Is Pollution Value-Maximizing?

The DuPont Case

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Litigation, regulation, and reputation are the key mechanisms to restrain companies from profiting by externalizing larger costs on society. We employ a case study of a major externality, namely, DuPont's emission of a toxic chemical named PFOA, to study why these mechanisms can jointly fail. By using internal company documents disclosed in trials, we show that it was ex-ante optimal from a shareholder-value perspective to pollute, even when anticipating the potential legal liability down the road. The key is the time lag: a large lag between deciding to emit the chemical and having to pay fines for it dilutes the deterrent effect of litigation. We then detail how regulation and reputation failed as well due to DuPont's ability to control the information environment. We evaluate potential ways to mitigate the information problem, such as by introducing an environmental Qui Tam or recalibrating director oversight duties.

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Do profit-maximizing companies generate significant negative externalities? 47% of the top financial economists surveyed by The Kent A. Clark Center for Global Markets at the University of Chicago do not think so, with only 30% agreeing. Since externalizing costs is generally profitable, the strength of this belief is based on the conviction that a combination of regulation, litigation, and reputation keeps companies' incentives to externalize costs in check. Granted, each of these mechanisms is imperfect in its own way. But as long as their flaws are not perfectly correlated, the prevailing presumption is that a combination of the three works to deter major externalities.

This paper focuses on how and why these three mechanisms can *simultaneously* fail. It does so through an in-depth analysis of a major case of negative externality: DuPont's pollution of the Ohio River Valley. We then merge the evidence from DuPont's case with recent empirical and theoretical studies of corporate deterrence, to evaluate potential policy levers that could prevent such a joint failure in the future.

In the process of manufacturing Teflon in its plant in West Virginia, DuPont emitted for decades an extremely toxic chemical called PFOA (often dubbed C8). In 1984, DuPont reached a decision point once they learned that C8 had entered the water supplies of nearby communities. By then, DuPont's insiders knew that C8 is toxic, does not break in the environment, and accumulates in human blood. Nevertheless, the company opted to continue emitting C8 (in fact it doubled production), in ways that caused massive harm to human health and the environment. The irony is that such a costly debacle happened to one of the most respected American companies. DuPont had "a track record of long-term investment and better-than-typical treatment of constituencies other than stockholders," as former Delaware Chief Justice Strine (2017) put it, and was a known leader in toxicological and occupational safety research. How could such bad behavior happen within such a good company?

Luckily for us, twenty years of litigation against DuPont unearthed a trove of internal company documents, which allow us to explore this question in depth. The documents suggest that many inside DuPont were aware of the toxicity of the chemical and the risks involved with using it. Nevertheless, they decided to double down.

One possible hypothesis is that DuPont underestimated the potential health damages of C8, and therefore underestimated its exposure to legal liability. The internal documents allow us to dispel this possibility. For one, DuPont insiders referred to C8 in real-time as the company's

"number one legal issue," indicating that they anticipated a very large legal sanction if caught. Further, we estimate the present value of the choices faced by DuPont in 1984 and show that even if DuPont had correctly anticipated the health damages, it would have been value-maximizing to keep polluting, as long as the probability of detection and conviction was less than 19%. While it is impossible to validate or reject a subjective probability assessment, we show that the success of the litigation against DuPont depended on so many unlikely events that it is hard to imagine that the probability of punishment was above 19%. The prospect of tort litigation was thus not enough to deter pollution.

We then consider the threat of regulatory intervention. DuPont had to know that the regulatory framework, namely, the Toxic Substances Control Act (TSCA), greatly limited the ability of regulators to monitor "grandfathered" chemicals like C8 that were already in use when TSCA went into effect in 1976. Regulation was built on the premise that DuPont would self-report problems with C8, but in effect only incentivized DuPont to suppress knowledge and refuse further research into C8's effects, so as to not trigger a major increase in costs. Even after damning information surfaced and reached the regulator, DuPont could pull levers to dilute regulatory enforcement, such as by hiring former regulators at the local and national levels.

Finally, the DuPont case illuminates conditions under which reputational discipline (the threat of losing future business opportunities) is ineffective. A large time lag between pollution and detection dilutes the force of labor-market reputational concerns. We show that by the time news about C8 started surfacing, all relevant players from the 1980s either died, retired, or emerged unscathed without even being mentioned in media coverage of C8. In fact, DuPont's CEOs in the relevant timeframe were hailed as environmental visionaries and secured prestigious positions after they left the company. At the organizational level, the internal documents show how giant corporations can fight to limit the credibility and diffusion of damning information even after it surfaces. In all, the ex-post settling up postulated by Fama (1980) does not seem to apply when the misconduct is against non-contractual claimants and the harms are delayed and probabilistic rather than immediate and certain.

At the end of the day, all three deterrence mechanisms failed because of DuPont's enormous informational advantage regarding the pollutant and its effects. And the company proactively fought to maintain this information monopoly for decades. Thus, policymakers who wish to bolster the effectiveness of litigation, regulation, and reputation need to focus on improving

the information flows from inside the company to the outside world, and on shortening the time lag from pollution to punishment. To this purpose, we discuss a set of proposals, such as recalibrating director oversight duties and prejudgment interest doctrines.

Our analysis is closely related to a well-developed literature on regulatory noncompliance. We differ from this extant literature in focus and methodology. In terms of focus, existing studies tend to be limited to only one of the three deterrence mechanisms per study. Some discuss how companies are under-deterred by tort litigation (e.g., Dewees & Trebilcock 1992), others (e.g., King & Sutinen 2010) how companies get away with violating regulations, and yet others (e.g., Karpoff 2012) point out that companies do not suffer significant reputational fallouts when they pollute. Our analysis showcases the need to think about corporate deterrence holistically: deterrence comes from a combination of the three mechanisms. From a policymaking perspective, our analysis spotlights the most worrisome sets of circumstances, namely, those that lead to the joint failure of all deterrence mechanisms.

In terms of methodology, our analysis is based on a rich case study and therefore does not purport to marshal statistical claims about the prevalence of noncompliance. We rather aim at fleshing out mechanisms that facilitate noncompliance. Getting a rare peek into a giant company's decision-making processes is especially valuable when one considers questions of deterrence. Deterrence is driven by perception: it is not about the magnitude of sanctions or likelihood of detection per se, but rather about how the intended audience perceives them. In that respect, our analysis is closer to a sub-genre of case studies that use internal company documents to show how suppression of information leads to massive regulatory failures, from car safety (Gioia 1992; Viscusi 2015), to cosmetic surgeries (Hersch 2002). One way in which our analysis differs from previous case studies is by quantifying the difference between social- and private incentives to pollute. Existing case studies either lament the absence of cost-benefit analysis (e.g., Viscusi 2015) or show just the company's side of it (e.g., Gioia 1992).[1]

The paper proceeds in four parts. Part I provides the factual background, explaining how DuPont started using C8, and how it reached a crucial decision point in 1984. Part II calculates the costs and benefits of each option that was on the table in the 1984 meeting, concluding that

[1] Our focus on companies' ability to dilute deterrence is also related to the "detection avoidance" literature (e.g., Sanchirico 2011). While that literature tends to focus on evidentiary misconduct (distorting information after a lawsuit was filed), we focus on earlier stages, whereby companies avoid being named and blamed by their victims to begin with, and reduce not just the expected legal sanction but also the expected reputational sanction.

DuPont's decision to continue emitting C8 without investing in abatement was a shareholder-value-maximizing decision ex-ante, despite being socially inefficient. Part III examines why the external systems of control – legal liability, regulation, and reputation – all failed to deter this socially harmful pollution. Part IV builds on the lessons from the DuPont case to reevaluate the desirability of oft-proposed policy solutions, and to offer some new solutions of our own.

I. BACKGROUND: DUPONT AND THE USE OF C8

DuPont is one of the oldest American companies, continually operating since 1802 in Wilmington, Delaware.[2] The company was born when Thomas Jefferson called the attention of its to-be founders to the young nation's need for gunpowder (Chaplinsky, Marston & Merker 2014). To this day DuPont is referred as "one of the most distinguished of any U.S. corporation", and scores highly on both environmental and corporate governance metrics (George 2015). Like any other chemical company, DuPont has faced multiple decision points under uncertainty, whereby a chemical that makes better products may also be damaging to the environment and human health. The C8 story is one of them.

