SECURING PROPERTY RIGHTS*

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ABSTRACT

A central challenge in securing property rights is the subversion of justice through legal skill, bribery, or physical force by the strong—the state or its powerful citizens—against the weak. We present evidence that undue influence on judges is a common concern in many countries, especially among the poor. We then present a model of a water polluter whose discharges contaminate adjacent land. If this polluter can subvert the assessment of damages caused by his activity, there is an efficiency case for granting the landowner the right to an injunction that stops the polluter, rather than the right to compensation for the harm. If the polluter can subvert even the determination of his responsibility for harm, there is an efficiency case for regulation that restricts pollution regardless of its effects. We then conduct an empirical analysis of water quality in the U.S. before and after the Clean Water Act, and show how regulation brought about cleaner water, particularly in states with higher corruption.

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"The question I have to decide is, whether the appeal to me by the defendant to deprive the plaintiff of his right of way and give him money damages instead, can be entertained. I think it cannot. [If it were,] of course that simply means the Court in every case, at the instance of the rich man, is to compel the poor man to sell him his property at a valuation. ... I am quite satisfied nothing of the kind was ever intended, and that if I acceded to this view ... I should add one more to the number of instances which we have from the days in which the Bible was written until the present moment, in which the man of large possessions has endeavoured to deprive his neighbour, the man with small possessions, of his property, with or without adequate compensation." (Krehl v. Burrell, 7 Ch.D. 553 [1878])

"*The whole point of a property regime is to restrain the strong from resorting to their strength… The weak are no longer vulnerable to unrestrained depredations, and they now have the chance of becoming rich without becoming strong… The only thing that is certain to be certain under property is effective protection of the weak against violent dispossession by the strong, and vice versa*" (Kennedy and Michelman 1980, p. 723).

1. Introduction

Economists since Montesquieu (1748) and Smith (1776) have seen protection of property rights as essential for growth and prosperity.[1] Yet, property in much of the world today remains insecure. Even in the developed world, exposure to dangerous pollution, or trespass by hunters or neighbors' cattle, are common concerns. In the developing world, the land and property of the weaker members of society are vulnerable to outright takings by the stronger ones—be they tribal chiefs, powerful neighbors, or even men taking from women (Ali, Deininger and Goldstein 2014; Ali et al. 2014). People everywhere fear expropriation by the state through eminent domain without just compensation (Munch 1976; Chang 2010;

[1] For the aggregate evidence in favor of this consensus, see, e.g., Barro (1990), De Long and Shleifer (1993), and Acemoglu, Johnson and Robinson (2001). For micro evidence, see Besley (1995), De Soto (2000), Field (2005, 2007), Goldstein and Udry (2008), Dell (2010), and Hornbeck (2010).

Singh 2012; Somin 2015). At the heart of insecurity of property is the belief that institutions of law and order such as the police and the courts do not protect the weak in conflicts with the strong.

We provide some evidence that such subversion of justice is a major concern for people in developing countries today. We then show theoretically that several key aspects of securing property can be understood from this perspective. Using a model of a "strong" water polluter who can influence a court, and a "weak" affected property owner who cannot, we compare the efficiency of alternative legal rules. We show that subversion of the assessment of harm caused by the strong polluter favors injunctions and other stark bright-line rules over compensation for harm in a liability regime. When even the determination of the polluter's responsibility for harm can be subverted, as for example would be the case with multiple polluters discharging into the same body of water, regulation becomes the efficient strategy of securing property rights. We then apply our approach to water pollution across U.S. counties, showing how historically the courts failed to protect private property from externalities, especially in the more corrupt places, and how regulation through the 1972 Clean Water Act has improved water quality.

Figure 1, based on surveys of around 1,000 households in each of 102 countries by the World Justice Project (WJP), illustrates the basic fact that motivates our analysis. It reports, for all sample countries with population above 50 million, aggregating over the surveyed households in each country, responses to the following question. "In your opinion, most judges decide cases according to: (single answer) 1. What the government tells them to do; 2. What powerful private interests tell them to do; 3. What the law says." In the median country, over half of respondents think that courts decide cases according to the preferences of private interests and the state rather than the law. That figure is over 80% in Mexico. Judges, according to most respondents, cater to the government and the strong. Experts from many countries surveyed by WJP, especially the developing ones, agree that courts are swayed by corruption and political influence, and that the poor are at a substantial disadvantage in courts.

In this world of uncertain justice, many people fear that the government will take their property without compensation. About 40-50% of WJP respondents in most countries say that it is "unlikely" or "very unlikely" that homeowners will "be fairly compensated by the government" if "the government decides to build a major public works project in your neighborhood (such as a railway station or a highway), and ... the construction of this public works project requires the demolition of private homes in your community/ neighborhood." In Appendix 1 we present individual-level regressions showing that, within countries, the poorer and the less educated have the gravest concerns about the security of their property. The justice system disproportionately fails the weak.

The subversion of justice by the strong and by the state suggests a new lens for asking how best to secure property from takings or nuisances such as pollution. This is extensively charted territory, but largely under the assumption that courts enforce the law, or make only random errors. Take the case of pollution. Should those who pollute the property of others pay compensation for harm caused to the owner, an approach called "liability rules" in law? Alternatively, should property be protected through "property rules" that enjoin polluters from emitting? Many scholars see liability rules that make victims whole as more efficient, on the grounds that such rules provide missing "prices" to potential violators (e.g., Cooter 1984; Ayres and Talley 1995; Kaplow and Shavell 1996). When polluters must fairly compensate victims for harm, they will take these costs into account. Yet many societies use injunctions to stop pollution, and even harsher measures such as legally permissible self-defense to stop trespass (Smith 2004). The quotes at the top of the paper suggest that such ways of securing property received wide support, particularly from those who believe that liability rules fail to protect the poor.

In Section 2, we revisit these debates in a model of an owner and a polluter. We assume throughout that the owner's property right to uncontaminated land is established and undisputed, although this question has also been examined by courts. Our question instead is how best to secure this existing property right. In Section 2, we further assume that the responsibility for pollution is indisputable—for instance because there is only one potential pollutant—and then compare liability rules and injunctions. In this framework, the case without any subversion of justice yields the conclusions of the Coase Theorem. However, when the polluter can subvert damage awards by influencing courts, injunctions and compensation are not equivalent, and the former are more efficient in environments of low law and order (greater subversion). We also examine the role of bargaining in achieving efficiency, and show how standard intuitions change when justice can be subverted. Our analysis explains the dominance of property rules and other control mechanisms as the means of securing property rights.

In Section 3, we consider the case where the responsibility for pollution is in dispute and can also be subverted, perhaps because there are multiple polluters of a water body, and a strong one can persuade a court that harm to the owner is not caused by his own polluting activity. In this case, injunctions do not work either, since they rely on the court accepting whom to stop. Regulation that limits emissions of pollutants regardless of whom they might harm becomes the efficient strategy of securing property rights.

A simple example under the assumption of perfect bargaining illustrates our argument. In the case of one polluter and one owner, and with well-functioning courts, all optimal legal rules and assignments of property rights are equivalent (Coase 1960). The two parties negotiate an efficient solution. If they do not, the courts bring it about with appropriate compensation for harm. Injunctions likewise bring about efficiency because they promote bargaining to an efficient outcome. When the polluter can subvert the calculation of damages, however, these equivalences break down. Liability rules do not work if the strong polluter can avoid paying. In contrast, as long as the responsibility for pollution is indisputable, property rules do work—with bargaining—because injunctions force the polluter to the bargaining table. He then has to pay for the right to pollute if that is efficient, and is unwilling to pay if it is not. If the responsibility for pollution is also is dispute, injunctions can likewise be subverted by the strong polluter. In this case, the optimal strategy might be the quantity control of emissions by the state.

Our analysis sheds light on several questions in law and economics, such as the famous argument by Calabresi and Melamed (1972) that property rules encourage efficiency-improving bargaining between parties. Kaplow and Shavell (1996) prove that this argument is incorrect when enforcement of liability rules is accurate or at least unbiased. We show, however, that when fact-intensive legal rules are vulnerable to subversion, property rules are more effective in promoting bargaining and restoring efficiency, thus reviving the Calabresi-Melamed claim.

Our analysis also clarifies some problems in economic development, such as the weak demand for legal title and for formality if property rights remain insecure. In Section 4, we consider a closely related problem of specific performance versus damage awards in addressing contract violations. Injunctions are similar to specific performance, and the choice of the legal rule turns on similar issues of subversion of justice. In the contract domain, the common-law tradition, current legal doctrine, and mainstream legal scholarship all concur on the optimality of damages, which are viewed as enabling efficient breach (Posner 2009). Leftist legal scholars reject this conclusion (Kennedy and Michelman 1980). We show they have a valid point, and use the famous *Peevyhouse* case to illustrate our argument (Maute 1995). When applied to contracts, our theory makes a strong prediction that weak parties will not contract with the strong. A substantial modern literature on FDI and vertical integration finds support for this prediction (e.g., Antras, Desai, and Foley 2009; Bohm and Oberfield 2018).

In Section 5, we apply our theory to the history of water pollution in the U.S. We summarize the evidence pointing to the failure of courts to stop water pollution. We then use micro data on water quality from Keiser and Shapiro (2019) to show how the Clean Water Act (CWA), by restricting emissions rather than focusing on harm, improved water quality. We show that the effects of the CWA were particularly pronounced in industrial as opposed to agricultural counties because the CWA did not directly regulate emissions from farms; and in the more corrupt states, where court enforcement was presumably weaker. The results suggest that, in this instance, regulation worked in ways suggested by the model.

Our analysis relates to several ideas and debates in law and economics. Glaeser and Shleifer (2003) argue that the transition from litigation to regulation in the United States was driven by concerns with subversion of justice; our analysis uses a different model and applies it to a broader set of issues, including alternative legal rules. As a result, it speaks to a long-standing debate on the relative merits of liability and property rules as ways of enforcing property rights (Calabresi and Melamed 1972; Polinsky

1979; Kaplow and Shavell 1996; Bebchuk 2001). In particular, our model portrays subversion as a systematic downside of fact-intensive rules such as damages, and injunction and regulation as less vulnerable to subversion. More generally, it shows how optimal legal rules turn on which facts can be disputed. Our perspective reflects the classic view of bright-line rules as a way to economize on enforcement costs (Kaplow 1992; Mookherjee and Png 1992, 1994), but shifts the focus from direct administrative costs to the indirect cost of subversion. Also related are the classic findings of Weitzman's (1974) study of price and quantity regulation and Cooter's (1984) study of legal prices and sanctions.

2. A Comparison of Injunction and Compensation

Our main model includes one owner and one polluter who may harm the owner's enjoyment of her property. The model also applies to other forms of interference with private property, such as trespass or outright takings (e.g., through eminent domain). We focus on the optimal means of protecting private property, where optimality is defined as maximizing the sum of benefits to the owner and the polluter.

Throughout, we make the assumption that property rights are recognized but may not be secure. In particular, we assume it is indisputable that pollution of the owner's property constitutes harm, and that he has an entitlement to enjoying his property without this harm. This of course need not be so: a court might take the view that the owner is entitled to a stream passing through her property, but not to a clean stream. Here we postulate that this issue has been resolved. The two questions that a property rights enforcer must address, therefore, are who is responsible for damages, and how big they are. Both questions need answers to administer a liability regime, but only the first needs an answer to administer an injunction. A third alternative is quantity regulation, whereby an enforcer restricts pollution without asking who causes harm to whom and how much. We consider that option in Section 3.

Our analysis turns crucially on the question of which facts are in dispute. We assume throughout that the property right itself is indisputable. In this section, we assume that the responsibility of a given polluter is likewise indisputable; in Section 3 we relax that assumption. The standard approach in law and economics is to assume that, even if some facts are in dispute, the court will establish them, perhaps with an error but without a predictable, systematic bias in favor of a litigant (Coase 1960; Kaplow and Shavell 1996). We make an alternative assumption and examine its consequences. Specifically, we assume that if a fact is indisputable, a court must rely on it faithfully, perhaps because it fears appellate courts or public disapproval. So if, for example, the responsibility of the polluter for damages is indisputable, a court will faithfully apply the relevant legal rules such as an injunction against this polluter. In contrast, when facts are in dispute, we assume for starkness that the court simply rules in favor of the strong. So if, for example, the level of harm from a strong polluter is in dispute, we assume that the court, because it is influenced or bribed, determines them to be negligible. Likewise, if the responsibility of a polluter is in dispute, the court can freely decide that a given polluter is not responsible. This, to us, is the essence of subversion of justice: judicial discretion when facts are in dispute[2].

We examine three institutional options: compensation, injunction and regulation. If the property owner is entitled to compensation (a liability rule), she can sue the polluter and the court assesses the harm she suffered and mandates the payment of damages. If instead the owner is entitled to injunctive relief (a property rule), she can demand that the court enjoin the polluter from engaging in the activity that causes her harm, independent of the precise level of harm suffered. Regulation, which we formally consider in Section 3, restricts the actions of polluter directly without any involvement of the owner.

In Coase (1960), bargaining is easy and damages are indisputable. Under his assumptions, alternative legal rules all yield first-best outcomes. To show how legal rules matter, we consider three forms of Coasian failure. First, we allow that bargaining may be difficult or impossible. We also consider two potential failures of courts: incorrect (and biased) assessment of damages when those are in dispute, and incorrect (and biased) attribution of harm when that fact is in dispute.

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[2] Judicial discretion is central to the analysis of legal rules (Frank 1932; Posner 2005). Courts' ability both to bias their interpretation of the law and to distort their findings of fact is a crucial factor driving the evolution of tort law and liability (Gennaioli and Shleifer 2007, 2008; Ponzetto and Fernandez 2008; Fernandez and Ponzetto 2012), as well as the development of contract law and the evolving structure of privately optimal contracts (Gennaioli 2013; Gennaioli and Ponzetto 2017).

2.1. The Model

The owner *O* owns a property that provides her with baseline utility *u*. A polluter *P* can take an action that yields him a benefit *b* but imposes a cost *c* on *O*. For example, a factory can dump runoff waste in a nearby lake, and *O* has a legal entitlement to an unpolluted beach. The cost *c* is heterogeneous and non-negative, with a minimum value less than *b*. It is important for our analysis that sometimes unmitigated pollution—or for that matter taking—is efficient: some realizations of *c* are below *b*.

We assume that when *P* pollutes, a violation of the owner's property right is indisputable, and, for the purposes of this section, so is *P*'s responsibility. For example, the polluter could be the only factory on the lake. Under the injunctive regime, the court then faces only indisputable facts, and has to impose the injunction. Under the compensation regime, however, the court accepts the same indisputable fact that *P* is responsible for pollution, but also faces a fact-intensive challenge of determining the extent of harm.[3] We assume that courts rule correctly when the relevant facts are indisputable, but when the facts are in dispute, they are corrupted by the more powerful litigant and accept his version of the facts. We focus on cases in which the polluter is powerful, but our results are unchanged if only a fraction of polluters are powerful or if powerful polluters are able to sway only certain corrupt judges. Appendix 3 shows that our results are also robust to the possibility that the owner may be the powerful party subverting the court.

Specifically, with probability $1 - \delta$ the extent of harm caused by pollution is indisputable, and we assume the court then faithfully applies the law. With probability δ, the extent of harm is in dispute, and we assume the court is then swayed through bribes or intimidation (or effective litigation) by a powerful *P* and sets damages to zero.

The parameter δ represents a compound event that the facts are in dispute and the court can be subverted by *P*. While we refer to δ as the probability that the facts are in dispute, empirically we think of

[3] At least in common-law countries, courts need not only compute the amount of harm, but also select from different doctrinal categories of damages to be applied, jointly or separately: expectation damages, reliance damages, restitution damages, punitive damages, etc. Fuller and Purdue (1936) famously argued for reliance damages in contract disputes, but scholarly debate remains open eighty years later.

this probability as capturing, in part, the weakness of institutions. A court in a country with good institutions would generally verify more facts accurately. Variation in δ across time and space is more likely to reflect differences in institutional quality than differences in the nature of evidence. As a result, the parameter δ serves as our proxy for the level of law and order in a society, which depends not only on the honesty of judges, but also on the checks these judges face from appellate courts and the public.

Our distinction between disputable and indisputable facts is different from that between verifiable and non-verifiable facts used as a foundation of incomplete contracts (Hart and Moore 1988). The idea there is that facts that can be verified will be verified honestly. For our model, it is easiest to think of all facts as verifiable, but a court can nevertheless choose to find such facts that are in dispute in favor of the strong. The better the institutional environment, the less likely is such a biased finding.[4]

The timing of the model is as follows.

In stage 1, with probability $1 - \beta$ the polluter and owner have a chance to bargain. Both actors know the harm created by pollution and whether its extent can be disputed. We assume that bargaining is efficient and achieves an equal split of the joint surplus, as in the Nash bargaining solution. With probability β there can be no bargaining between *O* and *P*, either because one of the two is absent or because they cannot write enforceable contracts.

In stage 2, the polluter decides whether or not to act. At this point, he knows the cost of pollution and whether the extent of harm is indisputable.

In stage 3, if *O*'s property rights were violated because *P* polluted without *O*'s permission, then *O* can sue (or complain to the police, if that is the relevant law enforcer). The outcome depends on the legal rule. Under injunctive relief, *P* is enjoined from polluting, in which case he loses the benefit and suffers some additional cost. *P* is then deterred by the threat of a fixed penalty $f > b$, which could be a monetary

[4] With non-verifiable facts, a court can also make a biased finding, but here one would also need a separate theory of how courts establish non-verifiable facts (which in reality they do all the time).

fine, imprisonment, or physical harm. We assume that f, whatever form it takes, does not depend on any fact-intensive verification of harm, and as such cannot be subverted by a powerful polluter.[5]

Under a compensation regime, if the level of harm is not in dispute, then P must pay damages c equal to the assessed harm. Higher damages serve no purpose in our model, since they are irrelevant when the courts are subverted and only distort behavior when the courts rule correctly.

If harm is in dispute, P subverts the court and the assessed damages are set to zero. Subversion in the assessment of damages means that the cost of pollution to a strong P is independent of legal rules raising damages above the court's estimate of harm, such as double and treble damages, unless they raise the minimum penalty for violation irrespective of harm, which is equivalent to injunctive relief.

We begin with the classic case in which harm is indisputable and the assessment of damages cannot be subverted. In this case, full compensation of c is mandated under a liability regime. Alternatively, an effective injunction is enforced by a high fixed penalty $f > b$ such that the polluter never pollutes without the owner's prior authorization.

If the parties can bargain, they can write two Coasian contracts. First, P can agree in exchange for a payment from O to refrain from inefficient pollution. Second, O can agree in exchange for a payment from P to allow efficient pollution. With perfect law and order, both of these contracts can be perfectly enforced. Our framework then embeds the classic Coase Theorem (all proofs appear in Appendix 2).

Lemma 1 (Coase 1960). Suppose that both the responsibility for pollution and the extent of harm are indisputable ($\delta = 0$), and that the owner and the polluter can always bargain ($\beta = 0$). Then the first-best social surplus is attained under both compensation and injunction.

In a compensation regime, the expectation of unbiased assessment of damages induces P to pollute if and only if $b > c$. This is the first best and yields expected benefits of $\Pi = \Pr(b > c)\, E(b - c \mid b >$

[5] We do not consider the possibility that O has access to a self-protection technology. If that technology is largely wasteful, then protecting property avoids that waste. If the technology is largely beneficial, then bargaining will lead to its adoption, irrespective of the strength of property rights protection. Without bargaining, beneficial self-protection is more likely to be adopted when property rights are weak than when they are strong (Bebchuk 2001).

c), which represent the expected social surplus from efficient pollution. In an injunction regime, O can simply stop any and all pollution. However, when $b > c$, P will find it efficient to buy her permission to pollute. Bargaining restores the first best.

The key asymmetry is that injunction requires bargaining to attain efficiency, while a compensation regime without any subversion can efficiently replace bargaining. This consideration implies a second classic result that underpins the traditional case for liability rules in law and economics.

> **Lemma 2 (Kaplow and Shavell 1996).** Suppose that both the responsibility of the polluter and the extent of harm are indisputable ($\delta = 0$), but that the owner and the polluter sometimes cannot bargain ($\beta > 0$). Then compensation attains the first-best social surplus but injunction does not.

When bargaining fails but courts cannot be subverted, it is efficient to let judges write ex post the contracts the parties would have liked to write ex ante. This reasoning does not require court enforcement to be perfect. We have assumed for simplicity that c is known precisely, but random measurement error is immaterial. However, efficiency requires that assessment of damages must be free of predictable, systematic bias in favor of either party. When there is a chance $\delta > 0$ that harm is in dispute, and then courts favor the powerful, compensation no longer achieves the first best.

Since injunction does not rely on the assessment of damages, any subversion of the court that leads to a low assessment of harm has no effect on a system of injunctive relief. If P and O are unable to bargain, O will obtain an injunction without any need to have the court assess harm. All pollution will be stopped and expected social surplus is equal to zero.

With bargaining, the only possible contract under an injunction regime is one in which O allows P to pollute in exchange for a payment. This contract is self-enforcing because the owner cannot physically prevent pollution. The polluter who signed a contract permitting him to pollute actually does so, and the court simply recognizes that the owner has relinquished her ability to demand an injunction.

Bargaining backed up by injunctive relief thus ensures that pollution occurs only when $b > c$, and it attains the first-best social surplus (Π) irrespective of subversion of the assessment of damages.

Under compensation, if the parties cannot bargain and a powerful *P* knows that the extent of harm will be in dispute, he always pollutes, safe in the knowledge he can subvert the assessment of harm if *O* sues him. This action results in expected social welfare of $E(c) - b = \Pi - \Lambda$, where $\Lambda = \Pr(c > b)\, E(c - b \mid c > b)$ represents the expected social loss from inefficient pollution.

