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Competition and Illicit Quality

Victor Manuel Bennett
Lamar Pierce
Jason A. Snyder
Michael W. Toffel

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Victor Manuel Bennett
University of Southern California

Lamar Pierce
Washington University in St. Louis

Jason A. Snyder
University of California, Los Angeles

Michael W. Toffel
Harvard Business School

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Competition among firms can have many positive outcomes, including low prices and high quality. Yet competition can have a darker side when firms gain competitive advantage through illicit and corrupt activities. In this paper, we argue that competition can lead organizations to provide illicit quality that satisfies customer demand but violates laws and regulations and that this outcome is particularly likely when price competition is restricted. Using 28 million vehicle emissions tests from more than 11,000 facilities, we show that increased competition is associated with greater inspection leniency, a form of illicit quality that customers value but is illegal and socially costly. Firms with more local competitors pass customers at considerably higher rates and are more likely to lose customers whom they do not pass, suggesting that the alternatives that competition provides to customers intensify the pressure on facilities to illegally provide leniency. We also show that, at least in contexts in which pricing is restricted, firms use illicit quality as an entry strategy.

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Competition and Illicit Quality

1. Introduction

Competition among firms produces many positive societal outcomes, including lower prices, higher productivity, and greater consumer surplus (Bresnahan and Reiss 1991, Syverson 2004). In contrast, market concentration is typically viewed with suspicion for eliciting higher prices, sluggish innovation, corruption, and discrimination (Blundell et al. 1999, Aghion et al. 2005, Ades and Di Tella 1999, Zitzewitz 2012). Despite the primary focus in economics being on competition's impact on price (e.g., Bresnahan and Reiss 1991, Dafny et al. 2011), one of the major benefits of competition is increased quality of goods and services (Spence 1975, Schmalensee 1979). Under intense competition, firms risk losing customers when quality is low on dimensions such as retail inventory (Olivares and Cachon 2009, Matsa 2011), convenience (Buell et al. 2011), product features and attributes (Shaked and Sutton 1982), health outcomes (Gaynor 2006), and timely delivery (Mazzeo 2003). The higher quality associated with competition is certainly better for the customers who receive it, but can competition sometimes yield higher quality to customers in ways that are socially costly or even illegal?

In this paper, we demonstrate that it can. We focus on circumstances in which customers encourage firms to engage in illicit activities that are socially harmful and often illegal, but nevertheless represent quality increases to the customer because they increase utility, willingness to pay, and ultimately demand.[1] In a competitive market structure, firms may feel compelled to comply with customer requests for illicit quality if they anticipate rivals' willingness to meet this demand. When the government is unable to adequately monitor and enforce laws and regulations, competitive pressure can drive firms to match one another's illicit strategies in a "race to the bottom." Recent theory by Schleifer (2004), Drugov (2010), and Bolton et al. (2011) suggests that such customer pressure for illicit quality may create a situation in which monopolies yield lower corruption and more socially efficient outcomes than duopolies do.

We study the impact of competition on the provision of illicit quality in the vehicle emissions testing market. While some states directly test passenger vehicles to enforce emissions standards, most outsource this practice to private firms under the justification of better service, lower costs, and more consumer choice. While the benefits of this outsourced system may be real, it creates a design similar to three-tiered agency models in economics (Tirole 1986), in which the principal (state) hires a supervisor (facility) to monitor the behavior of the agent (vehicle owner). The implication of these models is that the agent may engage in a side-contract with the supervisor charged with monitoring him in order to receive lenient

[1] This definition of quality is consistent with a well-established literature from economics (Griliches 1971, Leffler 1982), marketing (Parasuraman et al. 1985), and operations (Garvin 1984).

supervision, an arrangement known to increase fraud in financial auditing (Khalil and Lawaree 2006). In our setting, the government-licensed facilities trade the "high-quality service" of a passing result (regardless of actual emissions) for the side payment of a valuable future stream of service and repair business worth thousands of dollars per year.[2] The California Bureau of Automotive Repair (BAR) notes that "it appears, based on BAR enforcement cases, that some stations improperly pass vehicles to garner more consumer loyalty for delivering to consumers what they want: a passing Smog Check result" (California Bureau of Automotive Repair 2011: 22). When competition provides multiple options, customers may seek the facility that will provide the most leniency, a process referred to in the accounting literature as "audit shopping" (e.g., Davidson et al. 2006).

Using 28,001,355 emissions tests from 11,423 facilities in New York State, we show that increased facility density, defined as the number of facilities operating in the same market, is associated with higher pass rates. We demonstrate that these higher pass rates are very unlikely to be explained by vehicle differences and show that facilities significantly increase leniency only in the presence of a greater number of proximate facilities that are truly competitors capable of stealing customers. We exploit a discontinuity in testing policy to show that competition produces significantly more illicit leniency for those cars for which test results are easiest to manipulate.

We also explore how firm heterogeneity moderates the effect of competition on fraud. Our paper finds two important sources of heterogeneity. First, we show that new entrants, facing limited customer bases and low survival odds, are more likely than incumbents to be lenient in the face of competition. The entrants lead "the race to the bottom" rather than following the lead of the incumbents. These results, consistent with recent theory by Branco and Villas-Boas (2011), suggest that entry, much like competition among incumbents, may produce deleterious results when firms can skirt rules and regulations. Our findings also suggest that free entry may sometimes have negative consequences for market and social outcomes. We show that violating laws or regulations may function as a viable entry strategy, particularly when traditional strategies such as introductory pricing are restricted. Second, we find that client composition significantly affects a firm's response to intensified competition. Facilities that serve customers who are less likely to leave are less likely to increase leniency in response to competition.

New York State's substantial variation in population density also allows us to explore two critical issues in the literature on competition and market outcomes. Similar to Bresnahan and Reiss (1991), we estimate the marginal effect of additional competitors on illicit quality, finding a decreasing marginal

[2] While the vast majority of testing facilities are service/repair shops, others include dealers and gas stations, many of which also provide service and repairs. See Hubbard (2002) and Pierce and Toffel (2012) for a description of these organizational types.

impact of additional competitors. Unlike those authors' work, however, our paper demonstrates the marginal impact of competition on illicit quality when prices are fixed. Consistent with Olivares and Cachon's (2009) study of car dealer inventory, illicit quality in our market is impacted beyond the third competitor, with the marginal impact being positive up to the sixth competitor. We also complement Syverson's (2004) study of competition and productivity by exploring how competition changes the distribution of leniency in the market. As in his work, we find that competition has the biggest impact at the tails of the distribution, reducing the number of firms providing low levels of illicit quality.

This paper is the first to our knowledge to empirically demonstrate that increased competition can motivate firms to provide illicit quality to avoid losing business. Although Snyder (2010) shows a relationship between competition and dishonesty, the actions of the nonprofit liver-transplant centers he studies are not illegal and have little impact on social welfare. Similarly, Becker and Milbourn (2011) identify inflated credit ratings that, while costly, are not explicitly illegal. Furthermore, our research is the first to empirically validate recent models by Drugov (2010) and Bolton et al. (2011) that explain how markets with information manipulation by intermediaries might enjoy greater efficiency under monopoly structures. These results suggest that firms seeking to enforce legal and ethical conduct among managers and employees must be especially vigilant when there is tough competition. Similarly, creating internal competition with high-powered incentives could increase employees' tendency to use illicit means. Our results also suggest that increased competition within markets may encourage competitors to cross legal boundaries in ways that threaten the profits of the legally compliant firm. In the absence of effective monitoring by government institutions, firms may benefit from privately monitoring their competitors' behavior to ensure that rivals do not maintain a competitive advantage through illicit actions. Our results also suggest that policy makers must carefully consider the optimal market structure for industries in which illicit actions yield cost reductions or are demanded by customers. While competition may yield lower prices and better choice for customers, it may also bring the increased social costs of illegal behavior by firms.

2. Literature and Theory

While a large theoretical literature in economics has examined how market structure and entry might impact quality choices by firms (e.g., Spence 1975, Schmalensee 1979, Gans 2002), empirical work has yielded mixed results. Berry and Waldfogel (2010) find that larger markets feature higher-quality newspapers and more high-quality restaurants per capita. Research results on the relationship between competition and service quality (when measured by greater inventory) have been mixed. Whereas greater competition is associated with higher inventory levels among new car dealers and supermarkets (Matsa

2011, Olivares and Cachon 2009), the opposite effect is found among factories and retailers (Amihud and Mendelson 1989, Guar et al. 2005).

A few studies have explored why competition might increase illegal or unethical behavior by firms. This literature explains that while there are costs to unethical behavior from potential sanctions and reputation losses (Weigelt and Camerer 1988), illicit strategies may yield real gains. Shleifer (2004) suggested that competition in developing countries forces firms to compete by bribing government officials. Staw and Szwajkoski (1975) similarly argue that scarcity in market environments leads firms toward illegal activities, a correlation they find across a broad sample of corporations. In a more targeted study, Cai and Lin (2009) link competition with tax avoidance by Chinese manufacturers. Edelman and Larkin (2009) find similar results among university professors who fraudulently download their own papers when faced with internal competition and comparison with colleagues. Similar results linking competition to unethical behavior have been generated in laboratory experiments (Hegarty and Sims 1978, Schwieren and Weichselbaumer 2010; Kilduff et al. 2012) and examined in case studies (Kulik, O'Fallon, and Salimath 2008). More recently, Branco and Villas-Boas (2011) have formally modeled this link under quantity competition.

We combine these literatures by examining whether market competition increases quality provision on explicitly illegal dimensions. We define quality as attributes that increase customer utility or willingness-to-pay, similar to the definition used in hedonic price models (Griliches 1971; Rosen 1974). While no existing research has identified the link between competition and quality using explicitly illegal quality dimensions, recent work suggests that competition may motivate such behavior. Snyder (2010) showed that competition led healthcare organizations to exaggerate the seriousness of their patients' conditions to increase liver transplant priority. While these actions, which involved unnecessarily admitting patients to intensive care units, were dishonest, they were within the legal discretion of the medical facilities. Furthermore, the net impact of this deception on patient health was negligible because competitors' responses led to the same outcome that would have arisen with universal honesty. Similarly, Becker and Milbourn (2011) find that the entry of a third bond-rating agency increased ratings, which could be viewed as providing quality to the issuing firms that paid for these ratings.[3] While not explicitly illegal, this rating inflation was socially costly because it provided less accurate market information.