A. How DuPont Started Using C8

In the 1930s, a DuPont scientist accidentally created a substance that would later be known as Teflon®, when experimenting with refrigerants (Lyons 1994). Trying to reproduce Teflon on a mass scale proved to be dangerous and ineffective at first. But DuPont quickly learned that using a chemical known as PFOA (or C8) helps to stabilize the reaction needed to produce Teflon. A combination of carbon and fluorine made C8 very stable to heat and repellent to water, and thus great for production. Yet it also made the chemical potentially very dangerous to the environment and humans, as it is persistent in the environment and accumulative in human blood.

From 1951 to 2000, DuPont received C8 from a supplier called 3M. DuPont handled the material in their Washington Works plant, located in West Virginia near the Ohio border. By 2003, the Washington Works plant had released more than 1.7 million pounds of C8 into the nearby environment (Paustenbach et al. 2007 (detailing the amounts of emissions); Vieira et al. 2013 (detailing the geography of emissions)). C8 emissions came in three forms: poured from the

[2] In late 2017, after the events relevant to this study transpired, DuPont merged with Dow Chemical to form DowDuPont Inc.

outflow pipes of the plant into the Ohio River, where it traveled down- and upstream; transferred in trucks and buried in unmarked landfills, where it leached into drinking wells; and pumped through the plant's smokestacks into the air (Paustenbach et al. 2007). Throughout all these decades, people in nearby communities and relevant regulators knew little to nothing about the chemical or the fact that it is emitted on such a scale. That changed following the Tennant case.

B. Litigation Unveiling Problems with Using C8

In the mid-1990s, the Tennants – a family of farmers living near DuPont's West Virginia plant – started suspecting the plant's emissions. Their cattle all died after drinking water from a creek that was close to a DuPont landfill. The Tennant voiced their concerns to the company and local regulators. The latter brushed the farmers off, telling them that their cattle were dying because the farmers were not taking good care of them (Rich 2016a). The Tennant were not aware of C8 and its effects at the time, but as long-time farmers, they knew that something was wrong, and so they got a lawyer and sued. Little did they know that their individual lawsuit ("the Tennant Litigation") would end up surfacing a much bigger story. The discovery process in the Tennant case and subsequent litigation unearthed internal documents containing damning information about C8's effects, which were known inside DuPont and 3M in real time but kept away from the public eye.

Following the Tennant Litigation, citizens in nearby communities filed a class action against DuPont for contaminating the area's drinking water (hereinafter: the Class Action) (Young 2016). As part of settling said Class Action, DuPont agreed in 2004 to facilitate a thorough examination of C8's health effects by an independent science panel. In 2012, the panel published its results, finding that DuPont's C8 emissions are linked to six types of diseases: (1) high cholesterol; (2) ulcerative colitis; (3) thyroid diseases; (4) testicular cancer; (5) kidney cancer; and (6) pregnancy-induced hypertension (C8 Science Panel Report 2012). 3,500 of the 70,000 individuals drinking the contaminated water were diagnosed as suffering from the enumerated diseases.[3]

[3] Each of these individuals was set to litigate his or her own damages claim with DuPont (Young 2016). After several bellwether cases were tried in 2015–2016, ordering DuPont to pay damages ranging from $1.6ml to $12.5ml, the company settled all cases for $670ml in February 2017.

By 2013, shortly after the science panel submitted its conclusions, DuPont stopped using C8 and replaced it with a new chemical from the same family. The new chemical is supposed to be less persistent, but the jury is still out on its long-term health effects (Karoff 2023).

C. Reaching a Decision Point

Our focus is on decisions DuPont made, starting in the mid-1980s, to keep using C8 even in the face of alarming information about the potential consequences of C8 emissions. Among the many internal documents that surfaced in litigation, one is particularly useful: a lengthy internal memo concerning a meeting of DuPont's heads of business units, which took place at the company's headquarters in May 1984.[4] The 1984 memo allows us to deduce the several options that were on the table: (1) stopping using C8 altogether; (2) continuing using C8 but investing in abating measures; or: (3) continuing using C8 without investing in abatement. DuPont chose option (3). In fact, they doubled production.

The fundamental question is why. The option of abating C8 was relatively cheap and could have potentially prevented much of the horrific damage to the community as well as whatever legal and reputational sanctions DuPont ended up suffering. Why did not DuPont stop production, or at minimum invest in abatement? To answer this question, we must first reconstruct the information environment: what did the 1984 decision-makers know about C8 in real-time?

D. The Available Information

Several rounds of litigation exposed many of DuPont's internal documents, allowing us to systematically analyze who inside the company knew what about C8 and when. Most of the relevant documents are now publicly available through a dedicated website (hereinafter: "industry documents" website) (Gaber et al. 2023). We created our own dedicated website where we host nine of the most pertinent documents (hereinafter: "online sources appendix").[5] Going through the documents in chronological order reveals how knowledge about C8 evolved internally: to illustrate, by the early 1960s DuPont's Chief Toxicology Officer found that exposure to C8 enlarged rat and rabbit livers. In 1970, DuPont's scientists explicitly recognized that C8 is "highly

[4] The concluding page appears as figure 1. The full memo is available in our online source appendix.

[5] In some cases, when the internal documents were already extensively covered by journalistic exposés (e.g., Lerner 2015a, 2015b, 2015c), we refer the reader to these public sources instead. In other case, the regulator (EPA) detailed its findings about DuPont's behavior, and we refer to its Consent Agreement memo. In yet other cases, we refer to testimonies from two bellwether cases: Bartlett transcripts, and Vigneron transcripts.

toxic when inhaled and moderately toxic when ingested." In 1978, DuPont's occupational physician noted "unusually high" liver enzyme elevations in the blood of DuPont workers of the Parkesburg plant.[6] In 1979, DuPont's Haskell Lab reported that C8 causes "corneal opacity and ulceration in rats, death in dogs".[7] By the early 1980s, DuPont's top scientists were aware that C8 is toxic, bio-persistent, and bio-accumulative.

If that was not enough, by 1981 DuPont's scientists learned that C8 may travel from pregnant mothers to their babies and cause *birth defects in humans*. The realization came after 3M notified DuPont of a study whereby rat fetuses whose mothers were exposed to C8 developed eye defects.[8] At that point, DuPont's Chief Medical Officer notified the Vice President in charge of the business unit producing Teflon.[9] DuPont's scientists reviewed the 3M rat study and found it to be valid.[10] The company then started monitoring the babies of seven female workers who worked with C8 and were pregnant at the time. They found detectable C8 levels in the umbilical cord blood, indicating that C8 can indeed travel through the human placenta. And two of the seven monitored babies were born with birth defects in their eyes and nostrils.[11] DuPont responded by transferring its female workers from the C8 unit until the company could be sure that there exists a level of exposure that does not pose such potential harm.[12] Yet they did not alert the regulator or the nearby community to the new findings.

A crucial piece of damning information came in 1984 when DuPont learned that C8 was in the nearby communities' drinking waters. The company sent employees to quietly collect samples from tap water in one employee's home, from public water fountains in a gas station, and so forth. Several samples came back with detectable levels of C8 (EPA Consent Agreement 2005). Against this background, the company called in May 1984 the above-mentioned top-level meeting at its headquarters in Wilmington, Delaware, to discuss how to proceed with C8 (Figure 1).

Internal documents from after May 1984 complete the picture of damning information about C8's effects coming to DuPont's executives' attention. By 1986, 3M explicitly warned DuPont that C8 should either be incinerated or dumped in a commercial landfill (Salvatore 2016);

[6] Industry documents website (Bower et al., 1978).
[7] Industry documents website (Snyder et al., 1979).
[8] Online Sources Appendix (Karrh Memo).
[9] Online Sources Appendix (Karrh Memo).
[10] Online Sources Appendix (Raines Memo).
[11] Online Sources Appendix (Pregnancy Test Results). DuPont's own guidelines for the monitoring of female workers suggested ex ante that a 20% rate would be alarming. A 2-out-of-7 result should therefore have been treated as a red flag.
[12] Online Sources Appendix (Karrh Memo).