With bargaining, the only possible contract under a liability regime is one in which *O* pays *P* to refrain from polluting. This immediately raises the question of whether contractual obligations are more robust to subversion than damage payments. Can a contract be enforced against a powerful polluter? We assume that contract enforcement takes the usual form of compensating *O* for the harm she suffers because of *P*'s breach. In this case, when the extent of harm is in dispute, contracts cannot be enforced against a powerful polluter. The court will rule that any harm generated by his breach is minimal. If the contract is breached and *O* attempts to collect damages, *P* subverts justice and pays nothing. We discuss the case in which contracts can be enforced even when harm is in dispute in Appendix 3, and we show that our results are robust to this alternative assumption.

When a dispute over harm makes contracts unenforceable, *O* is unwilling to contract with a powerful *P* under a liability rule. This leads to inefficient pollution whenever harm is in dispute, whether or not parties can bargain. Comparing the expected social losses under the two rules, we obtain a formal characterization of the key tradeoff when there is both a chance the parties cannot bargain and a chance that courts fail to provide an unbiased assessment of damages.

> **Proposition 1.** Suppose that the responsibility of the polluter is indisputable, that the extent of harm might be in dispute ($\delta \geq 0$), and that the owner and the polluter sometimes cannot bargain ($\beta \geq 0$). Then the expected social surplus from compensation is greater than that from injunction if and only if $\delta < \beta\Pi/\Lambda$.

Proposition 1 highlights the key tradeoff. The downside of injunctive relief is that it deters all efficient pollution when bargaining is impossible. Compensation, instead, always allows it. On the other hand, when the assessment of damages can be subverted, compensation allows powerful polluters to act with impunity when the true extent of harm is in dispute. Injunction, instead, always stops them. This tradeoff between insufficient pollution under injunctive relief and excessive pollution under subverted compensation is at the heart of our analysis.

Since the downside of injunctions lies in letting the owner prevent all pollution when bargaining is impossible, compensation is more attractive when the benefits from efficient pollution (Π) are higher. Since the downside of compensation lies in letting the polluter get away with any pollution when courts can be subverted, compensation is more attractive when the costs imposed by inefficient pollution (Λ) are lower. More interesting, compensation is favored when the rule of law is stronger (δ is lower). As Lemma 2 established, in the case of unbiased law enforcement ($\delta = 0$), a compensation regime (liability) is always preferred as it achieves the first best even without bargaining. More generally, there is a unique threshold $\tilde{\delta}$ for the rule of law that determines whether compensation or injunction yields higher social benefits. Compensation is preferred in more orderly societies. This result may perhaps explain why legal scholars most familiar with experience in developed countries tend to favor liability rules.

The case for injunction gets unambiguously stronger when bargaining is more likely. With bargaining, injunctive relief is optimal even when the benefits from efficient pollution (Π) are much higher than the costs imposed by inefficient pollution (Λ). If bargaining is always possible ($\beta = 0$), injunctive relief attains the first best. For instance, injunctions are fully efficient if the court can both require and enable the parties to bargain: the judge requires P to pay $f > b$ for the permission to pollute, but also enables O to accept a lower price if she wishes. The parties also reach the first best if they can bargain without judicial mediation, but in the shadow of injunctive relief. Injunctions give O the power to stop the polluter, but she only uses that power to bargain, even with a strong P. In contrast, compensation does not facilitate bargaining between a weak *O* and a strong *P* when a strong *P* can break his promise not to pollute with impunity. A strong *P* literally needs to be stopped unless and until he pays.

This last result vindicates Calabresi and Melamed's (1972) original intuition that property rules and bargaining are complements. The Coasian argument to the contrary requires perfect enforcement of contracts, just as the classic argument for liability rules relies on their unbiased enforcement. When contract enforcement is vulnerable to subversion, owners whose entitlement is protected by injunctive relief can sell it to efficient polluters. In contrast, owners whose entitlement is protected by compensation cannot pay off powerful but inefficient polluters, because contracts are not reliably enforced against them.

An additional question our framework can speak to is one of investment in power. The possibility of subverting justice creates incentives to invest in litigation, political influence and corruption. Such investment is nearly universal—courts are almost everywhere regarded as subvertible, at least by "lawyering up" if not by outright corruption—but also potentially wasteful. In the case of exploitation of natural resources, it leads to the undermining of institutions known as the "resource curse." In Appendix 3, we ask which legal rules discourage more effectively such wasteful rent-seeking, and find that the case in favor of injunctions over compensation becomes stronger when influence can be acquired.

2.2. Demand for Titling

Protection of property rights is intimately related to the demand for formal titling. For decades, economists have advocated the formalization of property (and activity) through titling (and registration) in the developing world. The evidence in this area is puzzling. On the one hand, legalization of property rights appears to improve investment in land and property, especially in Latin America (e.g., Field 2005, 2007; Galiani and Schargrodsky 2010). On the other hand, the poor are often unwilling to pay much for title, or to enter formality (Kerekes and Williamson 2010; Ali et al. 2014; La Porta and Shleifer 2008).[6]

[6] Compounding this problem, not only is willingness to pay for title surprisingly low among poor people, but at the same time the costs of formal registration tend to be surprisingly high in developing countries (Arruñada 2012).

Formal title is just a piece of paper, and securing property requires enforcement. The challenges of formalization are better understood when such enforcement is unreliable. We define the willingness to pay for land title as the reduction in nuisance- or trespass-related costs (or the increase in benefits from selling the right to pollute or trespass) resulting from having legal title to a property. The title's only benefit is the ability to rely on the law to defend one's property. We then show the following result.

Proposition 2. The willingness to pay for land title is always positive, and higher with injunction than with compensation. The difference in the willingness to pay for legal ownership under the two rules increases with subversion of justice (δ) and the ability to bargain ($1 - \beta$).

Injunctive relief always increases the willingness to pay for formal title, because without bargaining, injunction prevents the pollution of the property, whereas with bargaining, injunction enables the owner to extract a higher payment from a strong polluter. Because compensation is common in eminent domain cases, abuse of those payments may reduce the demand for land titling in the developing world. Singh (2012) documents extremely low levels of compensation given to Indian farmers by government officials, and even by the courts, when the government takes land for large industrial projects. Consistent with this perspective, Bezu and Holden (2014, p. 201) note that "a fear of land expropriation, which may be more pronounced on larger farms, may negatively influence the [willingness to pay]" for a land registration certificate. When compensation fails to secure property rights, injunctive relief may raise the demand for both title and formality.

3. Regulation

We now consider our second judicial failure: the courts do not correctly establish the responsibility for harm when it is in dispute. This problem may be especially prevalent with multiple potential polluters, so each can argue that he did not cause the harm. This is a natural concern in cases of water pollution, where many actors may potentially discharge pollutants and harm adjacent properties.

We continue to assume that δ captures the probability that the extent of harm is in dispute. We now also assume that the source of the harm may be in dispute, even if both litigants know perfectly well the responsibility of the polluter. If the source of harm is in dispute, the court again favors the strong polluter and dismisses the case. Both the extent of the damages and their cause must be indisputable for the court to award damages to the owner in a compensation regime. Even in an injunction regime, the polluter's responsibility for harm must not be in dispute for the court to impose an injunction. Injunction remains less informationally intensive than liability, but it can still be too fact-intensive.

We assume that the responsibility of the polluter is in dispute with probability γ. The parameter γ is meant to capture the complexity of the situation, reflecting both the number of potential polluters and the observability and attribution of pollution. In a simple farm setting, γ may equal zero. If multiple industrial plants dispense pollutants into a river, then γ will be greater than zero and presumably rise with the number of plants. We previously assumed that if harm is in dispute, then powerful polluters cannot sign a binding contract that penalizes them for polluting. Similarly, if the polluter's responsibility is in dispute, we assume that he cannot sign a contract committing not to pollute, because if he violates that contract, the court will neither ascribe harm nor levy damages.

Under these assumptions, with probability $1 - \gamma$ the model is exactly as before. With probability γ, P always pollutes under either injunction or liability. Two results immediately follow. Proposition 1 continues to hold and injunction dominates liability if and only if $\delta > \beta\Pi/\Lambda$. Losses from both injunction and liability are increasing in γ, because an inability to assign responsibility unambiguously leads subverted courts to permit all harm. If establishing P's responsibility becomes impossible, then losses from either regime approach Λ, which represents lawlessness.

Given the limitations of both injunction and compensation when responsibility is in dispute, we next consider regulation as an alternative. We assume that the regulator has access to a public signal as to whether the action of the polluter is generating either high or low harm. The signal generates errors, so that with probability $\varphi < ½$ the regulator blocks efficient pollution (i.e., pollution with $c < b$) and with the same probability the regulator allows inefficient pollution (i.e., pollution with $c > b$). If the regulator follows the signal, the social losses equal $\varphi(\Pi + \Lambda)$. This signal can be interpreted as a meter attached to P's factory that measures emissions that imperfectly correspond to the level of harm, but does not attempt to determine which owner suffers from that harm.

Although the public signal is imperfect, it is never in dispute, so it leaves no room for the subversion of the regulator. A model with more regulatory discretion would open room for subversion of regulators, which is fundamental in many applications (Stigler 1971). Here we just assume that regulations are bright line indisputable rules. In line with this assumption, the rise of regulation in the U.S. and elsewhere was driven at least in part by the failure of courts to resolve disputes involving powerful litigants, as illustrated in Section 5 (Wilson 1913; Landis 1938; Shleifer 2012).

Proposition 3 compares a pure regulation regime, where the regulatory rule can follow the signal, always forbid pollution, or always allow it, with pure injunction and pure liability regimes. We do not consider mixed systems.

Proposition 3. If the responsibility of the polluter and the extent of the harm are sometimes disputable ($\gamma \geq 0$ and $\delta \geq 0$), and bargaining is sometimes impossible ($\beta \geq 0$), then there is a threshold $\tilde{\gamma}$ such that regulation yields higher expected social surplus than both compensation and injunction if and only if complexity is larger than the threshold ($\gamma \geq \tilde{\gamma}$). The threshold is increasing in the error rate of the public signal ($\partial\tilde{\gamma}/\partial\varphi \geq 0$) and in the parties' ability to bargain ($\partial\tilde{\gamma}/\partial\beta \leq 0$), and decreasing in the extent of subversion of justice ($\partial\tilde{\gamma}/\partial\delta \leq 0$). The threshold is increasing in the social cost of stopping efficient pollution ($\partial\tilde{\gamma}/\partial\Pi \geq 0$) and decreasing in the social cost of allowing inefficient pollution ($\partial\tilde{\gamma}/\partial\Lambda \leq 0$), unless $\varphi/(1 - \varphi) < \min\{\beta, \sqrt{\delta}\}$ and $\varphi/(1 - \varphi) < \Pi/\Lambda < \delta/\beta$.

Compensation is an ideal regime when courts correctly assess both the cause and the extent of harm, and its benefits do not rely on the ability to bargain. Injunction performs well when courts correctly assess the cause of harm but not the extent of damages, and its benefits are greater when bargaining is common. Regulation becomes an attractive regime when courts fail to correctly establish the cause of harm. In a low-density rural setting, it may be easy to link one farmer's roaming herd to another farmer's crop damage and bargaining may be straightforward, so an injunction protects property rights effectively. In a more complex economy where the sources of harm are legion, injunction may fail almost as often as compensation, and regulation becomes more attractive. In Section 5, we interpret the Clean Water Act as a regulation of this kind, in a context where the precise attribution of responsibility is challenging.

Proposition 3 establishes that regulation is preferable to both compensation and injunction when responsibility for pollution is hard to determine ex post, regulation is fairly accurate, the probability that the extent of harm is in dispute is high, and the probability of bargaining is low. At the margin, regulation is relatively more likely to block efficient pollution and compensation is relatively more likely to allow inefficient pollution. Injunction is also relatively more likely to allow inefficient pollution as long as $\beta < \varphi/(1 - \varphi)$. As prohibiting low-cost pollution becomes more harmful (higher Π) or allowing high-cost pollution less harmful (lower Λ), regulation becomes less attractive than judicial remedies. This result is not fully general, but the alternative seems unlikely because it requires the availability of a public signal of particularly high quality.[7]

While the threshold structure described by Proposition 3 is general, its statement does not guarantee that the threshold $\tilde{\gamma}$ is interior. If the regulator's signal is extremely accurate, then regulation may always dominate, and if it is extremely inaccurate, regulation may never be optimal.

Corollary 1. Regulation is undesirable for sufficiently low complexity ($\tilde{\gamma} > 0$) if and only if the regulatory signal is sufficiently inaccurate that $\varphi > \min\{\delta\Lambda, \beta\Pi\}/(\Pi + \Lambda)$.

If the signal generates few errors, bargaining often fails, and the subversion of justice is prevalent, then regulation dominates both injunction and compensation even when complexity is so low that the

[7] At the margin, regulation might be relatively more likely to allow inefficient pollution, and injunction relatively more likely to forbid efficient pollution. Then regulation would become more attractive as forbidding low-cost pollution becomes more harmful (higher Π) or allowing high-cost pollution less harmful (lower Λ). As Proposition 3 makes clear, this alternative requires signal quality to be high both in absolute terms ($\varphi/(1 - \varphi) < \Pi/\Lambda$, so nuanced regulation is better than a blanket ban), relative to injunction ($\varphi/(1 - \varphi) < \beta$, so at the margin regulation is relatively less likely to forbid efficient pollution) and relative to compensation ($\varphi/(1 - \varphi) < \sqrt{\delta}$, so the previous two conditions are consistent with the superiority of injunction relative to compensation, i.e., $\Pi/\Lambda < \delta/\beta$).

polluter's responsibility is never in doubt. Regulation will be inferior to courts when responsibility is indisputable (γ = 0), unless it also increases the availability of information, perhaps with better monitoring. Formally, if the polluter's responsibility is indisputable and $\varphi > \delta$, which means that regulators are less likely to catch high levels of harm than the courts, then liability is always preferred. Alternatively, regulation is preferred to litigation either because the regulator has access to superior information or because responsibility is in dispute, or both.

Corollary 2. Regulation is desirable for a sufficiently high complexity ($\tilde{\gamma} < 1$) if and only if the regulatory signal is accurate enough that $\varphi < \Lambda/(\Pi + \Lambda)$.

If the signal generates too many errors ($\varphi \to ½$), it becomes worthless, and regulation can only establish a blanket prohibition of all pollution. If complexity is so high that responsibility is always in doubt ($\gamma = 1$), then court enforcement also tends to become worthless. All that courts can do is to enable a regime of impunity in which all pollution is effectively allowed. If owners' property rights deserve protection on average (i.e., if $E(c) > b$ and thus $\Lambda > \Pi$), in this doubly dismal limit regulation remains the lesser evil ($\varphi \leq ½ < \Lambda/(\Pi + \Lambda)$).

4. Contract Enforcement

We next turn to the parallel case of contract enforcement, which can also be subverted by the strong. Just as injunctions can be less vulnerable to subversion than compensation, a parallel remedy in contract enforcement is specific performance. With this remedy, instead of accepting a breach of contract and mandating the payment of damages in compensation for its effects, the court simply orders a party to complete its performance of the contract as originally stipulated, refraining from any breach or fully correcting it. To establish the parallel between contracts and property, we keep the same symbols and describe how the basic logic applies to contract enforcement.

In stage 1, *O* and *P* can sign a contract that, if performed, generates a baseline surplus $u > 0$ which can be split between them. If the parties do not sign a contract, payoffs are normalized to zero.

In stage 2, *P* can breach the contract, leading to an added payoff of b to himself and $-c$ to *O*. The value of c is observed before the breach but after the contract is signed, while b is known at the time of the contract. As in Section 2, we assume that *P* is strong, so courts always favor *P* if the facts are in dispute. The facts are indisputable with probability $1 - \delta$, and when they are the courts enforce the contract. Whether facts are indisputable is known to *P* at the time of the breach, but not when the contract is originally signed. We do not allow renegotiation at this stage.

In stage 3, *O* can sue *P* for breach of contract. So long as specific performance can be enforced by courts, *P* can be forced to remedy the breach, which costs him $f > b$, since he must forego any benefits of breach and pay the costs to remedy the previous action. With contractual damages, *P* has to pay the cost of the damages to *O*, namely c if the contract is enforced, and 0 if not.

If the facts of the case are indisputable, contractual damages lead to efficient breach, which raises the baseline surplus. Instead, specific performance always prevents efficient breach, because we assumed no recontracting in stage 2. The baseline surplus is then the total surplus generated by the contract. If the court assessment of facts cannot be subverted, contractual damages thus lead to the textbook first-best outcome and specific performance does not. If facts are in dispute, however, the flexibility of contractual damages leads to subversion, as the strong persuade the court that damages are negligible. As noted by Cooter (2008, p. 1128) "the final advantage of specific performance concerns corruption," because "damages allow judges to vary the award over a continuous range, which makes disguising bribes easier." In this case, breach does not lead to large penalties imposed on the strong.[8]

Contract is always breached in this case, and the surplus is reduced by $E(c) - b$. For contracts, it is natural to assume that that $E(c) > b$ (hence $\Lambda > \Pi$). If an action yields positive expected surplus ($b > E(c)$), the contract would be written ex ante so that the action constitutes correct performance rather than breach. Because specific performance is not subverted, breach does not occur and surplus is not eroded.

[8] Dunworth and Rogers (1996) find that larger corporations typically outperform all other parties in contract disputes, including smaller businesses. Galanter (2001) similarly finds that corporations overwhelmingly defeat individuals in contract litigation.

The logic of this reinterpretation is identical to that of our core model. Contractual damages dominate specific performance when the probability of judicial subversion is low. Specific performance, like injunction, dominates when power is asymmetric and the probability of judicial subversion is high.

In the famous case of *Peevyhouse v. Garland Coal & Mining Co.* (382 P.2d 109, Okla. 1962), the Oklahoma Supreme Court ruled that the coal miner did not have to honor its contractual promise to perform remedial work in order to restore the small farmers' property after strip mining. Instead, it merely owed damages for nonperformance. The trial jury, taking into account both the diminished value of the property and the cost of remediation, awarded damages of $5,000. On appeal, the Supreme Court reduced damages to $300, ruling the cost of remediation immaterial. Many legal scholars celebrate this outcome as the triumph of economic efficiency over bleeding-heart sentimentalism, since the coal company paid damages rather than the high cost of restoring the land. Some, however, are concerned with the inequity of the outcome (Kennedy and Michelman 1980; Maute 1995).

In our framework, the matter is not just the inequity of the outcomes, but also their inefficiency. Enforceable Coasian contracts against the strong—if specific performance indeed enables them—improve efficiency because they encourage bargaining between a weak owner and a strong polluter.

Proposition 4. A contract enforced by specific performance is always signed. A contract enforced by compensatory damages is signed if and only if $\delta < (u + \Pi)/\Lambda$.

In equilibrium, when the remedy for breach is damages rather than specific performance, many contracts are avoided. The strong contract with the strong, the weak with the weak, and gains from trade between parties of different legal strengths are not realized. The trust necessary for parties to make Coasian bargains disappears when justice is subverted.

Proposition 4 has implications for the theory of the firm. If the weak and the strong have difficulty writing enforceable arm's length contracts, there is an added case for combining into a single firm. If a supplier has less legal power than its customer, a contract dispute may end up being resolved in favor of that powerful customer. With vertical integration of the two, this contracting problems can be avoided (Klein, Crawford, and Alchian 1978; Grossman and Hart 1986). This argument mirrors the classic claim that non-verifiable contracting requirements help explain the boundaries of the firm, but it emphasizes that institutional quality rather than verifiability determines the optimal firm size.

A good deal of recent empirical research considers closely related issues, both across countries with different legal institutions, and within countries. For example, Antras, Desai, and Foley (2009) show empirically that weak investor protection, which may capture the legal disadvantage of a foreign firm compared to a domestic trading partner, limits the activities of multinational firms as well as foreign direct investment. Boehm and Oberfield (2018) show directly for Indian manufacturing that firms in states with more congested courts, and therefore less effective contract enforcement, exhibit more vertical integration and less purchasing of inputs from outsiders. Less directly, our logic can help explain why newer, smaller firms are more likely to enter in markets where there an abundance of small-scale suppliers (Glaeser and Kerr 2009; Glaeser, Kerr and Ponzetto 2010). These existing smaller suppliers are less likely to enjoy a legal advantage than larger incumbents.

The absence of contracts between parties with asymmetric power may explain why damages have come to be preferred in many of the common-law legal debates on contract enforcement, while injunctive relief is still preferred to secure rights of possession.[9] Whereas asymmetric contracts can be avoided in equilibrium (albeit with a loss of gains from trade), the same does not apply to pollution, trespass or taking. A poor farmer can decide not to enter a contract with a powerful firm, but that firm can still damage his crops or even take his land.

[9] Schwartz (1979) is a prominent counter-example, advocating specific performance because of fears of under-compensation with damages.

5. Water Pollution

In this section, we bring the predictions of our theory to the Clean Water Act (CWA) of 1972. The CWA was intended as a regulatory response to the perceived failings of the common law. It introduced a measurement/reporting system for emissions of pollutants, which the government could restrict without investigating who is harmed, by whom, and how much. Our theory predicts that such regulatory enforcement should reduce pollution where it is applied and binding, and that pollution reductions should be particularly large in corrupt environments. We first briefly describe the history of water pollution control in the U.S. and then describe the pollution data collected by Keiser and Shapiro (2019), and present our analysis.

5.1. Legal History of Water Pollution Control

Prior to the passage of the CWA in 1972, the primary methods for regulating pollution in the U.S. were the common law notions of trespass and nuisance (Percival et al. 2017). Pollution posed challenges for common law, because establishing liability requires that a plaintiff show both that pollution caused harm and that the defendant's actions caused the pollution (Hines 1966). When multiple polluters contributed pollution to a single body of water, plaintiffs faced a nearly insurmountable burden of proof. Many jurisdictions even barred recovery when liability could not be divided among multiple polluters (e.g., *Walters v. Prairie Oil & Gas Co.*, 204 P. 906, Okla. 1922).[10] By the middle of the twentieth century, judges also became concerned that recovery of pollution damages interfered with useful economic activity, which led to both denial of liability and reduced damage awards (Goldstein 2010; Lewin 1989).