Like these ethically questionable behaviors, explicitly illegal behavior can be a viable strategy for organizations when it increases the value of products or services to customers. Customers might be complicit in the illegal behavior or be oblivious to its benefits; that is, they might seek out products and services from firms willing to break rules or laws or they might be unaware that a favored product contains an illegal chemical or was produced by child labor or with stolen intellectual property. When a

[3] Becker and Milbourn (2011) define quality in terms of ratings accuracy.

firm's adherence to organizational policies or government laws and regulations results in lower quality for customers, some of these customers may reward firms willing to cross legal lines with increased business and loyalty. For example, customers would certainly know that laws would be broken when asking a taxi driver to speed to their destination or when asking a bar to serve alcohol to an underage patron.

Firms that do not provide illicit quality risk losing business to competitors that do, which provides a strong incentive for firms to cheat, particularly when repeat business and long-term relationships are important. Under such pressure, firms that strictly obey the law may lose considerable market share as customers flee to more lax firms. When competition increases the threat of customer loss, firms are more likely to respond by matching their rivals' behavior and crossing legal boundaries. Therefore, markets with high competition will on average see higher levels of illicit quality than will those with greater concentration.

The pressure to provide illicit quality may be particularly intense for new firms entering markets with established incumbents. While studies of entry and local competition typically focus on price as the competitive dimension (e.g., Bresnahan and Reiss 1991, Berry 1992, Gowrisankaran and Krainer 2011), recent work highlights the importance of quality choice (Mazzeo 2003) as an entry strategy. If new entrants cannot implement introductory pricing strategies (Klemperer 1995) due to cost disadvantages from economies of learning in the market (Lieberman 1984), they may choose to compete instead on dimensions of quality, some of which may be illicit. These quality dimensions would be extremely important entry strategies in markets in which pricing is restricted or fixed (Douglas and Miller 1974, White 1972). Recent theory by Branco and Villas-Boas (2011) shows that entrants are indeed more likely to break market rules, but once established as incumbents, they adopt more compliant practices. We therefore expect the existing competition amongst incumbents to have a particularly strong impact on illicit quality provision by new entrants.

3. Empirical Setting

The vehicle emissions testing market in the United States has considerable potential for illicit behavior. The federal Environmental Protection Agency (EPA) requires many states to institute vehicle emissions programs, but allows state governments to decide how to implement them. While some state governments directly test vehicles at state-owned facilities, most outsource testing to licensed private-sector firms. Concerns about corruption and fraud date back to the 1970s, when the federal and state governments first debated whether or not to privatize emissions testing (Rule 1978, Lazare 1980). Environmental advocates immediately recognized that private facilities, with incentives to attract and retain long-term customers, were unlikely to fully enforce the regulations (Voas and Shelley 1995, Harrington and McConnell 1999). Concerns about the ubiquity of fraudulently passing vehicles continue today. Private-sector facilities conducting emissions tests "pass far more vehicles than would be the case if all [such] inspections were performed properly (California Bureau of Automotive Repair 2011: 22).

In New York, private testing facilities are legally required to follow strict testing procedures. Cars built before 1996 must undergo dynamometer-based tailpipe testing, a procedure widely understood to be manipulable. Mechanics can make temporary alterations that allow vehicles to pass emissions tests without ever addressing the underlying causes of the excess pollution. Even the most polluting cars can pass if inspectors substitute other cars during testing, a trick commonly referred to as "clean-piping" (Oliva 2012). Studies by Hubbard (1998), Oliva (2012), and Pierce and Snyder (2012) use data from California, Mexico, and New York, respectively, to estimate that between 20 and 50 percent of the cars that should fail are fraudulently passed. These results are consistent with a 2001 covert audit program in Salt Lake City, Utah that found nearly 10 percent of facilities overtly testing one car in place of another (Groark 2002).

Starting in 2004, New York State began testing all model-year 1996 and newer cars using a new technology referred to as "Onboard Diagnostics II" (OBD-II), a computer-based system that monitors emissions control and power-train (engine and transmission) systems for malfunctions that might lead to elevated emissions levels. If the OBD-II system detects a malfunction, it illuminates a malfunction indicator light (MIL) on the dashboard and stores trouble codes that can identify the source of the problem during an emissions test. OBD-II can identify problems before they become severe, takes less time than tailpipe testing, and costs significantly less to implement (Lyons and McCarthy 2009).

Cars failing an OBD-II test must be repaired and then operated until the readiness indicators allow the car to be retested (approximately 50 miles). Customers can then retest the vehicle at the facility of their choice. The repairs may involve simple (but time-intensive) replacements of engine seals or more expensive replacements of emission sensors or the catalytic converter. Repairs often result in a vehicle passing its retest after the fundamental mechanical problem has been corrected. In some cases, however, the car will continue to fail, as the mechanical problems are either too extensive to be fixed or too expensive for the customer. In this case, if the vehicle has received over $450 in repairs, the consumer can receive a one-year exemption from the Department of Motor Vehicles (DMV). The facility must keep receipts of these repairs on-site in case of a DMV audit.[4] While the facility could write fraudulent repair receipts for customers, this would increase the cost to the station of getting caught by involving much

[4] The New York Department of Motor Vehicles, the state agency responsible for ensuring the regulatory compliance of inspection stations, conducted nearly 7,000 overt and covert audits in 2010, including at least one audit per inspection facility (New York Department of Environmental Conservation 2011). These audits, along with consumer complaints, led to inspection license revocations for 66 facilities and license suspensions for 109 facilities that year. For annual reports describing the state's enforcement efforts, see New York Department of Environmental Conservation (2012).

more serious tax fraud implications. If the vehicle has already received its one-year exemption, the customer can either junk the car or resell it to a region with less stringent emissions requirements.

While prior work (Hubbard 1998, Pierce and Snyder 2008) has exclusively focused on tailpipe testing technology, no research has examined the newer OBD-II approach. This distinction is important for two reasons. First, OBD-II has widely replaced tailpipe testing across the United States and in most developed countries (although not in the developing world). Second, OBD-II is considered more difficult to manipulate, since the inspectors have considerably less discretion in testing.[5] Even so, facilities have found ways to fraudulently pass cars with OBD-II systems (Sosnowski and Gardetto 2001). "Clean-scanning"—the practice of collecting emissions data from a clean surrogate vehicle—is a common concern among regulators (Lyons and McCarthy 2009) and was recently used to fraudulently pass 1,400 deficient vehicles in Atlanta over a five-month period (Crosby 2011). While clean-scanning is notably harder to accomplish than clean-piping because it requires a surrogate car of the identical make and model, it is still considered a significant issue that must be addressed in emissions testing programs.

OBD-II testing can also be manipulated through "code-clearing," which involves turning off the MIL and erasing stored malfunction data prior to inspection. Mechanics can clear codes by using professional diagnostic tools or by disconnecting the battery, which may legitimately occur during repairs or due to a dead battery. OBD-II systems attempt to address this issue through a set of three to six readiness indicators that are only rendered "ready" after substantial driving following code-clearing. In New York, a vehicle's readiness for testing depends on its model year. For model-years 1996-2000, a vehicle can have up to two unset indicators. Cars manufactured in 2001 or later are limited to one. The importance of readiness codes for test manipulation was demonstrated in a study conducted by the University of California, Riverside's Center for Environmental Research and Technology. They found that with an allowance of two unset indicators, half of the failing vehicles they reset could be fraudulently passed because the car was deemed ready before the MIL illuminated. Reducing this allowance to one indicator cut the possibility of fraud by one-half (Lyons and McCarthy 2009).

Prior research indicates that firms have a strong incentive to exploit this opportunity to cheat: Customers are more likely to return to facilities that have previously passed them (Hubbard 2002). We confirmed that the loyalty incentives Hubbard found in California were also present in New York and found that failing an emissions test made vehicle owners 11 percent less likely to return to that facility the following year (see the Appendix and Table A-1). Firms in the emissions testing market profit from fraudulently passing older cars because it extends the time these cars can remain on the road and older cars are far more likely to require repairs than the newer cars that would replace them. While failing a

[5] Interviews with regulators revealed that the adoption of OBD-II technology was one of the principal conditions for the EPA allowing Missouri to decentralize its emissions testing system.

vehicle may bring the short-term benefit of repair work needed to pass the inspection, this incentive is limited by two factors. First, car owners are free to retest a failing car at another facility. As the California Bureau of Automotive Repair (2011: 22) recently noted, "Consumers can and do seek second opinions when their vehicle improperly fails" and they "may file a complaint that could result in disciplinary action of the station and or technician and monetary reimbursement." Second, owners receive a one-year waiver if they spend $450 and the vehicle continues to fail. With these limitations, the short-term benefit of failing a vehicle pales in comparison to the long-term benefit of retaining the customer's service and repair business. Annual service and repair expenses on a 2006 Jeep Grand Cherokee, for example, are estimated at over $2200/year by Edmunds.com,[6] with gross margins on such repairs typically at 50 percent (First Research 2007).

While individual inspectors may have some personal or career interest in providing leniency, due to managerial or peer pressure to ensure the financial health of the organization, direct financial incentives are unlikely to motivate this behavior. Inspectors are paid almost exclusively through hourly wages and undercover operations have found bribes to individual inspectors to be relatively rare (Hubbard 1998). This, along with evidence that inspectors conform to facility-level pass rates when changing jobs (Pierce and Snyder 2008), suggests that leniency is primarily a facility-level decision.

New York State, like many states, mandates a fixed price of approximately $27 for tests within the New York Metropolitan Area and $11 elsewhere.[7] Since this eliminates price as a dimension on which firms can compete for customers, facilities must compete on quality. In general, quality competition might involve timeliness or other dimensions of customer service, but in emissions testing, the critical dimension of quality is the test outcome.