DuPont did neither at the time. Starting in 1988, DuPont learned that C8 is an animal carcinogen and a potential human carcinogen as well (Salvatore 2016). In the early 1990s, DuPont set a threshold for C8 presence in drinking water of 1 part per billion (ppb) (reflecting awareness of just how staggeringly dangerous the chemical is[13]). But when the company detected C8 levels above this threshold in several samples, they opted to continue using C8 while not alerting the outside world (EPA 2005). Instead, they worked on revising the threshold.

We want to be careful about what we can or cannot say here. The internal documents do not necessarily give an impression of DuPont's higher-ups making conscious decisions to harm others. They rather reflect a lot of epistemic uncertainty in real time regarding the scope and magnitude of C8's effects. What the documents do reveal, however, are decisions to err on the side of continuing to use the profitable-yet-dangerous chemical, and decisions to not invest in reducing the epistemic uncertainty. In other words, unlike other case studies where the documents revealed an active campaign to spread false information (Gaber et al. 2023), here the documents reveal mostly sins of omission, as in not investigating potential red flags.

Note, in that regard, that by May 1984 the company's top scientists, lawyers, and heads of business units already knew that C8 is a substance that is bio-accumulative and bio-persistent. They, therefore, had to suspect that even exposure to very low doses could end up creating irreversible adverse health effects. Note further that DuPont's treatment of its own employees (following the baby-birth-defects study in 1981) indicates just how much they were aware of the risks involved. They immediately pulled all female employees of child-bearing age from the C8 unit and continued monitoring them in later years (Bartlett transcripts, Vol. 4, p. 162). They set super-low acceptable exposure levels (AEL) for employees, and the 1984 memo contains the assurance that current levels were safe. Yet, nowhere in the 1984 memo do we find *community* exposure guidelines (CEG). Nor do we find any indication that the current community exposure was at safe levels. Further, DuPont interrupted a continuing study of acceptable exposure levels on monkeys and to the best of our knowledge never resumed it.

[13] The accepted exposure levels that DuPont set for C8 were more than a thousand times higher than exposure levels to other extremely dangerous chemicals, such as Benzene.

II. WHY DUPONT CHOSE TO POLLUTE

Can companies make money for their shareholders by externalizing large costs on society? In recent years, more and more "win-win" accounts suggest that companies that treat the environment better will also do well financially, if only because their employees, customers, and investors will prefer doing business with companies that are greener. By contrast, companies that try to externalize the costs of pollution will suffer heavier regulation, legal sanctions through litigation, and reputational fallouts, or so the argument goes. The DuPont case illustrates the limits of this argument. While it may be obvious to many that not everything is "win-win" and that conflicts between shareholder-wealth-maximization and social welfare exist, the DuPont case provides a rare concrete example with numbers attached, as well as a peek behind the curtain into the mechanisms driving companies' decisions to "maximizing by externalizing."

Section A assesses whether using C8 to produce Teflon without investing in abatement was socially optimal, given what we know about its human health costs. Section B assesses whether such a decision was privately optimal for a long-term shareholder of DuPont, given what we know about the sanctions that the company ended up paying.

A. Was Pollution Socially Optimal?

Pollution comes with costs – but the optimal level of pollution is not zero. One should also consider, among other things, the benefits of using the chemical, such as a better cooking experience.[14] Thus, to establish whether producing Teflon while using C8 was socially beneficial, we estimate the costs and benefits as of 1984.

1. The Societal Benefits of Using C8

DuPont's executives estimated that replacing or stopping using C8 altogether would have jeopardized between $100-$200 million annually in profits. The production continued up to 2013, so – assuming perfect foresight – we have a stream of profits for 28 years. To discount it as of 1984 we use the T-bill rate at the time (9.8%)[15] and add a risk premium of 8% (thus assuming a beta of 1), for a discount rate of 17.1%.[16] We assume that the profits will grow at the expected rate

[14] Note one important difference between cases such as DuPont-C8 and cases such as cigarette smokers versus the tobacco industry. With the latter, one line of argument is "informed tradeoffs:" cigarette smokers supposedly knew that smoking is bad for them but engaged in it anyhow. With the former, the harmed individuals living nearby DuPont's plant did not know and certainly did not make an informed decision to drink C8 from their tap water.

[15] https://fred.stlouisfed.org/series/TB3MS/.

[16] A common alternative is to use as risk-free rate the rate of a 10-year Treasury minus 1% (the average risk premium embedded in a 10-year Treasury). The 10-Treasury in May 1984 was 13.9%, thus this will set the risk-free rate at 12.9%. Since this choice

of inflation (at the time 4.2%).[17] With these assumptions, the present value of profits from using C8 is between $760-$1,500 million.[18]

This number represents only the producer's surplus. Yet, Teflon was a trademarked product sold not directly to the public, but to retailers. Thus, we can assume that a shrewd producer like DuPont was able to extract a large part of the consumer surplus.[19] While it is unlikely that consumer surplus is zero, conservatively we are going to set the societal benefit of C8 use at the level of DuPont's profits from the product – around $1.1 billion. As Section 3 below will show, this underestimation does not affect our main conclusion.

2. The Societal Costs of Using C8

To estimate the societal costs of using C8 in the most conservative way possible, we limit ourselves to human health costs while ignoring damages to the environment. And we further narrow our scope to individuals living near the West Virginia plant (the six closest water districts). This gives us a group of 70,000 people who lived in the area with the highest exposure to C8 emissions. When quantifying the human health costs for these 70,000 people, we consider only costs associated with the six specific diseases enumerated in the science panel report. For these diseases, we focus only on the delta – the uptick in incidence and prevalence rates that can be expected in areas with high levels of exposure to C8, versus areas without C8 emissions. To get this number, we rely on calculations done in connection with the C8 medical monitoring program, which followed the unprecedented human health study that preceded the science panel report (C8 Medical Monitoring Program 2013).[20]

Appendix A describes in detail the calculations for each of the six diseases. The rough numbers are as follows: for every year of exposure to high levels of C8, a 70,000-people community will suffer 1.05 extra cases of testicular cancer, 21 additional cases of kidney cancer, 0.7 additional cases of ulcerative colitis, and 140 cases of thyroid disease (C8 Medical Monitoring Program 2013). We assume that such an uptick in incidences of diseases continues for the entire period C8 is used and stops with the end of C8 use (namely, the 1984–2013 period).

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will make our argument even starker, we choose the more conservative 9.8%.

[17] University of Michigan Inflation Expectation (https://fred.stlouisfed.org/series/MICH).

[18] If we were to use a different "social discount rate" of 7%, as suggested by the editor, the social benefit of C8 would be $1,200-1,800 million.

[19] Kotler & Pfoertsch (2010, 159) use Teflon as the paradigmatic example of powerful "ingredient branding," suggesting that DuPont had power to extract much of the surplus.

[20] For incidence and prevalence rates of the enumerated diseases, see also Kappelman et al. 2013; Vanderpump 2011; National Cancer Institute 2016.

To go from the incidence numbers to a societal cost number we need to put a value on the loss of life, and on the reduction in the quality of life. As expected, this turned out to be a fuzzy, challenging endeavor (Dolan 2000; Rowen & Brazier 2011), if only because estimates of the value of statistical life (VSL) vary greatly over the years and across regulatory agencies. For example, the EPA set VSL in 2009 at $9.1M (Appelbaum 2011); but an earlier meta-analysis of the VSL literature in the U.S. generates a median of around $7M (Viscusi & Aldy 2003). The arithmetic mean of 26 studies reviewed in Viscusi (1992), which cover the period that we focus on (the 1980s), yields a VSL of $6.2 million in 2000 dollars. We need to adjust this number to 1984. If we simply adjust it for the CPI inflation during the period, we obtain $3.6 million. If we also adjust for changes in per capita income, we obtain $2.9 million. We also subsume the reduction in the quality of human life due to cancer into the value of a lost life.[21]

Since all these costs are expressed in 1984 dollars, we discount them at the real rate at the time (= 9.8%-4.2%= 5.6%). In all, this ultra-conservative estimate of the societal costs of using C8 brings us to $310-369 million in 1984 terms (see Appendix A and Table 1).

