miles per year. Delivery routes typically extend over two weeks before the truck returns to a home base. Cross described its economic performance as excellent (“doing very well”) while Struggling described its economic situation as “struggling.” Yet both these companies have very new fleets -- all trucks no older than a 2003 model year. The same is true for a larger company, “Security.” Long-haul companies Almost and Weekly have shorter trips, with more frequent returns to base for maintenance and repair, and can thus afford to have less modern (2003 or newer) fleets, but essentially have no very old trucks in their fleets. Only Lunch kept very old trucks in its fleet despite hauling delicate loads over long distances. They managed this by limiting the distance traveled (3-day trips rather than 14-week trips), by choosing very carefully which second hand trucks they bought, and by developing an extremely aggressive maintenance program (the company owner is a diesel mechanic and owns a diesel maintenance shop as a separate enterprise).

Company “Nurse” has a very modern fleet, despite its very limited long haul market niche, because it transports goods that are perishable, temperature sensitive and delicate; a breakdown, even near to home, could erase the value of an entire load. A similar story can be told for companies Alternative and Tulane. Tulane’s fleet is somewhat older, however, because it claims to have extended its vehicles’ reliability to 5 or 6 years by developing an *extremely* vigilant preventive maintenance program.

In general, however, companies in our sample with shorter routes and daily returns to base purchased used vehicles to avoid the capital cost of new trucks. The major exception here was

Acombo, a small short-haul company that generally bought new trucks and turned them over every five or six years, simply because its owners could afford to do it[50].

3. Economic License and Idling. While longer trips drive trucking companies toward quicker vehicle turnover and newer vehicles, longer trips also push long-haul companies to longer idling times, as drivers sleep in the tractors at night and keep the engine idling to power air conditioning, heating, television, and other accessories. In addition, safety regulations require drivers to rest after specified numbers of hours on the road, and during such rest times engines are often left to idle. At some locations, drivers can turn off the engine and use alternative power systems (such as IdleAire's) that can be attached to the cab. Auxiliary power units can also installed in the truck, but these units add weight (and maintenance hassles) which some companies find problematic.[51]

Table 2 above indicates that length of trip in days is associated with higher idling (and hence higher emissions). But there are some notable exceptions. Company "Police" has low idling numbers despite the fact that 50% of their trips are long (14 day) haul, due to a series of company-wide policies. First, they have a pre-paid subscription for a network of truck stops that provide high speed internet, phone, television, AC and heating for $23/day. Second, company Police installed alternative power units in a number of their trucks because they deliver in California (where lengthy idling from the main engine was about to be (Nov 2006) outlawed).[52]

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[50] Acombo's scores on Table 2 do not quite reflect their strategy of frequently buying new trucks; purchases recently had been delayed because their preferred configuration of vehicle was no longer being produced.

[51] At the end of 2006, after our interviews were completed, a new regulation came into force in California forbidding trucks to idle the truck engine for more than 5 minutes at a time. Long haul trucks in the state are now mandated to make use of some other technology.

[52] Lunch, a small California company whose market niche is long-haul (albeit shortish trips), has fewer economic resources than Police. (Lunch's owner described his company as 'managing' whereas Police's self-described economic condition was 'excellent'). Lunch had decided that alternative power units would pay for themselves within 18 months, but could not afford the capital cost of installation. *Thus here another aspect of economic license pressures (profitability, rather than market niche) shaped environmental performance*. Similarly, other companies

Two other exceptions to the long haul-high idle story were short haul companies with high idling scores. In one case, the exception is explicable in terms of market niche. Company OBM works with a fleet of owner-operators hauling containers from the Ports of Los Angeles and Long Beach to local warehouses – which entails long waits getting into and out of the ports to pick up loads. The other exception, Alternative, provided no real explanation for its exceptionally high idling level.