Allowing polluting cars to pass emissions tests has clear costs for society, increasing air pollution in urban areas (Currie et al. 2009). There are proven health consequences from each of the three tested pollutants: carbon monoxide, hydrocarbons, and nitrogen oxides. Carbon monoxide, an odorless poisonous gas, inhibits the transport of oxygen from blood into tissues, and can cause general difficulties in the cardiovascular and neural systems. Hydrocarbons and nitrogen oxides, when combined in the presence of sunlight, form ground-level ozone that aggravates respiratory problems, especially in children, and may cause permanent lung damage (Utell, Warren, and Sawyer 1994). The health cost of vehicle emissions has been estimated at between $29 billion and $530 billion (National Research Council 2001). A 10-year study of children found evidence linking air pollution to reduced lung function growth, asthma exacerbation and development, and higher school absenteeism due to respiratory problems (Gauderman et al. 2002).

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[6] Annual service and repair costs for most recent cars can be viewed at http://www.edmunds.com/tco.html.
[7] Below, we describe an analysis that finds no impact of this price differential on pass rates.

4. Data and Measures

From the New York State Department of Environmental Conservation, we obtained all 28 million onboard diagnostic (OBD-II) inspections conducted for gasoline-powered vehicles under 8,500 pounds at the 11,423 licensed testing facilities throughout the state from 2007 through 2010. Emissions testing in New York is conducted by licensed private firms such as gasoline retailers, service and repair stations, and car dealers. Figure 1 presents the substantial variation in density, ranging from the highly dense New York Metropolitan Area to the rural areas and isolated markets upstate, which allows us to estimate the effects of competition when there are few competitors, much as in Bresnahan and Reiss (1991). During this period, all vehicles younger than model year 1996 (the vast majority) were required to use OBD-II technology. An additional value of using this sample is that markets using OBD-II technology have yet to be studied, despite the fact that it is broadly replacing older tailpipe testing.

Place Figure 1 about here

In our context, we look for evidence of facilities providing illicit quality by observing systematically higher vehicle pass rates after controlling for nearly all vehicle and test characteristics that might legitimately influence emissions test results across a facility's portfolio of cars (Pierce and Snyder 2008). Although individual vehicles have idiosyncratic characteristics that influence their emissions, these idiosyncrasies are unlikely to be consistent across a facility's portfolio of vehicles. This risk-adjustment approach is similar to that used in studies of worker productivity (Mas and Moretti 2009) and lawyer and surgeon skill (Abrams and Yoon 2007, Huckman and Pisano 2006).

As described below, our data include facility-, vehicle-, and inspection-level characteristics. The data include tests of vehicles owned by individuals, corporations, fleets, and government agencies, but confidentiality concerns prevented us from obtaining owner identity or characteristics.

Our dependent variable is whether or not a vehicle passed an inspection. We measure this as a dichotomous variable (*passed inspection*), coded "1" if it passed and "0" if it failed. A vehicle fails if (a) a malfunction indicator light is illuminated (with related fault code) or (b) the vehicle exceeds its allowable number of unset readiness indicators. As detailed earlier, vehicles with model years of 2000 or older are allowed two unset readiness indicators, whereas newer cars are only allowed one (Sosnowski and Gardetto 2001).

We created several measures to capture characteristics of the market in which each inspection facility operates. We measure the *number of proximate facilities* using a standard technique in the health economics literature (Garnick et al. 1987), obtaining latitude and longitude measures of each facility's location and counting the number of other facilities within a Euclidean radius. This method is based on consumer choice models in which, under limited price variation, geographic distance becomes the primary influence (e.g., Gowrisankaran and Krainer 2011). Since price is fixed, the customer selects a facility based on this distance and on service quality, assessing the latter both on legal dimensions (e.g., cleanliness or timeliness) and illegal dimensions (anticipated leniency). When the cost of visiting two facilities is similar because they are near one another, the customer's decision is predicated on quality. As we noted above, the primary quality dimension is the test outcome. For the researcher, the task is to select a radius that is large enough to include the facilities to which the focal facility will respond competitively. We selected a radius of 0.2 miles, or approximately two city blocks, within which facilities have an average of 1.6 competitors. This market definition is much smaller than that in previous work (Olivares and Cachon 2009), but still contains substantial variation in firm density due to the frequent agglomeration by facilities. Figure 2 presents a histogram depicting the number of proximate facilities faced by each facility in our sample. Because any geographic delineation of the market size is somewhat arbitrary, we later assess the robustness of our results to smaller and larger market definitions.

Place Figure 2 about here

We also developed several dichotomous measures to capture facility characteristics. *Fleet facilities* are inspection facilities that service their own fleet vehicles. These facilities are closed to individual consumers and thus are unlikely to be influenced by local competition. We identified fleet facilities as the 442 facilities owned by 257 companies whose names implied they were operated by municipal governments, universities, and utilities.[8] The remaining 10,981 facilities are *open facilities* that serve the general public; these include gasoline retailers, service and repair shops, and car dealers. We created a dichotomous variable, *entrant facility,* to flag inspections conducted by facilities that had only been conducting inspections for 12 months or less; we therefore consider a facility to have transitioned to incumbent status 12 months after entry. Because we do not observe the initial inspection date of facilities that had been conducting inspections at the beginning of our sample, we pursued a conservative approach and only considered facilities eligible for entrant status if they initially began conducting inspections in the third month or later of our sample. While this designates firms that entered in the first three months as incumbents, it biases against finding entrant-specific results. Entrants make up 17.5 percent of the facilities in our sample (2,004 of 11,423 facilities).

[8] This list is available from the authors. Examples of municipal governments or agencies include the New York City Police Department and the City of Canandaigua. Examples of universities include Alfred University and Ithaca College. Examples of utilities include Central Hudson Gas and Consolidated Edison. The telephone company Verizon operated the most fleet facilities, but its 95 facilities constitute only 21 percent of the total number of fleet facilities. No other fleets operated nearly as many facilities. While a few companies operated between 10 and 20 facilities (primarily electric utilities), the vast majority of fleets operated just one facility. Summary statistics specifically for fleet facilities are available from the authors.

We also obtained data on several vehicle characteristics, including vehicle make and model (e.g., Ford Taurus), model year, and odometer reading. We created *model year counter* to equal the model year minus 1996, the first year of our sample. We created a dichotomous variable to flag *luxury vehicles*, based on the vehicle make typology used by Gino and Pierce (2010).[9] Table 1 reports summary statistics.[10]

Place Table 1 about here
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5. Empirical Analysis

Our empirical analysis includes several steps to identify the explicit mechanism through which competition impacts illicit quality. In a preliminary analysis presented in the Appendix, we confirmed that competition increases facilities' incentives to exhibit leniency by showing that vehicles were significantly less likely to return to the same facility for future tests in markets with higher numbers of proximate facilities. In our primary analysis, we first directly test whether higher numbers of proximate facilities are associated with higher pass rates using linear probability models that control for geographic, vehicle, and time characteristics. Next, we estimate the distinct effects of proximate facilities on the pass rates of both proximate *fleet* and *open* facilities, showing that *open* facilities respond with leniency to local competition but that *fleet* facilities do not. Next, we exploit a model-year-based discontinuity in the difficulty of test manipulation to identify the fraudulent "code-clearing" technique as a primary mechanism through which competition impacts pass rates. We also show how competition influences the entry strategies of new facilities and the differential impact of competition on luxury vehicle owners. Finally, we show that competition has little impact on the pass rates of luxury cars, the owners of which are considerably less likely to switch facilities in the presence of alternative facilities.

5.1. Competition and Pass Rates

To investigate the effect of competition on illicit quality, we estimate empirical models with emissions tests as the unit of analysis, regressing a dummy variable indicating pass result on the number of proximate facilities. The detailed information on time and location of inspection as well as vehicle characteristics allows us to control for most predictors of vehicle deterioration and likely emissions. While linear probability models with robust standard errors have the risk of generating predicted values outside the actual data range, they are unbiased and do not suffer the potentially severe incidental parameters problem of logistic models with many fixed effects (Wooldridge 2002: 454-457, Katz 2001).[11]

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[9] Luxury vehicles includes the following vehicle makes: Acura, Alfa Romeo, Aston Martin, Audi, Bentley, BMW, Cadillac, Ferrari, Infiniti, Jaguar, Lamborghini, Lexus, Lotus, Maserati, Mercedes-Benz, Porsche, Rolls Royce, Saab, and Volvo (Gino and Pierce 2010).

[10] Summary statistics by facility type (fleet vs. open) are available from the authors.

[11] With 28 million observations, the linear probability model is an extremely close approximation of logistic regression.

In this and all other models, we cluster standard errors by facility. These primary models are presented in Table 2, which reports actual coefficient values and standard errors multiplied by 100.

Place Table 2 about here

5.1.1. Market Density. Our first model includes no controls and shows that a greater number of proximate facilities is associated with a higher pass rate (Column 1 of Table 2). An additional facility within 0.2 miles increases the probability of passing by 0.07 percentage points. While this coefficient is small, the 93-percent average pass rate implies that an additional competitor would lead to the passing of one out of 100 cars that should fail.[12] To verify that this relationship is not a product of sorting on omitted characteristics, the model reported in Column 2 controls for odometer (level, squared, and cubed values) as well as for neighborhood fixed effects (three-digit ZIP code). Our fully-controlled model in Column 3 adds vehicle model-year controls (*model year counter* and its squared value) as well as fixed effects for inspection year and vehicle make/model. The coefficient on the *number of proximate facilities* in these models is similar to that in the baseline model, remains statistically significant, and supports our hypothesis that competition increases leniency after controlling for physical features that should determine the test result.[13]

5.1.2 Density versus Competition. Whereas results from our primary model are consistent with competitive pressures to provide illicit quality, one might be concerned that other market mechanisms associated with facility density could be generating higher pass rates. For example, pass rates in dense regions might occur because density provides facilities greater opportunities to learn how to manipulate inspections through knowledge spillovers across nearby facilities (Argote et al. 1990) or through explicit cooperation (McGahan 1995). To investigate this, we leverage the difference between *fleet facilities* that exclusively test vehicles from dedicated fleets and *open facilities* that compete for individual and small-business vehicles. Because fleet facilities need not compete for business with other facilities, they should be unaffected by the proximity of other facilities. In contrast, *open facilities* should respond to other facilities because of their ability to steal unsatisfied customers from each other. Column 4 reports the results of a model akin to Column 3 except that we include an interaction term between the *number of proximate facilities* and *fleet facility.* This model yields separate estimates of the impact of proximate facilities on open and fleet-only facilities. The results indicate that the leniency of open facilities increases

[12] Since 7 percent of all cars fail, or 7000 out of 100,000, a marginal effect of 0.07 percent implies that 70 fewer cars would fail in the average presence of one additional competitor within 0.2 miles.