3. The Costs of Reducing C8 Pollution

The 1984 meeting included a discussion of a third possibility, namely, continuing to use C8 while investing in precautionary measures that would reduce emissions and their societal costs. In particular, we know from later testimonies by DuPont's own executives that building an incineration device would have been the best option to limit the societal costs of C8 pollution (Bartlett transcripts, Vol. 7, pp. 163–173). Luckily for us, the 1984 memo contains a detailed assessment of the cost of building such an incineration device: an up-front cost of $1 million and an ongoing operating cost of $1 million a year (Figure 1). Assuming that the operating costs remain constant in real terms and do not fluctuate with the market, we discount them at the same real rate we used for the social costs (5.6%). In so doing, we obtain a 1984 present-value of abatement costs equal to $18.8 million (Appendix A).

The upshot is straightforward. It matters less whether we grossly underestimated the societal costs of dropping C8 vis-à-vis the societal benefits of using C8[22] since the third option of

[21] Several studies suggest that the costs of dying from cancer should reflect a higher value than the VSL attached to dying from industrial accidents, since the former comes with a lengthy, agonizing morbidity period and dread (e.g., Revesz 1999, 972-4). In keeping with the theme of estimating conservatively so as not to overstate our results, we chose not to count this debatable morbidity factor. For studies measuring the costs of the other enumerated diseases included in our calculations see Cohen et al. (2010).

[22] Recall our key assumptions: 1) that the costs to the environment – besides the human health costs – are zero; 2) that the only health costs of C8 are the ones identified by the science panel; 3) that we attribute zero value to human suffering from deadly

using-while-abating clearly dominates. The societal cost of the prescribed abatement process ($19 million) is greatly inferior to even the most conservative estimate of C8 pollution ($310 million). DuPont's decision was therefore not good for society. But was it good for DuPont?

B. Was Pollution Privately Optimal?

Assume that the DuPont managers facing the 1984 decision point are interested in maximizing shareholder wealth over the long run.[23] What would they do? To model the 1984 decision from a shareholders' perspective, we use the classical economic theory of deterrence (Becker 1968; Bentham 1823). We compare the expected benefit accruing to shareholders from using C8 with the expected sanction, assuming risk neutrality. The expected sanction is a function of the probability of getting caught and the magnitude of the sanction imposed once you are caught.

$$B > \pi[L + R]$$

Let B denote the benefits accruing to DuPont. π denotes the probability that DuPont's mishandling of C8 will be detected. L denotes the legal damages DuPont will have to pay if detected. R denotes the reputational damages DuPont will suffer if detected, as in diminished future business opportunities. The idea is that a shareholder-wealth maximizer will continue using C8 only if the benefits exceed the expected sanctions as she perceives them.

We already explained how we estimated the benefits (producing Teflon is around $1.1 billion, whereas avoiding investment in abatement is around $19 million). Let us now construct the right-hand side of the equation.

1. Magnitude of Sanction

While there is little doubt that DuPont's decision-makers knew about the potential health effects of C8, it is hard to assume that they knew back in 1984 the exact magnitude of these costs. Still, the internal documents from the 1980s show DuPont insiders referring to C8 emissions as the company's "number one legal issue" (Bartlett transcripts, Vol. 5, p. 243), indicating that they

diseases such as cancer; 4) that DuPont could not have made profits from Teflon with an alternative, non-C8 surfactant; and 5) that the producer surplus approximates well the total surplus. The first four assumptions tend to underestimate the costs. See, e.g., Grandjean et al. 2017 (documenting how C8 is linked with additional problems, such as impaired immune function); Blissmer et al. 2006 (discussing emotional and social aspects of diseases that should also go into calculations). The last assumption underestimates the benefits.

[23] From DuPont's 1984 proxy filing we learn that all board members, except those belonging to the Compensation Committee, were beneficiaries of an incentive plan. The maximum amount available for the awards under the plan was a function of the company's earnings. In addition, executives were granted options under a stock option plan. Collectively, executive officers owned about 1.5 million options at an average strike price of $40.85. Many of the non-executive directors were former executives, who probably owned shares, and representatives of large shareholders. Thus, it is plausible to assume that DuPont 1984 board members had an incentive in maximizing shareholders' value.

expected a very large legal sanction if caught. For our purposes, we, therefore, assume that DuPont had perfect foresight regarding the legal liability imposed if caught.[24]

A tally of the various sanctions follows: the first sanction came in 1997 when the West Virginia regulator slapped DuPont on the wrist to the tune of $200,000 (EPA letter 2001, 10). DuPont then settled the Tennant case in 2001, for an undisclosed amount. In 2005 DuPont settled the drinking-water class action, for a reported $107 million (Janofsky 2005), while agreeing to finance an epidemiological study and medical monitoring valued at around $350 million (Young 2016). In 2005 the company settled the enforcement action the U.S. regulator brought against it for failing to disclose alarming information, for $16.5 million (EPA Consent Agreement 2005). The biggest sanction came in 2017, when DuPont announced that it had reached a settlement with the 3,500 private lawsuits emanating from the Class Action, for $670 million.

Assuming that the magnitude of legal sanctions is not correlated with the economy,[25] we can discount all these sanctions at the 1984 risk-free rate (9.8%). This puts the 1984 value of future legal sanctions at around $100 million.

2. Probability of Detection

If we temporarily set aside the reputational sanction to zero, we now have an equation with one unknown, namely, the probability of detection. A shareholder-wealth-maximizing manager will choose to invest in abatement ($19 million) to save the company from paying legal fines ($100 million) only if she perceives the probability of detection to be higher than 19%. In other words, 19% is the break-even probability, which makes a DuPont shareholder indifferent between investing in abatement and continuing production without abating.[26]

The next step is to assess how a 1984 shareholder-wealth-maximizing manager would have perceived the probability of detection in real time (below 19% or not). One way to do so is by looking at actual, objective enforcement data around that timeframe. In 1991, the EPA announced a limited "amnesty period" whereby chemical companies could retroactively report on risks without incurring full sanctions. 11,000 such reports came from the industry, which was four times more than all the reports submitted in the fifteen years prior to the amnesty period combined

[24] On the use of lagged actual sanctions as a proxy for perceptions of expected sanctions see Gray & Shimshack (2011).

[25] As we detail in Part IV below, jurors who assign punitive damages tend to focus on defendants' ability to pay. This, in turn, suggests that the magnitude of legal sanctions may indeed be positively correlated with the state of the economy. If we considered this correlation, the discount rate would be even higher and the present value of the sanction smaller, strengthening our conclusions.

[26] In this Part we assume perfect foresight on the timing of the payment of the fine. In Part IV infra we discuss how our results change if we relax this assumption.

(Coglianese, Zeckhauser & Parson 2004, 310; McGarity & Wagner 2008, 119). In other words, there was rampant underreporting and underenforcement when the 1984 decision was taken. Indeed, the U.S. Government Accountability Office and the Office of Management and Budget have acknowledged as much, noting that the EPA's ability to monitor chemicals was limited (Wagner 1997; Gray & Shimshack 2011).

Another way to illustrate why the perceived probability of detection was likely below 19% is to show that only a rare combination of low-probability events led to DuPont paying the fines that it did ex-post. Consider the following four unlikely events that transpired.[27]

First, the plaintiffs in the C8 trials were represented by a defendant-side lawyer, named Robert Bilott. The Tennant were able to land a top environmental lawyer from a defense-side big law firm by pure chance (a family connection; the story was so compelling that it became a focus of the Hollywood movie *Dark Waters*) (Rich 2016a). Bilott's unique background in representing the industry made him able to identify a needle in a haystack: an opaque reference out of thousands of documents to an obscure chemical. A defense-side lawyer going on an all-out war against the biggest name in the industry is a rare event.

Second, as Bilott himself reports, the only reason why he continued to litigate against DuPont after the Tennant case settled in the late 1990s, is because the West Virginia courts had just introduced (in 1999) the "medical monitoring" doctrine. "Medical monitoring" allows plaintiffs to litigate a class action without proving actual physical harm, by showing that the defendant exposed the group to a chemical that puts said group at risk. Without it, class actions on matters such as C8 emissions are likely to be dismissed at the outset. Even today, this doctrinal innovation exists only in less than a third of the U.S. states. Indeed, we have a clear counterfactual: litigation against 3M for the same C8 pollution did not go anywhere until the evidence produced in the DuPont case emerged, because 3M was located in Minnesota, which did not adopt the medical monitoring doctrinal innovation.

