Securing Property Rights

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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 courts is a common concern in many countries, especially among the poor. We then present a model of a water polluter whose discharges contaminate riparian properties belonging to multiple owners, and we compare property rules, liability rules, and regulation from the efficiency viewpoint. When the polluter can subvert the assessment of damages, property rules are preferred to liability rules when there are few parties and bargaining is feasible, but they excessively deter efficient pollution when bargaining between many parties fails. Regulation that enforces partial abatement may be preferred to either of the extreme rules. Our model helps explain the evolution of the legal treatment of water pollution from property rules to liability rules to regulation. An empirical analysis of water quality in the U.S. before and after the Clean Water Act shows that the effects of regulation are consistent with several predictions of the model.

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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;

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[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 fail to 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 in its determination of damages, and multiple "weak" affected property owners who cannot, we compare the efficiency of alternative legal rules, including property rules, liability rules, and regulation. The assumption of a strong polluter who can subvert the determination of damages is a central innovation of our model. The assumption of multiple victims is a standard way to model the limits of bargaining.

In this model, the upside of a property rule relative to a liability rule is that it grants land owners protection that is invulnerable to subversion by the polluter. The downside is that it relies on bargaining to attain efficiency, and when bargaining fails it stops efficient pollution. Regulation can address these inefficiencies by mandating abatement up to a pre-specified level, and enforcing this mandate with stark penalties like those of a property rule. Intuitively, regulation is thus equivalent to a partial property rule.

Both regulation and the property rule have the upside of reducing harm when courts are subverted, and the downside of being relatively inflexible. Regulation, however, does not fully stop pollution when bargaining fails. It is a crude instrument, like the property rule, but nonetheless avoids both extremes of no pollution or unabated pollution. Therefore it can do better than either pure legal rule. We then apply our approach to water pollution across U.S. counties, showing how historically court-enforced liability rules 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 court.

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 owners—a liability rule? Alternatively, should property be protected through a property rule that always deters polluters from emitting? And why would regulation, such as the Clean Water Act, ever be needed?

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 have received wide support, particularly from those who believe that liability rules fail to protect the poor. At the same time, in many situations such as pollution, property rules have increasingly been replaced by regulation, often combined with liability.

We revisit these debates in a model of multiple owners and a polluter. We assume throughout that the owners' 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. We further assume that interference with this property right is also indisputable—in our case because there is only one potential polluter—and first compare the liability rule and the property rule. In this framework, the case without any subversion of justice yields the conclusions of the Coase Theorem, so property and liability rules are equivalent. However, when the polluter can subvert damage awards by influencing courts, property and liability rules are not equivalent. Property rules have the advantage of stopping the polluter even when courts can be subverted, but they heavily rely on bargaining, and stop even efficient pollution when bargaining fails. Our analysis explains the dominance of property rules as the means of securing property rights when there is only one (or a couple) potential victims, so bargaining can work, and when courts cannot be relied upon to assess damages fairly.

But what if the courts are vulnerable to subversion and, as in the case of modern pollution, there are many potential victims, so bargaining is likely to fail? An alternative to the two legal rules is government regulation, whereby the polluter is required to abate his emissions beyond a regulated level and to install at some cost a monitoring system that measures compliance. The violation of these limits is punished by criminal or other heavy penalties that are independent of the harm done, as with a property rule. Within regulated limits, pollution is governed by a liability regime instead. This is not the only way to model regulation, but it captures the essential features of the Clean Water Act. We show that while such regulation rarely achieves full efficiency, it can do better than either the property or the liability rule, because it successfully enforces some, though not necessarily efficient, abatement when the subverted liability rule limits pollution too little, and the property rule without bargaining limits it too much.

In Section 5, we test the predictions of our model on the history of water pollution in the U.S. We summarize the evidence pointing to the failure of courts to stop water pollution. The legal literature following Horwitz (1973, 1977) argues that nineteenth-century courts moved from a property-rule approach to water pollution ("ancient use") to a liability-rule approach ("reasonable use") because bargaining among riparian owners became impossible when large-scale polluters impacted increasingly crowded waterscapes (Rose 1990; Paavola 2002). In practice, however, courts often failed to impose standard damages on large-scale polluters because, as the Pennsylvania Supreme Court ruled in 1886, "trifling inconveniences to particular persons must sometimes give way to the necessities of a great community" (*Pennsylvania Coal v. Sanderson*, 6 Atl. 453). Government regulation, starting with the states and followed by the federal Clean Water Act, was a response to this failure.

We use micro data on water quality from Keiser and Shapiro (2019) to show how the Clean Water Act (CWA), by restricting emissions directly rather than focusing on the harm they cause, 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 enforce abatement of emissions from farms; and in the more corrupt states, where court enforcement of the earlier liability regime was presumably weaker. The results suggest that, in this instance, regulation enforced by property-rule penalties worked in the ways suggested by our 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. 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 liability rules, and it shows that property rules and regulation are less vulnerable to subversion. As such, it delivers in a unified framework the Coase (1960) theorem, the

Kaplow-Shavell (1996) result that liability rules are preferred to property rules when courts make only random errors but bargaining can fail, and the related and influential Calabresi-Melamed (1972) hypothesis that property rules are crucial complements to bargaining.

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. Our approach to court subversion is related to the work of Milgrom (1988) and Milgrom and Roberts (1988) on influence in organizations, although we do not focus on the problem of obtaining information from self-interest litigants, nor on the "influence costs" they waste to manipulate such information. 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 Model

Our model contains multiple land owners and one polluter who may harm the owners' enjoyment of their property. The model also applies to other forms of interference with private property, such as trespass or outright takings. We focus on the optimal means of protecting private property, where optimality is defined as maximizing the sum of benefits to the owners and the polluter. We compare property rules, liability rules, and regulation using this definition of optimality.

In comparing alternative rules, our analysis turns crucially on the question of which facts are disputable. We assume throughout that the owners' property right itself is indisputable. Because we consider only one polluter, we are also assuming that his interference with that property right is indisputable. With multiple polluters disputable responsibility becomes a further realistic complication, which strengthens the case for regulation as we discuss in Appendix 3.2. On the other hand, we assume that the precise level of harm suffered by the owners as a result of pollution is disputable.

The standard approach in law and economics is to assume that, even if some facts are disputable, the court will establish them, perhaps with random error but without a predictable, systematic bias in favor of a litigant (Coase 1960; Kaplow and Shavell 1996). Instead, we see indisputable facts as obvious to outsiders, so if the court misrepresented these facts its malfeasance would also be indisputable. Disputable facts are not obvious to outsiders, so the court's bias and misrepresentation go unchecked.

This implies that, when the relevant legal rule depends only on indisputable facts such as the polluter's interference with the owners' property rights, a court always applies that rule faithfully. In contrast, when the legal rule requires the court to assess disputable facts such as the level of harm, a powerful polluter can subvert the court and distort the application of the rule. We assume for starkness that a subverted court simply rules in favor of the strong polluter, by assessing harm to be negligible. The essence of subversion of justice is judicial discretion when facts are disputable.[2] We examine the implications of this assumption for optimal legal rules, and then evaluate them empirically.[3]

In our model, a polluter P can take an action that yields him a private benefit but imposes costs on a set of owners O_i, for $i = 1, 2, \ldots, N$. For example, a factory might dump runoff waste in a nearby river that impacts riverfront properties. The polluter can also pay a cost to adopt an abatement technology that reduces the social costs of his action. All agents' payoffs are normalized to zero if the polluter takes no action. If P acts without abatement, his payoff is $b > 0$ and each owner suffers harm $c/N > 0$. Abatement reduces P's benefit to $(1 - \rho_b)b$ and each O_i's harm to $(1 - \rho_c)c/N$, for $0 < \rho_b < \rho_c < 1$.[4] We are particularly interested in the two extreme cases of $N = 1$, which corresponds to a classic trespass case, and large N, which corresponds to complex pollution cases.

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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).

[3] 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 disputable in favor of the strong. The better the institutional environment, the less likely is such a biased finding.

[4] We disregard the simpler case in which $\rho_c < \rho_b$: then abatement is a dominated option.

The private benefit b of the activity is deterministic. The social cost of action c is stochastic with cumulative distribution $F(c)$ with a minimum value of $0 < b$. Sometimes unabated pollution—or for that matter taking—is efficient. The realization of c for owners in a particular case is known by the polluter P and every owner O_i. We assume for simplicity that harm from P's action is certain for each case, and merely heterogeneous across cases; but in Appendix 3.1 we show how our model extends naturally to the case of inadvertent harm with residual ex-ante uncertainty in a particular case.

We consider three legal rules that aim to discourage inefficient action and to allow efficient action: a property rule, a liability rule, and regulation. Each rule specifies penalties that are enforced based on facts assessed by a court. The court observes everything and with probability $1 - \delta$ assesses all facts honestly. With probability δ, the court is subverted by a powerful polluter. If the court is subverted, it assesses indisputable facts honestly, but misrepresents disputable facts to improve the polluter's payoff.

We assume that whether P acted and therefore interfered with the O_is' property rights is indisputable. With one pollutant, the fact of his discharge into a river is obvious to all. However, the exact realization of harm c suffered by the owners is disputable. Experts hold different assessments of the actual damage suffered from any one pollutant. In the fraction δ of cases in which P subverts the court, harm is assessed at zero irrespective of its true realization c.

We assume that abatement is not automatically indisputable. However, the legislator can mandate that P invest in a monitoring technology, which costs m per case and makes abatement indisputable. For instance, the Environmental Protection Agency's (EPA) National Pollution Discharge Emission System (NPDES) "sets technology-based effluent limitations (TBELs) that the agency deems to be the best performing and affordable technology available to control the pollutant" (Shabman and Stephenson 2012, p. 210). The EPA specifies a pollution-abating technology for an industry, such as a particular form of filtration, and monitoring confirms that the technology has been adopted. The EPA enforces compliance through inspections and heavy penalties for violations of pre-specified conditions. EPA monitoring rules enforce technology adoption more than they regulate quantity because "if the EPA technology proves ineffective, and the source can show it has properly installed and operated the prescribed technology, that source will still be in compliance with its permit" (Shabman and Stephenson 2012, p. 211).[5]

The timeline of the model follows.

Stage 0. The legislator sets the legal rule protecting the owners and chooses whether to mandate a monitoring system to indisputably measure abatement.

Stage 1. The social cost c and P's ability to subvert the court are realized and privately observed by P and each O_i. The parties have a chance to bargain and write a contract, but each O_i is unable to join the bargaining table with probability β. The ability to bargain is drawn independently across owners. Bargaining is otherwise efficient among the parties able to join the negotiation.

Stage 2. P chooses whether to act and, if he acts, whether to abate.

Stage 3. If P acts, the court assesses facts and penalties are enforced.

In Stage 3, the court assesses facts about the polluter's action, which may have different implications for penalties depending on the contract written in Stage 1. For example, if all owners sign a contract allowing P to damage their property, then the court will not punish P for damaging their property. We consider the choice between different regimes for protecting property from harm, but with respect to contracts we assume that the only remedy for breach, in line with the common law practice, is the award of damages to the injured party proportional to the harm assessed by the court.[6]

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[5] Regulation often takes the form of mandates on technology that are then monitored by testing the levels of pollution outcomes. For example, emissions tests on automobile evolved out of a regulatory system that began in 1960 when California required cars sold in the state to have positive crankcase ventilation.

[6] This rule could be optimal averaging across all contracts, even though in a particular case like the one we consider it might be optimal instead to allow parties to specify a fixed, punitive penalty for breach of contract. General common law principles make all such contractual penalties unenforceable in the U.S.

2.1. Rules

In Stage 0, the legislator chooses one of three rules: the property rule, the liability rule, or regulation.[7] Each of these rules also allows the possibility of contracts between *P* and the owners, which we turn to next. We first discuss the implications of each rule in the absence of contracts.

Under the property rule, every owner is entitled to be spared from the polluter's harmful activity. Hence, if *P* acts, he suffers a fixed penalty $f > b$, which could be a monetary fine, imprisonment, or physical harm. Whatever form it takes, the penalty f is large and relies only on the indisputable fact that the polluter acted; it does not depend on any fact-intensive verification of harm, abatement, or the number of owners whose right is violated. This penalty cannot be subverted by a powerful polluter.

Under the liability rule, every owner is entitled to compensation for any harm suffered as a result of the polluter's action. Hence, if *P* acts, he must pay damages to each O_i equal to assessed harm. If he cannot subvert the court, *P*'s total payment equals the social cost of his action. This cost equals c if he acted without abatement, or $(1 - \rho_c)c$ if he acted with abatement. If *P* can subvert the court, it assesses negligible harm so *P* pays negligible damages. Damage awards that differ from assessed harm would serve no purpose in our model: they are irrelevant when the court is subverted and only distort behavior when it rules correctly.[8]

Under regulation, every owner is entitled to be spared from action without abatement. This is an absolute entitlement protected by property-rule remedies. Acting without abatement is deterred by the threat of a certain, fixed penalty $f > b$. The Clean Water Act requires factories to adopt abatement technologies and makes violations punishable with criminal penalties. On the other hand, regulation protects owners with only liability-rule protection against action with abatement. If *P* documents

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[7] In our model it is always preferable for the owners' property rights to be protected at least by the liability rule rather than not at all.

[8] Subversion in the assessment of harm means that the cost of pollution to *P* becomes independent of legal rules raising damages above the court's estimate of harm, such as double and treble damages. *P*'s action can be deterred only by a penalty for action irrespective of harm—the property rule. On the other hand, damages equal to actual harm align the cost of pollution to *P* with its social cost when courts are not subverted.

abatement through the indisputable monitoring technology, the owners are entitled only to fair compensation for any harm suffered.[9] Assessed damages will then be negligible if P can subvert the court.