Several states responded to the limitations of the common law with regulations that set quality standards for a given body of water, but enforcement was limited. According to Lazarus (2004, p. 74), "[t]he experience of regulators prior to 1972 was that there were so many factors that influenced the

[10] A related issue was the delay between when pollution is emitted and when its effects became clear (Lazarus 2004). In *Globe Aircraft Corp. v. Thompson* (203 S.W.2s 865, Tex. Civ. App. 1947), the court overturned a jury damage award for a farmer whose cows had allegedly been poisoned by water pollution because the plaintiff could not demonstrate that pollution had been emitted for the entire time the cows were harmed.

actual impact of pollutants on water quality, including temperature, flow, volume, and the presence of other pollutants, that regulation tied to such determinations would quickly become mired in protracted factfinding and scientific uncertainty." In many states these programs were also voluntary, partially because regulators were checked by the political forces aligned with the polluters (Andreen 2003a).

The CWA shifted the focus of regulation from water quality to compliance with emissions permits administered by the Environmental Protection Agency (EPA) (Andreen 2003b). The EPA issued permits that required measurement and limited emission of pollution from a "point source" into "a water of the United States." Although the Supreme Court held that the CWA does not preempt common law claims of nuisance (*International Paper Co. v. Ouellette,* 479 U.S. 481 [1987]), state court cases alleging trespass or nuisance from environmental harms fell 75 percent from the early 1970s to the early 1990s. Federal court cases based on trespass or nuisance fell by 21 percent over the same time period (Green 1998). The CWA shifted water pollution control from the common law to regulation.

The general finding is that water quality in the U.S. improved after the passage of the CWA, although there are some questions of attributing this improvement to the CWA rather than to general trends (Mehan 2010; Olmstead 2009). Keiser et al. (2018) review many of the cost-benefit analyses of the CWA and find that costs often appear to exceed benefits. Keiser and Shapiro (2019) provide the most comprehensive study of the CWA and national water quality, using data on nearly 50 million pollution readings dating back to the 1960s. They find that nearly all of the pollutants they study have declined since the passage of the CWA, but the trends in the reduction of several pollutants appear to have slowed after the enactment of the CWA.

The disparate treatment of point source and non-point source pollution under the CWA may explain the slowdown in pollution declines. While the CWA's permitting process seems to have reduced point source pollution, non-point sources have seen less improvement. Bingham et al. (2000) suggests that reducing point source pollution to zero would substantially improve only 10 percent of the river miles in the United States. Our empirical analysis focuses on the distinction between point source and non-point source regulation because the differential impact of the CWA on point-source pollution enables us to estimate the impact of regulation holding common law remedies and national trends constant.

5.2. Data

Keiser and Shapiro (2019) collected source material from the EPA's STORET Legacy database. This database records measures of water pollution in the United States since the 1960s. They provide a detailed description of the data that we use in this study. They conduct much of their analysis of water pollution trends at the monitor by hour by pollutant level. We aggregate this hourly monitor data to the county by year level by taking an annual average of the individual station readings for each pollutant in each county, since our covariates, and our treatment, discussed below, are at the county level. We restrict the years in the sample to 1962–1985 and follow Keiser and Shapiro (2019) in analyzing only data on pollution in rivers and lakes.

For each pollutant in the sample we calculate a *Z* score by county by year as the difference between the level of pollutant in the country during a year and the average level of that pollutant across all years in our sample divided by the standard deviation of that level across the sample. We sum *Z* scores across all pollutants in each county by year to get an annual pollution *Z* score for each county. We present results using the *Z* score for pollutants that the CWA defines as "conventional" as well (see Appendix 4). Keiser and Shapiro (2019) examine individual pollutants, but for our purposes the aggregate measure of pollution suffices.

We use data compiled by Keiser and Shapiro (2019) on the date and location of the permits issued by the EPA for facilities through the National Pollutant Discharge Emission System (NPDES).[11] The enforcement of the CWA was delayed for both administrative and political reasons (Jerch 2018). The first NPDES permits were issued in 1973 and set limits consistent with the "best professional judgement" of the permit writer about what emission levels would reduce water pollution (USEPA 1973).

[11] These permits are recorded in the Permit Compliance System (PCS), later the Integrated Compliance Information System (ICIS). Keiser and Shapiro (2019) received access to this data through a Freedom of Information Request.

We define counties that contain a facility that received a NPDES permit in either 1973 or 1974 as being treated by regulation. These counties should include all areas that had a fixed source of pollution at the beginning of the CWA era. In our primary analysis we drop counties in which the first regulated facility receives its permit after 1974 and before 1986. We do not include data from 1973 or 1974 in our analysis except to assign treatment.[12] As we are conditioning on the presence of a point source polluter in 1973 and 1974, we cannot be sure that the county had such a polluter during all of the years before the passage of the CWA, but this issue is likely to be small, since our treated counties do not experience a statistically discernible increase in water pollution in the years before the CWA.

The CWA only requires NPDES permits for polluters who convey a pollutant into a water of the United States from a defined point, such as an outflow pipe. Most agricultural polluters were excluded from regulation under the NPDES system because pollution from agriculture is typically runoff from fertilized fields that does not enter water bodies at any defined point. In practice, this meant that the EPA did not enforce pollution reduction requirements on agricultural polluters (or most other non-point polluters) until the early 1990s (Owen 2015). If regulation reduces pollution levels relative to the tort system, we would expect the CWA to entail a larger decline in pollution for non-agricultural counties.

We define a county as agricultural if its share of employment in agriculture in the 1972 County Business Patterns is greater than the 75th percentile for the country. While we distinguish between agricultural and non-agricultural counties because of the expected differences in how the NPDES regime influenced water pollution in each type of county, our classification of agricultural counties does not depend on NPDES permits in any way.

As judicial subversion is more likely in areas that are more corrupt, we expect that the levels of pollution will be higher before regulation and the benefits of regulation will be higher in more corrupt areas. To test these predictions, we follow Glaeser and Saks (2006) and use the number of federal, state

[12] In Appendix 4 we present robustness checks retaining 1973 and 1974, retaining counties that receive a permit between 1975 and 1985, and using a time-varying measure of treatment. We also look at a definition of agricultural based on the number of establishments rather than employment.

and local public officials convicted of a corruption-related federal crime in each state from the Department of Justice's "Report to Congress on the Activities and Operations of the Public Integrity Section."[13] We calculate the number of convictions over the state's population. We then assign the average of the state's annual conviction rate from 1976 (the earliest year in the DOJ data) to 1985 (the last year in our sample) to each county in a state. These corruption measures are only available at the state level so for these specifications, we cluster our standard errors at the state by year level. In Appendix 4, we also provide comparable results based on newspapers per capita (Gentzkow, Shapiro and Sinkinson 2011), which provide a noisy measure of the level of public scrutiny.[14]

5.3. Empirical Approach

We begin by estimating the standard difference-in-difference model:

$$y_{it} = \beta_0 + \beta_1 \, CWA_{it} + \pi \, X_{it} + \gamma_i + \varphi_t + \delta_j \, , \qquad (1)$$

where y_{it} is the summed Z score across all pollutants in county i in year t, CWA_{it} is an indicator that takes on a value of 1 for years after 1974 for those counties in which the CWA became enforceable because the EPA issued a permit in 1973 or 1974, and X_{it} is a vector of time-varying controls for economic conditions in country i (e.g., total employment). γ_i is a county fixed effect, φ_t is a year fixed effect and δ_j is a state (j) specific linear time trend. In equation (1), β_1 provides an estimate of the impact of the CWA becoming enforceable by measuring how pollution changes in counties in which the CWA becomes enforceable relative to counties in which the CWA does not become enforceable in our sample.

To measure the differential effect of the CWA on agricultural and non-agricultural counties we estimate the following variant of equation (1):

$$y_{it} = \beta_0 + \beta_1 \, CWA_{it} + \beta_2 \, CWA_{it} \times Non\text{-}ag_i + \pi \, X_{it} + \gamma_i + \varphi_t + \delta_j \, , \qquad (2)$$

[13] For details on what the DOJ considers a corruption-related crime see Glaeser and Saks (2006).
[14] Our measure of the number of per capita newspapers in 1972 uses Gentzkow, Shapiro and Sinkinson's (2011) digital record of newspaper circulation in presidential election years from 1872 to 2004. We calculate the per capita number of subscriptions as the total state circulation over the population of the state in 1972.

where the common terms are as before and $Non\text{-}ag_i$ is an indicator for whether county i is an agricultural county. In equation (2), β_2 describes the impact of the CWA becoming enforceable in non-agricultural counties relative to agricultural counties. We again define treatment as an indicator variable for whether the county had a permit in 1973 or 1974. Agricultural counties that did not contain a facility that received a permit for point source pollution are in the non-treated group. Roughly 3% of our counties are non-treated agricultural counties.

Finally, to measure the differential effect of the CWA in corrupt and non-corrupt states, we estimate:

$$y_{it} = \beta_0 + \beta_1\, CWA_{it} + \beta_2\, CWA_{it} \times Corrupt_i + \pi\, X_{it} + \gamma_i + \varphi_t + \delta_j\ , \qquad (3)$$

where the common terms are as before and $Corrupt_i$ is an indicator for whether county i is located in a state that we consider corrupt. In Equation (3), β_2 describes the impact of the CWA becoming enforceable in counties that are in corrupt states relative to non-corrupt states, as measured by the average per capita number of federal, state and local convictions.

5.4. Results

In Table 1 we present a comparison of the average level of pollution before and after the passage of the CWA in all counties for which we have data. The first row provides the basic evidence that pollution fell after the passage of the CWA by more than half of a standard deviation relative to prior years. This difference in means is highly significant.

Figure 2 shows the annual trend in pollution levels for the treated counties compared to those where it does not become enforceable prior to 1985 ("non-treated counties"). Pollution levels in non-treated counties have a slight upward trend over the sample period and no noticeable trend change after the passage of the CWA. Prior to the passage of the CWA treated counties have pollution levels that are roughly half of a standard deviation lower than non-treated counties. As we report in Table 1, after the passage of the CWA treated counties reduce their pollution levels by 0.64 standard deviations while non-treated counties remain roughly constant, increasing the difference between treated and non-treated counties to 1.5 standard deviations.

Figure 3 displays the annual trend in pollution levels in treated non-agricultural counties compared to treated agricultural and non-treated counties. Both treated agricultural and treated non-agricultural counties have lower pollution levels than non-treated counties before and after the passage of the CWA. Consistent with our predictions, treated non-agricultural counties see a noticeable downward trend in pollution levels relative to pre-1972. Treated agricultural counties display no such trend. Table 1 shows that the average level of pollution in treated non-agricultural counties falls by roughly 0.70 standard deviations after 1972 relative to the pre-1972 average. Treated agricultural counties, in contrast, see a 0.09 standard deviation increase in average pollution levels.

This difference in differences not only helps control for nationwide time trends in pollution, but also provides evidence supporting specifically the mechanism predicted by our theory. The model implies that regulation is effective when it relies on monitoring simple, indisputable facts. The CWA treatment of point sources (hence, non-agricultural counties) fits this model. Its treatment of non-point sources (hence, agricultural counties) does not. The evidence confirms that the effectiveness of the CWA resulted precisely from the adoption of bright-line rules, and not, e.g., simply from setting uniform nationwide environmental standards, or more generally replacing state with Federal bureaucracy.

We also made two predictions about the relationship between pollution and corruption. First, pollution levels should be higher in more corrupt places under a liability regime and, second, regulation should reduce pollution more in these corrupt places. Figure 4 suggests that both of these hypotheses are confirmed by our data. We show in Figure 4 the level of pollution in treated corrupt and treated non-corrupt counties. As predicted, pollution levels in corrupt counties are substantially higher prior to 1972 than in non-corrupt counties. However, levels in corrupt counties fall precipitously after 1972 and are substantially closer to levels in non-corrupt counties by the late 1970s. Table 1 confirms the findings in Figure 1, and shows that they are statistically highly significant.

The analysis so far does not control for pre-trends, which we take up next. Table 2 presents the results of differences-in-differences specifications described in equations (1) and (2). Conditional on the assumption of parallel trends in the pre-CWA period, these equations identify the impact of the CWA becoming enforceable in the treated counties with the receipt of the NPDES permit. In Appendix 4, we present evidence for the absence of pre-trends in the full sample and various subsamples. This finding differs from the trends that Keiser and Shapiro (2019) find for the subset of pollutants they examine. They find that across most of the individual pollutants they examine levels are declining prior to 1972. The difference seems to stem from our inclusion of all the available pollutant data in each year rather than focusing on individual pollutants. We show in Appendix 4 that we can replicate the pattern of trends they report when we focus on the same subset of pollutants.

When we consider the simple difference between treated and non-treated counties after the passage of the CWA in column 1, the results indicate that pollution in treated counties fell by between 0.5 and 1 standard deviation more than in non-treated counties. The impact of treatment is robust to the inclusion of both year fixed effects and state-specific linear time trends. It is also robust to inclusion of time-varying controls for measures of industry that might be correlated with pollution (e.g., total employment in mining). The magnitude of our treatment effect is substantially larger than the average change in pollution levels across all counties pre and post-passage of the CWA reported in table 1 and confirms that the decline in water pollution since 1972 was concentrated in treated counties.

Column 4 of Table 2 show the additional difference between the impact of treatment in agricultural and non-agricultural counties. Non-agricultural counties show a decline in pollution that is roughly 0.5 standard deviations larger than agricultural ones. The impact of treatment in non-agricultural counties is roughly 70% of the overall treatment effect estimated in the first three columns.

To test whether regulation is more effective in counties in corrupt states, we turn to the specification in equation (3). Table 3 shows that in more corrupt locations the introduction of the CWA had a substantially larger impact. Column 1 confirms the results in table 1 that corrupt states have substantially more pollution before the CWA: levels of pollution are 1.3 standard deviations higher prior to 1972. Column 2 confirms that counties in corrupt states saw greater reductions in pollution than non-corrupt counties. We define corrupt states here as those with more than the average number of convictions. The corrupt locations see a decline in pollution levels 0.9 standard deviations larger than non-corrupt ones.

6. Summary and Implications

We have started with the puzzle that, while the law and economics approach typically stresses the benefits of liability rules to protect property rights, most jurisdictions use very different strategies, including property rules such as injunctions, quantity regulation, or even criminal law, to achieve this goal. We have taken the efficiency perspective on the question of which approach is likely to prevail in a community.

The central mechanism whose consequences we explored is subversion of justice by the strong. When particular legal facts are in dispute, the strong litigant has the power to get a favorable court ruling on these facts. Focusing on the case of water pollution by a factory that affects a land owner, we compared the situations in which (a) neither the responsibility for pollution nor the level of harm is in dispute; (b) the responsibility for pollution is not in dispute but the level of harm is, and (c) even the responsibility for pollution is in dispute, perhaps because there are multiple polluters. We showed that in scenario (a) various legal rules work equally well and deliver the predictions of the Coase Theorem. In turn, scenario (b) bolsters the case for injunctions—a legal mechanism that does not rely on the calculation of harm—relative to liability rules, especially when the parties can bargain. Finally, in scenario (c), government regulation that limits emissions without regard for either the responsibility for harm or the level of harm looks like the most efficient strategy to secure property rights.

We argued that the case for injunctions is particularly strong in developing countries, where the inequality of weapons in legal disputes is substantial. The problem of insecurity of property rights in compensation regimes may explain the low demand for formality and legal title in developing countries.

Our approach suggests that property rules lead to less harm to the property of the weak, and thus to more efficient and equitable outcomes than do liability rules, particularly in developing countries. To the extent that efficiency considerations shape legal evolution, liability rules should become more common as the quality of law enforcement improves.

We then examined pollution trends across U.S. counties before and after the Clean Water Act, which replaced common law litigation by regulation restricting emissions. We showed that the CWA reduced pollution, especially in counties where it was enforced through direct monitoring of permitted emissions, namely in manufacturing rather than agricultural counties. We further showed that more corrupt states generally had higher levels of water pollution prior to the passage of the CWA, but also sharper subsequent reductions in pollution. Both predictions are consistent with our model.

The general message of our findings is to suggest the conditions under which liability rules, injunctions, and regulation are likely to be the most efficient method of securing property rights. Injunction is preferable in simple economies with weak institutions and ample opportunity to bargain. Those features characterized both pre-industrial England, where the common law evolved, and many developing economies today. When legal institutions are strong and the source of harm is indisputable, liability rules work well and can even eliminate the need for parties to bargain (Kaplow and Shavell 1996). When neither the source of harm nor the extent of damage is beyond dispute, the case for regulation becomes stronger. Regulation is most attractive under a combination of economic complexity and institutional weakness.

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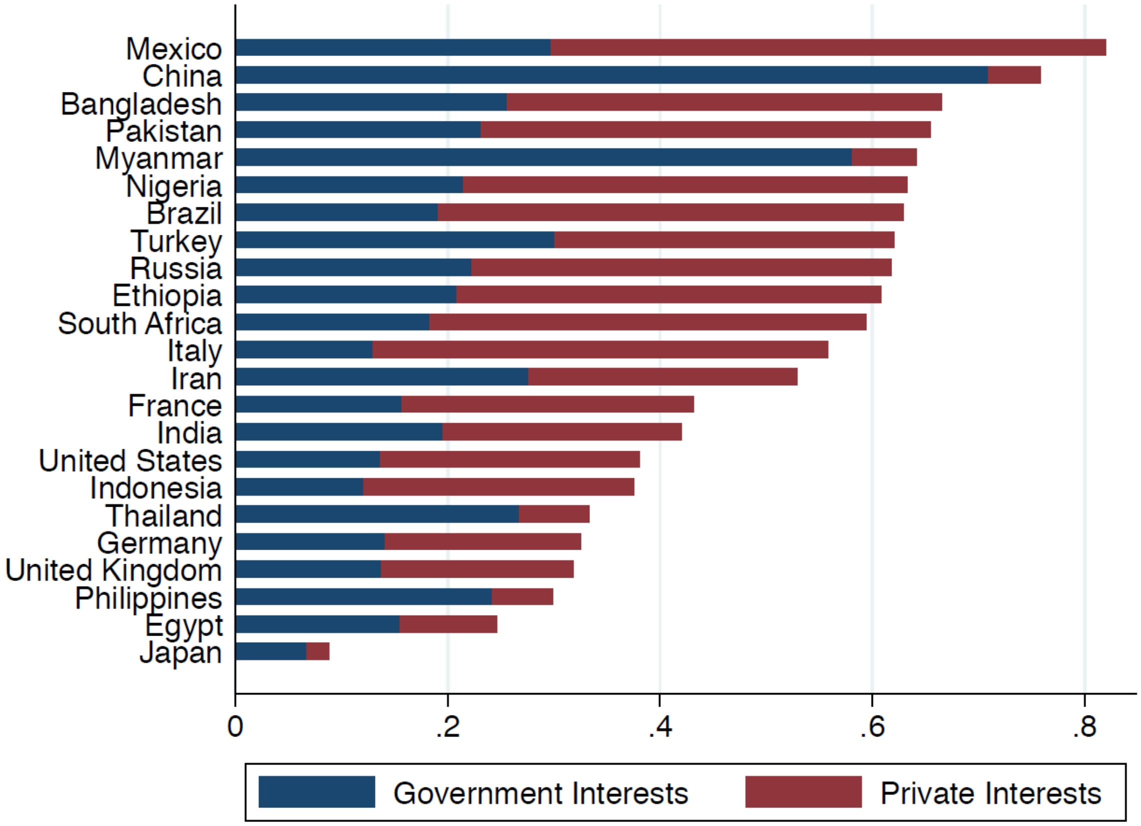
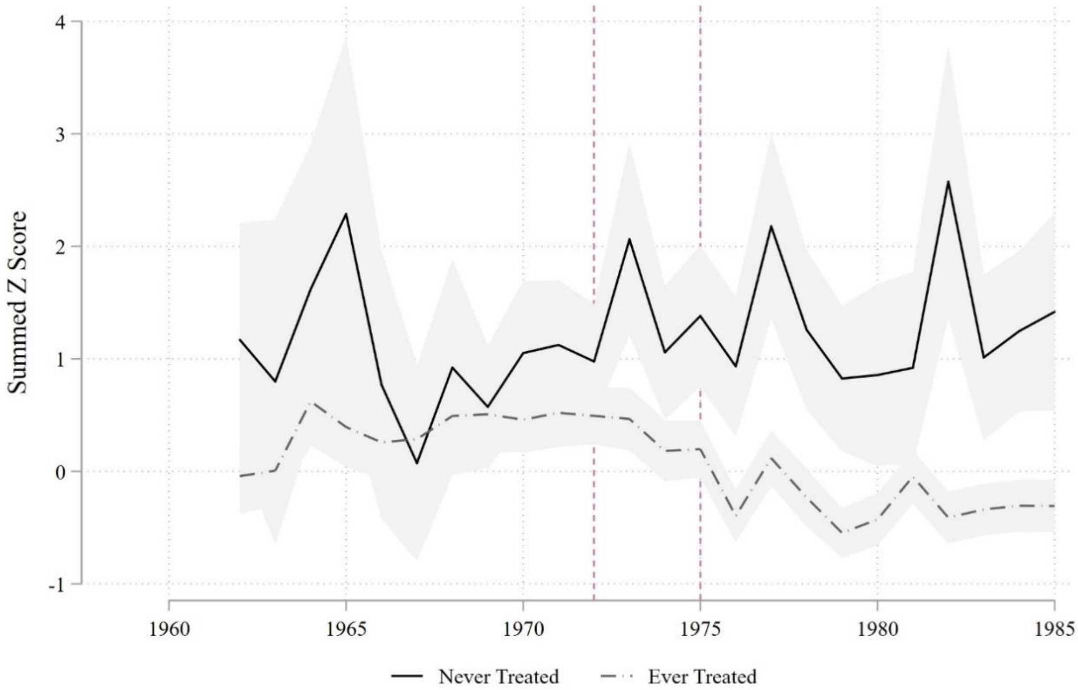
Figures and Tables

Figure 1. Popular Perception of Undue Influence over Judges



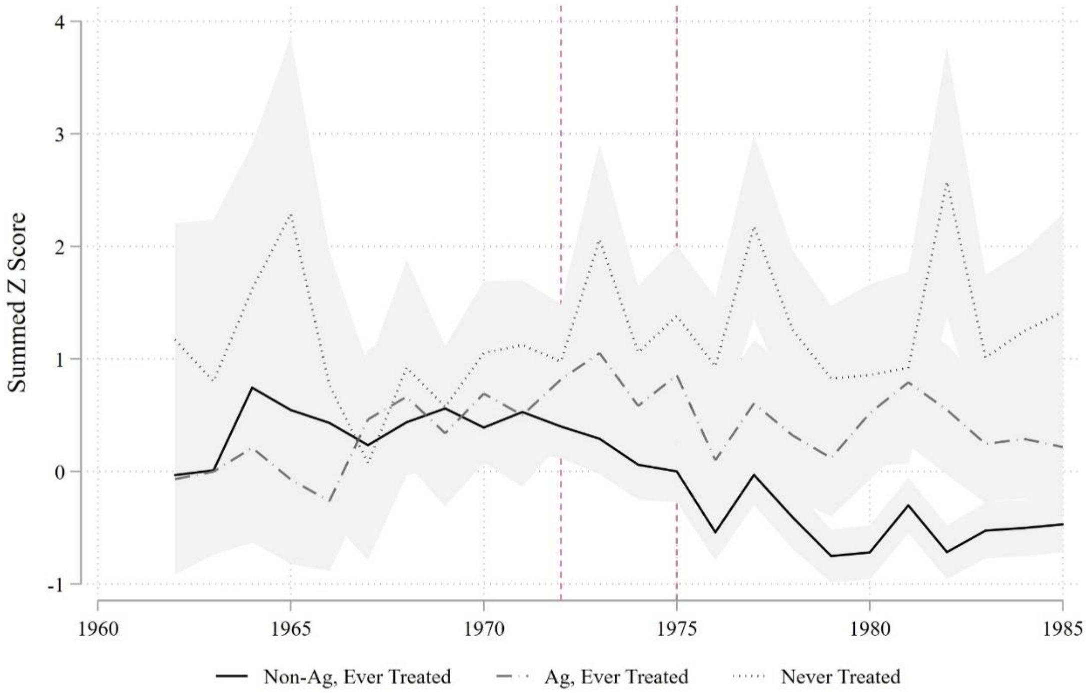
Notes: Survey responses from the World Justice Project, General Population Poll 2012-2014 for countries with population over 50 million in 2011. The graph depicts the share of respondents who give the following answers. "(q8) In your opinion, most judges decide cases according to (provide single answer): (1) What the government tells them to do [shown in blue]. (2) what powerful private interests tell them to do [shown in red]. (3) What the law says [remainder]."