A third low-probability event occurred after the settlement of the medical monitoring class action in the mid-2000s. The standard outcome would have been for the lawyers to use the $70 million that they got in settlement to cut small checks to the group members. But they ended up

[27] While it is impossible for us to come up with a precise probability for the various events, we can safely say that each of them was considered unlikely in 1984. And since the events are largely independent of each other, the compounding of these probabilities easily leads to an ex-ante probability of detection lower than 19%. To illustrate, the joint occurrence of four events with a probability of 50% each is only 6.25%.

investing the money in incentivizing tens of thousands of people to participate in a blood study, by offering $400 for each participant who agreed to draw blood and be interviewed (Blake 2015). This unheard-of strategy led to an unprecedented large-scale human study. The study was then analyzed by an independent science panel, which established links between C8 emissions and the six abovementioned diseases.[28] With the causal links established, the plaintiffs were able to extract a $670 million settlement.

Finally, part of the reason for the magnitude of the actual legal sanctions DuPont ended up paying was the evidence that higher-ups in the company knew about C8's disastrous effects in real-time (such evidence leads to punitive damages being a part of the equation). Yet the "incriminating" internal documents were exposed in our case only by happenstance. A DuPont lawyer held workshops inside the company on how to avoid creating a paper trail regarding C8's effects (Lerner 2015a). But in litigation the plaintiffs put their hands on a chain of private emails by that same lawyer, acknowledging the company's suppression of damning information. How can such an unanticipated mistake happen? These emails were transmitted in the first days of handheld devices, and it is reasonable to assume that even legal counselors did not fully grasp how personal emails sent from their work Blackberries could later become discoverable (Lerner 2015b).

In all, a monetary calculation of costs and benefits suggests that producing Teflon by using C8 while not investing in abatement was the rational action to take from the company's perspective, albeit inefficient from a social perspective. The next step is to understand why the institutions that are supposed to deter such large externalities failed.

III. WHY LITIGATION, REGULATION, AND REPUTATION DID NOT STOP DUPONT FROM POLLUTING

By itself, the fact that private and social incentives to pollute diverge is hardly surprising. Business companies have incentives to externalize costs on others. Institutions such as ex-ante requirements (regulation), ex-post liability (litigation), or the threat of losing future business opportunities (reputation) are meant to curb corporate externalities. What makes the DuPont case so illuminating is the internal documents showing that the decision-makers *anticipated in real time* the possibility

[28] Such innovative legal strategy was not lost on legal scholars, who now recommend adopting it in other cases (e.g., Wagner 2010, 1327-1328; Young 2016; Lahav 2020). The purported advantage is that an independent science panel is better at determining the health effects of opaque chemicals relative to judges or jurors. The disadvantage is higher administrative costs. We go back to this point when discussing policy implications in Part IV below.

of suffering massive legal and nonlegal sanctions for polluting. To illustrate, one internal memo explicitly warned that C8 could end up being DuPont's biggest legal problem (Bartlett transcripts, Vol. 4, p. 90; Vol. 5, p. 243). Other memos discussed the potential for grave "public liability" (reputation) and "corporate image" fallouts.[29] Yet, that did not stop DuPont from doubling down on C8 production. What was it that made the DuPont decision-makers discount the threat of litigation, regulation, and reputation? Are the factors that diluted deterrence in our case generalizable to other cases? These are the questions we turn to now.

A. Litigation

At first sight, The DuPont-C8 case appears as the poster child for the working of U.S.-style tort litigation. A private plaintiff used far-reaching discovery tools to extract information, uncovered a problem, held the company accountable to the tune of hundreds of millions of dollars, and received a hefty fee for it. However, a deeper dive reveals that even the threat of sizable fines ex-post may not be enough to deter pollution ex-ante.

The one condition that stands out is the *time lag* between when decisions to pollute are made and when fines for polluting are imposed. The first time that a victim of C8 pollution named, blamed, and claimed DuPont came only in the late 1990s (the Tennant litigation), fifteen years after the 1984 decision. It took two more decades until DuPont paid its first truly sizeable sanction ($670 million in 2017). Our calculations in Part II highlighted just how much such a lag erodes deterrence, even if managers care about the long run.

Importantly, the internal documents show that the time lag is not exogenous. In cases such as DuPont's, companies can count on their ability to significantly delay the sanction. For one, when the pollutant in question is a new manmade substance, the polluter enjoys extreme informational advantages. There are about 85,000 chemicals on the market, and 1,500 new ones are introduced each year (Krimsky 2017). Regulators are stretched too thin to closely monitor all these chemicals' effects. And most individual victims of pollution are unaware that the new toxic substance even exists, not to mention that it may be the source of their problems. Damning information about such substances would therefore have to come from inside the company.

[29] See for example the internal email at the Online Sources Appendix (labelled as Bowman Email (""our story is not a good one…" "…the biopersistence issue will kill us because of an overwhelming public attitude that anything biopersistence is harmful").

Polluting companies can go to great lengths to keep damning information from getting out. When a white paper about C8 was prepared and sent to top officials in 1994, the copies were numbered, and the recipients had to return them for shredding afterward.[30] And we already mentioned that DuPont's general counsel was holding workshops inside the company on what *not* to document and share regarding C8 (Lerner 2015b). Importantly, the company not just limited the circulation of existing information but also actively avoided the production of new damning information. To illustrate, the minutes of a 1991 meeting describe a request by the company's scientists to study how C8 exposure affected workers, to which the businesspersons replied: "Do the study after we are sued" (Lerner 2015a).

Beyond the time lag, another factor that dilutes legal deterrence is the divergence between the *private incentives of the plaintiffs* and their attorneys and the public interest (see generally Shavell 1997). Here the DuPont case serves as an exception that illustrates the rule. Plaintiff-side lawyers usually finance class action cases out of retained earnings or debt. They are therefore reluctant to litigate uncertain cases that are likely to prolong, such as claims based on probabilistic harm from exposure to pollutants whose effects are not yet known. Even in the rare cases where plaintiff attorneys stumble upon damning information, they are likely to agree to an early settlement that keeps the damning information from spreading out. In the DuPont case, by contrast, the plaintiffs were represented by a defense-side lawyer, who fought the company in court for almost twenty years while earning a salaried income from its large firm. Having a defense-side lawyer was thus crucial both in terms of knowledge (knowing how to find the C8-information needle in a haystack) and in terms of the business model (having the funding to litigate all the way to the end and flush out information). But defense-side lawyers rarely take such cases as plaintiffs.

B. Regulation

On paper, environmental regulation could overcome the abovementioned information and incentives problems that plague litigation. Regulators are supposedly more public-spirited and enjoy greater powers to extract information than private litigants. Ex ante, we would expect regulators to set requirements that prevent pollution to begin with. Ex post, we would expect regulators to vigorously enforce the requirements and punish companies that violate them. In reality, regulatory noncompliance is common (see, e.g., Cooper & Kroeger 2017 for

[30] Industry documents website (Boone et al. 1994).

noncompliance with labor regulation and de Gouw 2020 for noncompliance with environmental regulation). What the DuPont case adds in that regard is illuminating two mechanisms that enable noncompliance.

First, the DuPont case illustrates the flaws of a regulatory system that relies on *self-reporting*. The Toxic Substances Control Act (TSCA) was enacted in 1976 after C8 was already in use. TSCA "grandfathered" C8 and other tens of thousands of chemicals already in use. Grandfathered chemicals were presumed safe until proven otherwise, and TSCA limited the regulator's ability to proactively probe these chemicals' effects. Realistically, the only way for adverse information about a grandfathered chemical to come out is if the producer itself reveals it (U.S. Government Accountability Office Report 2000).[31] But the numbers from the DuPont case illustrate just how strong a company's incentives to err on the side of *under*reporting can be.