[13] To explore whether our results were driven simply by the difference between monopolies and facilities facing any level of competition, we also estimated this model on the subset of facilities that faced at least one local proximate facility (i.e., excluding firms with no local competitors). Those results were very similar to our primary results estimated on the full sample.

significantly with the number of local competitors, whereas we find a decrease in leniency for fleet-only facilities. These results support our hypothesis that competition is driving the relationship between facility density and pass rates.[14] As further evidence of this, Column 5 reestimates the model reported in Column 3 except only on the subsample of open facilities; the positive coefficient is nearly identical to that reported in Column 3.

5.1.3. Nonlinear Effects of Competition. Our results thus far indicate that firms facing more competition are more lenient, but the specifications have estimated a linear effect. Given that New York State has dramatic variation in population density that includes both isolated markets and dense urban centers, competition varies dramatically between markets. In a different setting with price competition and low differentiation, Bresnahan and Reiss (1991) find a nonlinear effect of competition on firm behavior that diminished almost to zero once a market contained three to five firms. Their results are consistent with Bertrand models of competition, in which even a single competitor induces competitive pricing by a former monopolist. In contrast, Olivares and Cachon (2009) found that under simultaneous price and quality competition, additional competitors continued to result in firms offering decreasing marginal increases in service quality up to the eighth competitor. We similarly investigate whether our context, with fixed pricing and competition on illicit quality, also features a nonlinear effect and whether the provision of illicit quality attenuates rapidly or slowly with increases in the number of competitors.

To identify this nonlinear effect, we reestimate our model from Column 3 but add the squared value of the number of proximate facilities. We report the predicted values and 95-percent confidence intervals in Figure 3. The predicted pass rate continues to increase up to the sixth competitor, although only to the fifth competitor with 95-percent confidence. The results suggest a nonlinear effect, but as in Olivares and Cachon (2009), the decreased precision at higher competition levels means that we cannot rule out a linear relationship. Nor can we rule out the possibility that competition continues to impact quality beyond the sixth competitor. Our results strongly suggest, however, that firms continue to increase illicit quality beyond the third competitor, whose impact on price was negligible in Bresnahan and Reiss (1991).

Place Figure 3 about here

5.2 Competition and Test Manipulation

Although our first two models strongly suggest competition through illicit quality, other plausible explanations remain. For example, lower pass rates might occur in less competitive markets because local monopolists, who face little threat of customer loss, might rationally limit capacity. This decreased

[14] Given that the vast majority of fleets operate just one facility (see footnote 8 for details), we see no reason to be concerned that our fleet results are driven by just a few large fleet operators,

capacity, which would maximize mechanics' labor utilization, would also create queues and provide mechanics with little time to help vehicles pass either through legitimate repairs or through manipulation.

To better identify whether test manipulation drives the positive relationship we observe between competition and pass rates, we exploit a discontinuity in EPA guidelines on OBD-II testing protocols. As described earlier, all vehicles of model-years 1996-2000 are allowed to continue an emissions test as long as no more than two readiness indicators are "unset," whereas newer vehicles (beginning with 2001) are allowed only one unset indicator. This allowance differential makes test manipulation using "code-clearing" techniques much easier with older vehicles than with newer ones. For example, consider a mechanic seeking to falsely pass a vehicle exhibiting three unset readiness indicators. The mechanic would need to override just one of these indicators for older vehicles, but would need to override two indicators for newer vehicles. The impact of this policy discontinuity on pass rates is evident in Figure 4, which presents the average pass rates of each model year between 1996 and 2008. Pass rates increase monotonically for each model year except 2001, for which they drop dramatically.

Place Figure 4 about here

We explore whether this discontinuity provides evidence that competition has a greater impact on the pass rates of older, more easily manipulated vehicles than on newer vehicles subject to more stringent test protocols. We estimate a model based on our primary specification (as reported in Table 2, Column 3) that also includes a dummy variable *model year 2001 or newer* and its interaction with *number of proximate facilities.* The results, reported in Column 1 of Table 3, yield a significant negative coefficient on this dummy, indicating that the newer vehicles (since model year 2001), facing tougher requirements, are indeed less likely to pass inspections. More importantly, the coefficient on the interaction term is also negative and significant; its magnitude is nearly identical to that of the coefficient on *number of proximate facilities*. This indicates that competition impacts leniency on the older, more manipulable vehicles but appears to have little effect on model-year-2001 and newer vehicles. These results suggest that, for pre-2001 vehicles, test manipulation through "code-clearing" is driving the positive relationship between competition and pass rates.

Place Table 3 about here

5.3 Market Entry

New entrant facilities' behavior can also shed light on whether the provision of illicit quality is driving the relationship between competition and pass rates. Successful entry and survival in our setting is extremely difficult. Of the 2,234 facilities that exited during our sample period (20 percent of all facilities), 91 percent (2,034) had been conducting inspections less than two years. Among all new entrants, 40 percent exited in the first year, with an additional 34 percent exiting in the second year. Given this survival hazard, new entrants should be particularly likely to respond to competition with unusually high pass rates because they are unable to use introductory pricing strategies to capture customers who feel some loyalty to an incumbent facility or who face high switching costs (Klemperer 1995). Under fixed prices, new entrants must acquire customers by competing on quality dimensions (Douglas and Miller 1974, White 1972), which, in our setting, means awarding a passing result even when this requires test manipulation. While such entrants may have fewer established customers to lose if their fraud were detected and their license suspended by the state, they are also less likely to survive the fines or lost business that would accompany detection and suspension. Our manipulation story predicts that, compared to the pass rates of incumbent facilities, the pass rates of entrant facilities will respond more strongly to the presence of greater local competition.

To identify this effect, we interact *entrant facility* with *number of proximate facilities* and include all the controls used in our previous models. The results, presented in Column 2 of Table 3, indicate that, while incumbents' pass rates increase in the face of competition ($\beta = 0.073$, $p < 0.01$), entrants' pass rates respond even more strongly ($\beta = 0.220$, $p < 0.01$). While an entrant's pass rate is 0.96 percentage points lower than other facilities when entering a market without an incumbent, it rises dramatically as the number of proximate facilities increases. These results suggest that while new entrants may on average be more reluctant to provide illicit quality to customers, their willingness increases when trying to win new customers in more competitive markets.

5.4 Competition for Luxury Cars

In competitive markets, firms have higher incentives to provide illicit quality to those customers at greatest risk of leaving. In our setting, luxury car owners are less prone to search for alternative facilities should their vehicle fail because they have a greater opportunity cost of time (Hall 2009). Furthermore, only a portion of the proximate facilities will actually be considered by these owners, who are unlikely to patronize low-end repair facilities. Indeed, in a supplemental analysis, we find luxury car owners are less likely than other owners to switch facilities in the presence of competition (Column 4 of Table A-1 in the Appendix). Because competitive pressures are less likely to cause luxury car owners to switch facilities, these facilities have less incentive to illicitly pass luxury vehicles and are more likely to be lenient with non-luxury vehicles than with luxury vehicles. These factors suggest that the effect of competition on pass rates should be stronger for non-luxury vehicles than for luxury vehicles. To test this, we add to our primary model an interaction term between *luxury vehicle* and *number of proximate facilities*. In the results presented in Column 3 of Table 3, the coefficient on *luxury vehicle* is absorbed by the make/model fixed effects, but the statistically significant negative coefficient on the interaction term indicates that the positive relationship between competition and pass rates is attenuated for luxury vehicles. The sum of these coefficients being nearly zero and non-significant (Wald F= -1.48; p=.14) indicates that competition increases pass rates for standard (non-luxury) vehicles but not for luxury vehicles. This result is consistent with our expectation that luxury car owners, with fewer options for “audit shopping,” are less likely than other owners to benefit from the increased provision of illicit quality in competitive markets.

5.5 Robustness Tests

Because any geographic delineation of a market size is somewhat arbitrary, we conducted a series of additional empirical tests to assess the sensitivity of our results to various definitions. We repeat our primary specifications, defining markets by using different radii and by using estimated driving time rather than Euclidean distance.

5.5.1. Market Definition. Our main results are based on a market size defined by a 0.2-mile radius around the focal facility. We reestimated our primary model with a full set of controls (as in Column 3 of Table 2), using nine alternate definitions of market size, with radii ranging from 0.1 to one mile in 0.1-mile increments. As displayed in Figure 5, which plots each model’s coefficient on *number of proximate facilities* and its 95-percent confidence interval, the effect of competition on pass rates is consistently positive and statistically larger than zero. Not surprisingly, our estimates of competition entail wider confidence intervals when using smaller radii, due to lower variation in the number of competitors across facilities, and our estimate magnitudes decline when using larger radii due to weaker competitive effects from distant competitors. As a whole, these results indicate that our finding that competition increases pass rates is not dependent on our choice of geographical market boundaries.

Place Figure 5 about here

5.5.2. Driving Time. Our primary measure of competition follows the prior literature (e.g., Ren et al. 2011) by defining competition based on a distance radius from the focal facility. But customers in different regions may bear different costs of travelling identical distances, depending on road congestion and speed limits. To assess whether our results are robust to a more nuanced distance measure that accounts for these differences in travel cost, we reestimated our primary model (Column 3 of Table 2) using driving-time radii of 30, 60, and 120 seconds. We calculated driving times between facilities using actual routes from the WebGIS system at the University of Southern California Spatial Sciences Institute (Goldberg and Wilson 2012). The results for each driving-time radius are consistent with the geographic market definitions.