Abatement plays a different role under each rule. Under the property rule, abatement plays no role in the absence of a contract. The property rule deters any and all action that is not authorized by all the owners. Under the liability rule, abatement plays only an indirect role. Abatement reduces the harm suffered by the owners, and thus the damages paid by P if he cannot subvert the court. However, the liability rule focuses exclusively on the level of harm, and the courts are not independently concerned with how P caused that harm. Liability penalties do not distinguish between an unabated action with intrinsically low social costs, and an intrinsically higher-cost action that was abated.

Under regulation, abatement plays a crucial direct role. Action without abatement is deterred by property-rule penalties, irrespective of the harm caused. Action with abatement is allowed, subject only to liability-rule damages.

2.2. Contracting

In Stage 1, the parties can bargain and write two kinds of Coasian contracts. The polluter can promise to refrain from acting, or the owners can permit the polluter's activity. In both cases, the contract can be conditional on abatement: the polluter can promise to refrain from unabated action, retaining the right to act with abatement; or the owners can permit abated action, retaining the right to stop action without abatement.

Under the liability rule, only the first kind of contract is possible: some O_is pay P to refrain from acting. Since contracts are enforced with court-assessed damages, a powerful polluter subverts the court and pays minimal damages after breaching the contract. As a consequence, no O_i is willing to pay P not to

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[9] In some cases a regulatory standard creates a safe harbor against tort, but there would be no advantage of such a safe harbor in this case unless there were powerful owners who engaged in nuisance lawsuits.

pollute when he can subvert the court. If *P* cannot subvert the court, a liability rule obviates any need for contracting, since it already induces *P* to pollute only when his benefit exceeds the cost to the owners.[10]

Under the property rule, only the second kind of contract is possible: all the O_is collectively allow *P* to act in exchange for a payment. The polluter who signs a contract permitting him to act actually does so, and the court simply recognizes that every owner has indisputably relinquished her entitlement to block his activity. If any O_i fails to join the bargaining table, then no contract can be written because *P* is still subject to the full penalty *f* for violating a single owner's rights without her consent.

If *P* cannot subvert the court, the owners can also sign a more nuanced contract permitting him to act but requiring him to abate. However, this contract turns into an all-out permission to act if *P* can subvert the court. By signing the contract, the owners forego their right to property-rule protection, and become entitled only to damages for breach of contract if the polluter does not abate. If *P* can subvert the court, he will breach the contract, pollute without abatement, and pay negligible damages.[11]

Since regulation combines liability-rule remedies for pollution with abatement, and property-rule protection against action without abatement, both contracts that stop action and contracts that permit pollution are possible under regulation. Just as with the pure liability rule, however, a contract that stops action with abatement is useless. If the court is subverted, then breach of contract is not punished and the contract is unenforceable. If the court is not subverted, then liability-rule remedies eliminate the need for such a contract. Just as with the pure property rule, instead, it is possible in theory for all the owners collectively to write an enforceable contract that allows action without abatement. Yet, when the number of owners *N* is large, this somewhat implausible possibility becomes vanishingly rare.

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[10] As the polluter will not pay more than the assessed damages, a contract will just duplicate the outcomes without a contract and so will be completely redundant.

[11] Subversion of the court's assessment of damages suffices to make this contract unenforceable, whether abatement is disputable or indisputable. Consequently, adopting a monitoring technology cannot expand the contracting space.

3. Efficient Rules

We begin with the textbook case in which the court's fact-finding cannot be subverted. In this case, full compensation of the actual social cost of action is mandated under the liability rule. Alternatively, the property rule is enforced by a high fixed penalty $f > b$ such that the polluter never acts without the owners' prior authorization. The monitoring technology is made redundant by the courts, which always assess correctly the social costs of pollution and whether P adopted the abatement strategy. All contracts are perfectly enforced. Our framework then embeds the classic Coase Theorem (all proofs appear in Appendix 2).

> **Lemma 1 (Coase 1960).** Suppose that the court can never be subverted ($\delta = 0$) and the polluter can always bargain with all the owners ($\beta = 0$). Then the first-best social surplus is attained under any of the liability rule, the property rule, or regulation, without monitoring.

Under the liability rule, the expectation of unbiased assessment of damages induces P to internalize exactly the expected social cost of his actions. He then chooses to act without abating if $c/b < \rho_b/\rho_c$, to act and abate if $\rho_b/\rho_c < c/b < (1 - \rho_b)/(1 - \rho_c)$, and not to act at all if $c/b > (1 - \rho_b)/(1 - \rho_c)$: these are the efficient choices. Under the property rule, each O_i can simply stop any polluting activity. However, when $\rho_b/\rho_c < c/b < (1 - \rho_b)/(1 - \rho_c)$, P finds it efficient to buy the permission to act while promising to abate, and when $c/b < \rho_b/\rho_c$ he further buys the permission to act without abating. Bargaining restores the first best. Likewise, under regulation the first best is attained through bargaining if $c/b < \rho_b/\rho_c$, and otherwise there is no need to bargain.

Whereas both the property rule and regulation require bargaining to attain efficiency in some situations, the liability rule 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 the court can never be subverted ($\delta = 0$), but the polluter cannot always bargain with all the owners ($\beta > 0$). Then the liability rule, without monitoring, attains the first-best social surplus; but the property rule and regulation do not.

When bargaining fails but the court 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 that harm can be assessed exactly if the court is not subverted, but random measurement error is immaterial. Efficiency does require that assessment of damages is free of any predictable systematic bias in favor of either party. When in some fraction $\delta > 0$ of cases a subverted court favors powerful polluters, the liability rule no longer achieves the first best. In this setting, the property rule and the partial property-rule protection granted by regulation reduce or eliminate reliance on court assessment of damages. Their appeal comes from their greater robustness to subversion.

3.1. Second-Best Rules: Laws without Regulation

We now turn to the simpler two-way comparison of the liability and the property rule, which largely characterized the legal landscape before World War I. In some cases, the cost of monitoring, captured by m in our model, was just too high to enable adoption of regulation, in part because technology was unavailable. In other cases, regulation may have been delayed because the political process was captured.

Since the adoption of the costly monitoring technology yields no efficiency gains under either the liability or the property rule, for the sake of brevity we refer from now on to the liability rule without monitoring as “the liability rule” and the property rule without monitoring as “the property rule.”

The liability rule generates the first best when the court is not subverted. But if a powerful P knows he can subvert the court’s assessment of harm, then the liability rule leads him to choose always the most profitable and most polluting option: action without abatement. His activity creates social costs of $\Lambda = \int_{b\rho_b/\rho_c}^{b(1-\rho_b)/(1-\rho_c)} (\rho_c c - \rho_b b)dF(c) + \int_{b(1-\rho_b)/(1-\rho_c)}^{\infty} (c - b)dF(c)$ from inefficient pollution. Consequently, the total expected social loss from a liability regime, relative to the first best, equals $\delta\Lambda$.

The property rule requires all the owners to consent to any action by the polluter. With probability $1 - (1 - \beta)^N$, at least one of the owners is unable to bargain. In that case, the property rule prevents inefficient and efficient action alike, causing the loss of the social value of efficient pollution, which equals $\Pi = \int_0^{b\rho_b/\rho_c} (b - c)dF(c) + \int_{b\rho_b/\rho_c}^{b(1-\rho_b)/(1-\rho_c)} [(1 - \rho_b)b - (1 - \rho_c)c]dF(c)$.

With probability $(1 - \beta)^N (1 - \delta)$, all the owners can bargain and the court is not subverted. The owners and the polluter can then reach a perfectly efficient contract. If that contract involves the polluter abating harm, this clause is enforced by the court's honest assessment of damages from breach.

With probability $(1 - \beta)^N \delta$, all owners can bargain, but the court is subverted. In this case, the court does not enforce a contract that specifies abatement, and sets damages for its breach to zero. However, the court does prevent the action if no contract is signed, since this action is indisputable. When the court is subverted, the owners and the polluter must then choose between no contract and no harm or a contract that allows pollution, which also leads to no abatement. They choose the better of these two options, and the resulting social loss is therefore smaller than either the full cost Λ of universal unabated action, or the full cost Π of universal inaction. The loss equals $\Lambda - \lambda_P$, where $\lambda_P = \int_b^{\infty}(c - b)dF(c) < \Lambda$ denotes the value of switching from unabated action to inaction when that switch increases efficiency.

Under the property rule, the social loss relative to the first best is then $[1 - (1 - \beta)^N]\Pi + (1 - \beta)^N \delta(\Lambda - \lambda_P)$. Proposition 1 compares the liability rule and the property rule in the second-best setting when there is both a chance the parties cannot bargain ($\beta \geq 0$) and a chance that the court is subverted ($\delta \geq 0$).

> **Proposition 1.** The liability rule yields greater social surplus than the property rule if and only if court subversion is unlikely enough: $\delta < \tilde{\delta} \equiv (\Pi/\Lambda)[1 - (1 - \beta)^N]/[1 - (1 - \beta)^N (1 - \lambda_P/\Lambda)]$.

The downside of the property rule is that it deters all efficient pollution when bargaining is impossible. The upside is that it also deters most inefficient pollution. The liability rule, instead, always allows efficient pollution. However, when the court's assessment of damages can be subverted, the liability rule also allows powerful polluters to act with impunity. This essential tradeoff compares insufficient pollution under the property rule and excessive pollution under the liability rule.

Since the downside of the property rule lies in letting the owners prevent all pollution when bargaining is impossible, the liability rule is more attractive when the benefits from efficient pollution (Π) are higher. Since the downside of the liability rule lies in letting the polluter get away with any pollution when the court can be subverted, the liability rule is more attractive when the costs of inefficient pollution (Λ) are lower. Since the property rule effectively enforces inaction, but does not induce optimal abatement when the court is subverted, the liability rule is less attractive when a greater share of inefficiency can be eliminated by simple shutdowns (i.e., when λ_P is higher).

More interesting, the liability rule is favored when the probability of court subversion (δ) is lower. As Lemma 2 shows, in the case of unbiased court assessment of damages ($\delta = 0$), the liability rule is always preferred as it achieves the first best even without bargaining. More generally, there is a unique threshold $\tilde{\delta}$ for court subversion that determines whether the liability or the property rule yields higher social benefits. The liability rule 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.[12]

The case for the property rule gets unambiguously stronger when bargaining is more likely ($\partial\tilde{\delta}/\partial\beta > 0$). With bargaining, the property rule is optimal even when the benefits from efficient pollution (Π) are much higher than the costs of inefficient pollution (Λ). If bargaining is always possible ($\beta = 0$), the property rule dominates the liability rule. Both systems attain the first best when the court cannot be

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[12] The complementarity of the property rule and the risk of court subversion is independent of our assumption that the power to subvert lies with powerful polluters. If instead the court were subverted by powerful owners, it would assess prohibitive damages for any action they have not explicitly authorized, making the liability rule and the property rule identical. Thus, the trade off between the two rules always depends only on the two cases we consider explicitly: no court subversion and court subversion by *P*.

subverted. When the court can be subverted, bargaining is not perfect with the property rule because the polluter still cannot commit to abatement, but the property rule still eliminates the most egregious cases of inefficient pollution, with social savings λ_P.

When N and β are small, the property rule enables the parties to bargain and reach an efficient outcome. An absolute entitlement gives each O_i the power to stop the polluter, but they only use that power to bargain, even with a strong P. In contrast, the liability rule does not facilitate bargaining between weak owners and strong polluters because a strong P cannot credibly commit not to pollute under the liability rule. A strong P literally needs to be stopped unless and until he pays.

These results vindicate 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 the property rule can sell it to efficient polluters. In contrast, owners whose entitlement is protected by the liability rule cannot pay off powerful but inefficient polluters, because contracts are not reliably enforced against them.

The complementarity between the property rule and bargaining also means that the liability rule becomes more attractive as the number of owners increases, because a greater number of owners raises the probability that not all of them are able to bargain ($\partial\tilde{\delta}/\partial N > 0$ for all $\beta > 0$). If the liability rule is better than a total shutdown of all activity (i.e., if $\delta < \Pi/\Lambda$), then it yields greater expected social surplus than the property rule if and only if $N > \ln[1 + \lambda_P/(\Pi/\delta - \Lambda)]/|\ln(1 - \beta)|$.

This last result may explain the path of case law around water pollution in nineteenth-century America. Before the industrial revolution, riparian rights more closely resembled the property rule discussed above. As Paavola (2002, p. 298) explains, "the riparians whose land abutted" water enjoyed "a right to receive water in its accustomed (and thus natural) quantity and quality," which was established by the concept of "natural flow" and the maxim of *sic utere tuo ut non alienum laedas*. But over the course of the 19th century, the scale of industrial pollution increased and so did the number of people who could plausibly claim that they were harmed by water pollution.

The logic of our model suggests that maintaining the property rule would have shut down most water-related industrial activity, and that may well have generated more harm than good. Courts understood that difficulty and reacted by moving to the liability rule for water pollution, weakening downstream riparian rights. After *Snow v. Parsons* (28 Vt. 459, 1856) many courts embraced the doctrine of “reasonable use” which allowed new users to harm downstream riparian owners as long as the court deemed that the activity did more good than harm. Later water regulation represents an attempt to roll back some of the leeway accorded to water polluters during the 19th century, and to restore in part an absolute entitlement to clean water for the owners, protected by property-rule remedies.

3.2. Second-Best Rules: Law and Regulation

A costly monitoring technology does not improve the efficiency of either the liability rule or the property rule, but it is critical for regulation. Regulation enforces absolute property-rule protection of the owners against unabated action only, while subjecting activity with abatement to a mere liability-rule requirement to compensate for damages. Without monitoring, abatement itself is disputable. Regulation is then dominated by the liability rule because it does not constrain a powerful polluter any more than the liability rule when the court is subverted, while it imposes inefficient constraints when the court is not subverted but not all owners can bargain. Since the adoption of the costly monitoring technology is necessary for regulation not to be a dominated option, for the sake of brevity we refer from now on to regulation with monitoring as simply “regulation.”