To be sure, not all self-regulation schemes are bound to fail. Yet there existed several design flaws in the system (a regulatory system that the industry itself – with DuPont playing a significant part – helped design). To illustrate, Section 8(e) of TSCA required manufacturers to self-report new information only if it led them to believe that a substance posed a *substantial* risk to health or the environment. Given that it may take decades to accumulate enough hard evidence of substantial risk, chemical producers had an easy way to justify not reporting ("Sure, we knew that there's some risk, but we had no evidence that it's substantial!"). Another flaw that chemical companies exploited was the ability to meet the TSCA's reporting requirements only nominally: even when reporting on substantial risks, companies often did so while omitting the chemical's name and other basic details, under the guise of trade-secret claims (McGarity & Wagner 2008).

Second, the DuPont case illustrates the various effects of the *revolving doors* between regulators and regulated entities. When information about C8 emissions started coming out, it was initially handled by the local regulator (West Virginia EPA). The director who signed the initial consent agreement with DuPont joined the consulting company that got paid by DuPont to implement the same agreement (EPA letter 2001, ex. 73). And three attorneys handling C8 issues for DuPont became regulators of C8 in the West Virginia EPA (Lyons 2007). Then, information

[31] Unless a material is considered unsafe to begin with and is regulated, the regulator would not conduct independent tests and regulate it. In 2016, the Lautenberg Act revised the TSCA, including on that aspect of the framework. The revised law requires the EPA to systematically assess the risks of all chemicals and not just new ones. The new criterion for prioritizing regulatory action is therefore not when a chemical was introduced but rather what is the potential risk stemming from its structure. To be sure, scarce regulatory resources and unfavorable political climate still hinder the EPA's ability to effectively monitor existing chemicals. But at least on paper, the regulatory framework today is better suited to address the issues that came up in the DuPont case.

about the scope and severity of the problem kept coming and the federal regulator (U.S. EPA) got involved. DuPont moved to hire Linda Fisher, U.S. EPA's deputy administrator between 2001 and 2003 as Vice President for Safety, Health, and Environment. And then hired Fisher's predecessor as U.S. EPA's deputy administrator, Michael McCabe, to handle communications with the regulators (his former colleagues and subordinates) (Lerner 2015c).

To be sure, the revolving door between regulators and industry is not categorically bad (Dal Bó 2006). Some studies suggest that the prospect of post-regulatory employment makes regulators work harder and enforce more vigorously to signal their high quality to prospective employers (deHaan et al., 2015). But the DuPont case highlights conditions under which revolving doors are likely to have a negative effect, even without assuming explicit quid-pro-quos. For expert chemists working as local regulators at the West Virginia EPA, DuPont may be the only viable option for post-regulatory employment. These local regulators are therefore less likely to enforce regulation aggressively out of fear of antagonizing the de facto monopsony in their relevant labor market. For federal regulators at the U.S. EPA, we note two important factors: first, DuPont hired higher-ups (two former number twos at the agency). The positive effects of revolving doors are pronounced with staffers at enforcement divisions (who signal expertise), whereas the negative effects are pronounced with heads of divisions who set the regulatory agenda (Cox & Thomas 2018). Second, DuPont hired these higher-ups not to develop and test new chemical products but rather to handle communications with the media and the regulator. For such positions, the more likely channel is "connections" rather than "technical expertise" (Zheng 2015, 1280).

C. Reputation

While the legal literature is full of theory and evidence about failures of regulation, there is a relative dearth of accounts of failures of reputation.[32] But reputational deterrence is hardly automatic, especially when it comes to pollution. For reputational concerns to deter pollution, at least four nontrivial conditions must hold, namely, revelation, diffusion, certification, and motivation.

First, someone must have access to information about pollution (revelation). Second, that someone must have the ability and incentives to disseminate the damning information (diffusion)

[32] As Cass Sunstein quipped, the legal literature suffers from "indefensible optimism about the operation of actual information markets." Sunstein 2009, 22.

widely. Third, the company's stakeholders must perceive the damning information as credible (certification). Finally, a critical mass of the company's stakeholders must be willing to act on the information (motivation). That is, stakeholders must find it in their best interests or be morally compelled to stop doing business with the polluter going forward. The DuPont case illustrates the circumstances under which it is virtually impossible to meet all conditions, as well as the many ways in which polluters can fight back and dilute expected reputational sanctions.

Section 1 illustrates why it is so hard for someone from outside the polluting company to reveal, diffuse, and certify damning information. Section 2 explains why even when such information is out, individual decision-makers inside the company do not necessarily face a hit to their labor-market reputations. Section 3 focuses on the organizational level, showing how companies can evade reputational fallout even after damning information about them is out.

1. Revealing, Disseminating, and Certifying Damning Information

Thus far we have focused on the informational advantage that chemical companies possess and their incentives to underreport damning information about their chemicals. But on paper, there exist other potential sources of information on toxic pollutants. Victims of pollution, investigative journalists, and academic experts could have the ability and incentives to reveal, certify and diffuse information on pollution. The DuPont case illustrates conditions under which these actors are less likely to break the information monopoly.

Victims. Victims are a good source of information when the harms that they suffer are immediate and concentrated. But victims are a weak source of information when harms are latent, probabilistic, and dispersed. With DuPont, it was not until the 2000s that residents of nearby communities could have an idea that their tap water was contaminated with some chemical later to be known as C8. The Tennant were only able to suspect DuPont's emissions because DuPont dumped massive quantities of C8 in a landfill adjacent to their property, and all their animals suddenly died. Had DuPont merely dumped lower quantities or lined the landfill, there is a chance that we all would still be unaware of C8 and its irreversible damages.

Even when victims gain access to information about a certain toxic pollutant that hurts them, they may not have the incentive to spread the damning information. For example, there may be significant social costs for spreading negative information about large corporations that are the biggest employer in town. Every victim that tried to fight DuPont faced high social costs such as ostracism by their neighbors. The Tennant had to change their church more than once, and people

would walk out of a restaurant when they entered (Rich 2016a; Blake 2015). The gym teacher who filed the drinking-water class action testified that "a guy called my wife and asked, 'If I lose my job are you going to pay for my wife and kids?'" (Mordock 2016a; Blake 2015). As the Washington Post observed, "Tension between the broader populace and those who say their health has been compromised by C8 is palpable in bingo halls, diners, and beauty parlors throughout the valley" (Williams 2015).

Media. Both local and national media were slow to hold DuPont accountable for the C8 debacle. On one hand, local journalists are closer to information sources and have stronger incentives to rectify wrongdoing that hurts the community that they are a part of. But on the other hand, local infomediaries are usually more dependent on corporate insiders for sourcing and advertising revenues, simply due to the size and concentration of the relevant market. Indeed, for local Parkersburg, West Virginia media, DuPont was basically the only game in town in terms of advertisement and financial support. And as the previous paragraph illustrated, scrutinizing the biggest employer in town ran the risk of upsetting their Parkersburg readers. Indeed, the few victims who came forward reported that when they tried to enlist the help of local journalists, no journalist wanted to touch the issue (Rich 2016b).[33]

National media, by contrast, are less dependent on a single company for information and advertising revenues (Dyck, Moss & Zingales 2013). At the same time, national media deem local problems less newsworthy. In other words, they are less likely to be captured, but also less likely to be interested in reporting the facts. The problem is especially pronounced when the information is less dramatic (famines, for example, are more dramatic and get more coverage than structural hunger cases. Sen 1983); and when the information does not involve the population at large (the destruction of the ozone layer, for example, is deemed more newsworthy than pollution at the West Virginia/Ohio border).

The DuPont case provides exceptions that illustrate the rule. The two short periods of national media attention to C8 (in 2003 and 2015) came only when litigation produced credible, libel-proof quotes and documents about C8's effects. In other words, litigation provided national reports with information subsidies. And in both instances, it took strong NGO activity to convince the national media that the story has national implications (see Wagner et al. (2011) on the link

[33] After the first draft of this Paper became public, several research teams have empirically tested and corroborated our hypotheses about local media and corporate misbehavior. *See, e.g.*, Hesse et al 2022; Gao et al 2020.

between public interest groups' activity and media attention to environmental issues). In general, national media seems to be good at spotlighting an already existing smoking gun but less good at revealing smoking guns or sticking with a story over the long run.