5.5.3. Price Differential. While inspection test prices are fixed by the government, the fixed price in the New York Metropolitan Area (approximately $27) differs from the fixed price in the upstate region

($11). Vehicle owners seeking inspections at upstate facilities might be especially likely to seek a second opinion when told that their vehicle failed because of the lower price of this second test, potentially making upstate facilities even more responsive to competition than facilities in the New York Metropolitan Area. However, the price differential might not be a material factor if vehicle owners view the $16 difference as trivial compared to their opportunity cost of the additional time required to obtain the second opinion. Furthermore, the many other differences between the New York Metropolitan Area and upstate regions besides inspection price (such as weather, road conditions, wealth, and population density) make it challenging to isolate the causal effect of inspection test prices on pass rates. The cleanest approach to assess the potential causal impact of inspection test prices on pass rates—isolating this effect from the many other differences between the metropolitan area and upstate—is to compare pass rates of facilities located near the price differential. We identified the facilities located in the five-digit ZIP codes adjacent to each side of the metropolitan area-upstate border and found no statistically significant difference in the effect of competition on leniency between facilities on the two sides of the border. This provides no evidence that the price differential affected pass rates.

5.6. Competition and the Distribution of Facility-level Leniency

Given the clear impact of competition on illicit leniency in our data, we next present the broader market impact of this effect across the entire state. Following Syverson (2004), we examine how competition affects the distribution of firm-specific outcomes in New York State. The point of this analysis is to highlight the differences in outcomes between firms under low versus high levels of competition. While Syverson (2004) shows that high-competition markets produce substantially more high-productivity firms, we present the distribution of pass rates to examine whether local markets with high competition produce more high-leniency firms. Figure 6 illustrates the impact of competition on illicit quality by depicting distinct kernel density graphs for two groups of facilities in New York State: those with no proximate facilities (within 0.2 miles) and those with at least one. We trim the top and bottom one percent of the overall distribution, leaving us with 11,197 facilities, and use vertical lines to demarcate the top and bottom ten percent of the overall distribution.

The impact of competition on increasing illicit quality is evident in both distributions. Competition primarily impacts the tails of the distribution, increasing the number of high-leniency facilities while decreasing the number of low-leniency ones. We test these differences using the number of firms above or below the 10-percent thresholds from Figure 6. Facilities facing no competition are approximately 1.8 percentage points more likely to fall in the bottom 10 percent of the distribution than those facing competition (t stat=3.27; p<0.01). Those facing no competition are also 0.8 percentage points less likely to fall in the top 10 percent of the distribution, although this difference is not statistically significant.[15]

Because these pass rates do not control for differences in facilities' neighborhood characteristics or vehicle portfolios, we estimated conditional pass rates as follows. We estimated a regression identical to Column 2 of Table 2, generated predicted pass rates for each test, and calculated facility averages from these predicted values. The difference between the observed facility pass rates and these predicted facility averages became our facility-level conditional pass rates. Figure 7 depicts the distributions of these conditional pass rates for the subsamples of (a) facilities with no local competitors and (b) facilities with at least one local competitor. These distributions are very similar to the unconditional distributions depicted in Figure 6. Facilities facing no local competitors are approximately 1.6 percentage points more likely to fall in the bottom 10 percent of the distribution than their counterparts that face local competition (t stat=2.89; p<0.01). Facilities that face no local competition are also 0.6 percentage points less likely to fall in the top 10 percent of the distribution, although this difference is not statistically significant.[16]

Place Figures 6 and 7 about here
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6. Discussion and Conclusion

In this paper we have shown that increased competition leads firms to provide higher levels of illicit quality to attract and retain customers. The market benefit of this strategy must be weighed against the legal sanctions it might bring. While we focus on one source of competitive pressure—consumer demand for leniency—firms may face a multitude of pressures both for and against illegal or unethical behavior. The calculus of firm ethics and legal compliance can be complicated, with both market and institutional stakeholders exerting complex pressures (Stevens et al. 2005, Ostrom 2000). While ethical and legal strategies may be in the long-term interest of many firms (e.g., Hosmer 1994), the plethora of laws and regulations that govern firm behavior suggest this is often not the case (Schwab 1998). Many firms, like those in our industry, break rules because the market rewards them for doing so.

We find that firm misconduct appears to increase with competitive pressure and the threat of losing customers to rival firms. In our context, in which pricing is fixed by regulation, misconduct that favors customers is a valuable quality dimension that appears to play a large role in competition. Many

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[15] We use 10-percent thresholds to be consistent with Syverson (2004). Alternative thresholds yield more favorable statistical tests.

[16] To ensure that these differences are not artifacts of data structure, we run 10,000 simulations, in which we randomly assign each of the 11,197 firms to a competitive or noncompetitive designation, then test the difference in the frequency with which a firm in each group is in the bottom 10 percent of the pass-rate distribution. Out of 10,000 simulations, only eight produce a t-statistic exceeding the value of 3.27 observed in our data.

emissions testing facilities that strictly follow the law risk losing substantial future business, much of which involves highly profitable repairs that inevitably befall older cars.

More importantly, we show that the impact of competition does not affect all firms equally. New entrants are especially likely to respond to competitive pressures, as are firms that serve consumers who are more likely to switch suppliers. By using market structure, organizational characteristics, and vehicle characteristics to identify the facilities most likely to violate rules or laws, our results can help government agencies monitor more efficiently. Similarly, private activist groups in areas such as environmental and labor compliance may wish to focus less time and effort on incumbents and more time on entrants, which are more likely to skirt rules and regulations when they enter competitive markets.

We acknowledge that several other market dynamics, while difficult to observe, might also be influencing our results. Given the geographic agglomeration of inspection facilities, we recognize that personal ties and communication among inspectors and managers is likely. This communication could lead to knowledge transfers of techniques for fraud or manipulation (Obloj and Sengul 2012), which would tend to increase with firm density. While this may explain some of the difference in leniency between new entrants and incumbents, we find it unlikely to explain differences among incumbents, given the ease of implementing fraud techniques and the frequent labor movement in this industry (Pierce and Snyder 2008). We also cannot rule out the possibility of collusion among proximate facilities (McGahan 1995), although we expect that increased collusion by densely located firms would lower pass rates (similar to the effect of monopolies) and therefore bias against our hypothesized results. Similarly, density might allow better monitoring by the government or by competitors, but this too should lead to reduced leniency in areas of high competition.

Finally, we recognize that facilities with local monopolies might restrict capacity, limiting the time they would have to spend on fraudulent "clean-scanning" techniques.[17] However, our evidence that "code-clearing" is an important technique makes this explanation less likely, since codes can be cleared quickly, with return tests scheduled for subsequent days. Furthermore, given the fixed price of inspections, facilities would be unable to install monopoly prices to benefit from capacity constraints. We also believe that monopolists constraining capacity are unlikely to be driving the effects we identify, given that we find significant marginal impacts on leniency well beyond the first competitor.

We believe that our results have serious implications for policy makers and managers. For policy makers choosing between the potential inefficiencies of local monopolies (or even state-run facilities) and of free-market competition, the calculus must include the erosion of monitoring stringency that accompanies competition. In 1980, when the New Jersey government was deciding whether to switch from its government-operated emissions testing system to a system relying on private-sector facilities,

[17] Schneider (2012) finds that facility capacity, based on time of day, predicts some automotive repair decisions.

“critics feared the move would weaken enforcement of the program” (Lazare 1980: S21). Several decades later, the National Research Council (2001: 189-190) concluded that “motorists, testing personnel, and technicians have found many ways to avoid compliance” with vehicle emissions testing protocols and that “decentralized programs have come under particular scrutiny because, it is argued, they present many opportunities for testing fraud….Motorists therefore shop around to find stations most likely to respond to incentives.” Government agencies have taken enforcement actions against emissions testing facilities exhibiting fraudulent leniency in part because fraudulent inspections create “an unfair competitive advantage” over facilities “conducting lawful emissions inspections” (States News Service 2009, 2010a, 2010b).

Policy makers must consider how to obtain the efficiency benefits of competition while mitigating the risk of companies gaining competitive advantage through corruption, fraud, and other unethical behaviors. If customers indeed demand illicit dimensions of quality, firms may feel compelled to cross ethical and legal boundaries simply to survive, often in response to the unethical behavior of just a few of their rivals. In markets with such potential, concentration with abnormally high prices and rents may be preferable, given the reduced prevalence of corruption (Shleifer 2004). The good intention to fix prices at low levels may eliminate legitimate ways in which firms can compete, unintentionally creating incentives for them to cross legal boundaries. Alternatively, policy makers can increase regulatory monitoring and enforcement efforts for highly competitive markets to ensure that incentives for illegality do not dictate survival in these markets.

An alternative approach to reducing the impact of competition on emissions testing fraud is improved monitoring technology. While the replacement of older tailpipe-based testing with newer OBD-II technology has likely reduced fraud, competition has motivated firms to innovate with new techniques for test manipulation, such as clean-scanning and code-clearing. So long as competition provides strong incentives to pass vehicles, firms will likely find new ways to overcome improvements in testing technology. The technological solutions most likely to reduce fraud are those that circumvent private firms altogether, such as remote sensors capable of capturing emissions measurements and vehicle identities on roads. But this technology, despite substantial evidence of efficacy and cost-effectiveness, has yet to be adopted beyond limited use in California.[18] If policy makers can overcome the associated financial and personal liberty concerns, these newer technologies might prove effective in reducing fraud in ways both convenient and unobtrusive to consumers.

The magnitude of our estimated effect, while small, is not trivial. Using our estimated 0.089-percent marginal impact of an additional proximate facility within 0.2 miles, we roughly estimate how many fewer cars would have passed had each firm been a monopoly within this radius, rather than having the

[18] See http://www.feat.biochem.du.edu/reports.html for numerous studies on remote emissions sensing.

observed average of 1.59 proximate facilities. This is a conservative test, given the willingness of consumers to drive far beyond 0.2 miles for a better result. Applying this coefficient to the 28 million tests conducted over the four-year sample period implies that at least 39,000 more tests would have resulted in failing outcomes.[19] The magnitude of this effect on *pollution levels*, however, is much larger. Widespread remote emissions sensing studies have revealed that the worst five percent of cars produce half of all emissions and the worst one percent of cars produce 20 percent of all emissions (Stedman 2002, Stedman et al. 2009). This suggests that each of the 39,000 fraudulent passes implied by our results might result in a twentyfold increase in mobile emissions compared to the average vehicle. Under these assumptions, these fraudulent passes result in excess emissions equivalent to an additional one million cars on the road.[20] Overall emissions might still decline even if such gross polluters were sold to non-regulated states because they typically replace even higher-polluting vehicles (Davis and Kahn 2010).