When the legislator mandates adoption of the monitoring technology, abatement becomes indisputable. Regulation can then successfully enforce abatement as a default irrespective of *P*’s ability to subvert the court. Two inefficiencies remain.

First, when P cannot bargain with all owners, regulation requires abatement even when unabated action is efficient. This distortion causes a social loss from inefficient abatement, but not the loss of the full social value Π of efficient pollution. The loss is reduced instead to $\Pi - \pi_R$, where $\pi_R = \int_0^{b(1-\rho_b)/(1-\rho_c)}[(1 - \rho_b)b - (1 - \rho_c)c]dF(c) < \Pi$ denotes the value of switching from inaction to abated action whenever that switch increases efficiency.

Second, when P can subvert the court, he chooses to act and abate even when inaction is efficient. Contracts, enforced by damage awards, cannot deter him. This distortion causes a social loss from inefficient pollution, but not the full cost Λ of inefficient pollution. The loss is reduced instead to $\Lambda - \lambda_R$, where $\lambda_R = \int_{b\rho_b/\rho_c}^{\infty}(\rho_c\, c - \rho_b\, b)dF(c) < \Lambda$ denotes the value of switching from unabated action to abated action whenever that switch increases efficiency.

Summarizing, regulation yields a social loss $[1 - (1 - \beta)^N](\Pi - \pi_R) + \delta(\Lambda - \lambda_R) + m$, including the cost m of adopting the monitoring technology. Proposition 2 characterizes the efficiency-maximizing rule whenever $(1 - \beta)^N \leq (\Lambda - \lambda_R)/(\Lambda - \lambda_P)$. This is the case of greater empirical interest, since in practice regulation is mainly adopted for activities with a large number of affected owners (N).[13] Appendix 2 shows that the characterization in Proposition 2 of the parameter values for which the liability rule is efficiency-maximizing is general. The alternative rule that is optimal for marginal changes in parameters away from this region is also always as described in Proposition 2. The condition affects only the relative appeal of the property rule and regulation for high values of court subversion (δ).

Proposition 2. Suppose that $(1 - \beta)^N \leq (\Lambda - \lambda_R)/(\Lambda - \lambda_P)$.

If adopting the monitoring technology is costly enough that $m > \bar{m} \equiv \Pi[\lambda_R/\Lambda + \pi_R/\Pi - 1 - (1 - \beta)^N(1 - \lambda_P/\Lambda)(1 - \pi_R/\Pi)][1 - (1 - \beta)^N]/[1 - (1 - \beta)^N(1 - \lambda_P/\Lambda)]$, then the efficiency-maximizing

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[13] Moreover, the condition holds for any β and N if the efficiency gains from switching from unabated action to abated action whenever desirable are lower than the efficiency gains from switching from unabated action to inaction whenever desirable ($\lambda_R \leq \lambda_P$).

rule is the liability rule if court subversion is rare enough that $\delta < \tilde{\delta}$ and the property rule if court subversion is common enough that $\delta > \tilde{\delta}$.

If adopting the monitoring technology is cheap enough that $m < \bar{m}$, then the efficiency-maximizing rule is the liability rule if court subversion is rare enough that $\delta < \tilde{\delta}_1 \equiv \{[1 - (1 - \beta)^N](\Pi - \pi_R) + m\}/\lambda_R$, the property rule if court subversion is frequent enough that $\delta > \tilde{\delta}_2 \equiv \{[1 - (1 - \beta)^N]\pi_R - m\}/[\Lambda - \lambda_R - (1 - \beta)^N (\Lambda - \lambda_P)]$, and regulation for intermediate levels of court subversion: $\tilde{\delta}_1 < \delta < \tilde{\delta}_2$.

Regulation is distinguished from both the liability rule and the property rule by its unique reliance on monitoring to enforce abatement even by powerful polluters who can subvert the court. Two intuitive consequences follow. First, regulation is a dominated option when monitoring technology is too costly ($m \geq \bar{m}$). Second, regulation can be attractive only if abatement is useful enough: either because most of the social costs from inefficient pollution can be avoided by requiring abated instead of unabated action (i.e., high λ_R/Λ), or because most of the social value of efficient pollution can be reaped by allowing abated action instead of inaction (i.e., high π_R/Π).[14]

If abatement is useful enough and the monitoring technology cheap enough, so that $0 \leq m < \bar{m}$, the appeal of the liability rule is reduced relative to what we found for a binary rule choice in Proposition 1. For intermediate levels of subversion ($\tilde{\delta}_1 < \delta < \tilde{\delta}$), the liability rule is preferable to the property rule, but regulation is most efficient. Regulation likewise replaces the property rule as the second best for some higher levels of subversion ($\tilde{\delta} < \delta < \tilde{\delta}_2$).

The appeal of regulation relative to both the liability rule and the property rule is intuitively greater if monitoring is cheaper ($\partial\tilde{\delta}_1/\partial m < 0 < \partial\tilde{\delta}_2/\partial m$) and if abatement is more useful (i.e., if λ_R or π_R are

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[14] Formally, $\bar{m} > 0$ if and only if $\lambda_R/\Lambda + \pi_R/\Pi - (\lambda_P/\Lambda)(\pi_R/\Pi)(1 - \beta)^N/[1 + (1 - \beta)^N] > 1$.

higher). Just as in Proposition 1, a higher chance that all owners can bargain makes liability less appealing ($\partial\tilde{\delta}_1/\partial\beta > 0 > \partial\tilde{\delta}_1/\partial N$).[15]

As a final theoretical point, we have presented our theory in the context of pollution, trespass, or other torts. Yet closely related ideas apply to contracts, and the question of specific performance versus compensatory damages as the remedy for breach. In Appendix A3.3, we develop this analysis, and show how it can shed light on some debates in the literature on contracts and on the theory of the firm.

4. Empirical Predictions

The propositions in the previous section were largely normative. If rules are chosen optimally or change in response to pressures for efficiency, then these propositions also yield predictions about the evolution of legal regimes. We consider these implications to be our first two empirical predictions. The first prediction is based on Proposition 1; the second is based on Proposition 2.

> **Institutional Prediction 1.** Property rules tend to be replaced by liability rules as court subversion becomes less prevalent, or as the number of impacted owners increases.

Proposition 1 shows that the property rule is particularly valuable when the court is likely to be subverted. This may explain the heavy reliance on property rules in developing countries, where the imbalance of power in legal disputes is substantial. As courts get better with development, the optimal institutional choice implies a movement from property to liability rules. A more interactive and connected economy will also lead to a transition from property rules to liability rules. When each polluter deals with only one owner, bargaining is easy and the property rule enables efficient bargaining. When a polluter can potentially impact hundreds or thousands of individuals, bargaining is impossible and the case for the liability rule becomes stronger.

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[15] Instead, the impact of bargaining on the relative appeal of the property rule and regulation is ambiguous: $\partial\tilde{\delta}_2/\partial\beta$ has the sign of $\pi_R(\lambda_P - \lambda_R) + m(\Lambda - \lambda_P)$.

Institutional Prediction 2. When pollution impacts a large number of owners, and abatement is sufficiently useful to avoid the inefficiencies of no pollution or unconstrained pollution, then liability rules tend to be replaced by regulation as the costs of monitoring fall.

For many activities that pollute the air and water, unconstrained action is better than no action at all. When the number of owners N is large, the liability rule is preferred to the property rule because the latter essentially forbids all activity that could pollute any large waterway (i.e., $\delta < \lim_{N\to\infty} \tilde{\delta} = \Pi/\Lambda$). Often, however, abatement allows reaping most of the benefits from efficient action, while entailing greatly reduced costs of inefficient pollution. As a result, regulation is better than the liability rule, and a fortiori than the property rule, when monitoring costs are low (i.e., $\delta > \lim_{N\to\infty} \tilde{\delta}_1 = (\Pi - \pi_R + m)/\lambda_R$). When instead monitoring costs are high, regulation is prohibitively expensive and the liability rule is the most efficient alternative. Our second prediction is that technology improvements should lead to more regulation in settings where many people can potentially be harmed.

We next turn to predictions that require no assumptions about efficiency-maximizing institutional choices and instead focus on the level of pollution. Proposition 3 looks at the impact of a switch from liability to regulation caused by either an exogenous event or a decline in monitoring costs.

Proposition 3. If a jurisdiction switches from the liability rule to regulation, and no parameters change other than the cost of monitoring m, the expected cost of pollution to the owners falls by $\rho_c\{[1-(1-\beta)^N]\int_0^{b\rho_b/\rho_c} c\,dF(c) + \delta\int_{b\rho_b/\rho_c}^{\infty} c dF(c)\} \geq 0$. The decline in harm, as a fraction of initial harm under the liability rule, is increasing with the probability of court subversion δ.

Proposition 3 shows that a switch from the liability rule to regulation leads to a reduction in the total costs of pollution and that this reduction is proportionally larger in places where subversion is more common. As we show in Appendix 2, the polluter's benefits from pollution also decline, and their decline is also proportionally larger where subversion is more common. This is our third empirical prediction.

Empirical Prediction 3. Pollution declines when liability rules are replaced by regulation, and its decline is larger where court subversion is more prevalent.

The first part of this prediction has essentially been tested already by the large number of studies documenting that environmental regulations, including the Clean Water and Clean Air Acts, have reduced pollution. In almost every case, there was a liability regime in place before the act, and the act replaced that liability regime with a regulation regime that uses property-rule remedies for enforcement.

The second part is more novel. Our model delivers the strong prediction that the liability rule should be more effective, both at enhancing social welfare and at reducing pollution, when the quality of courts is high. The impact of replacing the fact-intensive liability rule with a less nuanced regulatory regime is then larger where subversion is more prevalent.

To derive our final empirical prediction, we start from observing that the Clean Water Act distinguishes between pollution from point sources, including most industrial polluters, and non-point sources, including most agricultural polluters. This distinction largely reflects differences in monitoring technology. An industrial plant's discharges from an outflow pipe can be monitored much more easily than a farm's emissions leaching from its fields. Our final empirical prediction concerns situations in which a given share of polluters, denoted by α, is agricultural and thus not subject to a requirement for water-pollution abatement enforced by property-rule remedies. Our prediction does not depend on the total number of potential polluters, since we focus on proportional changes in pollution.

Corollary 1. If no parameters change other than the cost of monitoring m, and a jurisdiction switches from the liability rule to regulation for a share $1 - \alpha$ of polluters, the decline in total harm from pollution, as a fraction of initial harm, is monotone decreasing in the share α of polluters who remain subject to the liability rule.

When the key element of regulation is the enforcement of property rules against industrialists but not against farmers, then their impact will be larger when the share of industrialists is higher and the share of farmers is lower. This corollary leads to our final empirical prediction.

> **Empirical Prediction 4.** The decline in pollution when liability rules are replaced by a regulatory regime is larger in locations that have less agriculture, if the regulatory regime applies property-rule penalties only to non-agricultural polluters.

5. Water Pollution

Water is a shared resource such that actions upstream can reduce the value of riparian land downstream. Riparian rights have long been protected by the common law. Until the 19th century, these rights were protected like other forms of property, with violations stopped by injunction. During the 19th century, American courts moved closer to a liability standard, citing the social losses from shutting down successful enterprises that happened to pollute the water. As our model suggests, this appears to have allowed much more pollution. In 1972, the Clean Water Act (CWA) imposed regulations that were once again enforced with property-rule remedies. Our model predicts that water pollution fell when the liability rule was replaced by regulation. It further predicts that regulatory enforcement should reduce pollution where it is applied and binding, and that pollution reductions should be particularly large in more corrupt places. 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

Paavola (2002, p. 297) documents that, before the industrial revolution, “the early courts construed water uses, and the water quality they depended on, as private property.” Horwitz (1973, p. 252) explains that “a late eighteenth century New Jersey case (*Merritt v. Parker*, 1 N.J.L. 526) clearly expressed the prevailing conception” when it ruled that “when a man purchases a piece of land through which a natural water-course flows, he has a right to make use of it in its natural state, but not to stop or divert it", and that the water flow "cannot legally be diverted from its course without the consent of all who have any interest in it." The need for "consent of all" suggests the bargaining challenge highlighted by our model. The court also affirmed large penalties for violating this property rule: "I should think a jury right in giving almost any valuation which the party thus injured should think proper to affix to it." Rose (1990, p. 271) explicitly links bargaining and these property-rule riparian arrangements, which "simply look like a way of specifying rights between neighbors so that negotiations could take place and the resources could flow to the one who most valued them."

As opportunities for exploiting America's water resources increased during the 19th century, courts increasingly saw the property rule as an inefficient limitation on industrial expansion. As Horwitz (1977, p. 34) writes, "the evolving law of water rights had a greater impact than any other branch of law on the effort to adapt private law doctrines to the movement for economic growth." As the industrial riverscapes grew denser, the conflict between a single mill owner and his neighbor, which could be handled through property rights and negotiation, was replaced by "new water use conflicts that involved a number of injured downstream riparians" (Paavola 2002, p. 301). Rose (1990, p. 286) explains that "both upstream and downstream mill owners effectively claimed an exclusive right to control the entire current of the river," and, consequently, "to adopt either of these positions, in the large-numbers context of controlling the entire river current, might well freeze the use of the river for all users since no reallocation could be negotiated easily among all those effected riparians."