4: Economic License and Maintenance Practices, Highway Speeds, and Fuel Economy. All companies in our study had preventive maintenance programs in place. Good maintenance improved fuel efficiency, reliability, and avoided costly break-downs, and could reportedly extend the reliable life of a truck. It also reduces harmful emissions. But that was not the salient goal of firms that had excellent preventive maintenance programs. Firms such as Tulane, Alternative, Buttoned, Weekly, and Lunch with excellent programs [53] (see Table 1) viewed maintenance as the key to their economic success because of its impact on fuel economy. In addition, for Tulane, Weekly, and Lunch, excellent maintenance allowed them to avoid the capital cost of new trucks -- for Tulane, by extending the reliable life of their vehicles, and for Weekly and Lunch, by allowing them to use older trucks for longer hauls. For Cross, maintenance was critical for maintaining customer satisfaction by helping ensure on-time delivery in a market niche that required extremely long hauls and heavy loads.

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had looked into subscription services but had not found sufficient availability on their routes to make it economically viable.

[53] This can be more difficult than it appears at face value, as scheduling a truck so that it is at a home terminal when it needs routine maintenance can be difficult, and the logistics of scheduling become more complicated the greater the fleet's size. For owner-operators maintenance could become a difficult dilemma as maintenance represented not only the cost of maintenance itself, but also the opportunity cost of not being on the road.

Similarly, for most companies that had governing systems to ensure lower highway speeds, the goal was not to improve environmental emissions (which lower speeds do produce) , but to improve fuel economy. Indeed, for some companies, on-time delivery was more important to the company than the added fuel savings, and in those cases, vehicles were governed at higher speeds. Fuel costs in California are considerably higher than in Texas. The average price of diesel in 2006 was $2.92 in California and $2.64 in the Gulf Coast. Not surprisingly, governing speeds in California were lower than in Texas, and lowest among those with excellent maintenance program.[54]

In general, the fuel economy of California participants was considerably better than that of our Texas participants (see Table 3 below). Only one Texas firm (Weekly) had a fuel economy that exceeded 6 mpg whereas five California companies met or exceeded this value. Interestingly, when we calculated the average transportation cost ($ per mile) for our Texas and California companies,[55] we found that transportation costs were almost identical (49c in California v. 48c in Texas). It seems likely that the higher market price of diesel in California induces California companies to work harder to improve their fuel efficiency again, therefore, economic pressure, not regulation, shapes environmental outcomes.[56]

[54] OBM has such a low highway speed because its vehicles are engaged in drayage work at the Ports of Los Angeles and Long Beach and most of their time is spent on the congested LA highways at lower speeds.
[55] Transportation Cost (dollars per mile) = Avg. Diesel price in 2006 ($/gallon) / Average fuel economy for participants from that state (miles/gallon). For California: 2.92/6.0 = 0.49 $/mile. For Texas: 2.64/5.5 = 0.48 $/mile.
[56] While the similar economic incentives applied to all companies – improved maintenance improves fuel economy, lower speeds improves fuel economy, other economic factors sometimes trumped these. In other cases, companies did not have the management or technical sophistication to implement these programs.

Table 3: Fuel Economy for Texas and California Participants

TX	01 Computer	02 Police	03 Cross	04 Weekly	05 Buttoned[57]	06 Security	07 Almost	08 Struggling	State Average
MPG	5.8	5.8	5.3	6.3	5.5	5.5	5.5	4.5	5.5
CA	09 Lunch	10 Tulane	11 Acombo	13 Nurse	14 OBM	15 Fairgrav	16 Alternative	17 Phone	State Averge
MPG	6.0	7.2	6.0	6.5	5.5	5.5	6.0	5.0	6.0

G. The Effect of Size and Profitability on Environmental Performance

In our sample, all the larger companies – those with more than 100 vehicles -- described their economic performance as 'Doing Well' or "Excellent." Only half the companies with fewer than 100 trucks made the same claim.[58] Larger companies tend to have a higher proportion of modern (2003+) vehicles than do smaller companies. Two notable exceptions were Cross and Struggling, two very small companies engaged in nationwide, long-long-haul transportation. It appears, therefore, that size is an important factor in enabling companies to acquire the capital necessary to turn over their fleets –and thereby reduce emissions.. Fleet size and economic performance do *not* appear to be related to highway speed, mileage, idle time, nor maintenance practices.