Given the major health impacts of even small reductions in carbon monoxide emissions from mobile sources (e.g., Currie et al. 2009), the social impact of competition is significant. These results are particularly troubling in light of recent work by Fowlie et al. (2012) showing that mitigating mobile emissions is the most cost-effective way to reduce airborne pollution. Similarly, given the extreme cost of alternative programs designed to remove gross polluters, such as “Cash for Clunkers” (Knittel 2012), reducing emissions testing fraud appears relatively cost-effective. Furthermore, if local competition geographically concentrates the illicit passing of grossly polluting cars, the health threat may be particularly severe in these areas (Currie and Walker 2011).

The implications for managers are also important, since they, their employees, or their suppliers may be under considerable pressure to cross legal and ethical lines when market competition is high. Top managers and owners under intense competition must strengthen monitoring and governance mechanisms to ensure their own legal compliance if they fear government sanctions. Similarly, managers must understand that using internal competition among employees or divisions to improve performance may increase the likelihood that managers and other employees will engage in behavior that puts the firm at risk for legal sanctions or lost reputation. The cost of such behavior may be even greater, however, if it creates cultures of corruption that spill over to other workers (Ashforth and Anand 2003, Pierce and Snyder 2008).

Perhaps the most important implication for managers is that intense supply chain competition might lead suppliers to engage in illegal and unethical activities. Intensifying price pressure on suppliers in

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[19] This number is calculated as 28 million × 1.59 × 0.00087.

[20] Furthermore, because new vehicles have incorporated improved emissions-minimizing technologies, the share of pollution coming from the worst-polluting vehicles has increased over time (as evidenced in longitudinal studies such as Stedman et al. 2009). This exacerbates the impact of fraud on increasing pollution levels. At the same time, these newer technologies have made emissions repairs more expensive, generating higher incentives for customers to seek fraud.

countries that lack regulatory enforcement regimes can lead to these organizations to weaken safety conditions, employ child labor, and violate minimum wage laws, all of which pose reputational risks to buying organizations. Similarly, intense pressure for suppliers or partners to win access to local markets and resources might motivate bribery and other corruption, making those firms (and managers) liable under the U.S. Foreign Corrupt Practices Act.

Finally, managers must understand that government policy, firm decisions, or exogenous factors that increase market rivalry may necessitate the monitoring of competitors' behavior. The failure to do so may allow these rivals to gain advantage through illicit strategies, particularly under institutional regimes in which regulatory monitoring or enforcement is weak.

We acknowledge the value of the recent focus in the management and strategy literature on the impact of ethical and socially responsible behavior on firm performance, but, like Devinney (2009), we caution that a positive relationship between these measures should not be assumed. Our market setting provides a striking example that firms do not always "do well by doing good." We therefore encourage future work to focus on identifying circumstances in which we might expect market mechanisms to encourage compliant behavior in firms, whether those mechanisms come from consumers, partners, interest groups, or other stakeholders. In some markets, the market mechanism of competition may indeed simultaneously yield improved social welfare and financial returns for firms. But where market mechanisms such as competition pressure firms to cross legal boundaries to profit—or just survive—the solution to socially harmful strategies may necessarily be institutional.

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Appendix: Competition and Customer Pressure for Leniency

We earlier argued that, under fixed prices, firms compete by providing illicit quality to customers through test manipulation. By providing customers with more alternatives, competition pressures firms to take additional steps to retain or capture customers. In emissions testing, this suggests that increased competition provides customers with additional suppliers should they be dissatisfied with a failed test result. To empirically test for the presence of this incentive for leniency, we use a forward-looking sample of emissions tests that includes only those vehicles for which we can observe a test the following year. This sample excludes all emissions tests in the last year of our sample (since we cannot observe the subsequent test) and excludes vehicles that were sold out of state or scrapped following the final test.

Using this sample, we estimate a linear probability model with the individual test as the unit of analysis. The dependent variable is a dummy indicating whether a vehicle *returns next year* to the same inspection facility. The results indicate that passing the emissions test clearly increases the likelihood that a customer will return to the facility the next year (Table A-1, Column 1). Adding the number of proximate facilities to the model yields a statistically significant negative coefficient, which indicates that testing facilities face greater difficulty retaining customers who have more suppliers from which to choose (Column 2). These two results are robust to the inclusion of controls for the tested vehicle's vintage and usage and to the inclusion of fixed effects for inspection year, neighborhood, and make/model (Column 3).

Place Table A-1 & Figure A-1 about here

In Figure A-1, we plot the predicted probability of return at various levels of competition, based on a model that regresses *returns next year* on *number of proximate facilities* and on that value squared. The probability of return consistently decreases out to 10 competitors, suggesting that competition continues to impact firms far beyond the first, second, or third proximate firm. As mentioned earlier, Column 4 of Table A-1 presents the model with *luxury vehicle* interacted with *number of proximate facilities*. The results indicate that owners of luxury vehicles are less prone than owners of other vehicles to abandon their facility in local markets with greater competition.

Table 1: Summary statistics

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
Passed inspection (dummy)	28,001,335	.930	.255	0	1
Number of proximate facilities	28,001,335	1.586	2.178	0	20
Odometer (miles)	28,001,335	79,525	50,523	0	999,999
Fleet facility (dummy)	28,001,335	.005	.069	0	1
Inspection year	28,001,335	2008.5	1.095	2007	2010
Model year	28,001,335	2002	3.216	1996	2010
Model year 2001 or newer (dummy)	28,001,335	.659	.474	0	1
Entrant facility (dummy)	28,001,335	.040	.197	0	1
Luxury vehicle (dummy)	28,001,335	.089	.285	0	1
Returns next year (dummy)	21,411,677	.420	.494	0	1

Note: Last year of data omitted for returns next year.

Table 2: Impact of competition on facility leniency

	Dependent variable: Passed inspection				
	(1)	(2)	(3)	(4)	(5)
Number of proximate facilities	.072*** (.024)	.122*** (.027)	.089*** (.026)	.088*** (.026)	.085*** (.026)
Fleet facility				-4.317*** (.426)	
Number of proximate facilities X Fleet facility				-.908*** (.217)	
Odometer level, squared, and cubed		Included	Included	Included	Included
3-digit ZIP code fixed effects		Included	Included	Included	Included
Year fixed effects			Included	Included	Included
Model year and model year squared			Included	Included	Included
Make X model fixed effects			Included	Included	Included
Sample	All Facilities	All Facilities	All Facilities	All Facilities	Open Facilities
Observations	28,001,355	28,001,355	28,001,355	28,001,355	27,868,131

Note: *, **, *** indicate significance at the 10%, 5%, and 1% confidence levels, respectively. Results reported are OLS coefficients and standard errors multiplied by 100. Parentheses contain standard errors clustered at the facility level.

Table 3: Factors moderating competition's impact on facility leniency

	Dependent variable: Passed inspection		
	(1)	(2)	(3)
Number of proximate facilities	.254*** (.036)	.073*** (.027)	.107*** (.027)
Model year 2001 or newer	-2.978*** (.057)		
Number of proximate facilities X Model year 2001 or newer	-.257*** (.025)		
Entrant facility		-.957*** (.166)	
Number of proximate facilities X Entrant facility		.220*** (.058)	
Luxury vehicle			Absorbed
Number of proximate facilities X Luxury vehicle			-.169*** (.027)
Odometer level, squared, and cubed	Included	Included	Included
3-digit ZIP code fixed effects	Included	Included	Included
Year fixed effects	Included	Included	Included
Model year and model year squared	Included	Included	Included
Make X model fixed effects	Included	Included	Included
Sample	All Facilities	All Facilities	All Facilities
Observations	28,001,355	28,001,355	28,001,355

Note: *, **, *** indicate significance at the 10%, 5%, and 1% confidence levels, respectively. Results reported are OLS coefficients and standard errors multiplied by 100. Parentheses contain standard errors clustered at the facility level.

Appendix Table A-1: Impact of competition on return probability

	Dependent variable: Returns next year			
	(1)	(2)	(3)	(4)
Passed inspection	12.580*** (.127)	12.610*** (.126)	10.677*** (.113)	10.68*** (.113)
Number of proximate facilities		-1.070*** (.086)	-.677*** (.088)	-.729*** (.089)
Luxury vehicle				Absorbed
Number of proximate facilities X Luxury vehicle				.480*** (.167)
Odometer level, squared, and cubed		Included	Included	Included
3-digit ZIP code fixed effects		Included	Included	Included
Year fixed effects			Included	Included
Model year and model year squared			Included	Included
Make X model fixed effects			Included	Included
Sample	All facilities	All facilities	All facilities	All facilities
Observations	21,411,677	21,411,677	21,411,677	21,411,677

Note: *, **, *** indicate significance at the 10%, 5%, and 1% confidence levels, respectively. Results reported are OLS coefficients and standard errors multiplied by 100. Parentheses contain standard errors clustered at the facility level.