In a series of cases including *Palmer v. Mulligan* (3 Cai. R. 307; NY 1805), *Tyler v. Wilkinson* (24 F. Cas. 472; RI 1827), *Snow v. Parsons* and *Pennsylvania Coal Co. v. Sanderson*, the courts increasing embraced the doctrine of reasonable use, which replaced the old property rule with a liability rule (Institutional Prediction 1). But, as our approach argues, the courts often failed to impose damages for actions that were deemed to be "reasonable." As Chief Justice Redfield wrote in his opinion in *Snow v. Parsons*: "within reasonable limits, those who have a common interest in the use of air and running water must submit to small inconveniences to afford a disproportionate advantage to others." When the State Supreme Court of Pennsylvania rejected any damages owed to a riparian owner who claimed that "acid mine drainage had spoiled a brook's water, killed all the fish, and corroded a new water distribution as his farm", the court ruled that "to encourage the development of the great natural resources of a country trifling inconveniences to particular persons must some times give way to the necessities of a great community" (Paavola 2002, p. 305-306).

This transformation technically left riparian owners and other water-users with common-law remedies for pollution, such as the notions of trespass and nuisance (Percival et al. 2017). None of the nineteenth-century cases mentioned above reject the liability rule that damages should be awarded if it can be proven that an upstream polluter did great harm to a downstream riparian. Yet, pollution posed challenges for common law, because establishing liability requires that a plaintiff both show that pollution caused harm and attribute the level of harm to the specific polluter (Hines 1966). Such attribution becomes very challenging, especially with multiple polluters.[16] Following the logic of the Pennsylvania Supreme Court, judges reduced damage awards, or even denied any liability for damages, because they did not want to burden American industry (Goldstein 2010; Lewin 1989).

Several states responded to the limitations of the common-law liability rule 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 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).

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[16] 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). 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.

The CWA shifted the focus of regulation from water quality to compliance with emissions permits administered by the Environmental Protection Agency (EPA) (Andreen 2003b), and enforced that compliance with property-rule penalties. The EPA issues permits that require measurement and limit discharges 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 liability rule enforced by the common law to regulation enforced with fixed penalties (Institutional Prediction 2).

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, Kling and Shapiro (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.

A central feature of the CWA is the disparate treatment of point source pollution, produced primarily by industrial activity, and non-point source pollution produced by agriculture. The CWA requires point-source polluters to have a permit, and failure to comply with a permit is punished by property-rule penalties, like injunction and criminal prosecution.[17] Point-source polluters can also be sued for damages under the common law. Non-point source polluters do not require permits, but can be sued

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[17] Point-source pollution is much easier to attribute to a source than non-point source pollution, but it is today a less important source of water pollution. 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.

for damages. The differential impact of the CWA on point-source and non-point source pollution provides a test of whether the regulatory permitting and the associated property-rule remedies mattered, or whether other changes in the legal and regulatory environment drove changes in water pollution levels. 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 (Empirical Prediction 4).

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. Keiser and Shapiro (2019) describe their data in detail. 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 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 county during a year and the average level of that pollutant across all county-by-year observations in our sample divided by the standard deviation of that level across the sample. For each county, we sum Z scores across all pollutants by year to get an annual pollution Z score. 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 us the aggregate 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).[18] The enforcement of the CWA was delayed for both administrative and political reasons (Jerch 2019). The

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[18] 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.

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).

To measure whether a switch from common-law liability rules to regulation induces an overall reduction in pollution, as predicted by the first part of our Empirical Prediction 3, 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 any point 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.[19] 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 minor, 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 1990's (Owen 2015). If regulation reduces pollution by replacing the liability-rule tort remedies with property-rule sanctions for non-compliance with permits, we would expect the CWA to entail a larger decline in pollution for non-agricultural counties (Empirical Prediction 4).

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 of the distribution of the agricultural employment

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[19] 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.

share across all counties.[20] 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.

Another implication of our theory, predicted by the second part of our Empirical Prediction 3, is that property rules and regulation should both reduce harm more, relative to a liability rule, where court subversion is more common. We proxy for court subversion with measures of corruption at the state level. We expect that areas that are more corrupt will have higher levels of pollution before the CWA and that the impact 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 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."[21] 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. We create an indicator for corrupt counties as those in states where the conviction rate is above the mean. 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. [22]

5.3. *Empirical Approach*

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

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

where y_{ijt} is the summed Z score across all pollutants in county i in state j and 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

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[20] In Appendix 4 we also consider an alternative definition of agricultural counties based on the number of establishments rather than the employment share.

[21] For details on what the DOJ considers a corruption-related crime, see Glaeser and Saks (2006).

[22] 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.

because the EPA issued a permit in 1973 or 1974, and X_{it} is a vector of time-varying controls for economic conditions in county 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-specific linear time trend. In Equation 1, β_1 provides a test of the first part of Empirical Prediction 3 by estimating 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:

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

where the common terms are as before and $Non\text{-}ag_i$ is an indicator for whether county i is a non-agricultural county. In Equation 2, β_2 provides a test of Empirical Prediction 4 by estimating the differential 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. In estimating Equations 1 and 2 we cluster standard errors at the county level.

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

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

where the common terms are as before and $Corrupt_j$ is an indicator for whether county i is located in a state j that we consider corrupt (i.e., one with a conviction rate above the mean in the sample). In Equation 3, β_2 provides a test of the second part of Empirical Prediction 3 by estimating the differential 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. These corruption measures are only available at the state level, so in estimating Equation 3 we cluster standard errors at the state level.

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 the CWA 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. Consistent with the first part of Empirical Prediction 3, our findings indicate that water pollution declined with the enforcement of regulation under the CWA, and not simply with the passage of time.

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 bears out Empirical Prediction 4.

The analysis so far does not control for pre-trends, which we take up next. Table 2 presents the results of the difference-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. 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 (Empirical Prediction 3, first part).

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 accounts for roughly 70% of the overall treatment effect estimated in the first three columns.

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, as highlighted by Empirical Prediction 4. Our model implies that regulation is effective when it relies on monitoring simple, indisputable facts and enforcing abatement with property-rule remedies. 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 a pair of 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 such places, as in the second part of Empirical Prediction 3. Figure 4 indicates that both of these predictions hold in 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 ones. Moreover, 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 4, and shows that they are statistically highly significant.

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, regulation, and 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 the subversion of justice by the strong. When particular legal facts are disputable, a strong litigant may have the power to get a favorable court ruling on these facts. Focusing on the case of water pollution by a factory that affects multiple adjacent land owners, we examined the case in which the polluter's interference with the owners' property right is indisputable, but the precise extent of harm they suffer because of it is disputable. We showed that the upside of a property rule relative to a liability rule is that it stops inefficient pollution when the strong polluter can subvert the court's assessment of damages. The downside of a property rule is that it relies on bargaining to reach efficient solutions, which can fail when there are many victims. In this situation, regulation that limits but does not eliminate pollution can work better than either legal rule, because the partial mandated abatement of pollution cannot be effectively subverted. Our model predicts when alternative forms of securing property rights are more efficient.

We then examined pollution trends across U.S. counties before and after the Clean Water Act. We discuss how American courts replaced property rules with liability for pollution in the 19th century, and how CWA legislation then replaced the liability rules with regulation restricting emissions, enforced by stark property-rule sanctions. Both transitions are consistent with the predictions of our model for optimal rules under changing conditions. We further 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 findings confirm the empirical predictions of our model.

The key message of our findings is to suggest the conditions under which liability rules, property rules, and regulation are likely to be the most efficient method of securing property rights, starting with the perspective that the subversion of justice is a central feature of property rights enforcement. Perhaps other features of the systems of law enforcement both across space and over time can be understood through this general lens.

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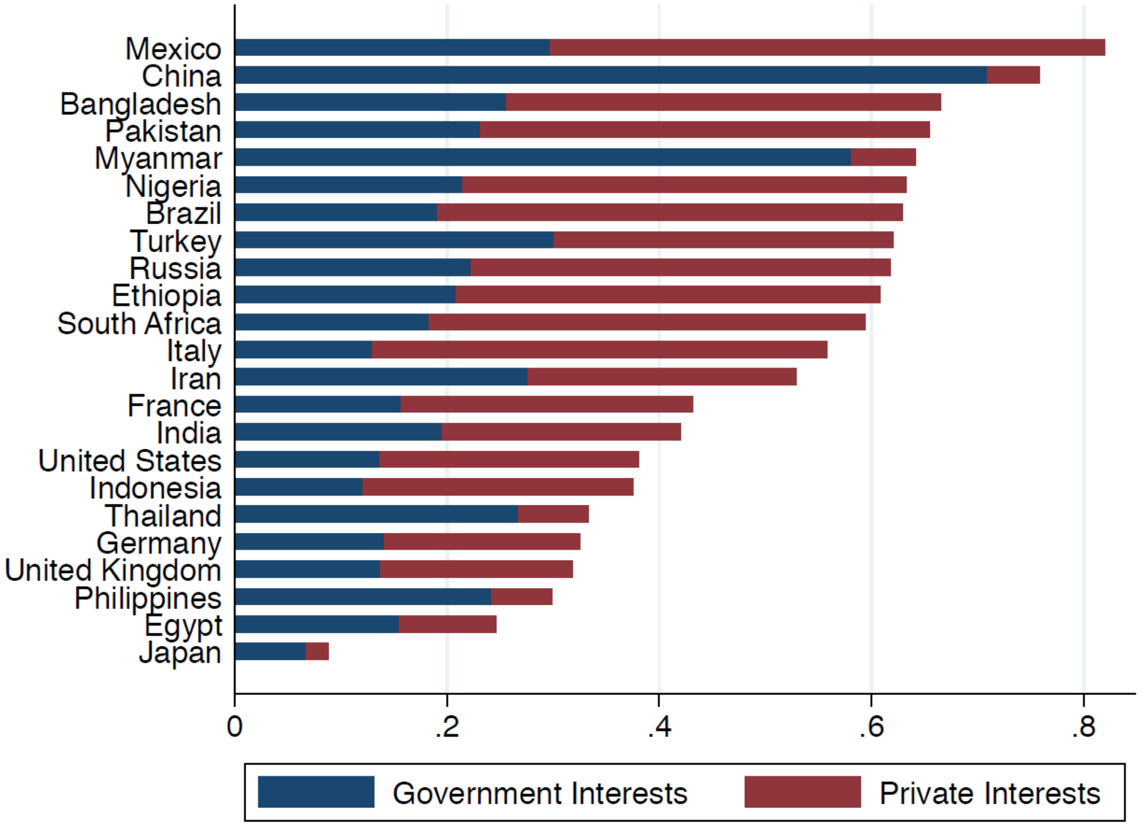
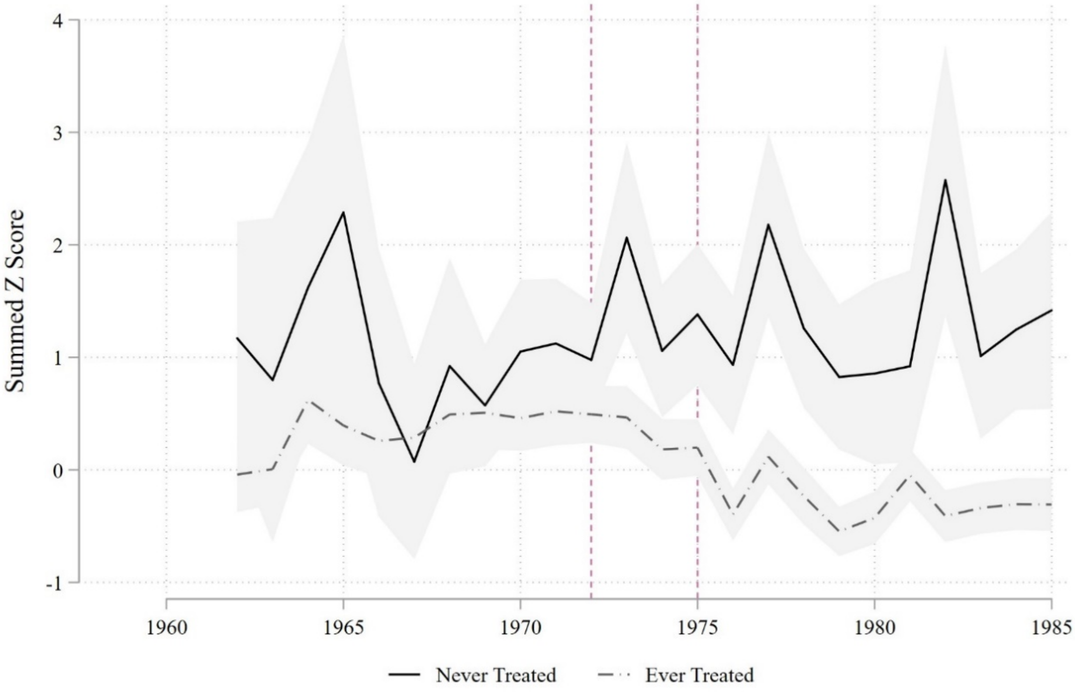
Figures and Tables

Figure 1. Popular Perception of Undue Influence over Judges



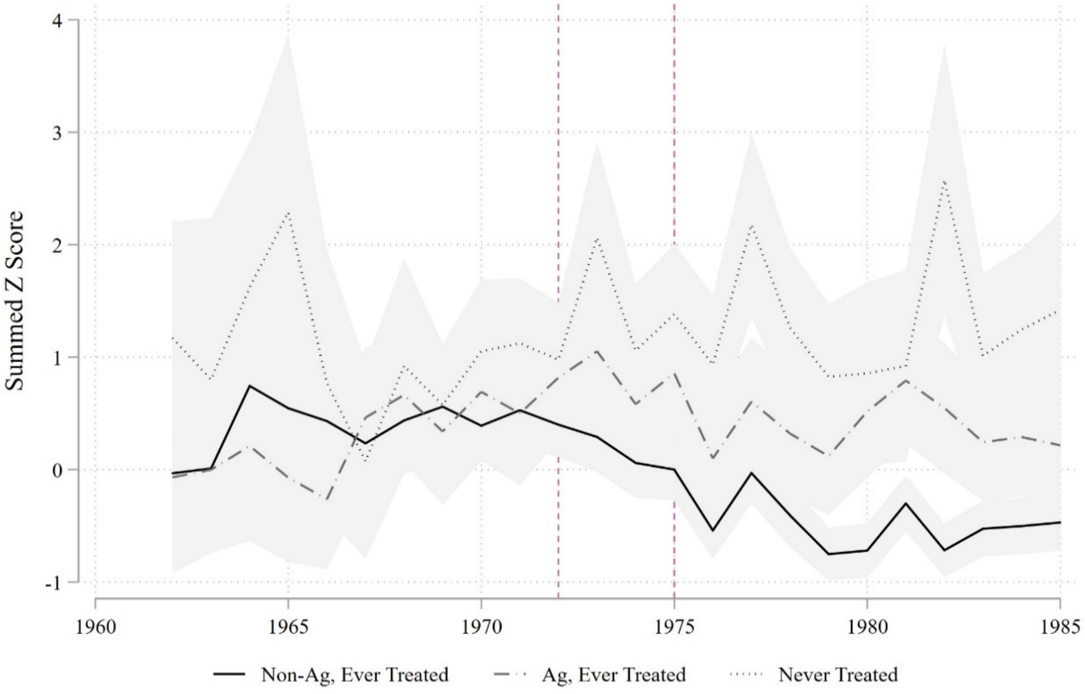
Notes: Survey responses from the World Justice Project, General Population Poll 2012–2014 for countries with population over 50 million in 2011. The graph depicts the share of respondents who give the following answers. "(q8) In your opinion, most judges decide cases according to (provide single answer): (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. Averages across counties 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 average 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. Averages across counties 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 employment in agriculture in 1972 was above the 75th percentile of its distribution across all counties. 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 average 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. Averages across counties 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 average summed *Z* score.