Figure 2: Pollution Trends



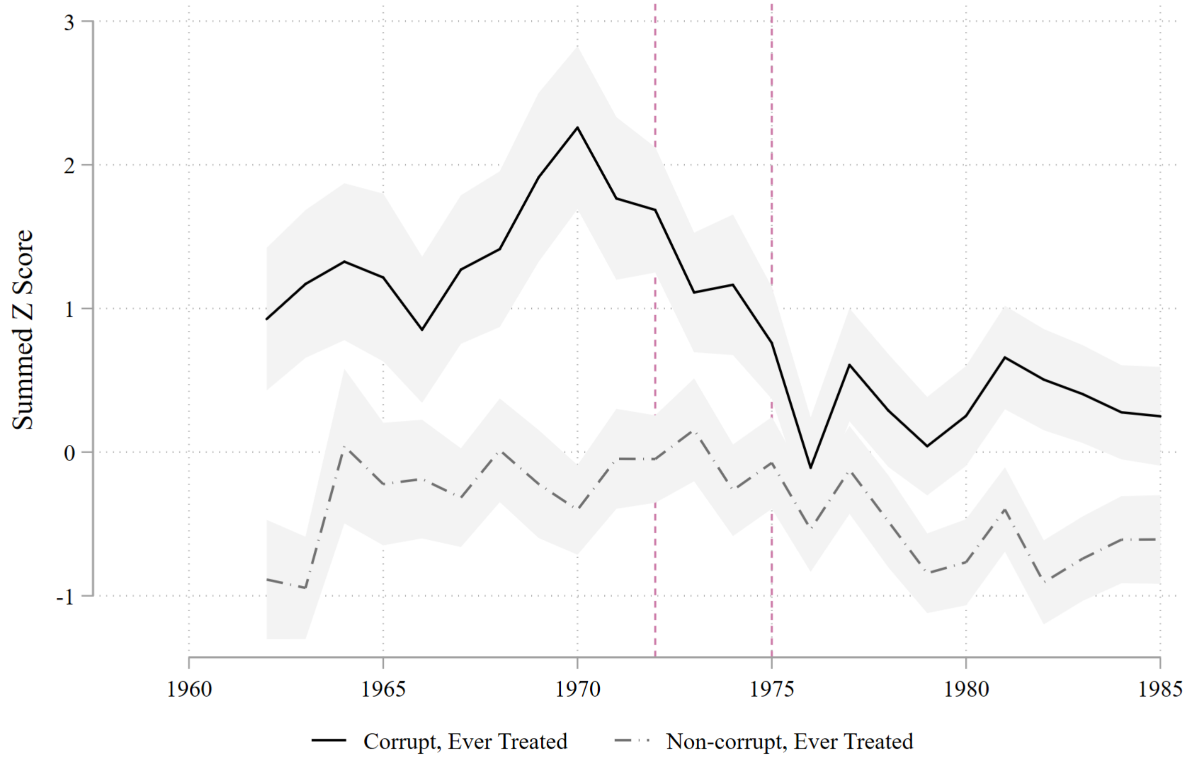
Notes: The figure shows the annual trend in the average summed *Z* score of water pollution for treated and non-treated counties. *Z* scores are calculated for each pollutant in each year (negative *Z* scores indicate lower than average pollution) and then *Z* scores for all pollutants are summed by county-year. Country-wide averages are calculated by year. Treated counties are those that contain a facility that received a NPDES permit in 1973 or 1974. Counties that contain a facility that received a permit after 1974 are dropped. Non-treated counties do not contain a facility that received a NPDES permit between 1972 and 1985. The grey shaded area is the 95% confidence interval for the mean summed *Z* score.

Figure 3: Pollution Trends: Agricultural and Non-Agricultural



Notes: The figure shows the annual trend in the average summed *Z* score of water pollution for treated agricultural and non-agricultural counties and all non-treated counties. *Z* scores are calculated for each pollutant in each year (negative Z scores indicate lower than average pollution) and then *Z* scores for all pollutants are summed by county-year. Country-wide averages are calculated by year. Treated counties are those that contain a facility that receives a NPDES permit in 1973 or 1974. Counties that contain a facility that receives a permit after 1974 are dropped. Non-treated counties do not contain a facility that received a NPDES permit between 1972 and 1985. Agricultural counties are those whose share of employed workers in agriculture in 1972 was above the 75th percentile for the country. Non-treated agricultural and non-treated non-agricultural counties are pooled in the nontreated group. The grey shaded area is the 95% confidence interval for the mean summed *Z* score.

Figure 4: Pollution Trends: Corrupt and Non-Corrupt



Notes: The figure shows the annual trend in the average summed *Z* score of water pollution for corrupt and non-corrupt counties that are treated. *Z* scores are calculated for each pollutant in each year (negative *Z* scores indicate lower than average pollution) and then *Z* scores for all pollutants are summed by county-year. Country-wide averages are calculated by year. Treated counties are those that contain a facility that receives a NPDES permit in 1973 or 1974. Counties that contain a facility that receives a permit after 1974 are dropped. Non-treated counties do not contain a facility that received a NPDES permit between 1972 and 1985. Corrupt counties are those in states where the average number of federal convictions per 10,000 state residents is above the mean. Conviction rates are calculated as the average of the annual number of convictions per capita over the years 1976-1985. The grey shaded area is the 95% confidence interval for the mean summed *Z* score.

Table 1: Pre- and Post-1972 Means by Pollutant Type

	Pre-CWA		Post-CWA		Difference in Means	
	Mean	St. Dev.	Mean	St. Dev.	$\mu_{post} - \mu_{pre}$	*t* stat.
All Counties	0.48	4.37	−0.05	4.51	−0.53	−9.07
Non-Agricultural Counties	0.45	4.31	−0.27	4.26	−0.72	−11.22
Agricultural Counties	0.60	4.54	0.69	5.17	0.09	0.64
Treated Counties	0.40	4.34	−0.24	4.33	−0.64	−10.64
Non-Treated	0.98	4.47	1.31	5.39	0.33	1.81
Non-Corrupt	0.04	4.26	-0.20	4.77	−0.24	−11.73
Corrupt	1.38	4.44	0.28	3.83	−1.10	−11.73

Notes: Statistics are reported for the summed *Z* score of pollution. *Z* scores are calculated for each pollutant in each year (negative *Z* scores indicate lower than average pollution) and then *Z* scores for all pollutants are summed by county-year. "All Counties" reports the statistics across all the counties in our sample. "Agricultural Counties" are defined based on their share of employment in the agricultural sector in 1972. Counties whose share of employed workers in agriculture in 1972 was above the 75th percentile for the country are considered agricultural. Results using agricultural establishments instead of employment are similar. "Treated Counties" are those that contain a facility that receives a NPDES permit in 1973 or 1974 while "Non-Treated Counties" are those that do not contain a facility that receives a NPDES permit from 1972 to 1985. Counties that contain facilities that receive a permit from 1975 to 1985 are dropped. "Non-Corrupt Counties" ("Corrupt Counties") are those in states where the average number of federal convictions per 10,000 state residents is below (above) the mean. Conviction rates are calculated as the average of the annual number of convictions per capita over the years 1976-1985. The reported *t* statistic is from a paired *t* test that the means pre- and post-passage of the Clean Water Act (CWA) in 1972 are the same.

Table 2: Difference-in-Differences Results

	(1)	(2)	(3)	(4)
CWA Enforceable	−0.689***	−0.683***	−0.846***	−0.475
	(0.129)	(0.128)	(0.272)	(0.334)
CWA Enforceable × Non-Agricultural				−0.485**
				(0.224)
N	25,455	25,455	25,455	25,455
R^2	0.55	0.55	0.56	0.56
County FE	X	X	X	X
Year FE			X	X
State Trend	X	X	X	X
Controls		X	X	X

Notes: The table reports the results of two specifications. Columns 1–3 report the difference-in-differences specification described in equation 1 with and without year fixed effects and with and without controls. Column 4 reports the additional difference between agricultural and non-agricultural counties described in equation 2. We consider the CWA enforceable starting in the year the first facility in a county receives its first NPDES permit if that is prior to 1975. Counties that only contain facilities that receive their first permit between 1975 and 1985 are dropped. We consider the CWA non-enforceable in counties that do not contain a facility that receives a permit by 1985. Whether a county is agricultural is determined by its share of employment in the agricultural sector in 1972. Counties whose share of employed workers in agriculture in 1972 was above the 75th percentile for the country are considered agricultural. Controls include total employment, manufacturing employment and mining employment. Standard errors are clustered at the county level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table 3: Convictions per Capita

	(1)	(2)
Corrupt	1.334**	
	(0.656)	
CWA Enforceable		−0.587***
		(0.217)
CWA Enforceable × Corrupt		−0.922**
		(0.439)
N	9,106	25,455
R^2	0.04	0.56
County FE		X
Year FE	X	X
State Trend		X
Controls	X	X

Notes: The table reports the results of two specifications. Column 1 reports $y_{it} = \beta\ Corrupt_{it} + \psi_t$. Column 2 reports $y_{it} = \beta\ CWA_{it} + \omega\ CWA_{it} \times Corrupt_{it} + \gamma_i + \delta_t + \psi_t$. y_{it} is the summed Z score across all pollutants in county i in year t, CWA_{it} is an indicator for whether the CWA was enforceable in county i in year t. We consider the CWA enforceable starting in the year the first facility in a county receives its first NPDES permit if that is prior to 1975. $Corrupt_{it}$ is an indicator for whether a county is corrupt (1=Yes). Corrupt counties are those in states where the number of federal convictions per 10,000 state residents is above the mean. Conviction rates are calculated as the average of the annual number of convictions per capita over the years 1976-1985. Controls include total employment, manufacturing employment and mining employment at the county level and rates of college attendance at the state level. γ_i is a county fixed effect, ψ_t is a year fixed effect and δ_t is a state specific linear time trend. Standard errors are clustered at the state level. $^{*}\ p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$.

Appendix 1. Individual-Level Evidence from the World Justice Project

The World Justice Project (WJP) is an independent non-profit organization founded by the American Bar Association in 2006 to advance the rule of law around the world. It provides a quantitative assessment of the rule of law in 102 countries through surveys of both experts and ordinary people. The surveys query respondents about their real experiences and about hypothetical situations, such as cases in which the government uses eminent domain.

In this appendix, we briefly present some individual-level evidence on the central premise of this paper: the poor are disadvantaged in their access to justice. To differentiate the experience of the weak and the empowered, we rely on evidence from the WJP General Population Polls conducted in 2012, 2013 and 2014. Overall, there were 108,489 ordinary people in the survey: typically 1,000 living in the three largest cities of each country.

We consider how individuals characterize their interactions with the legal system as a function of their education and home ownership. The WJP also includes some data on household income, but we rely on education because the data are more reliable. We divide respondents into those that have less than middle school education (the omitted category), those with middle or high school education, those with a college degree, and those with a postgraduate degree. The regressions are estimated on a pooled sample with country fixed effects, so we have up to 100,000 observations.

Table 1 presents the results on a hypothetical taking of land by the government for a public project, where individuals are asked about their beliefs about the fairness of this process. It is very clear that more educated people are more likely to believe that (1) the government would fairly compensate owners for the taking of the land; (2) homeowners would sue if it did not; and (3) courts would provide a fair compensation. We see the same pattern of beliefs again in a general question on whether judges would block an illegal action by the government. The relationships are generally monotonic in the level of education. Even within countries, the better educated feel better protected by the law from takings than the less educated. Likewise, homeowners feel more likely to have access to justice than those who do not own homes. In this most basic case of the security of property rights, the weakest members of society, across countries, feel least protected by the law.

Table 2 presents related evidence on contract disputes between private parties. Compared to the less educated respondents, the more educated ones are more likely to have had such a dispute, to have filed a legal claim, and to feel that the process was objective and unbiased when they did file a claim. More generally, better educated respondents are more likely to feel that courts guarantee everyone a fair trial. The evidence again suggests that the poor neither use nor believe in the courts.

Table A1: Perceptions of Lawfulness

	Government compensates homeowners fairly for taking	Homeowners sue government for unfair compensation	Court awards homeowners fair compensation	Judges stop illegal government decision
	(1)	(2)	(3)	(4)
Post-Graduate Degree	0.065***	0.028**	0.041**	0.058***
	(0.014)	(0.012)	(0.016)	(0.013)
College Degree	0.028**	0.025***	0.014	0.053***
	(0.011)	(0.009)	(0.012)	(0.011)
High- or Middle-School Diploma	0.012	0.010	-0.003	0.028***
	(0.009)	(0.006)	(0.009)	(0.008)
Homeowner	0.015**	0.013**	0.020***	0.026***
	(0.006)	(0.005)	(0.006)	(0.006)
N	95,828	96,342	94,708	95,062
Adjusted R^2	0.104	0.149	0.098	0.123
Country FE	X	X	X	X

Notes: Survey responses from the World Justice Project, General Population Poll 2012-2014. Regressions report, as a function of self-reported educational attainment (omitted category: primary-school diploma or less) and homeownership, the probability that respondents answer "Very likely" or "Likely" to the following questions. For the first three columns: "Please assume that the government decides to build a major public works project in your neighborhood (such as a railway station or a highway), and assume the construction of this public works project requires the demolition of private homes in your community/neighborhood. (q1a) How likely are these homeowners to be fairly compensated by the government? Now, assume that the monetary compensation offered by the government for the demolition of the houses is clearly unfair and inadequate. How likely are the following outcomes? (q1b.1) Homeowners would sue the government in court. [...] (q1c) Finally, if the homeowners sue the government, how likely is it that they obtain fair compensation in court?" For the fourth column: "Assume that a government officer makes a decision that is clearly illegal and unfair, and people complain against this decision before the judges. (q10a) In practice, how likely is that the judges are able to stop the illegal decision?" Standard errors are clustered at the country level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table A2: Resolution of Contract Disputes

	Had contract dispute during past 3 years	Resorted to courts for dispute resolution	Court process was objective and unbiased	Courts guarantee everyone a fair trial
	(1)	(2)	(3)	(4)
	Linear Probability Model			
Post-Graduate Degree	0.054***	0.032	0.084*	0.051***
	(0.008)	(0.025)	(0.049)	(0.013)
College Degree	0.034***	0.058***	0.056	0.031***
	(0.007)	(0.018)	(0.044)	(0.011)
High- or Middle-School	0.013***	0.011	0.060	0.005
Diploma	(0.004)	(0.016)	(0.043)	(0.009)
Homeowner	−0.002	0.022*	−0.002	0.017**
	(0.005)	(0.013)	(0.021)	(0.007)
N	96,125	10,857	3,362	93,082
Adjusted R^2	0.072	0.106	0.102	0.158
Country FE	X	X	X	X

Notes: Survey responses from the World Justice Project, General Population Poll 2012-2014. Regressions report, as a function of self-reported educational attainment and homeownership, the probability of the following answers. In Column 1: "(q35) During the past three years, have you or someone in your household had a conflict with someone who refused to fulfill a contract or pay a debt? Yes." Conditionally, in Column 2: "(q35a) Which one of the following mechanisms was used to solve the conflict? Filed a lawsuit in court / Used a small-claims court or procedure." Conditionally, in Column 3: "(q35b) In your opinion, was the process objective and unbiased? Yes." In Column 4: "Please tell me how often would you say that (q37c) the courts in [country] guarantee everyone a fair trial? Always / Often." Standard errors are clustered at the country level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Appendix 2. Proofs

A2.1. Proof of Proposition 1 and Lemmas 1 and 2

Suppose that the responsibility of the polluter is indisputable. Relative to the first best surplus Π, the expected social loss from compensation equals $\delta\Lambda$. The expected social loss from injunction equals $\beta\Pi$. The results follow.

A2.2. Proof of Proposition 2

Suppose that the responsibility of the polluter is indisputable. Without title, *O* suffers the cost of pollution whenever bargaining is impossible or harm is in dispute. When bargaining is possible and harm is indisputable, she can pay a powerful *P* to refrain from inefficient pollution. Therefore, her expected payoff equals $-\text{E}(c) + ½(1-\beta)(1-\delta)\Lambda$.

With compensation, title enables *O* to avoid harm or obtain compensation from *P* when harm is indisputable. When harm is in dispute, *P* pollutes because he would subvert contract enforcement. Therefore, *O*'s expected payoff equals $-\delta\text{E}(c)$. Hence her willingness to pay for title under a compensation regime is $V_C = (1-\delta)[\text{E}(c) - ½(1-\beta)\Lambda] > 0$.

With injunction, title enables *O* to stop pollution when she cannot bargain, and to allow it for a price when she can. Therefore, her expected payoff equals $½(1-\beta)\Pi$. Hence her willingness to pay for title under injunctive relief is $V_I = ½(1-\beta)\Pi + \text{E}(c) - ½(1-\beta)(1-\delta)\Lambda > 0$.

The difference in the willingness to pay for legal ownership generated by injunction relative to compensation equals $V_I - V_C = ½(1-\beta)\Pi + \delta\text{E}(c) > 0$, which is decreasing in β and increasing in δ.

A2.3. Proof of Proposition 3 and Corollaries 1 and 2

The expected social loss from compensation equals $(\delta + \gamma - \delta\gamma)\Lambda$. The expected social loss from injunction equals $\beta(1 - \gamma)\Pi + \gamma\Lambda$. The expected social loss from regulation equals $\varphi(\Pi + \Lambda)$ if regulation exploits the public signal, or Π if it imposes a blanket prohibition.

Thus, regulation is optimal if and only if:

$$\gamma \geq \tilde{\gamma} = [\min\{\varphi(\Pi + \Lambda), \Pi\} - \min\{\delta\Lambda, \beta\Pi\}]/[\Lambda - \min\{\delta\Lambda, \beta\Pi\}]$$

such that $\partial\tilde{\gamma}/\partial\beta \leq 0$ and $\partial\tilde{\gamma}/\partial\delta \leq 0$, while $\partial\tilde{\gamma}/\partial\varphi \geq 0$. Moreover, $\tilde{\gamma}$ depends on Π and Λ only through their ratio, and $\partial\tilde{\gamma}/\partial(\Pi/\Lambda) < 0$ if and only if (1) regulation is better than blanket prohibition: $\varphi/(1 - \varphi) < \Pi/\Lambda$; and (2) injunction is better than compensation: $\Pi/\Lambda < \delta/\beta$; and (3) $\beta > \varphi/(1 - \varphi)$. These conditions jointly require that $\varphi/(1 - \varphi) < \sqrt{\delta}$.

$\tilde{\gamma} > 0$ if and only if $\varphi > \min\{\delta\Lambda, \beta\Pi\}/(\Pi + \Lambda)$; while $\tilde{\gamma} < 1$ if and only if $\varphi < \Lambda/(\Pi + \Lambda)$, and thus in particular for all $\varphi \leq ½$ if $\Lambda > \Pi$.