Figure 1: Facilities in New York State, January 2010

Figure 2: Distribution of proximate facilities

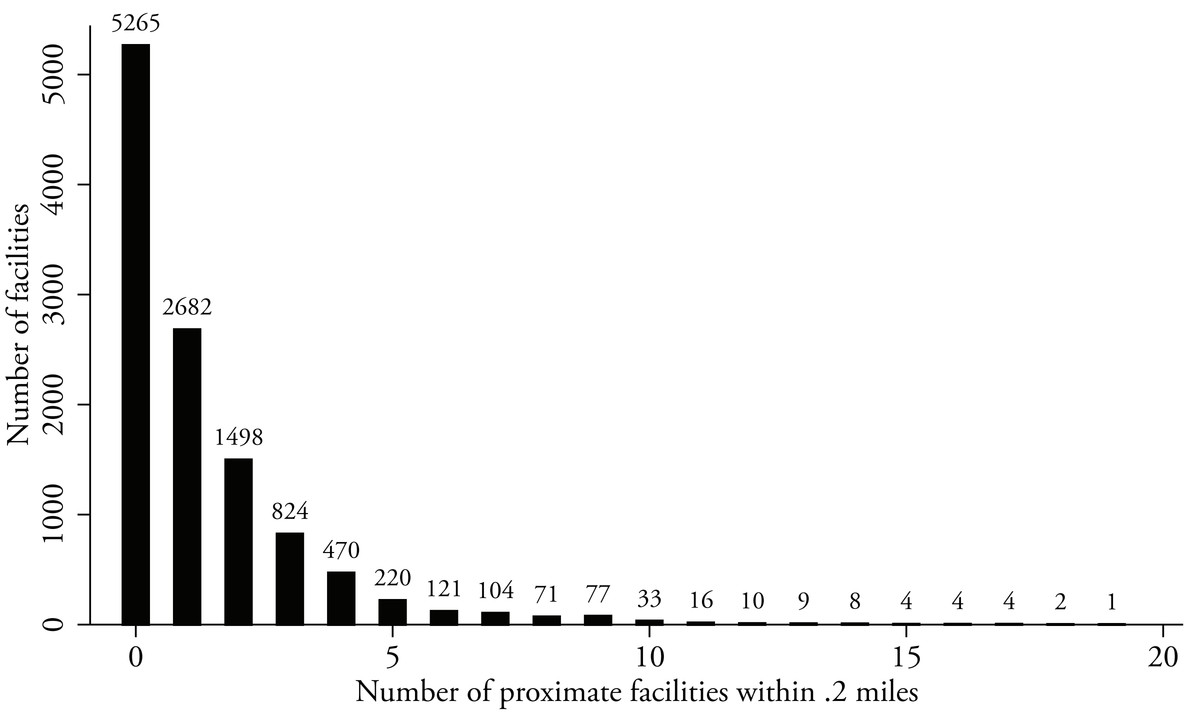
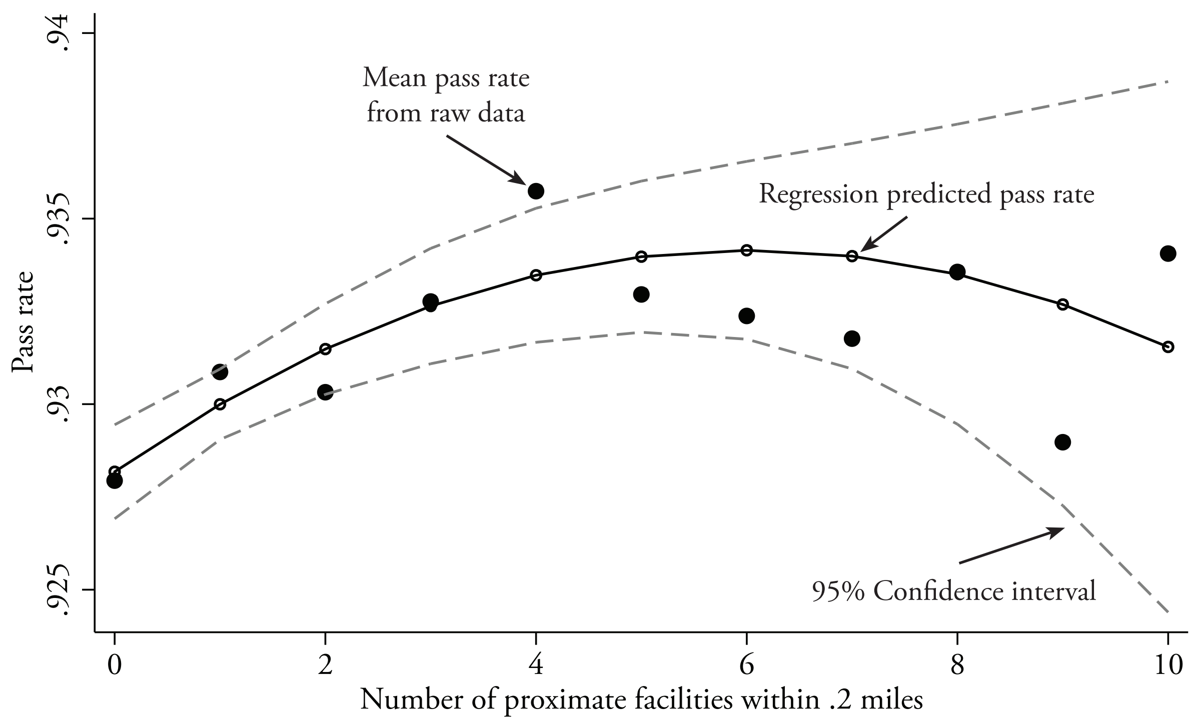
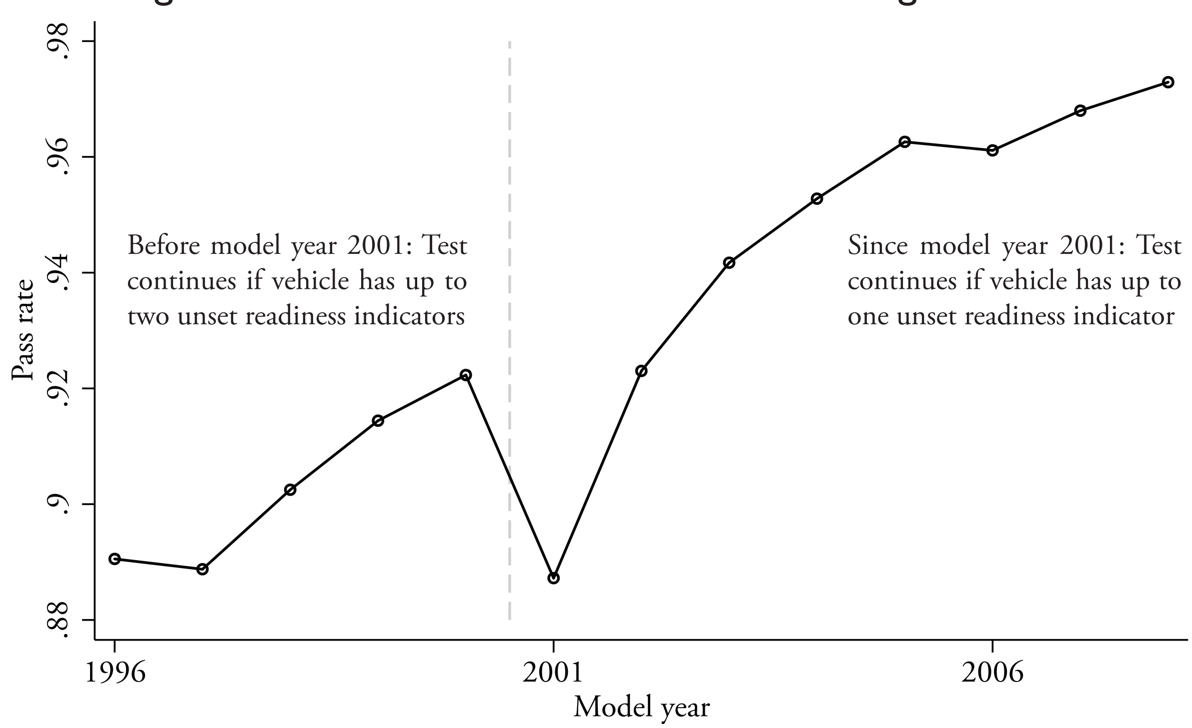


Figure 3: Pass rate by number of proximate facilities



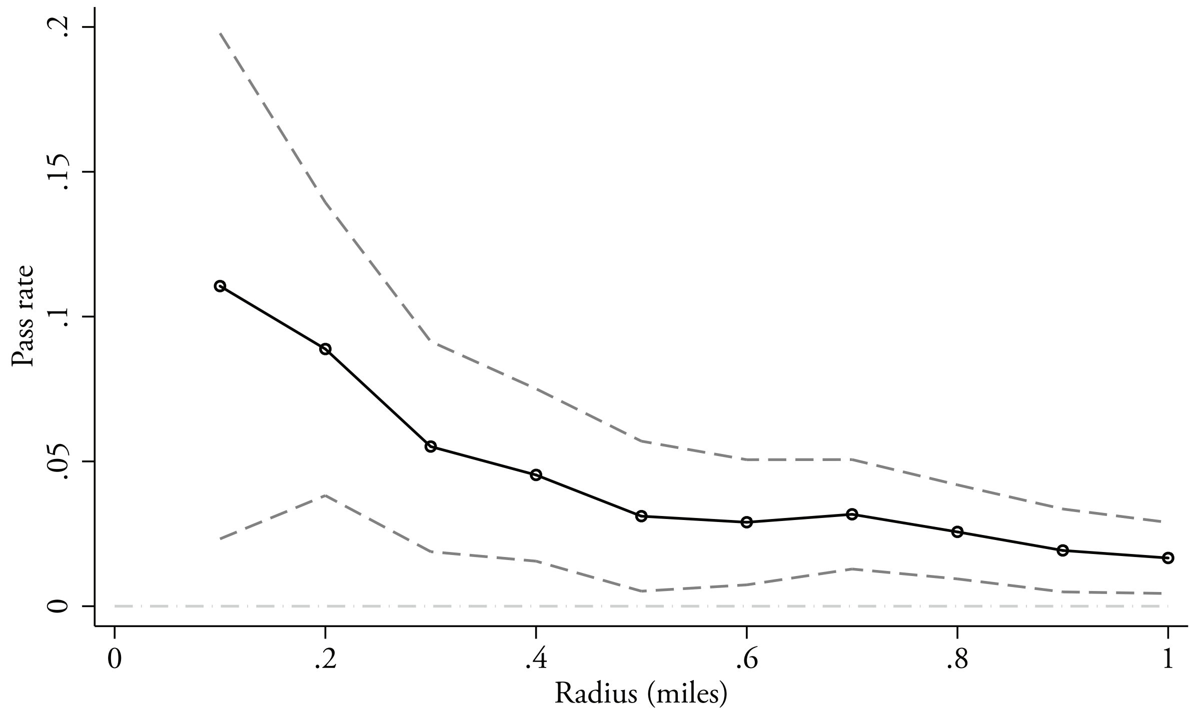
Note: Predicted pass rates and confidence intervals are derived from regressing passed inspection on number of proximate facilities and number of proximate facilities squared.