III. Conclusion

In conclusion, we have shown that firms' economic license factors affect firm performance with respect to all of the major technological and operational drivers of lower emissions -- and thus the firm's overall environmental performance -- in profound ways. That is, in the absence of direct "best technology" regulatory demands and intense social scrutiny, economic incentives

[57] Buttoned had an excellent maintenance program resulted in average fuel economy in the state despite its very old fleet.
[58] However the relationship between size and economic performance for smaller companies is complicated. Acombo, with 7 trucks rated its performance as 'excellent' while Struggling, with 10 trucks, rated its economic performance as "bad."

drive the choice of alternative vs. diesel fuel, the age-distribution of the fleet, maintenance practices, highway speed, and controls on idling. Economic license pressures operate on three levels: (a) the general market – how well the economy is doing, the price of fuel, the price of labor where the company operates; (b) the particular firm's market niche – the kinds of goods are being hauled, and how far they are being hauled; and (c) company-level financial condition. Each company employs a complex mix of technologies and policies that influence its environmental performance, but it is the economic license variables that are front and center in shaping those choices.

At an aggregate level, even in a 'green' state like California, regulators and politicians have only recently begun to consider direct regulations requiring private trucking companies -- by far the largest source of harmful NOx and PM emissions -- to rapidly phase out older, more polluting diesel trucks or engines. The reason we speculate, again is an economic one: the staggering cost of retrofitting or replacing the entire diesel fleet, destroying the residual economic value of old trucks.[59] That is why, we believe, both federal and state regulators have tended to postpone direct confrontation of diesel emissions from older private truck fleets, focusing on incentive programs that can have at best a marginal impact, by focusing on new vehicle emissions standards while ignoring how long diesel trucks are kept in operation, and by putting off requiring trucks to install best available control technologies.

In California, the environmental impacts of trucks can no longer be ignored, as the state is almost entirely in non-attainment for ozone, and has two extreme non-attainment ozone areas. In addition, California's toxics legislation has made reducing diesel emissions a policy priority. In the next two years, therefore, California regulators must confront the reality of getting someone

[59] In June 2007, www.truckpaper.com was advertising a 1974 model year truck for $45,000, a 1977 model year truck for 20,000, and a 1981 model year truck for $47,500 in California; and a 1977 model year truck for $14,000, a 1979 model year truck for $18,500 and a 1981 model year truck for $17,500 dollars.

to pay for modernization of its diesel truck fleet. Rules requiring companies to retrofit or replace their older, more polluting trucks are expected to be passed in late 2007 and early 2008. Moreover,in the next year or two, the Clean Air Action Plan of the Ports of Long Beach and Los Angeles is supposed to come into effect, requiring trucks that serve the port (generally the oldest trucks in the state's fleet) to replace or retrofit older vehicles. These direct regulations, if fully implemented, would dramatically change the age-distribution (and perhaps the size) of the California fleet. But it remains to be seen whether regulators and politicians will be able to resist compromise, as thousands of marginally- capitalized small trucking companies are faced with potentially insurmountable compliance costs.

Appendix A

Using data obtained from interviews and from California's EMFAC 2007 model, we calculated seven measures of each company's environmental performance. EMFAC is the EMission FACtors model developed by California's Air Resources Board and used to calculate emissiosn rates from on-road heavy duty trucks that operate on highways, freeways and local roads in California. EMFAC 2007 is the most recent version of this model. From EMFAC 2007 documentation, we obtained the following estimates:

- Zero-mile (new vehicle) emissions rates in grams per mile for each model year
- Deterioration rates over time – the amount of additional grams/mile emitted for each 10,000 miles added to the engine
- The influence of fuel formulation on emissions rates
- The influence of highway speed on emissions rates for each model year
- Idle emissions rates in grams per hour

We assumed that a truck spent 80% of its miles at highway speeds for long-haul trips, and 50% of its time at highway speeds for short haul trips.

Measures of environmental performance with respect to ***both NOx and PM*** emissions:

1. On-road average emissions (gram/mile) for all the company's trucks is largely measure of how close to BACT the fleet is, but takes into account the formulation of fuel used, deterioration rates (with lower rates for excellent maintenance), and highway speed.