A2.4. Proof of Proposition 4

A contract enforced by specific performance is never breached, so it yields surplus $u > 0$ with certainty. A contract enforced by compensatory damages is breached whenever breach is efficient or a powerful P can subvert the assessment of damages. Thus, it yields expected surplus $u + \Pi - \delta\Lambda$, which is positive if and only if $\delta < (u + \Pi)/\Lambda$.

Appendix 3. Theoretical Extensions

A3.1. Powerful owners

We assumed in our baseline model that the court assessment of damages is subverted only by powerful polluters. This asymmetric assumption is not necessary to derive our results. In this appendix we show that our findings are qualitatively preserved when we allow for the possibility that the assessment of damages is subverted instead by powerful owners.

As in the baseline model, we assume that there is a probability δ that the extent of harm is in dispute. In that case, we now assume that *O* can subvert justice in her own favor with probability ω, and *P* can subvert justice with probability $1 - \omega$. If the owner is powerful, then in a compensation regime the polluter will be required to pay arbitrarily high damages. In this way, powerful owners effectively transform a compensation regime into an injunction regime. As before, whether either party is powerful is observed before bargaining or pollution take place.

We first discuss how our results change when there is a single polluter whose responsibility for harm is indisputable ($\gamma = 0$). Under injunctive relief, *P* never pollutes without bargaining because *O* just stops him. Either party's power to subvert the assessment of damages is irrelevant because courts are not tasked with assessing damages. With bargaining, injunctive relief ensures that all efficient pollution takes place. In this case, *P* will buy the right to pollute from *O*. The possibility that *O* is powerful is irrelevant because once she has sold *P* her permission to pollute, she has no contractual obligation to perform and thus there is no need to enforce the contract against her.

Under a compensation regime, the first best is attained without bargaining when the extent of harm is indisputable. When the extent of harm is in dispute, however, if *P* is powerful compensation fails to prevent inefficient pollution; if *O* is powerful instead, compensation fails to enable efficient pollution. Bargaining suffices to solve the latter problem because even a powerful *O* is able to sell the right to pollute. Bargaining does not solve the problem of over-pollution by a powerful *P* because the courts will assess zero damages for his breach of contract. Hence, as before, *P* cannot credibly sell a promise not to pollute.

Proposition A1 generalizes Proposition 1, which it includes as the special case $\omega = 0$. Lemmas 1 and 2 are exactly unchanged because power does not matter when all facts are indisputable.

Proposition A1. Suppose that the responsibility of the polluter is indisputable, that the extent of harm might be in dispute ($\delta \geq 0$), and that the owner and the polluter sometimes cannot bargain ($\beta \geq 0$). Then the expected social surplus from compensation is greater than that from injunction if and only if $\delta < \beta\Pi/[\beta\omega\Pi + (1 - \omega)\Lambda]$.

Proof. Relative to the first best surplus Π, the expected social loss from compensation equals $\delta[\beta\omega\Pi + (1 - \omega)\Lambda]$. The expected social loss from injunction equals $\beta\Pi$. The result follows. ■

Intuitively, the appeal of compensation is the possibility that courts deliver an unbiased assessment of damages. Both kinds of subversion reduce the probability of this happening, so two wrongs do not make a right in our model. If subversion is equally likely from owners or polluters, or even if only owners are powerful, there are still inefficiencies from the compensation regime, because powerful owners prevent efficient pollution when bargaining is impossible.

Powerful owners do, however, make compensation more appealing relative to injunction. Powerful owners essentially turn the compensation regime into an injunction regime when facts are in dispute, so their ownership rights are always protected. However, compensation also retains the advantages of a correct assessment of damages when facts are indisputable. Then compensation always allows for efficient pollution, while injunction does so only when bargaining succeeds as well.

As a result, the comparison of Propositions 1 and A1 shows that injunction is more likely to be preferred to compensation the more power is concentrated in the hands of polluters (the lower ω). The broader point is that the strong protection of property rights created by injunction is particularly important when owners are weak. When owners are strong, they can still protect their property in a legal regime prone to subversion. When owners are weak, then a system like compensation, which hinges on the effective public scrutiny of a fair and capable judiciary, leaves them vulnerable. When bargaining is sufficiently common and both parties are likely capable of subverting justice, injunction remains optimal because powerful owners are capable of selling permission to weak polluters, whereas weak owners cannot trust powerful polluters' promise not to pollute in exchange for a payment.

The different importance of secure enforcement of property rights for the weak and the strong is highlighted by Proposition A2, which generalizes Proposition 2.

Proposition A2. The willingness to pay for land title is always positive, and higher with injunction than with compensation. The difference in the willingness to pay for legal ownership generated by injunction relative to compensation increases with the ability to bargain $(1 - \beta)$ and decreases with the power of owners (ω). It increases with subversion of justice (δ) if and only if polluters are sufficiently powerful that $\omega/(1 - \omega) < 2\mathrm{E}(c)/[½(1 - \beta)\Pi]$.

Proof. Without title, power enables O to pay P to refrain from inefficient pollution when the extent of harm is in dispute but bargaining is possible. Her expected payoff equals $-\mathrm{E}(c) + ½(1 - \beta)(1 - \delta + \delta\omega)\Lambda$.

With title protected by compensation, when harm is in dispute power enables O either to stop P from polluting, or—when bargaining is possible—to force him to buy the right to pollute without being sued. Her expected payoff equals $\delta[½(1 - \beta)\omega\Pi - (1 - \omega)\mathrm{E}(c)]$. Her willingness to pay for title is then $V_C = ½(1 - \beta)\delta\omega\Pi + (1 - \delta + \delta\omega)[\mathrm{E}(c) - ½(1 - \beta)\Lambda] > 0$.

With title protected by injunction, power is immaterial and O's expected payoff equals $½(1 - \beta)\Pi$. Her willingness to pay for title is then $V_I = ½(1 - \beta)\Pi + \mathrm{E}(c) - ½(1 - \beta)(1 - \delta + \delta\omega)\Lambda > 0$.

The difference in the willingness to pay for legal ownership generated by injunction relative to compensation equals $V_I - V_C = ½(1 - \beta)(1 - \delta\omega)\Pi + \delta(1 - \omega)\mathrm{E}(c) > 0$, which is decreasing in β and in ω. It is increasing in δ if and only if $\omega/(1 - \omega) < 2\mathrm{E}(c)/[½(1 - \beta)\Pi]$. ■

Proposition A2 confirms our baseline results: a switch from an injunction regime to a compensation regime (such as eminent domain) always reduces the value of legal title, and the more so the greater the parties' ability to bargain.

In addition, the Proposition establishes that the switch from injunction to compensation reduces the value of title particularly for weak owners, and not so much for strong ones. Moreover, the difference in the reduction of the willingness to pay of the powerful and that of the powerless increases with the subversion of justice. A lower level of law and order implies that a compensation regime subjects the weak to greater abuse by the strong. Intuitively, this makes injunctive relief more valuable for weaker owners, like those considered in Proposition 2 ($\omega = 0$). On the contrary, if the owner more powerful than polluter ($\omega = 1$), lower law and order merely increases her ability to subvert compensation and stop all pollution. Thus, it reduces her desire to acquire the same power legally through an injunction regime.

While Proposition A2 confirms that legal protection of property rights through formal titling is always beneficial to owners, in principle it need no longer be socially beneficial when powerful owners can subvert justice. When the main threat of subversion comes from *O* rather than *P*, it might become appealing not to recognize her property rights at all. This can be interpreted as a third enforcement regime that denies the owner any legal recourse. Then, when bargaining is impossible she can neither enjoin efficient pollution nor deter it through her ability to subvert the assessment of damages. This regime thus permits all efficient pollution, but it also permits inefficient pollution whenever the parties cannot bargain, or when a contract cannot be enforced against *P* because he is powerful and the extent of harm is in dispute. Such a no-recourse regime is dominated by injunction when pollution is inefficient on average ($b < E(c)$ and thus $\Lambda > \Pi$), an assumption that we adopt for the remainder of this appendix.[15]

We now turn to the general case in which the environment is sufficiently complex, and potential polluters sufficiently numerous, that responsibility for pollution may be in dispute with probability $\gamma > 0$. Under injunction, if the owner is powerful then the polluter will be enjoined even if his responsibility for harm is in dispute. Consequently, a powerful owner will stop all action if there is no bargaining. If there is bargaining, then the first best is achieved: the owner can sell the ability to pollute when the cause of harm is not evident to the public, just as when the level of harm isn't.

In a compensation regime, if the owner is powerful and the extent of harm is indisputable, the first best is achieved regardless of bargaining and the court's reliability in assessing the cause of harm. A powerful owner can always sue the polluter and win a damage award, but public scrutiny prevents the court from awarding her damages greater than true harm. Instead, if the level of harm is in dispute, the powerful owner will receive maximum damages from any lawsuit. This means she will stop all pollution in the absence of bargaining, but she will again achieve the first best if bargaining is possible.

Losses under a regulatory regime are unaffected by powerful owners, just as they are unaffected by powerful polluters. The optimal legal regime has the following characterization.

Proposition A3. If the responsibility of the polluter and the extent of the harm are sometimes disputable ($\gamma > 0$ and $\delta \geq 0$), and bargaining is sometimes impossible ($\beta \geq 0$), then there is a threshold $\tilde{\gamma}$ such that regulation yields higher expected social surplus than both compensation and injunction if and only if complexity is larger than the threshold ($\gamma \geq \tilde{\gamma}$). The threshold is increasing in the error rate of the public signal ($\partial\tilde{\gamma}/\partial\varphi \geq 0$) and in the parties' ability to bargain ($\partial\tilde{\gamma}/\partial\beta \leq 0$), and decreasing in the extent of subversion of justice ($\partial\tilde{\gamma}/\partial\delta \leq 0$).

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[15] The expected social loss from no recourse equals $[\beta + (1-\beta)\delta(1-\omega)]\Lambda$. Hence, injunction yields higher expected social surplus than no recourse if and only if $\beta(\Lambda - \Pi) + (1-\beta)\delta(1-\omega)\Lambda > 0$, and thus for any values of β, δ and ω if $\Lambda > \Pi$.

Proof. The expected social loss from compensation equals $L_C = \beta\delta\omega\Pi + (\delta + \gamma - \delta\gamma)(1 - \omega)\Lambda$, such that $\partial L_C/\partial\beta > 0$, $\partial L_C/\partial\gamma > 0$ and $\partial L_C/\partial\delta > 0$. Moreover, $\partial L_C/\partial\omega = \beta\delta\Pi - (\delta + \gamma - \delta\gamma)\Lambda < 0$ if $\Lambda > \Pi$. The expected social loss from injunction equals $L_I = (1 - \gamma + \gamma\omega)\beta\Pi + \gamma(1 - \omega)\Lambda$, such that $\partial L_I/\partial\beta > 0 = \partial L_I/\partial \delta > 0$. Moreover, $\partial L_I/\partial\gamma = (1 - \omega)(\Lambda - \beta\Pi) > 0 > \partial L_I/\partial\omega = \gamma(\beta\Pi - \Lambda)$ if $\Lambda > \beta\Pi$, a necessary condition for $L_I < L_C$. The expected social loss from regulation equals $L_R = \min\{\varphi(\Pi + \Lambda), \Pi\}$ such that $\partial L_R/\partial\beta = \partial L_R/\partial\gamma = \partial L_R/\partial\delta = \partial L_R/\partial\omega$ $0 < \partial L_R/\partial\varphi$. Since $\partial L_R/\partial\gamma = 0 < \partial\min\{L_C, L_I\}/\partial\gamma$, regulation is optimal if and only if $\gamma \geq \tilde{\gamma}$, for a threshold implicitly defined by $\min\{L_C(\tilde{\gamma}), L_I(\tilde{\gamma})\} = L_R$, such that $\partial\tilde{\gamma}/\partial\beta \leq 0$, $\partial\tilde{\gamma}/\partial\delta \leq 0$ and $\partial\tilde{\gamma}/\partial\varphi \geq 0$, while $\partial\tilde{\gamma}/\partial\omega \geq 0$ if $\Lambda > \Pi$. ■

Proposition A3 confirms that owner power does not radically change the tradeoff between regulation and judicial remedies. Just as before, if a more complex economic environment makes it more difficult to identify the cause of harm, then there is a stronger case for regulation. A higher probability of owner power unambiguously makes the threshold for regulation higher as long as stopping high-cost pollution is the primary social concern ($\Lambda > \Pi$). This is intuitive because powerful owners are more likely to stop pollution under judicial regimes. Consequently, owner power makes the judicial regimes more attractive while it does not change at all the properties of the regulatory regime.

Powerful owners also does not qualitatively change the result that the threshold for regulation typically increases with the social cost of stopping efficient pollution ($\partial\tilde{\gamma}/\partial\Pi \geq 0$) and decreasing in the social cost of allowing inefficient pollution ($\partial\tilde{\gamma}/\partial\Lambda \leq 0$). As in Proposition 3, the opposite requires the regulator to rely on signal so good that $\varphi/(1 - \varphi) < \Pi/\Lambda$, while either $\varphi/(1 - \varphi) < \beta$ if injunction is preferable to compensation or $\varphi < \beta\delta\omega$ and compensation is preferable to injunction.

The conditions for an interior threshold in Corollaries 1 and 2 are likewise qualitatively unaffected. Regulation is not a fully dominant alternative ($\tilde{\gamma} > 0$) if $\varphi(\Pi + \Lambda) > \min\{\delta[\beta\omega\Pi + (1 - \omega)\Lambda], \beta\Pi\}$. Regulation is not fully dominated ($\tilde{\gamma} < 1$) if $\min\{\varphi(\Pi + \Lambda), \Pi\} < \beta\delta\omega\Pi + (1 - \omega)\Lambda$.

We conclude this appendix by revisiting the parallel case of contract enforcement. For a powerful *O*, there is no difference between a contract enforced by specific performance and one enforced by damages. In both cases, breach will never happen without her express authorization. If bargaining is possible, she will allow efficient breach, relinquishing her right to sue and therefore her ability to wield her power to subvert the assessment of damages. Proposition 4 admits a straightforward extension.

Proposition A4. A contract enforced by specific performance is always signed. A contract enforced by compensatory damages is signed if and only if $\delta < (u + \Pi)/ [(1 - \omega)\Lambda]$.

Proof. A contract enforced by specific performance yields surplus $u > 0$ with certainty. A contract enforced by compensatory damages is breached whenever breach is efficient or a powerful P can subvert the assessment of damages. Thus, it yields expected surplus $u + \Pi - \delta(1 - \omega)\Lambda$, which is positive if and only if $\delta < (u + \Pi)/[(1 - \omega)\Lambda]$. ■

Proposition A4 confirms that using damages as the remedy for breach hinders disproportionately the contracting ability of the weak. A powerful O can buy the services of a less powerful P without fearing inefficient breach and subversion of justice. Conversely, a weak O can only self-protect by avoiding contracts with stronger parties. Thus, the lower owner power ω the more likely a contract is signed when specific performance is unavailable.

A3.2. Perfect Contract Enforcement

We assumed in our baseline model that contracts cannot be enforced against a powerful P when the extent of harm caused by pollution is in dispute. This assumption is natural because the standard remedy for breach of contracts is compensation for damages. Then a powerful will subvert the assessment of damages for his breach of contract, just as he would for his violation of O's property rights. However, other remedies for breach of contract would allow enforcement against a powerful polluter even when the extent of harm is in dispute. In particular, the contract could specify liquidated damages high enough they deter pollution, just like the penalty f that underpins an injunction regime. Alternatively, contracts could require specific performance. Under these alternative assumptions, compensation and injunction become identical if bargaining is possible, and the only difference between the two legal rules occurs in the absence of bargaining. In this appendix we show that our findings are qualitatively preserved when we allow for this possibility. For simplicity, we consider our baseline case in which *P* is the powerful party.

When contracts can be perfectly enforced even though the extent of harm is in dispute, Coasian bargaining occurs with probability $1 - \beta$ even under a pure compensation regime. Then *O* can but a promise not to pollute even from a powerful *P*, who can credibly commit to keep the promise. As a result, with probability $1 - \beta$ we are back to the Coasian world in which efficient outcomes are achieved regardless of initial entitlement and of the rules protecting them.

Lemmas 1 and 2 are exactly unchanged, because contract enforcement is never a problem if courts can never be subverted. More generally, the analogue of Proposition 1 shows that case for injunctive relief is weakened but not eliminated by perfect contract enforcement..

Proposition A5. Suppose that the responsibility of the polluter is indisputable, that the extent of harm might be in dispute ($\delta \geq 0$), and that the owner and the polluter sometimes cannot bargain ($\beta \geq 0$), but that if they can bargain their contracts can be perfectly enforced even if the extent of harm is in dispute. Then the expected social surplus from compensation is greater than that from injunction if and only if $\delta < \Pi/\Lambda$.

Proof. Relative to the first best surplus Π, the expected social loss from compensation equals $\beta\delta\Lambda$. The expected social loss from injunction equals $\beta\Pi$. The result follows. ■

Just as in Proposition 1, compensation is favored if and only if the rule of law is strong enough (δ is low), and it remains more appealing when the benefits from efficient pollution (Π) are higher and the costs of inefficient pollution (Λ) lower. However, it is unambiguously more appealing than when contracts cannot be enforced if harm is not evident to the public.

When contracts are always enforceable against a powerful *P*, injunction can be optimal only if the expected costs of pollution are greater than its benefits ($E(c) > b$ so $\Lambda > \Pi$). Moreover, its optimality is independent of the probability of bargaining failure β. Like Lemma 2, this result reflects the classic insight of Kaplow and Shavell (1996). When bargaining is efficient and contracts are perfectly enforced, the optimal legal rule concerns only those cases in which bargaining is impossible. Then, if and only if pollution is socially wasteful on average, it can be better to let *O* enjoin all pollution—including efficient pollution—rather than enabling unrestrained pollution by the powerful.

Even with perfect contract enforcement, however, injunction may in fact be complementary to bargaining because owners are typically easier to identify than potential polluters. With injunction, *P* needs to bargain with *O* in order to pollute, while with compensation *O* needs to bargain with *P* in order to avoid pollution. We could formally capture the different ease of identifying the counterpart by assuming that *P* can initiate bargaining with probability $1 - \beta$, while *O* can with probability $(1 - \beta)z$ for $z < 1$. The appeal of injunctive relief would then once again decrease with β.

Proposition A6. Suppose that contracts can be perfectly enforced even if the extent of harm is in dispute. The willingness to pay for land title is always positive, and higher with injunction than with compensation. The difference in the willingness to pay for legal ownership under the two rules increases with subversion of justice (δ) and the ability to bargain ($1 - \beta$).

Proof. Without title, perfect contract enforcement enables *O* to pay a powerful *P* to refrain from inefficient pollution when bargaining is possible but harm is in dispute. Her expected payoff equals $-\mathrm{E}(c) + \frac{1}{2}(1 - \beta)\Lambda$.

Perfect contract enforcement has the same benefit with title protected by compensation. *O*'s expected payoff equals $\delta[-\mathrm{E}(c) + \frac{1}{2}(1 - \beta)\Lambda]$. Hence her willingness to pay for title under a compensation regime is $V_C = (1 - \delta)[\mathrm{E}(c) - \frac{1}{2}(1 - \beta)\Lambda] > 0$.

With title protected by injunction, there is no need to enforce contract against a powerful *P*. *O*'s expected payoff equals $\frac{1}{2}(1 - \beta)\Pi$. Hence her willingness to pay for title under injunctive relief is $V_I = \frac{1}{2}(1 - \beta)\Pi + \mathrm{E}(c) - \frac{1}{2}(1 - \beta)\Lambda > 0$.

The difference in the willingness to pay for legal ownership generated by injunction relative to compensation equals $V_I - V_C = ½(1 - \beta)\Pi + \delta[\text{E}(c) - ½(1 - \beta)\Lambda] > 0$, which is increasing in δ. It is also decreasing in β if and only if $\delta < \Pi/\Lambda$. ■

The only difference between this result and Proposition 2 is that a greater likelihood of bargaining no longer unambiguously raises the benefits of injunctive relief. Coasian bargaining with perfect enforcement solves all inefficiencies, so it is of greater help in the more inefficient scenario—which is compensation if subversion is prevalent enough.

We now turn to the general case in which the environment is sufficiently complex, and potential polluters sufficiently numerous, that responsibility for pollution may be in dispute with probability $\gamma > 0$. If contracts can be enforced through specific performance, establishing the cause of harm becomes unnecessary: *O* does not need to prove that *P*'s breach caused him any harm, but can simply get the court to force *P* not to pollute in breach of contract. Then contract enforcement achieves the first best whenever parties can bargain.

The results of Proposition 3 are essentially unchanged.

Proposition A7. Suppose the responsibility of the polluter and the extent of the harm are sometimes disputable ($\gamma > 0$ and $\delta \geq 0$), and that bargaining is sometimes impossible ($\beta \geq 0$), but that if bargaining is possible contracts can be perfectly enforced even if the extent of harm is in dispute. Then there is a threshold $\tilde{\gamma}$ such that regulation yields higher expected social surplus than both compensation and injunction if and only if complexity is larger than the threshold ($\gamma \geq \tilde{\gamma}$). The threshold is increasing in the error rate of the public signal ($\partial\tilde{\gamma}/\partial\varphi \geq 0$) and in the parties' ability to bargain ($\partial\tilde{\gamma}/\partial\beta \leq 0$), and decreasing in the extent of subversion of justice ($\partial\tilde{\gamma}/\partial\delta \leq 0$). The threshold is increasing in the social cost of stopping efficient pollution ($\partial\tilde{\gamma}/\partial\Pi \geq 0$) and decreasing in the social cost of allowing inefficient pollution ($\partial\tilde{\gamma}/\partial\Lambda \leq 0$), unless $\varphi < ½\beta$ and $\varphi/(1 - \varphi) < \Pi/\Lambda < \delta$.