Figure 4: Pass rate decreases with more stringent tests



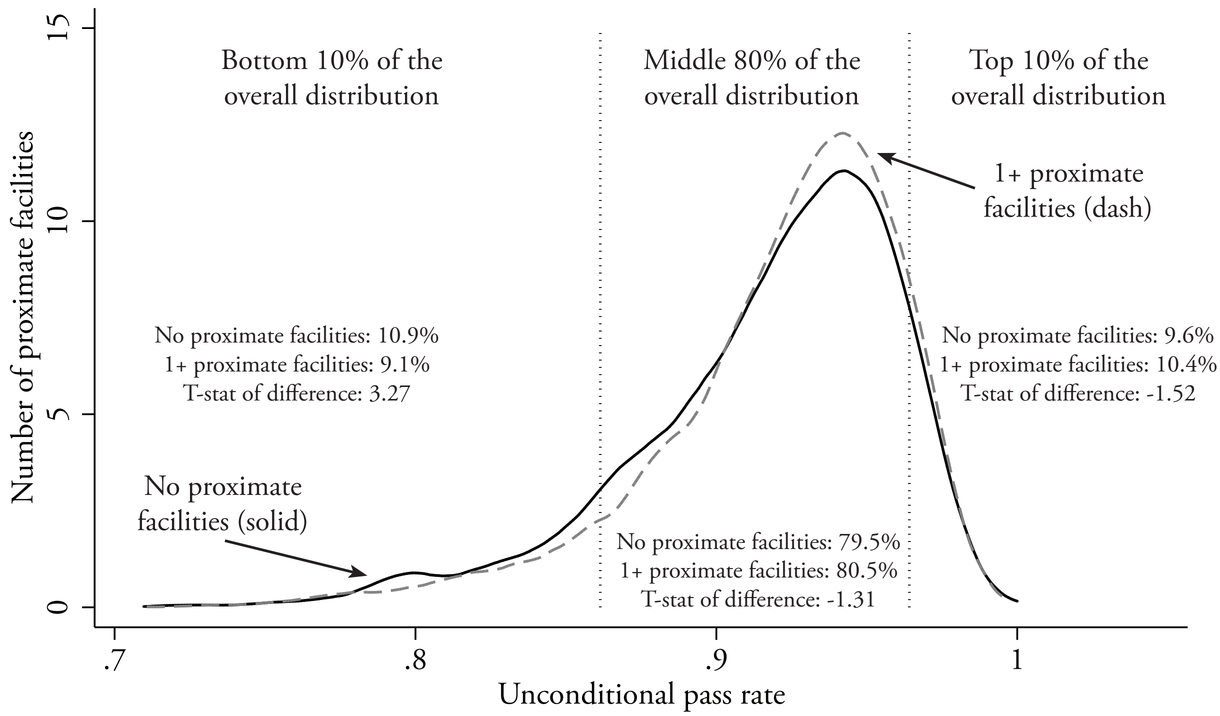
Note: Figures are averages from the raw data.

Figure 5: Robustness to market size definition



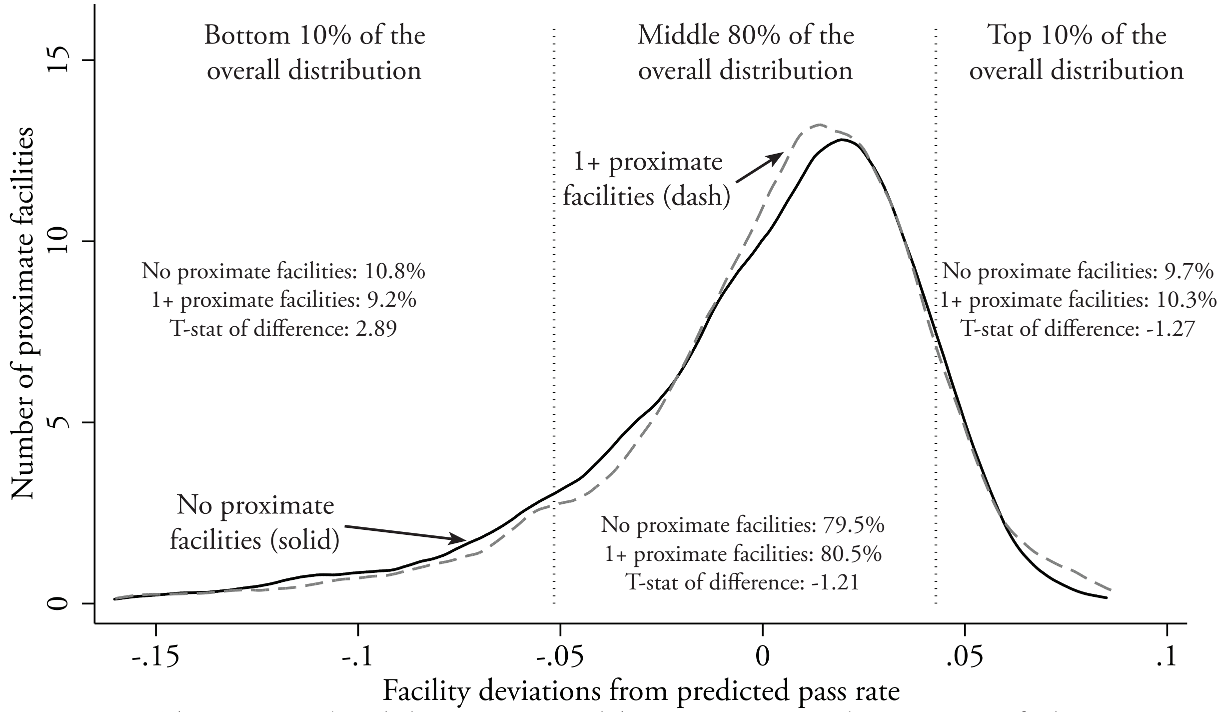
Note: Predicted pass rates and confidence intervals are derived from the regression specification in Table 3, column 3, with number of proximate facilities calculated based on varying radii.

Figure 6: Distribution of unconditional pass rates, by market structure



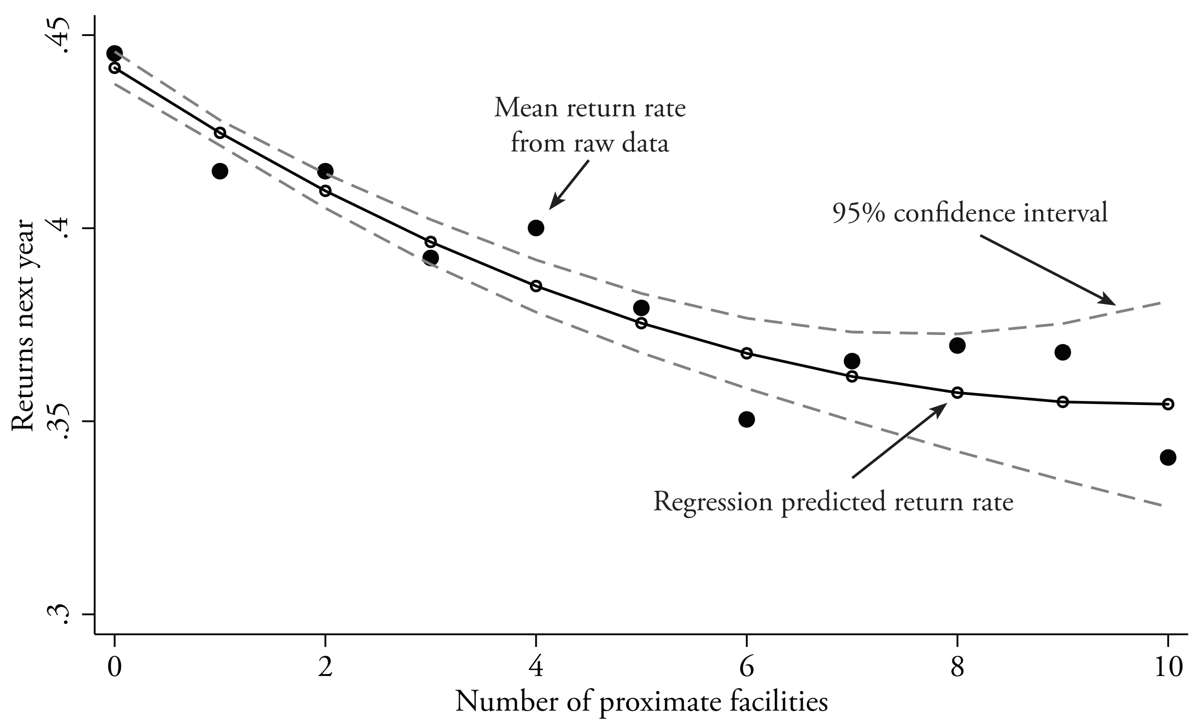
Note: There are 11,194 total observations. Kernel density estimation used. No proximate facilities means that the facility never faced a neighboring test center during the sample period. Number of proximate facilities calculated using a 0.2-mile ring around the focal facility.

Figure 7: Distribution of conditional pass rates, by market structure



Note: There are 11,194 total observations. Kernel density estimation used. No proximate facilities means that the facility never faced a neighboring test center during the sample period. Number of proximate facilities calculated using a 0.2-mile ring around the focal facility.

Appendix Figure A-1: Predicted return rate by competition level



Note: Note: Predicted pass rates and confidence intervals are derived from regressing returns next year on number of proximate facilities and on that value squared. Number of proximate facilities calculated using a 0.2-mile ring around the focal facility.