Table 1: Pre- and Post-CWA Average Pollution Levels by County Type

	Pre-CWA		Post-CWA		Difference in Means	
	Mean	St. Dev.	Mean	St. Dev.	$\mu_{\text{post}} - \mu_{\text{pre}}$	*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	−3.15
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 those whose share of employment in agriculture in 1972 was above the 75th percentile of its distribution across all counties. 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	Yes	Yes	Yes	Yes
Year FE			Yes	Yes
State-Specific Linear Time Trend	Yes	Yes	Yes	Yes
Controls		Yes	Yes	Yes

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. Agricultural counties are those whose share of employment in agriculture in 1972 was above the 75th percentile of its distribution across all counties. 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: Impact of the CWA in Corrupt Counties

	(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		Yes
Year FE	Yes	Yes
State-Specific Linear Time Trend		Yes
Controls	Yes	Yes

Notes: The table reports the results of two specifications. Column 1 reports $y_{ijt} = \beta\ Corrupt_j + \psi_t$. Column 2 reports $y_{ijt} = \beta\ CWA_{it} + \omega\ CWA_{it} \times Corrupt_j + \gamma_i + \delta_j\, t + \psi_t$. y_{ijt} is the summed Z score across all pollutants in county i in state j and 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. $Corrupt_j$ is an indicator for whether a county is in a corrupt state (1 = Yes). Corrupt states are those 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_j 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^{***} (0.014)	0.028^{**} (0.012)	0.041^{**} (0.016)	0.058^{***} (0.013)
College Degree	0.028^{**} (0.011)	0.025^{***} (0.009)	0.014 (0.012)	0.053^{***} (0.011)
High- or Middle-School Diploma	0.012 (0.009)	0.010 (0.006)	-0.003 (0.009)	0.028^{***} (0.008)
Homeowner	0.015^{**} (0.006)	0.013^{**} (0.005)	0.020^{***} (0.006)	0.026^{***} (0.006)
N	95,828	96,342	94,708	95,062
Adjusted R^2	0.104	0.149	0.098	0.123
Country FE	Yes	Yes	Yes	Yes

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 Diploma	0.013^{***}	0.011	0.060	0.005
	(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	Yes	Yes	Yes	Yes

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

The social loss from the liability rule without monitoring is $L_L = \delta\Lambda$. The social loss from the property rule without monitoring is $L_P = [1 - (1 - \beta)^N]\Pi + (1 - \beta)^N \delta(\Lambda - \lambda_P)$. The social loss from regulation with monitoring is $L_R = [1 - (1 - \beta)^N](\Pi - \pi_R) + \delta(\Lambda - \lambda_R) + m$. The social loss from regulation without monitoring is $\text{Ł}_R = \delta\Lambda + [1 - (1 - \beta)^N](1 - \delta)\Pi$.

A2.1. Proof of Lemma 1

If $\beta = \delta = 0$ then $L_L = L_P = \text{Ł}_R = 0 \leq L_R = m$.

A2.2. Proof of Lemma 2

If $\beta > \delta = 0$ then $L_L = 0$ while $L_P = \text{Ł}_R = [1 - (1 - \beta)^N]\Pi > 0$ and $L_R = [1 - (1 - \beta)^N](\Pi - \pi_R) + m > 0$.

A2.3. Proof of Proposition 1

$L_L \leq L_P$ if and only if $\delta \leq \tilde{\delta} \equiv (\Pi/\Lambda)[1 - (1 - \beta)^N]/[1 - (1 - \beta)^N (1 - \lambda_P/\Lambda)]$.

A2.4. Proof of Proposition 2

Regulation without monitoring is dominated because $\text{Ł}_R \geq L_L$, with strict inequality unless $\beta = 0$ or $\delta = 1$. Regulation with monitoring has $\partial L_R/\partial\delta \leq \partial L_L/\partial\delta$. It also has $\partial L_R/\partial\delta \geq \partial L_P/\partial\delta$ if and only if $(1 - \beta)^N \leq (\Lambda - \lambda_R)/(\Lambda - \lambda_P)$. Suppose this condition is satisfied.

Then $L_R \geq \min\{L_L, L_P\}$ for all $\delta \geq 0$ if and only if $L_R \geq L_L = L_P$ for $\delta = \tilde{\delta}$, namely if and only if: $m \geq \bar{m} \equiv \Pi[1 - (1 - \beta)^N][\lambda_R/\Lambda + \pi_R/\Pi - 1 - (1 - \beta)^N (1 - \lambda_P/\Lambda)(1 - \pi_R/\Pi)]/[1 - (1 - \beta)^N (1 - \lambda_P/\Lambda)]$. The ranking of L_L and L_P is as in Proposition 1.

If instead $m < \bar{m}$, then $L_R < \min\{L_L, L_P\}$ if and only if $\{[1 - (1 - \beta)^N](\Pi - \pi_R) + m\}/\lambda_R \equiv \tilde{\delta}_1 < \delta < \tilde{\delta}_2 \equiv \{[1 - (1 - \beta)^N]\pi_R - m\}/[\Lambda - \lambda_R - (1 - \beta)^N(\Lambda - \lambda_P)]$. Otherwise, $L_L < L_R < L_P$ for $\delta < \tilde{\delta}_1$, while $L_L > L_R > L_P$ for $\delta > \tilde{\delta}_2$.

A2.5. Generalization of Proposition 2

Suppose that $(1 - \beta)^N > (\Lambda - \lambda_R)/(\Lambda - \lambda_P)$ and thus $\partial L_R/\partial\delta < \partial L_P/\partial\delta \leq \partial L_L/\partial\delta$. If $m \geq \bar{m}$, then $L_L < L_P < L_R$ for $\delta < \tilde{\delta}$, while $L_P < \min\{L_L, L_R\}$ for $\tilde{\delta} < \delta < \tilde{\delta}_2$, and $L_R < L_P < L_L$ for $\delta > \tilde{\delta}_2$. If instead $m < \bar{m}$, then $L_P \geq \min\{L_L, L_R\}$ for all $\delta \geq 0$. $L_L < L_R$ if and only if $\delta < \tilde{\delta}_1$.

A2.6. Proof of Proposition 3

The expected cost of pollution to the owners is:

$$C_L = \int_0^{b\rho_b/\rho_c} c dF(c) + (1 - \rho_c + \delta\rho_c)\int_{b\rho_b/\rho_c}^{b(1-\rho_b)/(1-\rho_c)} c dF(c) + \delta\int_{b(1-\rho_b)/(1-\rho_c)}^{\infty} c dF(c)$$

under the liability rule, or:

$$C_R = \left[1 - \rho_c + (1 - \beta)^N \rho_c\right]\int_0^{b\rho_b/\rho_c} c dF(c) + (1 - \rho_c)\int_{b\rho_b/\rho_c}^{b(1-\rho_b)/(1-\rho_c)} c dF(c) + \delta(1 - \rho_c)\int_{b(1-\rho_b)/(1-\rho_c)}^{\infty} c dF(c)$$

under regulation, such that:

$$\begin{aligned} C_R\, \partial C_L/\partial\delta - C_L\, \partial C_R/\partial\delta = \rho_c &\left\{\left[1 - \rho_c + (1 - \beta)^N \rho_c\right]\int_0^{b\rho_b/\rho_c} c dF(c) + (1 - \rho_c)\int_{b\rho_b/\rho_c}^{b(1-\rho_b)/(1-\rho_c)} c dF(c)\right\} \\ \times \int_{b\rho_b/\rho_c}^{b(1-\rho_b)/(1-\rho_c)} c dF(c) + \rho_c &\left[(1 - \beta)^N \int_0^{b\rho_b/\rho_c} c dF(c) + (1 - \rho_c)\int_{b\rho_b/\rho_c}^{b(1-\rho_b)/(1-\rho_c)} c dF(c)\right]\int_{b(1-\rho_b)/(1-\rho_c)}^{\infty} c dF(c) \geq 0 \end{aligned}$$

and therefore $\partial[(C_L - C_R)/C_L]/\partial\delta = (C_R\partial C_L/\partial\delta - C_L\, \partial C_R/\partial\delta)/(C_L)^2 \geq 0$.

A2.7. Generalization of Proposition 3

The expected benefit of activity to the polluter is:

$$B_L = b\{F(b\rho_b/\rho_c) + (1 - \rho_b + \delta\rho_b)[F(b(1 - \rho_b)/(1 - \rho_c)) - F(b\rho_b/\rho_c)] + \delta[1 - F(b(1 - \rho_b)/(1 - \rho_c))]\}$$

under the liability rule, or:

$$B_R = b\{[1 - \rho_b + (1 - \beta)^N\rho_b]F(b\rho_b/\rho_c) + (1 - \rho_b)[F(b(1 - \rho_b)/(1 - \rho_c)) - F(b\rho_b/\rho_c)] + \delta(1 - \rho_b)$$

$[1 - F(b(1 - \rho_b)/(1 - \rho_c))]\}$

under regulation, such that:

$$B_R\, \partial B_L/\partial\delta - B_L\, \partial B_R/\partial\delta = b^2\rho_b\{[1 - \rho_b + (1 - \beta)^N\rho_b]F(b\rho_b/\rho_c) + (1 - \rho_b)[F(b(1 - \rho_b)/(1 - \rho_c)) - F(b\rho_b/\rho_c)]\} \times [F(b(1 - \rho_b)/(1 - \rho_c)) - F(b\rho_b/\rho_c)] + b^2\rho_b\{(1 - \beta)^N F_1 + (1 - \rho_b)[F(b(1 - \rho_b)/(1 - \rho_c)) - F(b\rho_b/\rho_c)]\}[1 - F(b(1 - \rho_b)/(1 - \rho_c))] \geq 0$$

and therefore $\partial[(B_L - B_R)/B_L]/\partial\delta = (B_R\partial B_L/\partial\delta - B_L\, \partial B_R/\partial\delta)/(B_L)^2 \geq 0$.

Appendix 3. Theoretical Extensions

A3.1. Inadvertent Harm

In our baseline model we have assumed for simplicity that P's action causes a certain harm c to the owners, known ex ante both to them and to the polluter. In reality, however, the connection between pollution and the ensuing harm to affected owners is often less direct and less certain. In many cases, a polluter's actions do not directly cause harm to the owners, but merely expose the owners to a risk of harm. P's deliberate choice is not whether to harm each O_i, but rather whether to adopt precautions that would prevent or reduce the risk of the owners being harmed inadvertently as a by-product of his risky activities. Our model applies identically to this setting, with a slightly more complicated exposition.

Formally, if P acts without abatement he exposes each O_i to the risk of suffering harm c_i, which is a random variable with expectation $E(c_i) = c/N$ conditional on the characteristics of a particular case. Abatement shifts down the distribution of harm c_i, reducing its expectation to $(1 - \rho_c)c/N$. The conditional expectation c of the total social harm that pollution risks causing in a particular case is itself another random variable with cumulative distribution $F(c)$. Its realization for a particular case is privately known to the polluter P and every owner O_i. The court eventually observes the true realization of harm c_i, to each O_i, but its amount is always disputable.

The timeline of the model is the following.

Stage 0. The legislator sets the legal rule protecting the owners and chooses whether to mandate a monitoring system to indisputably measure abatement.

Stage 1. The conditional expectation of social costs c and P's ability to subvert the court are realized and privately observed by P and each O_i. The parties have a chance to bargain and write a contract, but each O_i is unable to join the bargaining table with probability β. The ability to bargain is drawn independently across owners. Bargaining is otherwise efficient among the parties able to join the negotiation.

Stage 2. P chooses whether to act and, if he acts, whether to abate.

Stage 3. If P acts, harm c_i to each O_i is realized. The court assesses facts and penalties are enforced.

Under the property rule, each O_i is entitled to enjoin the polluter's activity. Hence, if P acts he suffers a large penalty $f > b$, which does not depend on any fact-intensive verification of whether any owners were harmed by his risky actions, how many, or how much. Under the liability rule, if P acts he must pay damages to each O_i equal to assessed harm, hence equal to the true realization of harm c_i if P cannot subvert the court, or to zero if he can. Under regulation, each O_i is entitled to enjoin P from acting without abatement, but only to compensation for any harm suffered if P acts with abatement.