Proof. The expected social loss from compensation equals $\beta(\delta + \gamma - \delta\gamma)\Lambda$. The expected social loss from injunction equals $\beta[(1 - \gamma)\Pi + \gamma\Lambda]$. The expected social loss from regulation equals $\varphi(\Pi + \Lambda)$ if regulation exploits the public signal, or Π if it imposes a blanket prohibition.

Thus, regulation is optimal if and only if:

$$\gamma \geq \tilde{\gamma} = [\min\{\varphi(\Pi + \Lambda), \Pi\}/\beta - \min\{\delta\Lambda, \Pi\}]/[\Lambda - \min\{\delta\Lambda, \Pi\}]$$

such that $\partial\tilde{\gamma}/\partial\beta \leq 0$ and $\partial\tilde{\gamma}/\partial\delta \leq 0$, while $\partial\tilde{\gamma}/\partial\varphi \geq 0$. Moreover, $\tilde{\gamma}$ depends on Π and Λ only through their ratio, and $\partial\tilde{\gamma}/\partial(\Pi/\Lambda) < 0$ if and only if (1) regulation is better than blanket prohibition: $\varphi/(1 - \varphi) < \Pi/\Lambda$; and (2) injunction is better than compensation: $\Pi/\Lambda < \delta$; and (3) $\varphi < ½\,\beta$. ■

The only difference between these results and those in the main text is that the case for regulation is weakened but not eliminated by perfect contract enforcement. Judicial remedies are more attractive when contracts are always perfectly enforced, because greater economic complexity then does not stop bargaining from attaining the first best.

The conditions for an interior threshold in Corollaries 1 and 2 are also qualitatively unaffected. Regulation is not a fully dominant alternative ($\tilde{\gamma} > 0$) if $\varphi > \beta\min\{\delta\Lambda, \Pi\}/(\Pi + \Lambda)$. Regulation is not fully dominated ($\tilde{\gamma} < 1$) if $\min\{\varphi(\Pi + \Lambda), \Pi\} < \beta\Lambda$.

A3.3. Investment in Power

Our leading example of industrial pollution is characterized by companies that spend vast resources acquiring institutional influence. In developed countries, such expenditure may take the form of hiring lobbyists and in-house legal counsel. In the context of resource extraction in developing countries, it extends to hiring private military protection and bribing politicians and judges.

Some evidence from the U.S. suggests that our comparison of injunctions and compensation may be relevant for thinking about the problem of investment in legal and political power. Disputes related to real property appear to reach courts much less frequently and to cost less than contract and tort disputes.

Data from the latest Civil Justice Survey of State Courts show that of the approximately 27,000 civil trials disposed of by state courts in 2005, about 61% were tort claims, 33% contract cases, and only 6% real property cases.[16] Moreover, real property cases cost, on average, about half to pursue of what, say, malpractice tort claims do. These observations raise the possibility that a further benefit of injunction, as compared to compensation, is to curtail disputes. Our baseline model can easily be modified to address this conjecture.

We assume that, at stage 0, the polluter has the opportunity to invest i to become powerful. The decision to invest in power occurs before P knows whether he will be able to bargain with O. The cost of investment i is heterogeneous with cumulative distribution function $F(i)$. If P does not invest in power, courts are not subverted, even though the extent of harm may be in dispute. If P invests in power, the baseline model applies. We continue to focus on the case in which the attribution of harm is indisputable.

Proposition A8. Suppose that the responsibility of the polluter is indisputable, that the extent of harm might be in dispute ($\delta \geq 0$), that the owner and the polluter sometimes cannot bargain ($\beta \geq 0$), and that the polluter can invest in becoming powerful. With injunction, there is a threshold $\bar{\imath} = \delta(b - \Pi) > 0$ such that the polluter invests in power if and only if the cost of doing so is less than the threshold ($i < \bar{\imath}$).

Proof. With injunction, P is deterred from polluting unless he can bargain with O and buy her permission. His expected payoff is $\frac{1}{2}(1 - \beta)\Pi$ irrespective of his power. Since power does not increase P's payoff, he never invests in acquiring it.

With compensation, if P is weak he is always induced to act optimally and his expected payoff equals the social value of efficient action, Π. If P is strong, when the extent of harm is in dispute he simply pollutes irrespective of the cost to O. His expected payoff is $\delta b + (1 - \delta)\Pi$. Therefore, he invests in power if and only if $i < \delta(b - \Pi)$. ■

[16] This breakdown reflects differences in the prevalence of litigation rather than in the selection of disputes disposed through trial. In a subsample of jurisdiction for which more detailed data are available, there were over 8 times as many tort cases as real property cases, including both trial and non-trial dispositions.

With injunction there is no investment in power because power yields no returns when responsibility for harm is indisputable. Pollution simply does not occur when it is inefficient or when bargaining is impossible. If pollution is efficient and bargaining is possible, then *P* will pay some amount to *O* to permit pollution. Under injunctive relief, there is no reason why the terms of this contract should depend on the polluter's power because contract enforcement is unnecessary.

Instead, compensation induces wasteful investment in power because the powerful can extract rents by subverting justice. In the absence of bargaining, a weak *P* is forced to internalize the social costs of pollution, so his private returns are equalized to the social returns (Π). A powerful *P* in contrast can ignore the social costs of his action while fully enjoying its private benefits. The rents from exercising power are thus $b - \Pi > 0$. Crucially, they can be enjoyed only when law and order fails and facts are in dispute. Thus, Proposition A8 accounts for the greater prevalence of wasteful private investments in rent-seeking in environments with lower institutional quality.

Proposition A9 describes the optimal regime when power is endogenous. Comparative statics with respect to Π and Λ are taken with respect to the distribution of harm *c*, keeping *P*'s private benefit *b* constant.

The threshold is increasing in the error rate of the public signal ($\partial\tilde{\gamma}/\partial\varphi \geq 0$) and in the parties' ability to bargain ($\partial\tilde{\gamma}/\partial\beta \leq 0$), and decreasing in the extent of subversion of justice ($\partial\tilde{\gamma}/\partial\delta \leq 0$). The threshold is increasing in the social cost of stopping efficient pollution ($\partial\tilde{\gamma}/\partial\Pi \geq 0$) and decreasing in the social cost of allowing inefficient pollution ($\partial\tilde{\gamma}/\partial\Lambda \leq 0$), unless $\varphi/(1-\varphi) < \min\{\beta, \sqrt{\delta}\}$ and $\varphi/(1-\varphi) < \Pi/\Lambda < \delta/\beta$.

Proposition A9. Suppose that the responsibility of the polluter is indisputable, that the extent of harm might be in dispute ($\delta \geq 0$), that the owner and the polluter sometimes cannot bargain ($\beta \geq 0$), and that the polluter can invest in becoming powerful. Then there is a threshold $\tilde{\bar{\delta}} > 0$ such that compensation yields higher expected social surplus than injunction if and only if the extent of subversion of justice is smaller than the threshold ($\delta < \tilde{\bar{\delta}}$). The threshold is decreasing in the parties' ability to bargain ($\partial\tilde{\delta}/\partial\beta > 0$) and in the social cost of allowing inefficient pollution ($\partial\tilde{\delta}/\partial\Lambda < 0$), and increasing in the social cost of stopping efficient pollution ($\partial\tilde{\delta}/\partial\Pi \geq 0$).

Proof. When P can invest in power the expected social loss from compensation, relative to the first-best surplus Π, equals $L_C = F(\bar{\imath})[\delta\Lambda + \mathrm{E}(i \mid i < \bar{\imath})]$ for $\bar{\imath} = \delta(b - \Pi)$, such that $\partial L_C/\partial\delta > 0 = \partial L_C/\partial\beta$ and $\partial L_C/\partial\Lambda > 0 > \partial L_C/\partial\Pi$. The expected social loss from injunction equals $\beta\Pi$. Hence, compensation is socially optimal if and only if $\delta < \tilde{\delta}$, for a threshold implicitly defined by $L_C(\tilde{\delta}) = \beta\Pi$, such that $\partial\tilde{\delta}/\partial\beta > 0$ and $\partial\tilde{\delta}/\partial\Lambda < 0 < \partial\tilde{\delta}/\partial\Pi$. ■

Just as in Proposition 1, the downside of compensation is that its subversion enables inefficient pollution by the powerful when the extent of harm is in dispute. Compensation is optimal when the loss from inefficient pollution is sufficiently low, the value of efficient pollution sufficiently high, and bargaining sufficiently likely to enable attaining the first best under compensation.

Crucially, compensation is again optimal only when low and order is sufficiently high. In Proposition A9, this is not only because subversion enables the distortive exercise of power, but also because flexibility of a compensation regime raises the returns to power, and thus encourages wasteful investment in influencing courts. If low and order is low enough that $F(\delta(b - \Pi)) = 1$, P is powerful with certainty as in Proposition 1, but the social loss from a compensation regime is strictly greater than in the baseline case of exogenous power. This feature helps explain the enduring appeal of simple property rules.

Appendix 4. Data Discussion

In what follows and in the main text we classify agricultural counties using SIC codes from the 1972 County Business Patters Data. We consider agricultural any employment or establishment listed under the "01-09" codes in the 1972 CBP.

A4.1. Calculation of Z Scores

In our primary analysis we use all of the available pollution data collected by Keiser and Shapiro (2019) for each county in each year in our sample. For each pollutant in our sample we calculate an annual *Z* score for each pollutant × county as:

$$Z_{itp} = (L_{itp} - \bar{L}_p)/\sigma_p$$

where L_{itp} is the level of pollutant *p* in county *i* in year *t*. $\bar{L}_p$ denotes the average level of that pollutant across all years of our sample while σ_p is the standard deviation in the level of that pollutant across the sample. In addition to our primary outcome we calculate a *Z* score that sums across the set of pollutants that the CWA defines as "conventional" and is particularly focused on: Biochemical Oxygen Demand, Fecal Coliforms, Total Suspended Solids and pH.

A4.2. Comparison of Z Scores to Raw Pollution Levels

In Figures A1 and A2 we compare the ranking of how polluted a given county × year pair is using our preferred measure of the summed *Z* score with rankings based on the *Z* score for individual pollutants (A1) and the raw levels of individual pollutants (A2). Across all six pollutants we consider (Dissolved Oxygen Deficit, Total Suspended Solids, Total Dissolved Solids, pH, Fecal Coliforms and Biochemical Oxygen Demand) our measure compares favorably to the individual pollutant *Z* scores and the raw levels.

A4.3. Pre-Trends

In Table A3 we present two measures of pre-trends in water pollution in treated counties. In the first column we show the coefficient on t from the regression: $y_{it} = \beta_0 + \beta_1 t + \gamma_i$, where y_{it} is the Z score of pollution in county i in year t and γ_i is a county fixed effect. We include all the counties and years prior to 1972 in this estimate. In column 2 we present the estimates of ω_τ from the regression: $y_{it} = \sum_{\tau \in T} \omega_\tau Y_\tau + \gamma_i$, where Y_τ is an indicator for year τ in the set T = {1962, 1963, 1964, 1965, 1966, 1967, 1968, 1969, 1970, 1971, 1972}, γ_i is a county fixed effect and 1972 is the base year.

Neither measure suggests strong pre-trends prior to 1972. In the continuous measure the coefficient on years is both close to zero and insignificant. In the dummy approach only the coefficient on 1964 is significant and across the set of years the coefficients oscillate around zero.

A4.4. Event Studies

The trends in Figures 2 – 4 in the main text suggest that the CWA led to substantial reductions in pollution in treated counties. Moreover, these reductions were larger in agricultural and in corrupt counties, consistent with the predictions of our theory. In order to show more clearly that the effects we find are not the result of preexisting trends, we estimate several "event study" specifications of the form:

$$y_{it} = E_{it} \times \sum_{\tau \in T} \omega_\tau Y_\tau + \gamma_i, \qquad \text{(A1)}$$

where E_{it} is an indicator for whether the CWA became enforceable in county i after 1972. Y_τ is an indicator for year τ in the set T = {1962, 1964, 1966, 1968, 1970, 1972, 1974, 1976, 1978, 1980} and γ_i is a county fixed effect. The coefficients $\omega_{\tau \in T}$ summarize trends in the average pollution level in treated and non-treated counties relative to a baseline year chosen to be 1971, the year prior to the passage of the CWA.

Figure A5 presents the coefficients for $\omega_{\tau \in T}$ from equation A1. The estimated coefficients indicate that while pollution levels were stable relative to their 1971 baseline in both treated and non-treated counties prior to 1972, in treated counties pollution levels begin to trend downward substantially after the passage of the CWA in 1972. Non-treated counties, by contrast, show no significant change in the levels after 1972.

To examine the impact of treatment in agricultural and non-agricultural counties we modify equation A1 to be:

$$y_{it} = A_{it} \times \sum_{\tau \in T} \omega_\tau Y_\tau + \gamma_i, \qquad \text{(A2)}$$

where A_{it} is an indicator for whether county i is agricultural. We estimate equation A2 on the sample of treated counties. Figure A6 presents the results. Both agricultural and non-agricultural counties have consistent levels of pollution leading up to 1971. After passage of the CWA pollution falls faster and further in the non-agricultural counties. This is consistent with the hypothesis the initial enforcement of the CWA, via NPDES permits, was more effective in reducing pollution in non-agricultural counties because a greater share of the pollution in these counties came from point source pollution and was therefore covered by the new regulation while the majority of pollution in agricultural counties remained subject to the less effective liability regime.

We test the hypothesis that pollution falls more in corrupt counties after passage of the CWA by modifying equation A1 to be:

$$y_{it} = C_{it} \times \sum_{\tau \in T} \omega_\tau Y_\tau + \gamma_i + \delta_j\,, \qquad \text{(A3)}$$

where C_{it} is an indicator for whether county i is corrupt and δ_j is a state-specific linear time trend. Figure A7 reports the coefficient estimates. Prior to treatment, pollution levels in non-corrupt counties are stable relative to the 1971 baseline. In corrupt counties the levels are noisily estimated but have no significant trend through 1970. Beginning in 1972 pollution begins to decline in both corrupt and non-corrupt counties. With the caveat that the estimates remain noisy, they appear to fall faster and further for corrupt counties relative to non-corrupt counties.

A4.5. Robustness Checks

We estimate several variations of the main specification in the paper. Starting with Table A4, we estimate the main specification retaining data from 1973 and 1974. Our point estimates are smaller and less precise, as would be expected given mis-assignment in treatment, but consistent with our main results. Table A5 reports estimates when we include counties that contain facilities that receive permits between 1975 and 1985 and classify them as untreated. Again, as expected our estimates are smaller and less precise, but consistent with the main results. When we allow treatment to vary flexibly across the sample—in Table A6, a county is considered treated in the year its first facility receives a permit regardless of whether that year is 1973 or 1974—the overall treatment effect remains significant in specifications leaving out year fixed effects. Adding year fixed effects reduces the size of the estimate but it remains negative. Our estimates of the differential treatment effect across agricultural and non-agricultural counties also shrink but remains significant. Focusing only on the subset of pollutants defined as "conventional," our estimates become much less precise (Table A7). We still find the expected negative and significant ($p < 5\%$) effects of treatment in our preferred specification with year fixed effects. The differential impact across agricultural and non-agricultural counties shows the expected pattern but is significant only when we define counties as agricultural based on establishments rather than employment (column 5). When we examine the effect of treatment on the full set of pollutants using establishments to determine agricultural status we find very similar results to those reported in the paper using employment (Table A8).

In Table A9 we mimic table 3 from the main text but measure corruption using the continuous measure of convictions per capita rather than a binary determination of whether a location is corrupt based on the level of convictions relative to the mean. Using both levels and logs we find that additional convictions increase (make more negative) the impact of treatment but only the specification in levels is significant. In Table A10 we combine Table 3 from the text and Table A9 but measure corruption using the number of newspaper subscriptions per capita in 1972 from Gentzkow, Shapiro and Sinkinson (2011).

This measure takes the number of newspaper subscriptions in a state in 1972, calculates a per capita rate using population data from the BLS and assigns corruption status to a state for the whole sample period based on the number of subscriptions per capita in 1972.

The pattern of results using newspaper subscriptions is similar to that when we use convictions but more imprecise. Given that newspaper subscriptions are a noisy measure of government transparency we should expect our estimates to be noisier. In general Table A10 suggests that corrupt counties do have more pollution prior to 1972 (column 1).[17] The positive, but insignificant coefficients in columns 2 and 3 suggest that places with more newspapers reduce pollution less after treatment than those with fewer papers. Conversely, the negative coefficient in column 4 suggests that when we assign a binary indicator based on whether the number of newspaper subscriptions is above or below the mean the places that are corrupt reduce pollution more after treatment than those that are considered not corrupt.

A4.6. Replication of Keiser and Shapiro (2019) Trends

In Table A11 we replicate Table 1 from Keiser and Shapiro (2019) showing the trends in Dissolved Oxygen Deficit, Biochemical Oxygen Demand, Fecal Coliforms and Total Suspended Solids. In columns 1 and 2 we report Keiser and Shapiro's estimates with significance stars. In columns 3 and 4 we report the results we get estimating their equations on pollutant specific Z scores in our county × year data. While the magnitudes differ due to our use of Z scores, the general patterns are the same. Overall, all four pollutants trend down over the sample period but, similar to their results, in three of the four cases the trend is steeper prior to 1972 than after. In the fourth case we find no evidence of a change in the trend.

A4.7. Placebo Tests

In Table A12 we replicate Table 2 from the main text but assume that the CWA becomes enforceable in 1971 and 1972 instead of 1973 and 1974 (in table A13 we assume the CWA becomes enforceable in 1975

[17] Note that for the continuous measures the expected signs on the coefficients should be opposite for newspapers than for convictions because more papers indicates less corruption while more convictions indicates more corruption.

and 1976). If the effect we measure in Table 2 is truly due to the CWA becoming enforceable in 1973 and 1974, assigning treatment in earlier and later years (as we do in Table A13) should result in estimated effects that are smaller and less precise. The results in Table A12 and A13 fit this pattern and give us confidence that the effect we measure in the main text is due to the receipt of an NPDES permit and not other contemporaneous trends. In Table A12 we find smaller coefficients across all specifications relative to those in Table 2 and all except column 1 are statistically insignificant. In Table A13 we again find smaller coefficients relative to Table 2.

In Table A14 we compare the effect if we only look at counties treated in 1975 to that estimated in Table 2. Recalling that a county is treated in the year the first facility in that county receives an NPDES permit, more counties are treated in 1973 and 1974 than in 1975. Given the weaker treatment in 1975 we expect the estimated effects of treatment using only 1975 to be smaller as well. Table A14 confirms our expectations. The pattern of treatment effects is the same as we find using 1973 and 1974 but the effect sizes are much smaller and less significant.

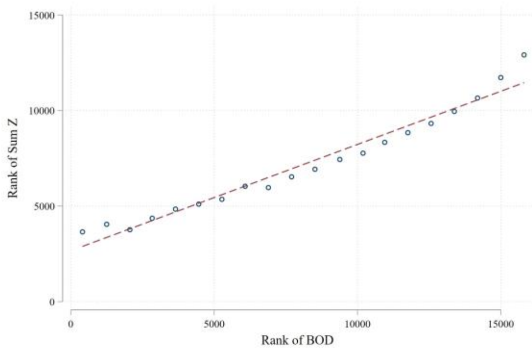
In Figures A8 and A9 we randomize treatment and county agricultural status before estimating equations 1 and 2 from the text 1,000 times. Doing so gives us an approximation of the likelihood of observing our coefficient values under the null of a zero true effect. In Figure A8 we show the distribution of the estimates of the impact of the CWA becoming enforceable (equivalent to Column 3 in Table 2) with our estimated effect indicated by the dashed red line. As can be seen from the figure, our observed effect is in the far tail of the distribution of effects when treatment is assigned randomly making it highly unlikely that our results would be observed if the true effect was zero. In A9 we show the joint distribution of the estimated impact of the CWA becoming enforceable in Agricultural (on the y-axis) and Non-Agricultural counties (on the x-axis). The figure is equivalent to Column 4 in Table 2. Our joint estimates, indicated by the red dot, are well outside the joint distribution of the estimates from randomization, again suggesting that the probability of observing our results under the null of no effect is extremely small.

A4.8. Predicting Treatment Timing

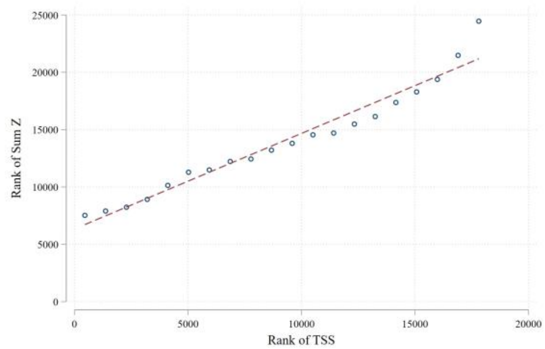
To better understand whether there is meaningful selection in which counties contain facilities that receive NPDES permits in 1973 and 1974 compared to later years we try to predict the timing of when the CWA becomes enforceable in the counties in our sample. We use data on county economic conditions in 1972 and regress a set of county characteristics, including employment levels in different industries in 1972 and a state fixed effect, on a dummy for whether the county was treated from 1973 to 1974 or later. We present the results in Table A15. In general, it appears more polluted areas were treated sooner – this makes sense as an area necessarily had to have a polluter in order to receive a permit – and areas with more mining activity are treated sooner. Our other measures of economic activity do not appear to significantly predict treatment timing.