2. Total emissions per truck (on-road average g/mile x average miles per year + idling emissions) takes into account the average miles traveled per truck per year and total emissions from idling each year. Because miles traveled varied from 16,000 miles per year to 145,000 miles per year, any company with high annual mileage is heavily penalized by this measure of environmental performance. And since the purpose of a trucking company is to deliver goods, which for some companies entails traveling long distances, it seemed an inappropriate comparative measure of environmental performance.

3. Total emissions per truck for a 100,000 mile year (on-road average g/mile x 100,000 miles per year + idling emissions) compares environmental performance for a standardized annual mileage, so that long-haul companies with have average annual mileage are not penalized in the performance measure.

The final measure of environmental performance used was ***fuel economy***, which can be thought of as a proxy for carbon dioxide (a greenhouse gas) emissions. These results are shown in Table A below. We also noted whether a fleet had any alternatively-fueled vehicles. The precise description of the calculations is given below Table A. The rank of each company for each outcome measure is given (best performer=1, worst performer=16) is shown in the table. The table is sorted by the average rank. As can be seen in Table 1, there is tremendous variation at a company level in environmental impact: the best environmental performers can have emissions 10 times lower for NOx (per 100,000 miles) and 70 times lower for PM (per 100,000 miles) than the worst environmental performers. And the best fuel economy is 1.6 times better than the worst fuel economy.

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Table A: Environmental Performance

	Avg Rank	Total NOx	Total PM	Total NOx (100K)	Total PM (100K)	Fuel econ	On-road NOx	On-road PM	Rank Total NOx	Rank Total PM	Rank NOx (100K)	Rank PM (100K)	Rank Fuel econ	Rank Road NOx	Rank Road PM	Rank Alt Fuel
10 Tulane	3.38	52,283	3,434	52,283	3,434	7.20	13.49	9.99	3	1	2	1	1	5	2	12
13 Nurse	5.88	115,126	16,954	122,435	23,692	6.50	10.72	9.88	6	7	6	9	2	4	1	12
02 Police	6.25	48,945	6,629	52,325	10,469	5.77	16.73	19.00	2	3	3	2	7	7	14	12
16 Alternative*	6.50	324,427	19,735	327,551	22,390	6.00	13.54	11.51	11	8	11	7	4	6	4	1
01 Computer	6.75	9,950	3,630	28,367	21,719	5.75	18.64	18.30	1	2	1	6	8	11	13	12
05 Buttoned	7.63	57,939	13,517	57,939	13,517	5.48	17.68	16.69	5	4	4	3	13	8	12	12
06 Security	8.75	498,081	15,781	498,081	15,781	5.50	10.35	14.61	15	5	15	4	10	1	8	12
15 Fairgrav	8.75	55,390	20,870	107,024	58,580	5.50	19.06	13.92	4	9	5	11	10	13	6	12
04 Weekly	9.63	267,235	33,269	267,235	33,269	6.25	18.24	20.73	9	11	8	10	3	9	15	12
14 OBM	9.88	432,931	16,510	434,751	17,627	5.50	21.05	12.92	13	6	13	5	10	15	5	12
11 Acombo	10.13	197,759	132,813	303,676	207,427	6.00	20.60	14.51	7	12	9	16	4	14	7	12
07 Almost	10.63	323,625	23,330	323,625	23,330	5.52	18.46	20.81	10	10	10	8	9	10	16	12
09 Lunch	10.63	474,276	159,438	474,276	159,438	6.00	18.80	10.94	14	13	14	13	4	12	3	12
03 Cross	11.00	422,935	203,191	389,692	151,452	5.25	10.45	16.26	12	15	12	12	14	2	9	12
17 Phone	12.00	223,988	162,845	223,988	162,845	5.00	21.94	16.27	8	14	7	14	15	16	10	12
08 Struggling	13.13	643,690	243,782	596,360	170,000	4.50	10.52	16.40	16	16	16	15	16	3	11	12

*Numbers reported reflect only the diesel portion of the fleet (about a third of the fleet is alternatively fueled).

Average rank includes the alternative fuel rank.

As we move down the table there are fewer firm's with rankings in the top five for any environmental performance measure.

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