This more complicated version of the model is identical to our simpler baseline. Whether the consequences of P's action are certain as in the baseline, or residually uncertain as in this extension, damages fairly assessed when the court is not subverted perfectly align his incentives with aggregate efficiency; damages assessed by a subverted court can never provide any incentives; while large fixed penalties always provide complete deterrence.

A3.2. Disputable Activity

In our baseline model we have assumed that the polluter's action is indisputable, so monitoring is not required to enforce the property rule. However, in some cases monitoring could be needed to make action itself indisputable. For instance, with multiple factories, the indisputable presence of effluents in a body of water does not suffice to prove that any one factory polluted the water. Then a subverted court could refuse to apply the sanction f to a powerful polluter, ruling that he is not responsible for pollution and the ensuing harm to the owners. Enforcing the property rule would then require adoption of the monitoring technology.[23]

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[23] In addition, legislation might be required to clarify that every owner is always entitled to be spared from the polluter's activity, and not only when the court deems his activity to be harmful. Otherwise a subverted court might grant that the polluter is indisputably responsible for his polluting activity, yet still refuse to enforce the property

Needless to say, this alternative scenario would imply that the property rule is less attractive, since the social loss it induces must increase by the cost of necessary monitoring (m). However, our baseline results would be qualitatively unchanged. To state the analogues of our main results, we switch terminology so that "the property rule" now denotes the property rule with monitoring.

> **Proposition A1.** Suppose that the polluter's activity is disputable unless the monitoring technology is adopted. Then the liability rule yields greater social surplus than the property rule if and only if court subversion is unlikely enough: $\delta < \tilde{\delta}' \equiv \{[1 - (1 - \beta)^N]\Pi + m\}/[\Lambda - (1 - \beta)^N(\Lambda - \lambda_P)]$.
>
> *Proof*. The social loss from the liability rule (without monitoring) is $L_L = \delta\Lambda$. The social loss from the property rule (with monitoring) is $L'_P = [1 - (1 - \beta)^N]\Pi + (1 - \beta)^N\delta(\Lambda - \lambda_P) + m$. Thus, $L_L < L'_P$ if and only if $\delta < \tilde{\delta}'$. ■

Intuitively, the comparison between the liability rule and the property rule is the same as in our baseline scenario if and only if the monitoring technology is costless ($\lim_{m\to 0} \tilde{\delta}' = \tilde{\delta}$). As the monitoring cost increases, the property rule becomes less and less appealing ($\partial\tilde{\delta}'/\partial m > 0$). Thus, the liability rule dominates the property rule for all $\delta \leq 1$ if monitoring is costly enough that $m \geq [1 - (1 - \beta)^N](\Lambda - \Pi) + (1 - \beta)^N\lambda_P$.

> **Proposition A2.** Suppose that the polluter's activity is disputable unless the monitoring technology is adopted, and that $(1 - \beta)^N \leq (\Lambda - \lambda_R)/(\Lambda - \lambda_P)$.
>
> If adopting the monitoring technology is costly enough that $m > \bar{m}' \equiv \Pi[\lambda_R/\Lambda + \pi_R/\Pi - 1 + (1 - \beta)^N(1 - \lambda_P/\Lambda)(1 - \pi_R/\Pi)]\,[1 - (1 - \beta)^N]/[1 - \lambda_R/\Lambda - (1 - \beta)^N(1 - \lambda_P/\Lambda)]$, then the efficiency-maximizing rule is the liability rule if court subversion is rare enough that $\delta < \tilde{\delta}'$ and the property rule if court subversion is common enough that $\delta > \tilde{\delta}'$.

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rule by denying that his polluting activity is harmful to the owners. The need for such legislative intervention would be immaterial in our model, since we assume it is costless to choose the rule that protects the owners.

If adopting the monitoring technology is cheap enough that $m < \bar{m}'$, then the efficiency-maximizing rule is the liability rule if court subversion is rare enough that $\delta < \tilde{\delta}_1$, the property rule if court subversion is frequent enough that $\delta > \tilde{\delta}'_2 \equiv [1 - (1 - \beta)^N]\pi_R/[\Lambda - \lambda_R - (1 - \beta)^N (\Lambda - \lambda_P)]$, and regulation for intermediate levels of court subversion: $\tilde{\delta}_1 < \delta < \tilde{\delta}'_2$.

Proof. The social loss from the liability rule (without monitoring) is $L_L = \delta\Lambda$. The social loss from the property rule (with monitoring) is $L'_P = [1 - (1 - \beta)^N]\Pi + (1 - \beta)^N \delta(\Lambda - \lambda_P) + m$. The social loss from regulation (with monitoring) is $L_R = [1 - (1 - \beta)^N](\Pi - \pi_R) + \delta(\Lambda - \lambda_R) + m$. Thus, $L_R \geq \min\{L_L, L'_P\}$ for all $\delta \geq 0$ if and only if $L_R \geq L_L = L_P$ for $\delta = \tilde{\delta}'$, namely if and only if: $m \geq \bar{m}'$. If instead $m < \bar{m}$, then $L_R < \min\{L_L, L'_P\}$ if and only if $\tilde{\delta}_1 < \delta < \tilde{\delta}'_2$. Otherwise, $L_L < L_R < L'_P$ for $\delta < \tilde{\delta}_1$, while $L_L > L_R > L'_P$ for $\delta > \tilde{\delta}'_2$. ■

Intuitively, when enforcing the property rule requires monitoring, the range of monitoring costs for which regulation is not a dominated option expands ($\bar{m}' > \bar{m}$), and so does the range of court subversion for which regulation is the most efficient option ($\tilde{\delta}'_2 = \lim_{m \to 0} \tilde{\delta}_2 > \tilde{\delta}_2$).

A3.3. Contract Enforcement

In our baseline model we have considered the case of torts. We turn here to the parallel case of contract enforcement, which can also be subverted by the strong. Just as the property rule is less vulnerable to subversion than the liability rule, 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, when breach of contract yields a deterministic benefit b to the breaching party but imposes a stochastic cost c on the counterparty—which we assume now to be a single individual ($N = 1$). The timeline follows.

Stage 0. The legislator sets the legal rule enforcing contracts.

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.

Stage 2. *P*'s ability to subvert the court and the cost *c* that *O* would suffer from a breach is realized and privately observed by the parties. *P* chooses whether to breach.

Stage 3. If *P* breaches, the court assesses facts and penalties are enforced.

Whether *P* can subvert the court is known at the time of the breach, but not when the contract is originally signed. We do not allow renegotiation in stage 2, so *P* decides whether to breach unilaterally, in the shadow of the legal rules that governs enforcement of the original contract.

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 he cannot subvert the court, and 0 if he can.

If the court is not subverted, 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 cannot be subverted, contractual damages thus lead to the textbook first-best outcome and specific performance does not. If the court can be subverted, however, the flexibility of contractual damages enables a strong *P* to 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.[24]

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[24] 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.

Contract is always breached in this case, and the surplus is reduced by $\mathrm{E}(c) - b$. For contracts, it is natural to assume that that $\mathrm{E}(c) > b$ (hence $\Lambda > \Pi$). If an action yields positive expected surplus ($b > \mathrm{E}(c)$), 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.

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 the property rule, dominates when the probability of court 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 (Posner 2009). 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 A4. A contract enforced by specific performance is always signed. A contract enforced by compensatory damages is signed if and only if $\delta < (u + \Pi)/\Lambda$.

Proof. A contract enforced by specific performance is never breached, so it yields surplus $u > 0$. A contract enforced by compensatory damages is breached whenever breach is efficient or a powerful P can subvert the court. Thus, it yields expected surplus $u + \Pi - \delta\Lambda$, which is positive 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 A4 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 property rules are still preferred to secure rights of possession.[25] Whereas asymmetric contracts can be avoided in equilibrium (albeit with a loss of gains from trade), the same does not apply to torts. A poor farmer can decide not to contract with a powerful firm, but that firm can still damage his crops or even take his land.

While we have focused for simplicity on the classic case of deliberate breach, as in *Peevyhouse*, many real-world cases of contractual breach are inadvertent. The key decision by P is not whether to breach, but how much to invest in reducing the risk of a breach (Kornhauser 1983; Craswell 1988; Bebchuk and Png 1999). Our analysis also applies to such inadvertent breaches, so long as it remains possible to remedy them by specific performance. Our model is exactly unchanged if we consider the simple case of a binary choice of the level of care. The contract yields the baseline surplus u if P performs his obligation with a high degree of care.[26] Choosing a low degree of care instead yields a saving b in P's cost of performance, but it creates a risk of breach whose expected cost to O equals c.

When courts are not subverted, our model then replicates Bebchuk and Png's (1999) result that specific performance is dominated by expectation damages: it induces excessively high care by P, reducing total surplus from the first best $u + \Pi$ to u. However, Proposition A4 highlights that specific performance comes into its own when courts can be subverted: then damages induce insufficient care, so much so that they can destroy all surplus from the contract and lead O to refrain from signing it.[27]

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[25] Schwartz (1979) prominently advocates specific performance because of under-compensation with damages.

[26] In this setting, a high degree of care may mean either fully avoiding inadvertent breach, or remedying it ex post whenever it proves unavoidable ex ante.

[27] Our model could also be extended to include investment in reliance by O. When courts are not subverted, specific performance induces over-reliance (Kornhauser 1983; Bebchuk and Png 1999). However, court subversion implies that damages induce under-reliance, which may reach the extreme of no reliance whatsoever---i.e., no contracting.

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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 county × year observations in 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: i.e., 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: $y_{ijt} = \beta_0 + \beta_1 t + \gamma_i$, where y_{ijt} is the Z score of pollution in county i in state j and 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: $y_{ijt} = \sum_{\tau\in T} \omega_\tau Y_\tau + \gamma_i$, 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 estimated linear time trend 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 non-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:

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

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:

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

where A_i 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 Empirical Prediction 4: 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:

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

where C_j is an indicator for whether county i is in a corrupt state j 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 strengthen (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).[28] 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

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[28] 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.

1975 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 to 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.

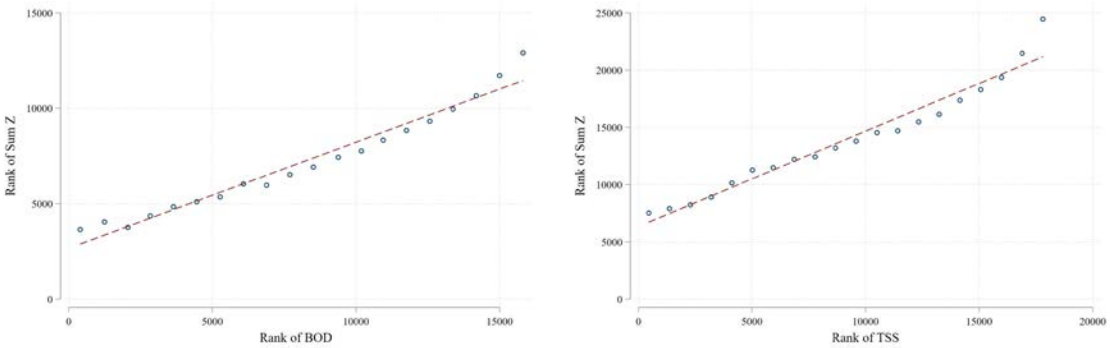
In Figures A8 and A9 we randomize treatment and county agricultural status before estimating Equations 1 and 2 from the text 1,000 times. Doing so gives us an approximation of the likelihood of observing our coefficient values under the null of a zero true effect. In Figure A8 we show the distribution 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 Figure 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

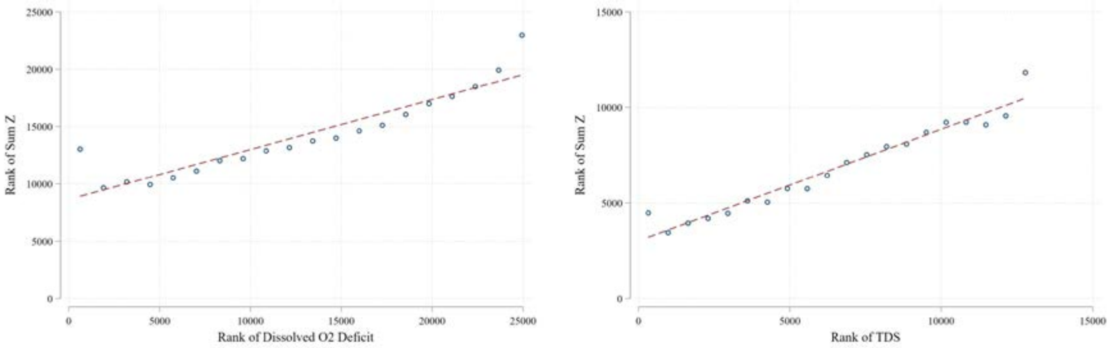
To understand better whether there is meaningful selection in which counties contain facilities that receive NPDES permits in 1973 and 1974 compared to later years, we try to predict the timing of when the CWA becomes enforceable in the counties in our sample. We use data on county economic conditions 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 is expected 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

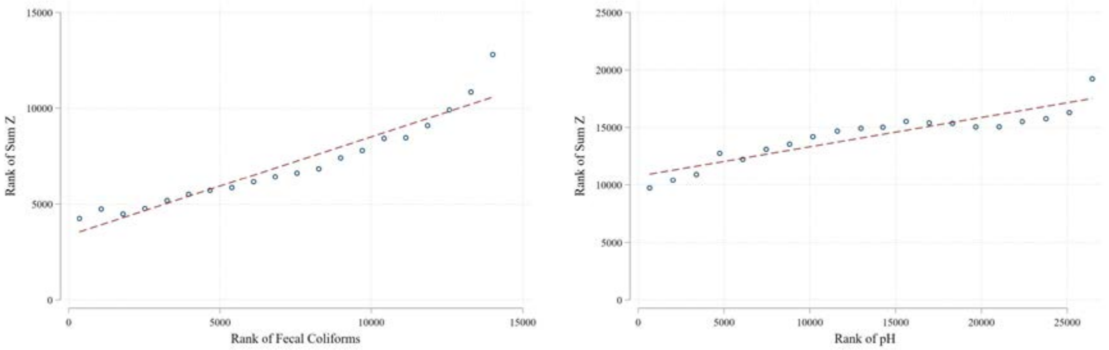
(a) Biochemical Oxygen Demand (b) Total Suspended Solids



(c) Dissolved Oxygen Deficit (d) Total Dissolved Solids

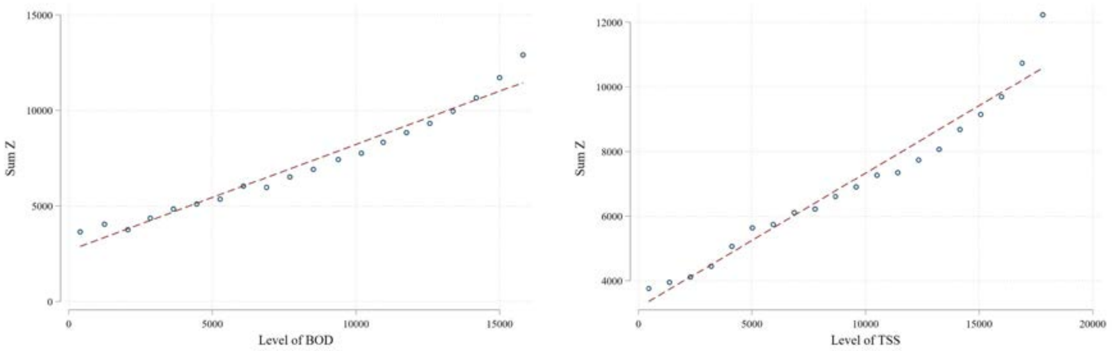


(e) Fecal Coliforms (f) pH



Notes: We report here the bin scatter plots 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.