Academia. On paper, academic experts can study, diffuse, and lend credibility to damning information about a pollutant's effect. But the DuPont case illustrates how some of the forces that lead to the capture of regulatory experts can also lead to the capture of academic experts (Zingales 2014). In the first decades of C8 emissions, academic experts have little knowledge about the chemical or that it even exists. The experts who had access to information were the ones working inside DuPont and 3M. But in-house experts have little incentive to widely publish research that jeopardizes the bottom line of their employers.

When information about C8 started becoming public thanks to litigation, academics who wanted to study the chemical in-depth and publish damning findings faced an uphill battle. To illustrate, in 2004 Dr. James Dahlgren and a group of coauthors attempted to publish a paper on the adverse effects of C8 on community members.[34] Dahlgren's paper was accepted for publication by the *Archives of Environmental Health*, going through the peer-review process and several back-and-forth implementations of reviewers' comments. But then the already-accepted paper was yanked. Dahlgren received notice that the presiding editor of the journal who accepted his paper had been fired, and then that the new editor had decided to retract Dahlgren's paper.[35]

We were not able to corroborate an alleged link between DuPont's pressures and the retraction decision, as the editor who was fired had since died, while the editor who replaced him was adamant that the retraction had nothing to do with DuPont. The effects of retracting an already accepted paper, however, are clear: DuPont has consistently emphasized, both inside and outside the courtroom, the fact that Dahlgren's paper ended up not being published, presumably to reduce the credibility of his findings (Bartlett transcripts, vol. 5, p. 125; McGarity & Wagner 2008, 140).[36]

One of the internal documents exposed in litigation is especially revealing in that regard: when news about C8 started coming out in the early 2000s, a PR firm named Weinberg sent a

[34] It should be noted that Dahlgren was retained by the class action plaintiffs.

[35] In an interview with us, Dahlgren maintains that when he presented a draft of his findings in a Society of Environmental Toxicology and Chemistry (SETAC) conference in Prague, a DuPont representative reached out to him, telling him that he was surprised that Dahlgren's presentation was not excluded from SETAC.

[36] Another story comes from Eileen Murphy, who headed New Jersey's Water Quality Institute, and was conducting research on safety standards for C8 in drinking water. Murphy reports that when she wanted to publish her team's findings she received a call from her overseer, asking her to halt the publication. Murphy relays that when she went ahead and published the study anyhow, she was subsequently reassigned and effectively shown the door (Lerner 2015c).

memo to DuPont detailing its proposed strategy to reduce the reputational fallout. A key part of the plan was to "facilitate the publication of papers and articles dispelling the alleged nexus between PFOA and teratogenicity,"[37] and "to begin to identify and retain leading scientists to consult on the range of issues involving PFOA so as to develop a premium expert panel and concurrently conflict out experts from consulting with plaintiffs." In other words, the plan was to use the profits from emissions to buy academic experts and have them manufacture doubt. In all, it seems that research that serves the industry's interests is easily facilitated, whereas research findings that go against the industry's interests are harder to produce.[38]

2. Individual Reputational Concerns

Classic corporate governance accounts assume that managers are disciplined by the threat of damage to their labor-market reputation (Fama 1980). The idea is intuitive: market participants take bad news about a company as a signal that the quality of said company's managers is low. As a result, these market participants revise downward their beliefs about the managers' capacity and integrity, and the managers' wages would go down. The DuPont case fleshes out conditions under which the reputational settling-up theory is unlikely to work.

First among them is the significant time lag. To examine whether the DuPont executives who were embroiled in the C8 debacle suffered a blow to their reputation, we (1) identified all the top executives who sent or received the internal documents reviewed here; and (2) searched the Lexis News and ProQuest databases for articles during the 1984–2015 period that mention the names of said executives along with terms associated with the C8 debacle, such as "PFOA," "C8," "carcinogenic," "Washington Works," and "Teflon." We did not find any indication of the executives' names getting dragged through the mud (see Table 2).[39] That should come as no surprise since almost two decades have passed between the decisions that we reviewed and the time that mainline media started seriously scrutinizing the C8 debacle. By that time, the DuPont

[37] The memo is available at the Online Sources Appendix.

[38] To be sure, it is unlikely that a company can capture the entire academic publication process. Still, large companies can affect the research incentives at the margin. They can facilitate pro-industry research by granting access to data and funding. And they can also mount obstacles to research that goes against industry interests, as in through their connections with journal editors or through threatening with libel or intellectual property claims. Note that DuPont has always been a very generous research funder. It runs the "DuPont-MIT Alliance," a $35 million grant to fund graduate students at MIT; and it finances every year eight "Early Career Grants" to promising university research leaders; to name a couple out of many more examples.

[39] There was one exception: one of the DuPont's executives signing some of the above-cited memos was Bruce Karrh, who was the chief medical officer, and was later deposed in trial. Karrh's name was mentioned several times in media coverage. Remember, though, that the decision we examine is one in which the business executives overruled the scientific and legal departments' considerations. Those business units' managers, whose names appear on the meeting notes and memos, were not mentioned by the press.

executives who were mentioned and reached out to for response were those who were running the company in the 2000s and not those who took the critical decisions in the 1980s.

We then ran the same search with the names of all of DuPont's 1984 directors. The internal documents that we reviewed do not reflect direct involvement by the directors in C8 decisions. Nevertheless, the corporate governance literature tends to focus on directors as the subject of reputational discipline when bad things happen to companies. Accordingly, we extracted the names of the twenty-nine directors on DuPont's board from the company's 1984 proxy statement. Table 2 presents a list of all the 1984 directors and their post-DuPont careers. We discovered two interesting points. First, by the time serious media attention was directed at the C8 debacle (2003), nineteen of the twenty-nine original directors had already died or retired from professional activity. Labor-market reputation had thus stopped being a concern for most of the board. Second, even the ten directors who were still somewhat engaged in professional activity in 2003 were unlikely to suffer reputational fallout, as media coverage had not associated them with the C8 debacle.

Other circumstances in which the reputational settling-up theory is unlikely to work is when the employer does not care about a particular dimension of reputation, or is having trouble attributing corporate failures on that dimension to a specific individual. Karpoff (2012) finds that companies do not suffer significant reputational fallouts when they pollute or corrupt, presumably because their shareholders might not care so much about the externalities produced by these activities. A cursory look at the labor market outcomes of the DuPont's CEOs during the relevant timeframe reveals the same upshot.

Ricard Heckert – CEO between 1986 and 1989 – was remembered in a Wall Street Journal obituary as an environmental visionary who "shut down the chemical giant's production of chemicals suspected of destroying the ozone layer, and ended its work on nuclear weapons." (Miller 2010). In 2000, after 3M publicly announced that it would stop producing C8, Chad Holliday was the CEO when DuPont decided to double down on C8, building a plant to manufacture C8 on its own. Despite this decision, after stepping down from his position at DuPont in 2009, Holliday was appointed chairman of the board at Bank of America and Shell, specifically citing his commitment to "green conscience" (BBC 2014).

In all, top managers who were interested only in their monetary payoff would have rationally chosen to pollute even if they had perfect foresight about their future reputational costs. For these managers, dropping C8 or investing in abatement would have come with immediate,

clear costs in terms of reduced income. Incurring these costs to safeguard against future reputational fallouts probably did not make sense for them, given the time lag and the difficulties to attribute such problems to specific individuals.

3. Organizational Reputational Concerns

Unlike individual reputational concerns, corporate reputational concerns are seemingly perpetual. Yet here the DuPont case illustrates several levers that companies can pull to limit the reputational fallout when they are caught polluting. First and foremost, there exist the information-suppression tactics that we discussed in Section III.A above (limiting the circulation and preventing the production of damning information).

Second, the specific type of corporate misbehavior in question – namely, environmental degradation – is not one that typically leads to strong reputational sanctions. As mentioned, empirical studies of reputational sanctions reveal that companies that are hurting non-contractual third parties (as in polluting) suffer much smaller reputational sanctions than companies that are hurting contractual partners (as in inflating their financial reports) (Karpoff 2012).