Figure A1: Comparison of Summed *Z* Score Ranks and Pollution Ranks

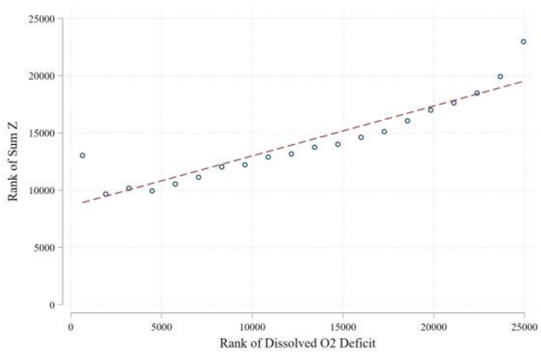
(a) Biochemical Oxygen Demand



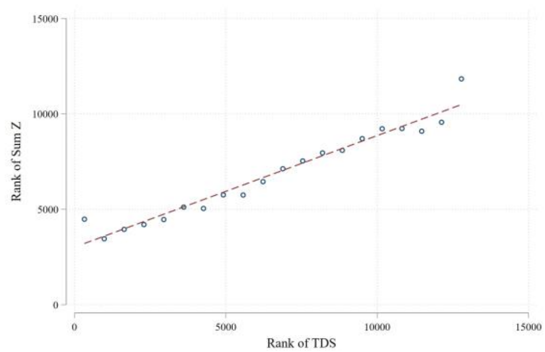
(b) Total Suspended Solids



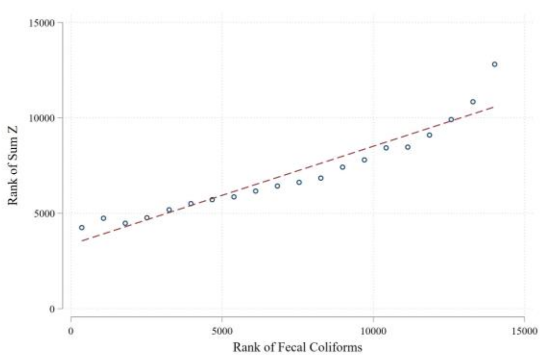
(c) Dissolved Oxygen Deficit



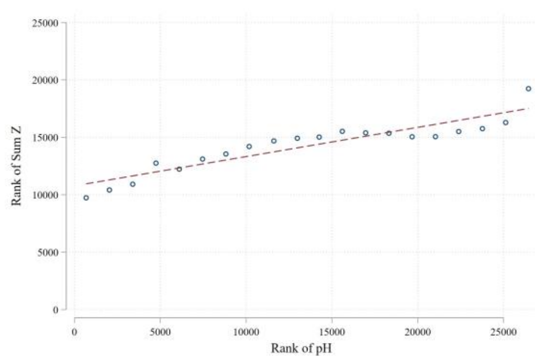
(d) Total Dissolved Solids



(e) Fecal Coliforms



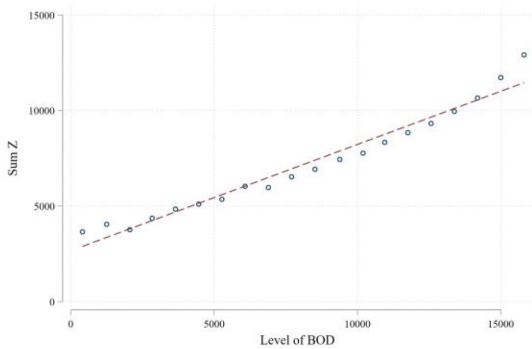
(f) pH



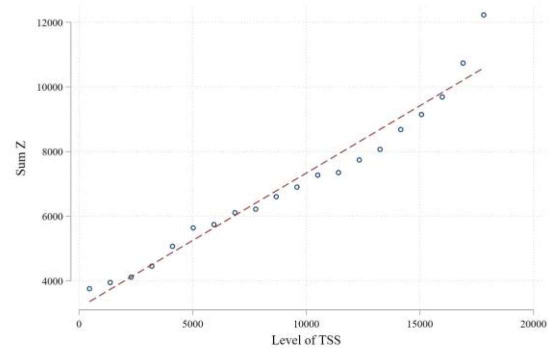
Notes: We report here the binscatters of the rank of county-year observations based on their summed *Z* score across all pollutants for which we have a reading in that county-year compared to the rank based on their level of six individual pollutants. *Z* scores are calculated for each pollutant in each year (negative *Z* scores indicate lower than average pollution). To calculate summed *Z* scores we sum the *Z* scores across all pollutants for which we have data in a county-year.

Figure A2: Comparison of Summed Z Score and Pollution Levels

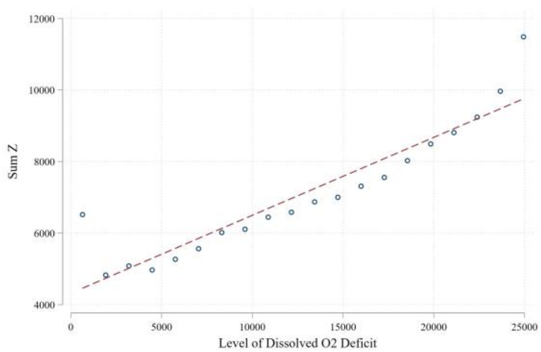
(a) Biochemical Oxygen Demand



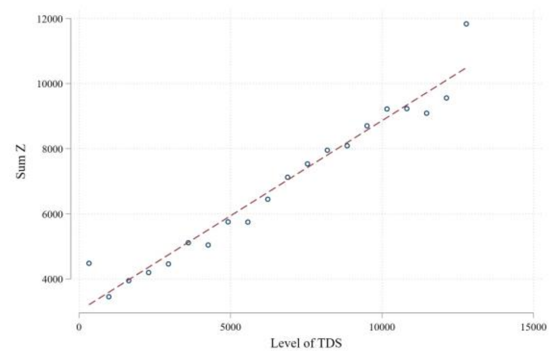
(b) Total Suspended Solids



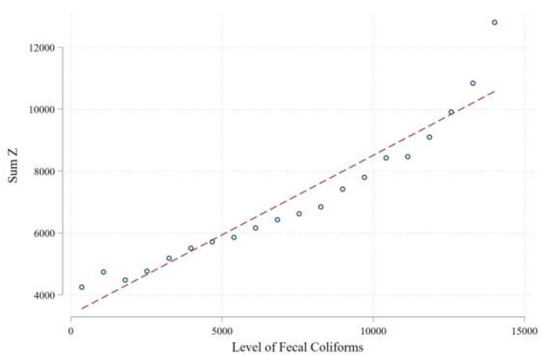
(c) Dissolved Oxygen Deficit



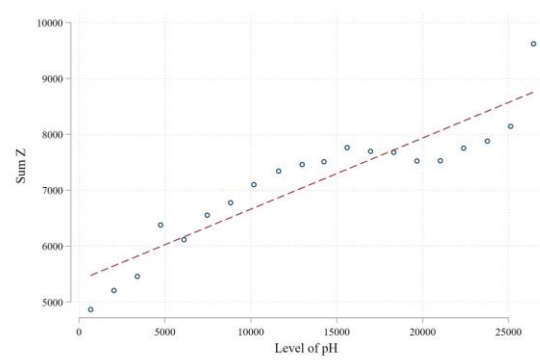
(d) Total Dissolved Solids



(e) Fecal Coliforms

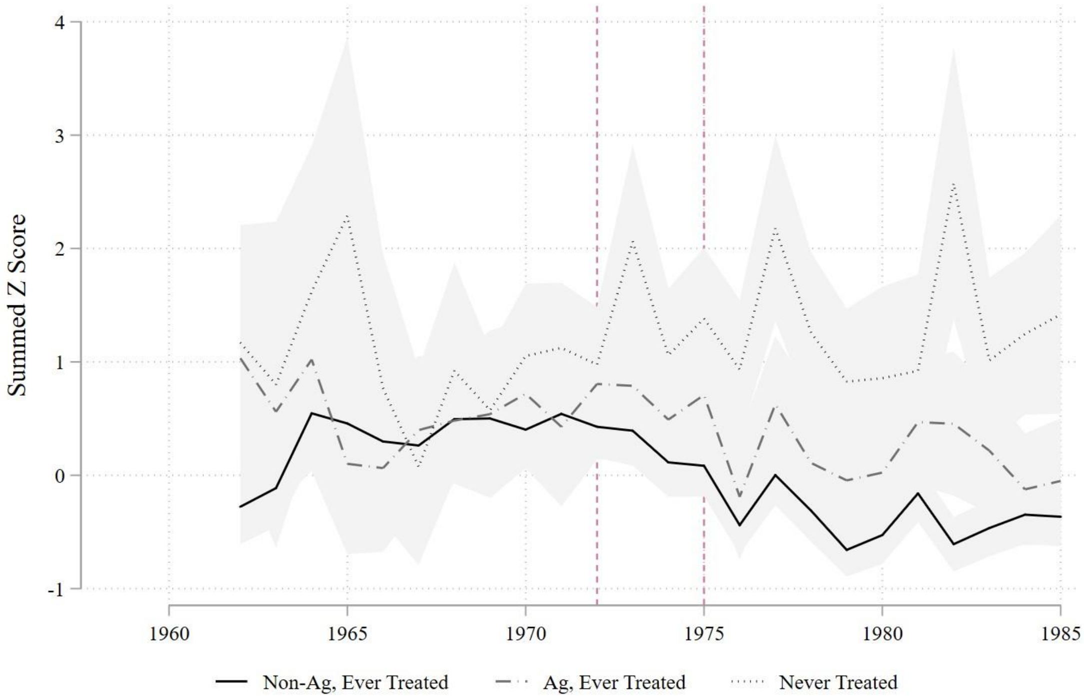


(f) pH



Notes: We report here the binscatters of the rank of county-year observations based on their summed *Z* score across all pollutants for which we have a reading in that county-year compared to the raw level of pollution for six individual pollutants at the same county × year level. *Z* scores are calculated for each pollutant in each year (negative *Z* scores indicate lower than average pollution). To calculate summed *Z* scores we sum the *Z* scores across all pollutants for which we have data in a county-year.

Figure A3: Pollution Trends: Agricultural and Non-Agricultural

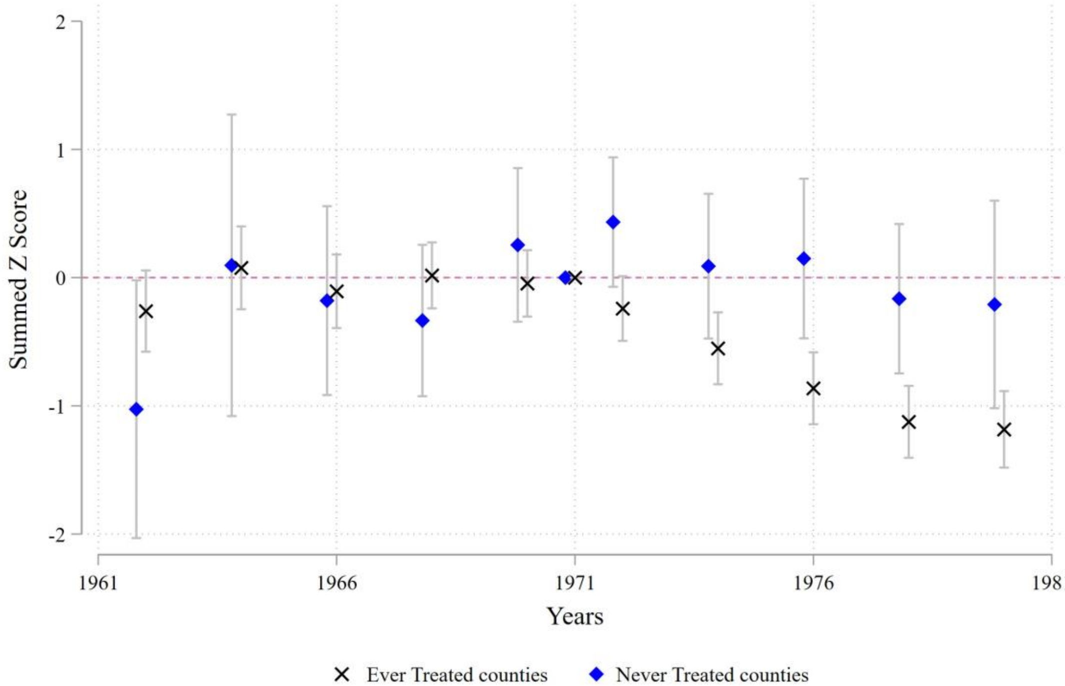


Notes: The figure replicates figure 3 from the main text but defines agricultural counties based on agricultural establishments instead of employment. The figure shows the annual trend in the average summed *Z* score of water pollution for treated agricultural and non-agricultural counties and all non-treated counties. *Z* scores are calculated for each pollutant in each year (negative Z scores indicate lower than average pollution) and then *Z* scores for all pollutants are summed by county-year. Country-wide averages are calculated by year. Treated counties are those that contain a facility that receives a NPDES permit in 1973 or 1974. Counties that contain a facility that receives a permit after 1974 are dropped. Non-treated counties do not contain a facility that received a NPDES permit between 1972 and 1985. Agricultural counties are those whose share of establishments in agriculture in 1972 was above the 75^{th} percentile for the country. Non-treated agricultural and non-treated non-agricultural counties are pooled in the non-treated group. The grey shaded area is the 95% confidence interval for the mean summed *Z* score.

Figure A4: Pollution Trends: Corrupt and Non-Corrupt

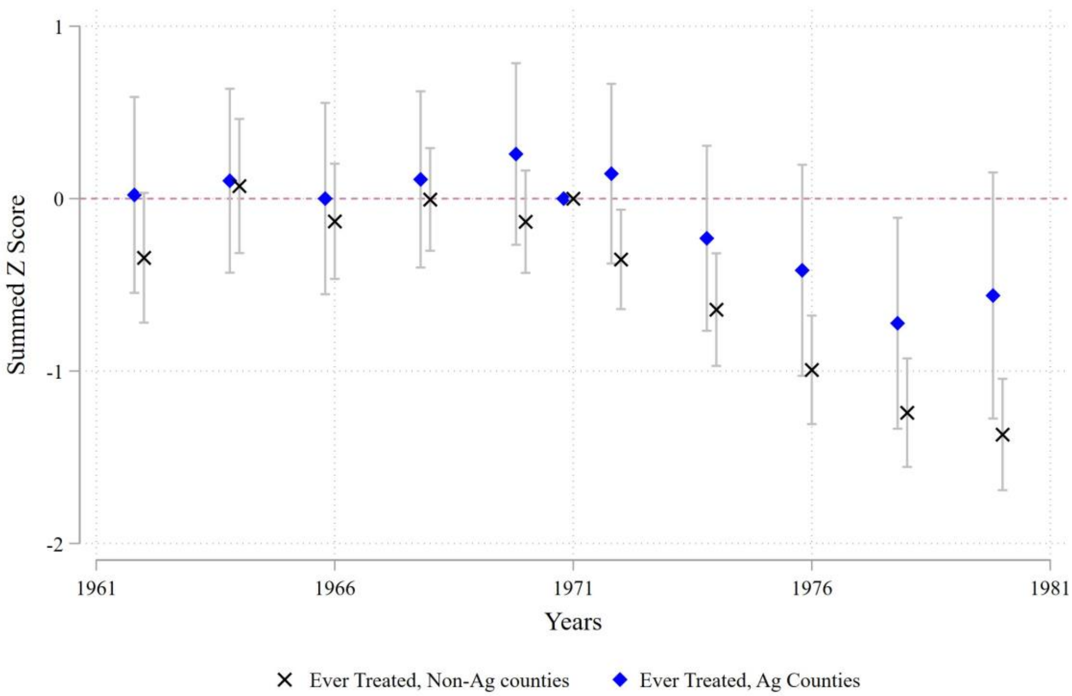
Notes: This figure replicates figure 4 from the main text but defines corruption based on per capita newspapers subscriptions instead of conviction rates. The figure shows the annual trend in the average summed *Z* score of water pollution for corrupt and non-corrupt counties that are treated. *Z* scores are calculated for each pollutant in each year (negative *Z* scores indicate lower than average pollution) and then *Z* scores for all pollutants are summed by county-year. Country-wide averages are calculated by year. Treated counties are those that contain a facility that receives a NPDES permit in 1973 or 1974. Counties that contain a facility that receives a permit after 1974 are dropped. Non-treated counties do not contain a facility that received a NPDES permit between 1972 and 1985. Corrupt counties are those in states where the number of newspaper subscriptions per 1,000 residents in 1972 is below the mean. The grey shaded area is the 95% confidence interval for the mean summed *Z* score.

Figure A5: Event Study Estimates: Treated vs. Non-Treated



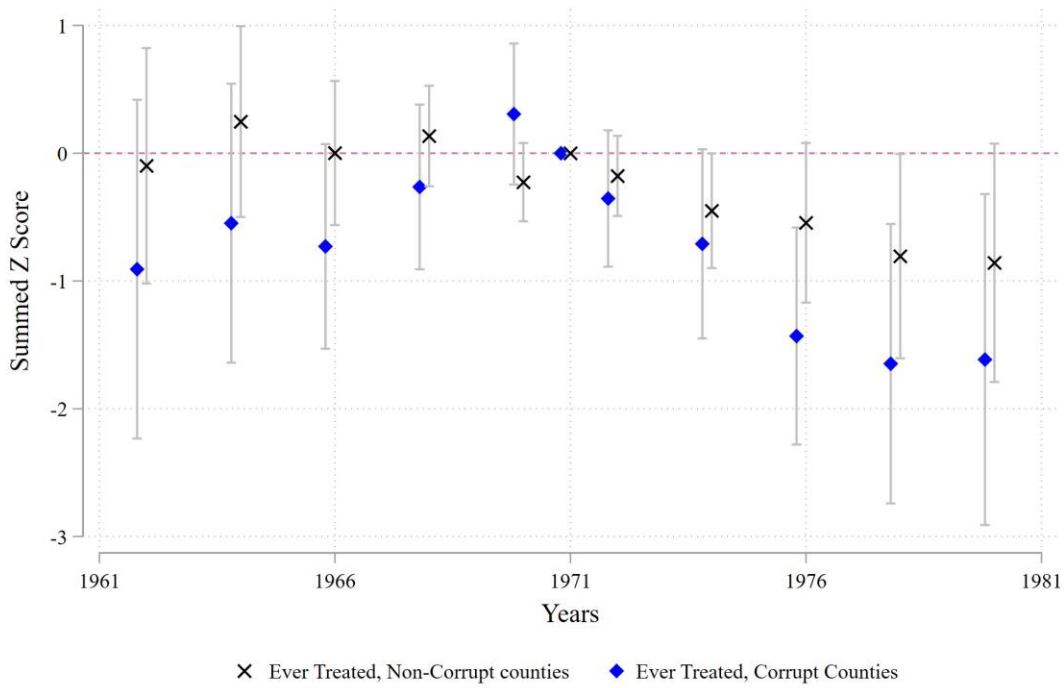
Notes: This figure displays the response of pollution levels by county to the passage of the CWA. Each point is the estimated ω_τ coefficient from the regression described in equation A1. The treated series shows the estimates on the sample of counties in which the CWA becomes enforceable in 1973 or 1974. Non-Treated shows the estimates in the sample counties in which the CWA does not become enforceable between 1972 and 1985. The omitted year is the year prior to the passage of the CWA, 1971. The dark grey bars indicate the 95% confidence interval on the estimates, clustered at counties.

Figure A6: Event Study Estimates: Agricultural vs. Non-Agricultural



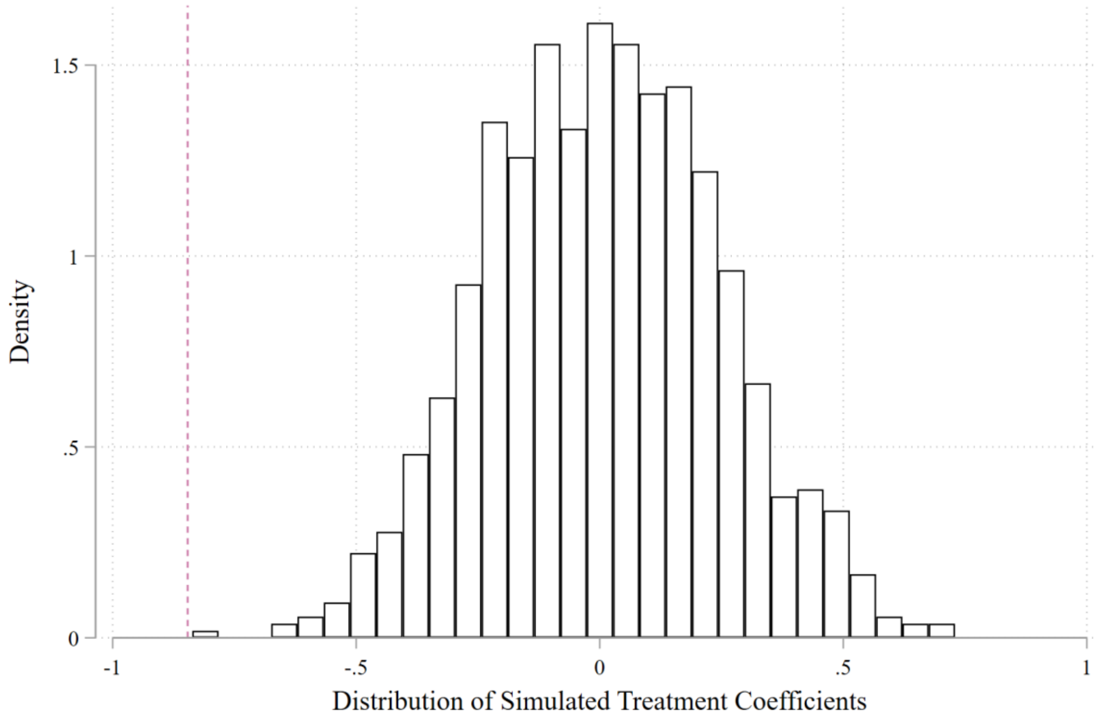
Notes: This figure displays the response of pollution levels by county in treated agricultural and non-agricultural counties to the passage of the CWA. Each point is the estimated ω_τ coefficient from the regression described in equation A2. Agricultural counties are those whose share of employment in agriculture in 1972 was greater than the 75th percentile in the country. The omitted year is the year prior to the passage of the CWA, 1971. The dark grey bars indicate the 95% confidence interval on the estimates, clustered at counties.