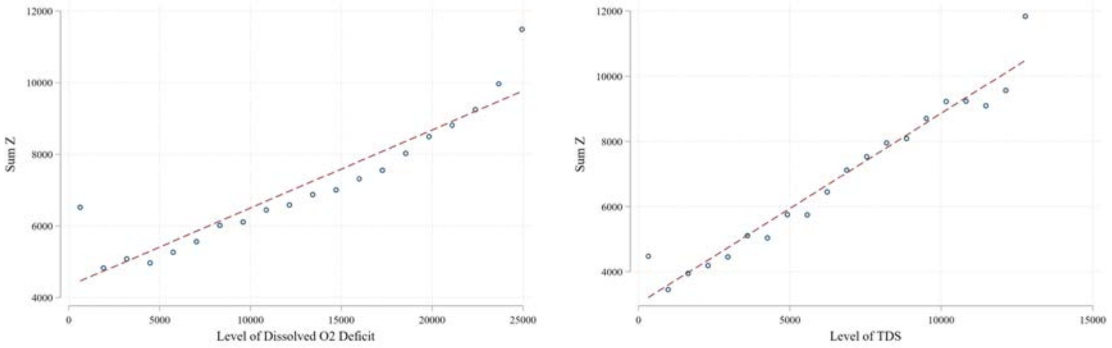
Figure A2: Comparison of Summed Z Score and Pollution Levels


(a) Biochemical Oxygen Demand

(b) Total Suspended Solids

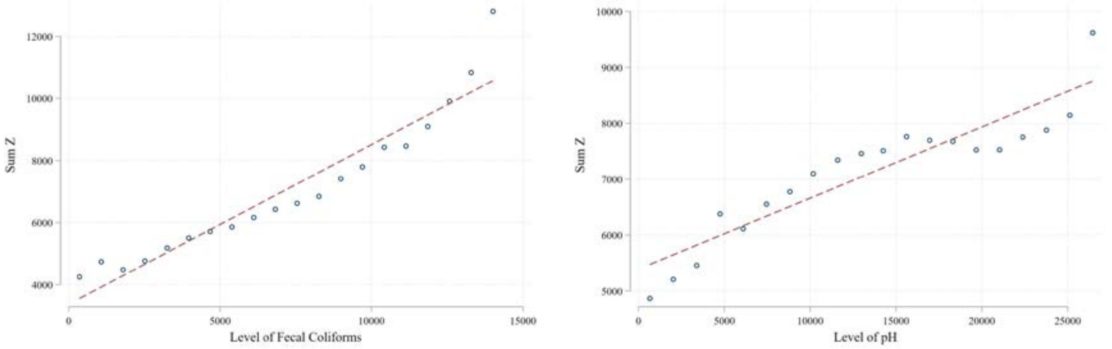
(c) Dissolved Oxygen Deficit

(d) Total Dissolved Solids



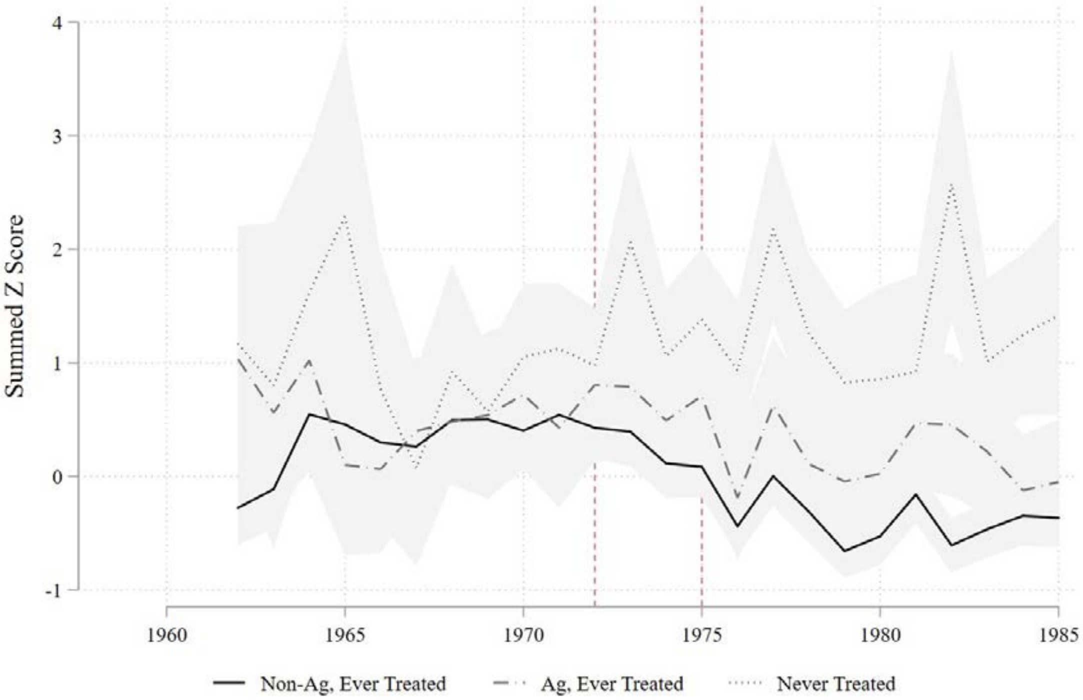
(e) Fecal Coliforms

(f) pH



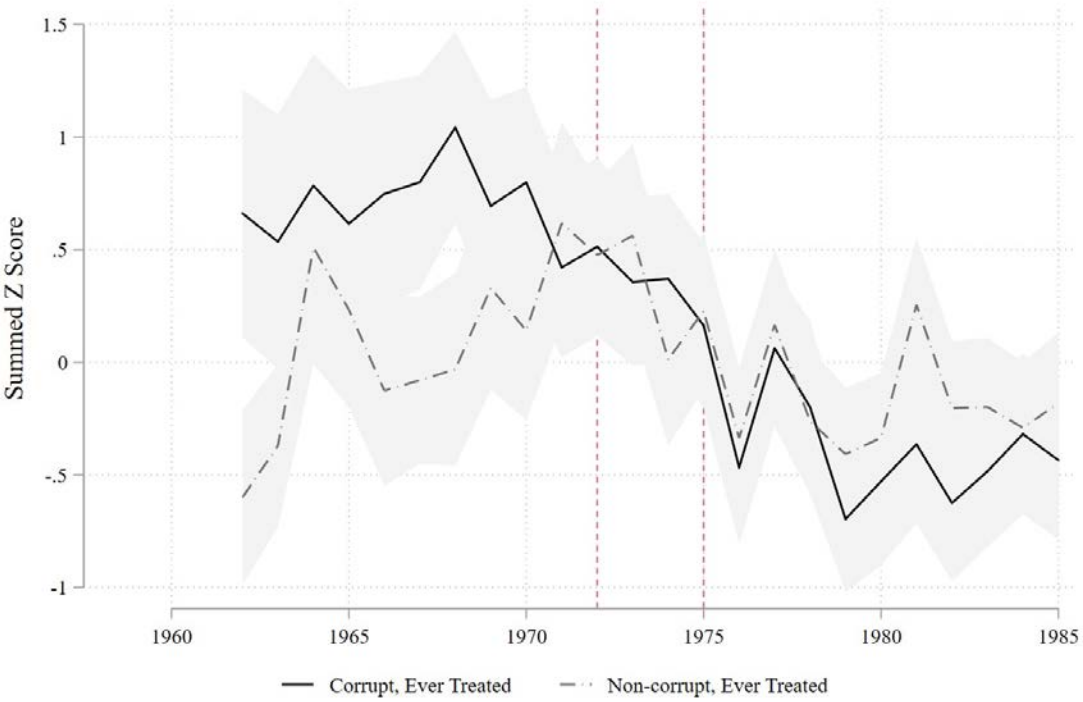
Notes: We report here the bin scatter plots of the rank of county-year observations based on their summed *Z* score across all pollutants for which we have a reading in that county-year compared to the raw level of pollution for six individual pollutants at the same county × year level. *Z* scores are 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



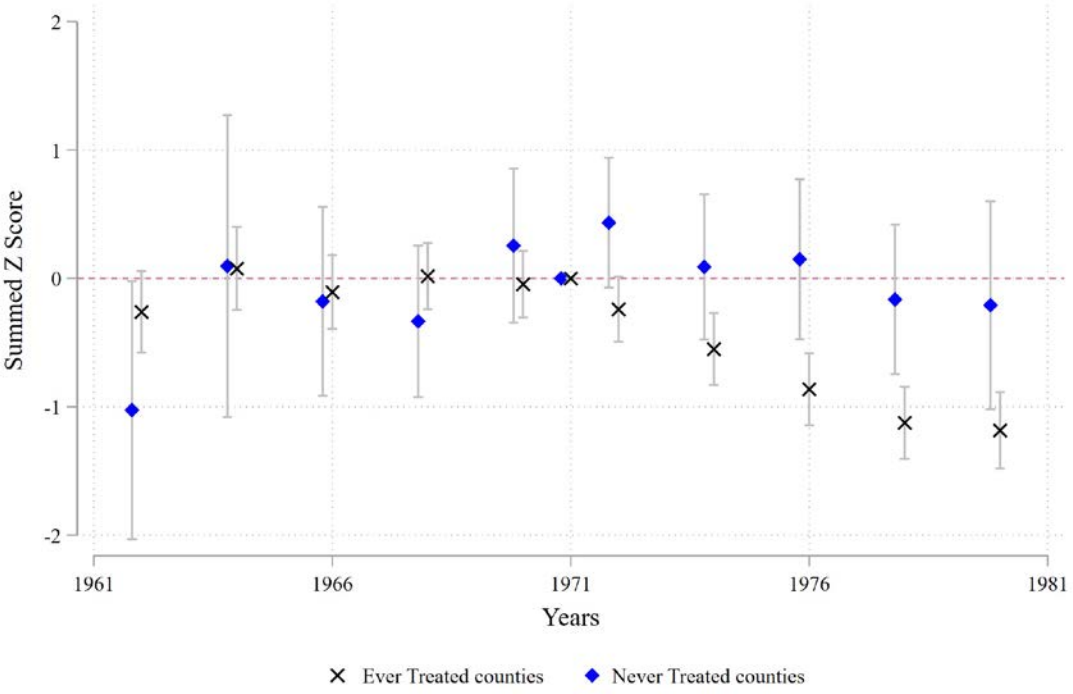
Notes: The figure replicates figure 3 from the main text but defines agricultural counties based on agricultural establishments instead of employment. The figure shows the annual trend in the average summed *Z* score of water pollution for treated agricultural and non-agricultural counties and all non-treated 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. Averages across counties 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 75th percentile of its distribution across all counties. 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



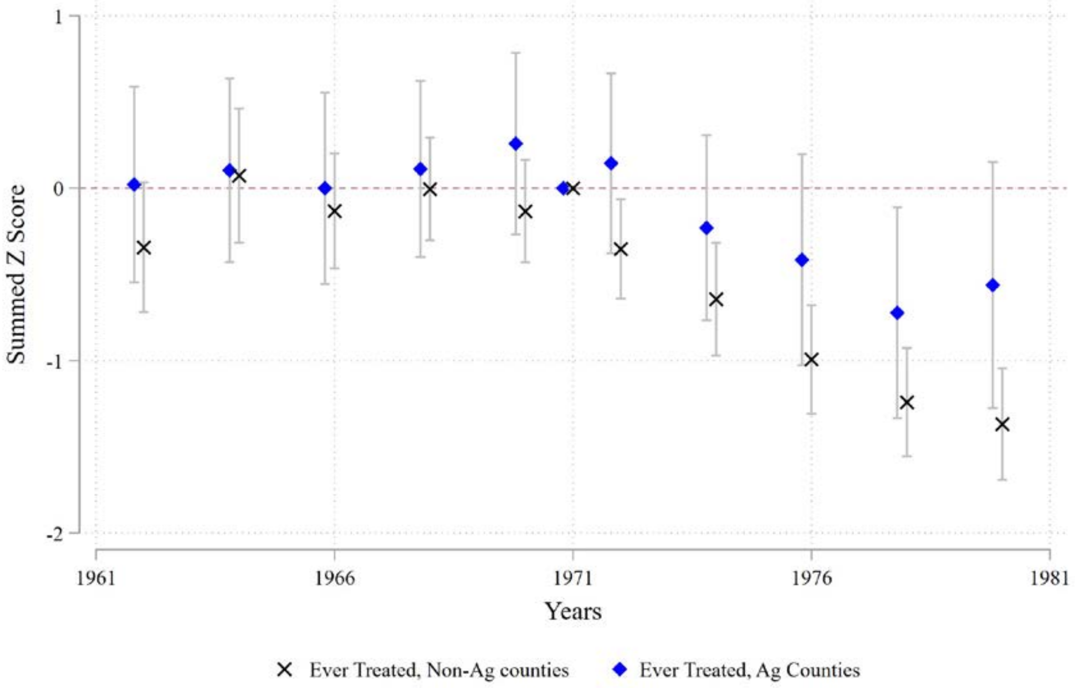
Notes: This figure replicates figure 4 from the main text but defines corruption based on per capita newspapers subscriptions instead of conviction rates. The figure shows the annual trend in the average summed *Z* score of water pollution for corrupt and non-corrupt counties that are treated. *Z* scores 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. Averages across counties 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



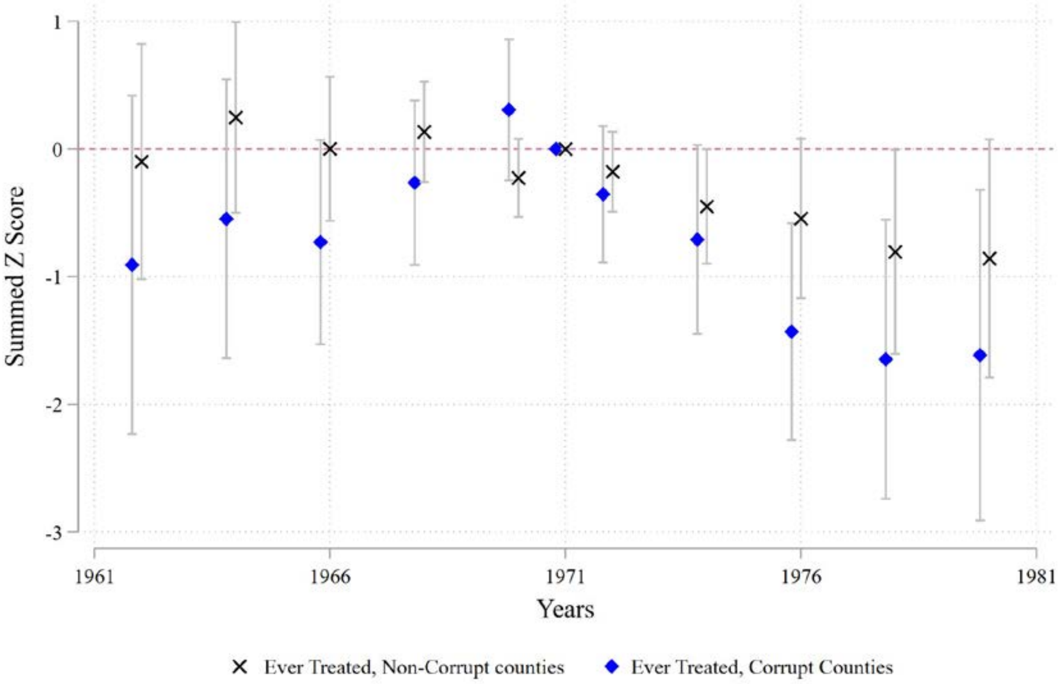
Notes: This figure displays the response of pollution levels by county to the passage of the CWA. Each point is the estimated ω_τ coefficient from the regression described in Equation A1. The treated series shows the estimates on the sample of counties in which the CWA becomes enforceable in 1973 or 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 the county level.

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



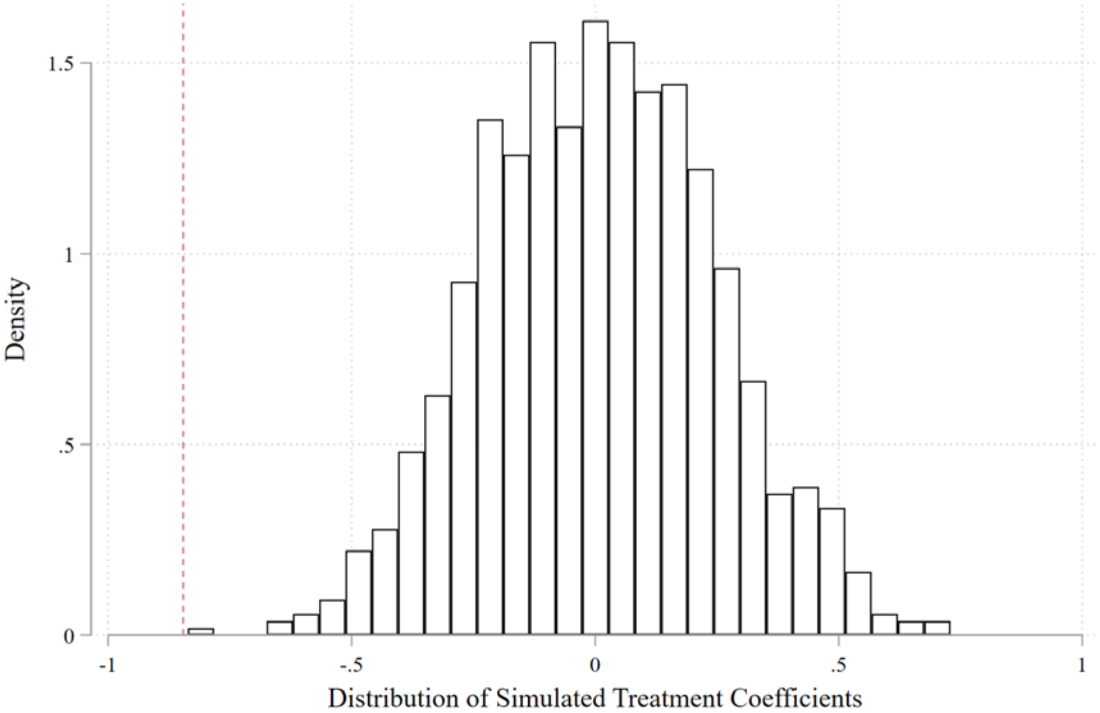
Notes: This figure displays the response of pollution levels by county in treated agricultural and non-agricultural counties to the passage of the CWA. Each point is the estimated ω_τ coefficient from the regression described in Equation A2. Agricultural counties are those whose share of employment in agriculture in 1972 was above the 75th percentile of its distribution across all counties. 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 the county level.

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



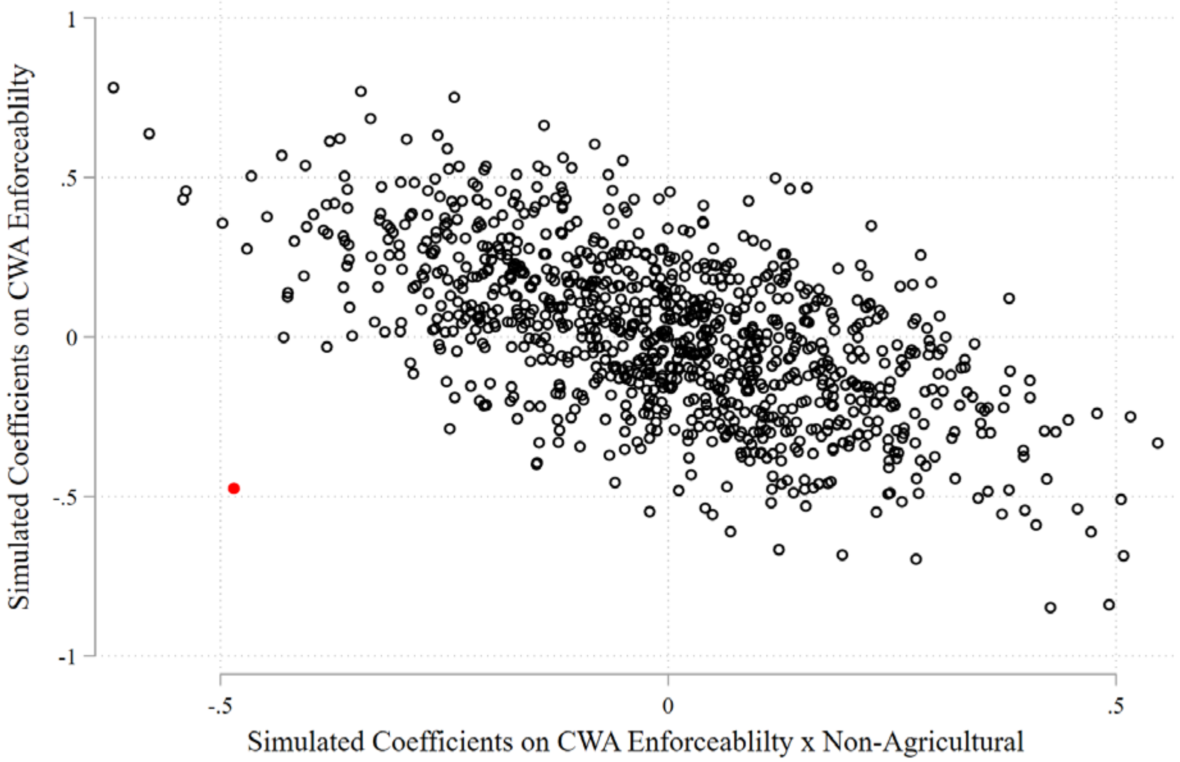
Notes: This figure displays the response of pollution levels by county in treated corrupt and noncorrupt counties to the passage of the CWA. Each point is the estimated ω_τ coefficient from the regression described in Equation A3. Corrupt counties are those in states where the average number of federal 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 the county level.

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: Joint 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	Yes	Yes

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	Yes	Yes	Yes	Yes
Year FE			Yes	Yes
State-Specific Linear Time Trend	Yes	Yes	Yes	Yes
Controls		Yes	Yes	Yes

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. Agricultural counties are those whose share of employment in agriculture in 1972 was above the 75th percentile of its distribution across all counties. 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	Yes	Yes	Yes	Yes
Year FE			Yes	Yes
State-Specific Linear Time Trend	Yes	Yes	Yes	Yes
Controls		Yes	Yes	Yes

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. Agricultural counties are those whose share of employment in agriculture in 1972 was above the 75th percentile of its distribution across all counties. 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	Yes	Yes	Yes	Yes
Year FE			Yes	Yes
State-Specific Linear Time Trend	Yes	Yes	Yes	Yes
Controls		Yes	Yes	Yes

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. Agricultural counties are those whose share of employment in agriculture in 1972 was above the 75th percentile of its distribution across all counties. 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	Yes	Yes	Yes	Yes	Yes
Year FE			Yes	Yes	Yes
State-Specific Linear Time Trend	Yes	Yes	Yes	Yes	Yes
Controls		Yes	Yes	Yes	Yes

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. Agricultural counties are those whose share of employment in agriculture in 1972 was above the 75th percentile of its distribution across all counties. 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	Yes	Yes	Yes	Yes
Year FE			Yes	Yes
State-Specific Linear Time Trend	Yes	Yes	Yes	Yes
Controls		Yes	Yes	Yes

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. Agricultural counties are those whose share of establishments in agriculture in 1972 was above the 75th percentile of its distribution across all counties. 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	Yes	Yes
Year FE	Yes	Yes
State-Specific Linear Time Trend	Yes	Yes
Controls	Yes	Yes

Notes: The table reports $y_{ijt} = \beta\ CWA_{it} + \omega\ CWA_{it} \times Conviction\ Rate_j + \gamma_i + \delta_j\ t + \psi_t$. y_{ijt} is the summed Z score across all pollutants in county i in state j and 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 for each state 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		Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
State-Specific Linear Time Trend		Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes

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 $y_{ijt} = \beta\ Corrupt_j + \psi_t$. Column 2 reports $y_{ijt} = \beta\ CWA_{it} + \omega\ CWA_{it} \times Corrupt_j + \gamma_i + \delta_j\, t + \psi_t$. Columns 3 and 4 report $y_{ijt} = \beta\ CWA_{it} + \omega\ CWA_{it} \times Subscription\ Rate_j + \gamma_i + \delta_j\, t + \psi_t$. y_{ijt} is the summed Z score across all pollutants in county i in state j and 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. $Corrupt_j$ is an indicator for whether a county is in a corrupt state (1 = Yes). Corrupt states are those 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	Yes	Yes	Yes	Yes
Year FE			Yes	Yes
State-Specific Linear Time Trend	Yes	Yes	Yes	Yes
Controls		Yes	Yes	Yes

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. Agricultural counties are those whose share of establishments in agriculture in 1972 was above the 75th percentile of its distribution across all counties. 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	Yes	Yes	Yes	Yes
Year FE			Yes	Yes
State-Specific Linear Time Trend	Yes	Yes	Yes	Yes
Controls		Yes	Yes	Yes

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. Agricultural counties are those whose share of establishments in agriculture in 1972 was above the 75th percentile of its distribution across all counties. 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	Yes	Yes	Yes	Yes
Year FE			Yes	Yes
State-Specific Linear Time Trend	Yes	Yes	Yes	Yes
Controls		Yes	Yes	Yes

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. Agricultural counties are those whose share of establishments in agriculture in 1972 was above the 75th percentile of its distribution across all counties. 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. * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.