Figure A7: Event Study Estimates: Corrupt vs. Non-Corrupt



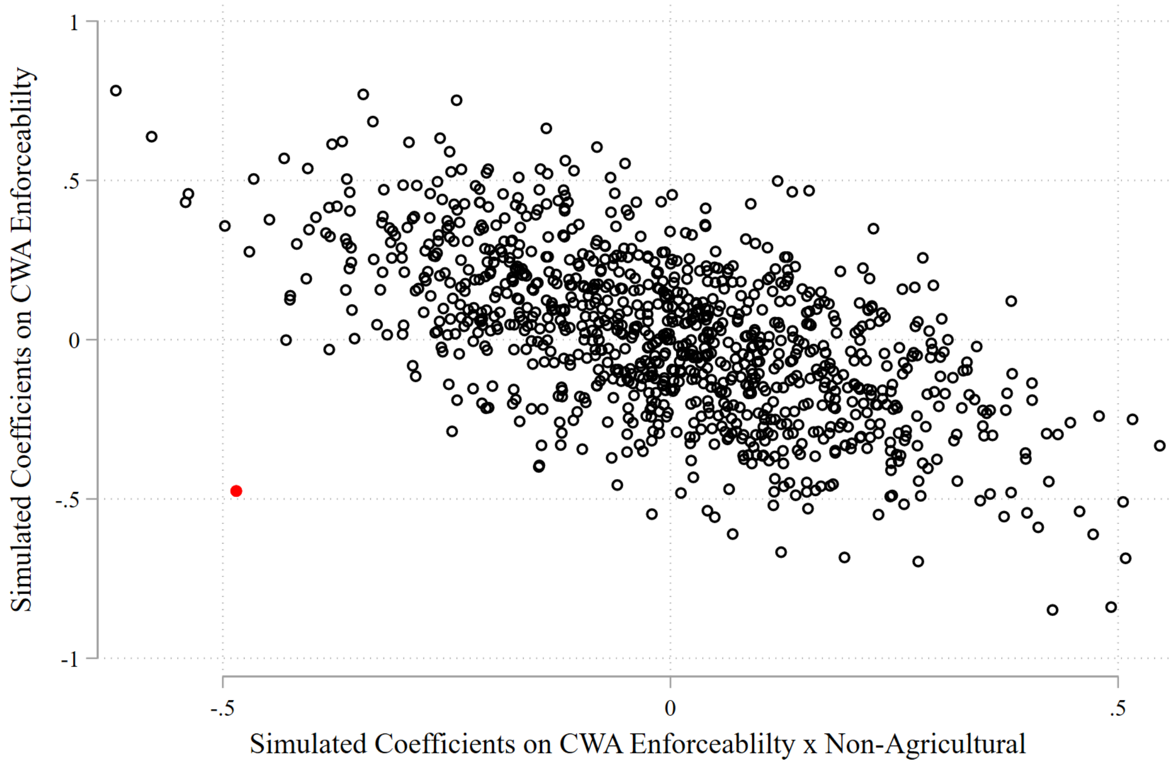
Notes: This figure displays the response of pollution levels by county in treated corrupt and noncorrupt counties to the passage of the CWA. Each point is the estimated ω_τ coefficient from the regression described in equation A3. Corrupt counties are those in states where the average number of federal convictions per 10,000 state residents is above the mean. Conviction rates are calculated as the average of the annual number of convictions per capita over the years 1976-1985. The dark grey bars indicate the 95% confidence interval on the estimates, clustered at counties.

Figure A8: Distribution of Randomized Treatment Placebo Estimates



Notes: This figure displays the distribution of the estimates of the impact of the CWA becoming enforceable from equation 1 when we randomly assign treatment to counties and re-estimate the equation 1,000 times. The vertical red dashed line indicates our estimate of the impact of the CWA becoming enforceable given the actual pattern of enforcement that we report in column 3 of table 2.

Figure A9: Join Distribution of Randomized Treatment Placebo Estimates



Notes: This figure displays the joint distribution of the estimates of the impact of the CWA becoming enforceable and the impact of the CWA becoming enforceable in non-agricultural counties from equation 2 when we randomly assign treatment and agricultural status to counties and re-estimate the equation 1,000 times. The red point indicates our estimate of the CWA becoming enforceable and the impact of enforceability in non-agricultural counties given the actual pattern of enforcement that we report in column 4 of table 2.

Table A3: Pre-Trends in Treated Counties

	(1)	(2)
Year	0.012	
	(0.016)	
Year = 1962		−0.154
		(0.171)
Year = 1963		−0.077
		(0.155)
Year = 1964		0.426**
		(0.186)
Year = 1965		−0.068
		(0.172)
Year = 1966		−0.067
		(0.168)
Year = 1967		0.101
		(0.144)
Year = 1968		0.200
		(0.130)
Year = 1969		0.200
		(0.145)
Year = 1970		0.136
		(0.134)
Year = 1971		0.200
		(0.136)
N	7,641	7,641
R^2	0.66	0.66
County FE	X	X

Notes: Column 1 reports the coefficient on a continuous Year variable regressed on the *Z* score of pollution in treated counties in a specification with county fixed effects in a sample from 1962 to 1972. Column 2 reports the coefficients on a series of dummies for each year from 1962 to 1972 with 1972 set as the base year and county fixed effects. Standard errors are clustered at the county level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A4: Difference-in-Differences Results – Retain 1973 and 1974

	(1)	(2)	(3)	(4)
CWA Enforceable	−0.505***	−0.502***	−0.396**	−0.117
	(0.100)	(0.100)	(0.170)	(0.233)
CWA Enforceable × Non-Agricultural				−0.361*
				(0.195)
N	28,589	28,589	28,589	28,589
R^2	0.54	0.54	0.55	0.55
County FE	X	X	X	X
Year FE			X	X
State Trend	X	X	X	X
Controls		X	X	X

Notes: This table replicates table 2 from the text but retains all data from 1973 and 1974 and includes them in the regressions. Columns 1–3 report the difference-in-differences specification described in equation 1 with and without year fixed effects and with and without controls. Column 4 reports the additional difference between agricultural and non-agricultural counties described in equation 2. We consider the CWA enforceable starting in the year the first facility in a county receives its first NPDES permit if that is prior to 1975. Counties that only contain facilities that receive their first permit between 1975 and 1985 are dropped. We consider the CWA non-enforceable in counties that do not contain a facility that receives a permit by 1985. Whether a county is agricultural is determined by its share of employment in the agricultural sector in 1972. Counties whose share of employed workers in agriculture in 1972 was above the 75th percentile for the country are considered agricultural. Controls include total employment, manufacturing employment and mining employment. Standard errors are clustered at the county level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A5: Difference-in-Differences Results – Retain post-1974

	(1)	(2)	(3)	(4)
CWA Enforceable	−0.599***	−0.586***	−0.359**	−0.016
	(0.120)	(0.118)	(0.161)	(0.244)
CWA Enforceable × Non-Agricultural				−0.457**
				(0.224)
N	32,434	32,434	32,434	32,434
R^2	0.57	0.57	0.57	0.57
County FE	X	X	X	X
Year FE			X	X
State Trend	X	X	X	X
Controls		X	X	X

Notes: This table replicates table 2 from the text but retains counties that contain a facility that receives a permit between 1975 and 1985 and considers them untreated. Columns 1–3 report the difference-in-differences specification described in equation 1 with and without year fixed effects and with and without controls. Column 4 reports the additional difference between agricultural and non-agricultural counties described in equation 2. We consider the CWA enforceable starting in the year the first facility in a county receives its first NPDES permit if that is prior to 1975. We consider the CWA non-enforceable in counties that do not contain a facility that receives a permit by 1975. Whether a county is agricultural is determined by its share of employment in the agricultural sector in 1972. Counties whose share of employed workers in agriculture in 1972 was above the 75th percentile for the country are considered agricultural. Controls include total employment, manufacturing employment and mining employment. Standard errors are clustered at the county level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A6: Difference-in-Differences Results – Time-Varying Treatment

	(1)	(2)	(3)	(4)
CWA Enforceable	-0.420^{***}	-0.418^{***}	−0.083	0.202
	(0.085)	(0.085)	(0.109)	(0.170)
CWA Enforceable × Non-Agricultural				-0.362^{**}
				(0.165)
N	36,442	36,442	36,442	36,442
R^2	0.56	0.56	0.56	0.56
County FE	X	X	X	X
Year FE			X	X
State Trend	X	X	X	X
Controls		X	X	X

Notes: This table replicates table 2 from the text but classifies all counties as treated in the year the first facility within them receives an NPDES permit. Columns 1–3 report the difference-in-differences specification described in equation 1 with and without year fixed effects and with and without controls. Column 4 reports the additional difference between agricultural and non-agricultural counties described in equation 2. We consider the CWA enforceable starting in the year the first facility in a county receives its first NPDES permit. We consider the CWA non-enforceable in counties that do not contain a facility that receives a permit by 1985. Whether a county is agricultural is determined by its share of employment in the agricultural sector in 1972. Counties whose share of employed workers in agriculture in 1972 was above the 75th percentile for the country are considered agricultural. Controls include total employment, manufacturing employment and mining employment. Standard errors are clustered at the county level. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A7: Difference-in-Differences Results – Conventional Pollutants

	(1)	(2)	(3)	(4)	(5)
CWA Enforceable	0.018	0.020	-0.245^{**}	−0.158	−0.384
	(0.048)	(0.048)	(0.107)	(0.125)	(0.357)
CWA Enforceable × Non-Agricultural				−0.113	-0.568^{**}
				(0.086)	(0.265)
N	24,531	24,531	24,531	24,531	25,455
R^2	0.49	0.49	0.49	0.49	0.56
County FE	X	X	X	X	X
Year FE			X	X	X
State Trend	X	X	X	X	X
Controls		X	X	X	X

Notes: This table replicates table 2 from the text but for the set of pollutants the CWA defined as conventional and was particularly focused on: Biochemical Oxygen Demand, Fecal Coliforms, Total Suspended Solids and pH. Columns 1–3 report the difference-in-differences specification described in equation 1 with and without year fixed effects and with and without controls. Columns 4–5 reports the additional difference between agricultural and non-agricultural counties described in equation 2. We consider the CWA enforceable starting in the year the first facility in a county receives its first NPDES permit if that is prior to 1975. Counties that only contain facilities that receive their first permit between 1975 and 1985 are dropped. We consider the CWA non-enforceable in counties that do not contain a facility that receives a permit by 1985. Whether a county is agricultural is determined by its share of employment (or establishments) in the agricultural sector in 1972. Counties whose share of employed workers (or establishments) in agriculture in 1972 was above the 75th percentile for the country are considered agricultural. Column 4 reports results defining agricultural counties based on employment and column 5 report results using establishments. Controls include total employment, manufacturing employment and mining employment. Standard errors are clustered at the county level.* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A8: Difference-in-Differences Results – Establishments

	(1)	(2)	(3)	(4)
CWA Enforceable	-0.689^{***}	-0.683^{***}	-0.846^{***}	-0.384
	(0.129)	(0.128)	(0.272)	(0.357)
CWA Enforceable × Non-Agricultural				-0.568^{***}
				(0.265)
N	25,455	25,455	25,455	25,455
R^2	0.55	0.55	0.55	0.55
County FE	X	X	X	X
Year FE			X	X
State Trend	X	X	X	X
Controls		X	X	X

Notes: This table replicates table 2 from the text but defines agricultural counties based on establishments instead of employment. Columns 1–3 report the difference-in-differences specification described in equation 1 with and without year fixed effects and with and without controls. Column 4 reports the additional difference between agricultural and non-agricultural counties described in equation 2. We consider the CWA enforceable starting in the year the first facility in a county receives its first NPDES permit if that is prior to 1975. Counties that only contain facilities that receive their first permit between 1975 and 1985 are dropped. We consider the CWA non-enforceable in counties that do not contain a facility that receives a permit by 1985. Whether a county is agricultural is determined by its share of establishments in the agricultural sector in 1972. Counties whose share of establishments in agriculture in 1972 was above the 75th percentile for the country are considered agricultural. Controls include total employment, manufacturing employment and mining employment. Standard errors are clustered at the county level. * p < 0.1, ** p < 0.05, *** p < 0.01.

Table A9: Convictions per Capita – Continuous

	(1)	(2)
CWA Enforceable	-0.052	-1.412
	(0.222)	(0.938)
CWA Enforceable × Convictions, p.c.	-16.816^{**}	
	(7.903)	
CWA Enforceable × ln(Convictions, p.c.)		-0.246
		(0.229)
N	28,589	28,589
R^2	0.55	0.55
County FE	X	X
Year FE	X	X
State Trend	X	X
Controls	X	X

Notes: The table reports $y_{it} = \beta\ CWA_{it} + \omega\ CWA_{it} \times Conviction\ Rate_{it} + \gamma_i + \delta_t + \psi_t$. y_{it} is the summed Z score across all pollutants in county i in year t. CWA_{it} is an indicator for whether the CWA was enforceable in county i in year t. We consider the CWA enforceable starting in the year the first facility in a county receives its first NPDES permit if that is prior to 1975. Conviction rates are calculated as the average of the annual number of federal convictions per capita over the years 1976-1985. Controls include total employment, manufacturing employment and mining employment at the county level and rates of college attendance at the state level. Standard errors are clustered at the state level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A10: Convictions per Capita – Newspapers

	(1)	(2)	(3)	(4)
Corrupt	0.310			
	(0.714)			
CWA Enforceable		−0.832***	−9.139	−2.407*
		(0.285)	(6.542)	(1.216)
CWA Enforceable × Corrupt.		−0.029		
		(0.440)		
CWA Enforceable × Newspapers, p.c			0.006	
			(0.004)	
CWA Enforceable × ln(Newspapers, p.c.)				1.481
				(1.170)
N	9,106	25,455	25,455	25,455
R^2	0.02	0.56	0.56	0.56
County FE		X	X	X
Year FE	X	X	X	X
State Trend		X	X	X
Controls	X	X	X	X

Notes: This table replicates table 3 in the main text but defines corruption based on newspapers per capita. It adds the continuous measures of corruption as in table A9, again using newspapers per capita instead of conviction rates. Column 1 reports $y_{it} = \beta\ Corrupt_{it} + \psi_t$. Column 2 reports $y_{it} = \beta\ CWA_{it} + \omega\ CWA_{it} \times Corrupt_{it} + \gamma_i + \delta_t + \psi_t$. Columns 3 and 4 report $y_{it} = \beta\ CWA_{it} + \omega\ CWA_{it} \times Subscription\ Rate_{it} + \gamma_i + \delta_t + \psi_t$. y_{it} is the summed Z score across all pollutants in county i in year t. CWA_{it} is an indicator for whether the CWA was enforceable in county i in year t. We consider the CWA enforceable starting in the year the first facility in a county receives its first NPDES permit if that is prior to 1975. $Corrupt_{it}$ is an indicator for whether a county is corrupt (1=Yes). Corrupt counties are those in states where the number of newspaper subscriptions per 1,000 residents in 1972 is below the mean. Controls include total employment, manufacturing employment and mining employment at the county level and rates of college attendance at the state level. Standard errors are clustered at the state level. $^{*}\ p < 0.1$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$.

Table A11: Replication of Keiser and Shapiro (2019)

	KS Trend	KS Trend Break	Trend	Trend Break
Dissolved O_2 Deficit				
Year	-0.24^{***}	-1.027^{***}	-0.013^{***}	-0.009^{**}
			(0.001)	(0.004)
Year × Post1972		0.834^{***}		−0.006
				(0.005)
Biochemical O_2 Demand				
Year	-0.065^{***}	-0.124^{***}	-0.020^{***}	-0.022^{***}
			(0.002)	(0.005)
Year × Post1972		0.062^{***}		0.003
				(0.006)
Fecal Coliforms				
Year	-81.097^{***}	-255.462^{***}	-0.023^{***}	-0.063^{***}
			(0.003)	(0.015)
Year × Post1972		179.134^{**}		0.044^{***}
				(0.015)
Total Suspended Solids				
Year	-0.915^{***}	−1.113*	-0.009^{***}	-0.023^{***}
			(0.002)	(0.005)
Year × Post1972		0.203		0.018^{***}
				(0.006)

Notes: This table compares the results in Keiser and Shapiro (2019) Table I to our results running their trend specification with our county-level pollution Z scores. The first column reports the coefficients Keiser and Shapiro (2019) find in a regression of pollutant levels on a year trend. Column 2 reports their coefficients in a regression of pollutant levels on year and an interaction of year and a post-1972 dummy. Columns 3 and 4 replicate their regression specifications with our county level data using the Z score of the named pollutant as the outcome. Key differences between the data we use and those in Keiser and Shapiro (2019): their observation is at the monitor-day-hour level so they can include monitor fixed effects. We only include county fixed effects. Further, they include cubic polynomials to control for season and time of day. Our data is an average over all seasons and times of day. They report coefficients on pollution levels while we report coefficients in terms of the Z score of the pollutants. Standard errors are clustered at the county level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A12: Difference-in-Differences Results – Placebo Treatment in 1971-1972

	(1)	(2)	(3)	(4)
CWA Enforceable	−0.328*	−0.280	−0.258	0.128
	(0.197)	(0.200)	(0.212)	(0.506)
CWA Enforceable × Non-Agricultural				−0.479
				(0.528)
N	26,164	26,164	26,164	26,164
R^2	0.55	0.55	0.56	0.56
County FE	X	X	X	X
Year FE			X	X
State Trend	X	X	X	X
Controls		X	X	X

Notes: This table replicates table 2 from the text but assigns treatment in 1971 and 1972 as a placebo test. Columns 1–3 report the difference-in-differences specification described in equation 1 with and without year fixed effects and with and without controls. Column 4 reports the additional difference between agricultural and non-agricultural counties described in equation 2. In the placebo test we assume that treatment follows the same pattern observed in the data but we consider treated counties treated beginning in 1971-1972 as opposed to 1973-1974. We still drop counties that only contain facilities that receive their first permit between 1975 and 1985. We consider the CWA non-enforceable in counties that do not contain a facility that receives a permit by 1985. Whether a county is agricultural is determined by its share of establishments in the agricultural sector in 1972. Counties whose share of establishments in agriculture in 1972 was above the 75th percentile for the country are considered agricultural. Controls include total employment, manufacturing employment and mining employment. Standard errors are clustered at the county level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A13: Difference-in-Differences Results – Placebo Treatment in 1975-1976

	(1)	(2)	(3)	(4)
CWA Enforceable	−0.550***	−0.541***	−0.165	−0.295
	(0.117)	(0.116)	(0.172)	(0.320)
CWA Enforceable × Non-Agricultural				−0.415**
				(0.204)
N	25,378	25,378	25,378	25,378
R^2	0.55	0.55	0.55	0.55
County FE	X	X	X	X
Year FE			X	X
State Trend	X	X	X	X
Controls		X	X	X

Notes: This table replicates table 2 from the text but assigns treatment in 1975 and 1976 as a placebo test. Columns 1–3 report the difference-in-differences specification described in equation 1 with and without year fixed effects and with and without controls. Column 4 reports the additional difference between agricultural and non-agricultural counties described in equation 2. In the placebo test we assume that treatment follows the same pattern observed in the data but we consider treated counties treated beginning in 1975-1976 as opposed to 1973-1974. We still drop counties that only contain facilities that receive their first permit between 1975 and 1985. We consider the CWA non-enforceable in counties that do not contain a facility that receives a permit by 1985. Whether a county is agricultural is determined by its share of establishments in the agricultural sector in 1972. Counties whose share of establishments in agriculture in 1972 was above the 75th percentile for the country are considered agricultural. Controls include total employment, manufacturing employment and mining employment. Standard errors are clustered at the county level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A14: Difference-in-Differences Results – Counties Treated in 1975

	(1)	(2)	(3)	(4)
CWA Enforceable	−0.435*	−0.422*	−0.355	−0.031
	(0.237)	(0.236)	(0.293)	(0.399)
CWA Enforceable × Non-Agricultural				−0.421
				(0.375)
N	7,986	7,986	7,986	7,986
R^2	0.55	0.55	0.56	0.56
County FE	X	X	X	X
Year FE			X	X
State Trend	X	X	X	X
Controls		X	X	X

Notes: This table replicates table 2 from the text but assigns treatment in 1975 as a placebo test. Columns 1–3 report the difference-in-differences specification described in equation 1 with and without year fixed effects and with and without controls. Column 4 reports the additional difference between agricultural and non-agricultural counties described in equation 2. In the placebo test we drop counties treated in 1973 or 1974 and assign treatment to those counties that contain a facility that receives an NPDES permit in 1975. We drop counties that only contain facilities that receive their first permit between 1976 and 1985. We consider the CWA non-enforceable in counties that do not contain a facility that receives a permit by 1985. Whether a county is agricultural is determined by its share of establishments in the agricultural sector in 1972. Counties whose share of establishments in agriculture in 1972 was above the 75th percentile for the country are considered agricultural. Controls include total employment, manufacturing employment and mining employment. Standard errors are clustered at the county level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Table A15: Predicting Treatment Timing

	(1)
Sum Z Score	0.008**
	(0.003)
Total Employment	-0.0826
	(0.0761)
Manufacturing Employment	0.232
	(0.19)
Mining Employment	3.889***
	(1.006)
Agricultural Employment	0.0011
	(0.002)
N	2,113
R^2	0.41

Notes: This table reports the results of an OLS regression predicting whether a county contained a facility that received an NPDES permit prior to 1974. Our outcome is a dummy for whether the county contains such a facility and we include state fixed effects. Standard errors are clustered at the state level. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.