Third, large companies such as DuPont can invest in a do-gooder, "green" image as a buffer against future reputational fallouts. Stakeholders are less likely to attribute bad intentions to a perceivably nice or high-status company, chalking up the bad news to a one-off past mistake rather than a deep-seated flaw (*cf*. Greve, Palmer & Pozner 2010, 87).[40] DuPont fits the description perfectly: it has traditionally invested heavily in its corporate social responsibility image, and apparently further ramped up its efforts since the C8 bad news broke.[41]

Finally, large companies can dilute reputational fallouts by spinning off blame. Before they lost their first bellwether case and received an onslaught of negative publicity (including a New York Times exposé and a Hollywood movie), DuPont spun off its Performance Chemicals Unit that dealt with C8 to a new company named Chemours.[42] The judge presiding over the litigation made it clear at the outset that the spinoff would not necessarily spare DuPont from its legal liabilities. But we are interested here in the possibility that spinoffs can minimize *reputational* liabilities. A cursory look at DuPont's media strategy since the spinoff seems to provide support

[40] Enron, for example, was considered the poster child for CSR before its collapse. Several scholars and activists suggested that the accolades showered upon Enron for its CSR image contributed to the slow detection and reaction to Enron's misbehavior (Shapira 2012, 1939).

[41] For example, in 2008, just three years after it paid the EPA $16.5 million for the alleged failures to report on C8, DuPont opened a PR campaign titled "Open Science."

[42] To emphasize: we do not claim that the main impetus for DuPont's reorganization was the C8 litigation. Our claim is simply that such reorganization carries with it understudied reputational consequences.

to this thesis. DuPont is constantly referring any media inquiry on the trial issue to Chemours, refusing to comment further, while pointing out that it is not DuPont's business. Other postmortem analyses of corporate debacles, such as Union Carbide's Bhopal disaster, follow similar dynamics (Reuters 2010).[43]

IV. IMPLICATIONS

The DuPont-C8 case may be unique in the academic sense of providing access to internal decision-making processes in large corporations. But the case is hardly unique in the sense of real-world outcomes, namely, large corporations emitting toxic chemicals that cause great harm and suppressing information about it.[44] Indeed, while working on this draft, we kept reading news about Monsanto being found liable for suppressing for years information about the risks of its popular pesticide Roundup, Johnson & Johnson being caught hiding information about the asbestos content of its famous talc, and so on. While the specifics of each case vary, it seems that in all cases of this ilk the various deterrence mechanisms – litigation, regulation, and reputation – have jointly failed. Our analysis thus far has flushed out the key driver of this joint failure, namely, extreme information asymmetries regarding the pollutant.[45] This Part utilizes the lessons from the DuPont-C8 case to reevaluate the desirability of existing legal institutions, such as punitive damages and prejudgment interest, and to propose several new solutions, such as extending the Qui Tam mechanism to environmental pollution.

A. Increasing the Severity of Sanctions?

If a low probability of detection dilutes legal deterrence, why can't we simply raise the magnitude of the sanction for polluting? For example, we can subject the misbehaving firms to aggressive punitive damages or impose criminal sanctions on individual decision-makers. While proposals to raise the severity of sanctions should be taken seriously, the DuPont case illustrates at least three limits.[46]

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[43] After the first draft of this Paper became public, a Stanford research team has elaborated on our hypotheses regarding the consequences of spinoffs following corporate debacles. Baker, Larcker & Tayan 2020.

[44] Indeed, White & Bero (2010) find similar techniques being used across several industries.

[45] Other factors diluting deterrence are the *market power* of the polluting company (making it harder on victims, whistleblowers, media, and academia to hold it accountable); and the type of their misbehavior, namely, *externalities* (contrast DuPont's treatment of its employees to its treatment of nearby communities).

[46] There exists a rich literature qualifying Gary Becker's simple prescription, raising different points than the ones we highlight here. See, e.g., Stigler (1970) (introducing cross-offenses considerations); Polinsky and Shavell (1979) (introducing risk-aversion considerations); Bebchuk and Kaplow (1992) (introducing the costs of errors in judging probability of detection).

First, in practice courts and jurors rarely assign punitive damages according to optimal deterrence theory. They rather focus on less relevant factors such as defendants' wealth (Polinsky & Shavell 2000, 775-6; Viscusi 2015). Indeed, in the C8 bellwether trials, after DuPont was held liable and it was time to argue for the size of the sanction, the plaintiffs marshaled just one expert witness, who focused in his testimony on how much money DuPont makes per minute (Vigneron transcripts, vol. 25, p. 36).

Second, increasing the sanction ex-post also raises companies' ex-ante incentives to avoid detection (Malik 1990). The internal documents are illuminating in that regard: the in-house realization, in the early 1990s, that C8 may end up being their "number one legal issue," was not followed by stopping pollution and coming out clean. In fact, it was followed by company lawyers conducting workshops on what *not* to document and top decision-makers deciding not to conduct further studies until the company is sued (Lerner 2015a).

Finally and most intuitively, the legal liability that can be imposed on a company is bounded above by the market value of the company's stock. Thus, delaying the realization of the liability (and paying out large dividends in the meantime) is a very profitable strategy for companies even when everybody is perfectly rational and prejudgment interest is awarded (more about this in the next section).[47]

B. Reducing the Time Lag

Instead of focusing on the size of the sanction that will be imposed, policymakers may be better off focusing on reducing the time lag for detection and enforcement. The DuPont case illustrates: if the delay in punishment was reduced by 10 years, the present value of future legal liabilities would go from $100 million to $255 million. In this case, the probability of detection would have to be below 7.4% for polluting to be optimal. If the delay was reduced by 20 years, the present value of future legal liabilities would go to $746 million and the probability of detection would have to be below 2.5% for polluting to be optimal. Thus, a reduction in the time lag for detection and enforcement is a very effective mechanism to increase compliance.

The question becomes how to do it effectively. The DuPont case suggests thinking about two types of solutions to two different facets of the problem: detection and litigation. The first couple of decades of time lag were due to delayed detection due to the company's monopoly on

[47] Indeed, the asbestos litigation led to the bankruptcy of two major companies. Carroll et al. 2005.

information (difficult to know what happened). Section C below proposes ways to break this monopoly. But even after information about C8 was out in the late 1990s, it took almost two more decades for DuPont to pay (difficult to prove culpability). This is at least partly due to DuPont's litigation strategy.[48] Here one could argue that there exists a simple solution, namely, *awarding prejudgment interest* (Knoll 1996).

Prejudgment interest compensates the victims for losing the time value of money between the moment their claims accrued and the moment final judgment was rendered. In theory, then, prejudgment interest could reduce companies' incentives to engage in delay tactics. Yet the DuPont case illustrates the on-the-ground hurdles for applying this tool effectively.

For one, there are clear legal hurdles. While prejudgment interest laws vary by state, in most states the interest is capped by statute, and most courts are reluctant to use the interest as an optimal deterrence mechanism (*Brainard v. Trinity Universal Ins. Co*. 216 S.W.3d 809 (Tex. 2006)). Further, plaintiffs must meet certain nontrivial conditions to be eligible for receiving prejudgment interest. In the DuPont example, the relevant state law requires plaintiffs to show that they wanted to settle all along, but the defendants did not entertain the thought.[49] Then there are also issues with incentives. Plaintiff attorneys do not focus on fighting the uphill battle of meeting the conditions for prejudgment interest. They rather focus on establishing liability and proving up damages, on the way to a hefty settlement. Potential prejudgment interest is thus relegated to a contingent hypothetical afterthought (Chancery Daily 2023).

Going forward, policymakers should consider revising prejudgment interest laws, to make them easier to use aggressively when needed. Beyond relaxing the conditions for awarding interest, courts should also rethink the interest that they charge. Currently, most courts award basic interest. But sophisticated commercial parties neither borrow nor lend in simple interest rates. Some compounding is needed to replicate economic reality and achieve better deterrence (Williams v. Energy Transfer, C.A. No. 12168-VCG (Del. Ch. 2020)).

In addition, delaying the payment transfers some business risk onto the tort victims, who will see their award trimmed in case of a decline in the market value of the defendant (as per our

[48] Recent exposés suggest that this is a pervasive problem: defendant-side law firms employ aggressive delay tactics with immense costs to society. Enrich 2022.

[49] See Ohio Rev. Code 1343.03(C); Kalain v. Smith, 25 Ohio St. 3d 157, 159, 495 N.E.2d 572, 574 (1986).

discussion above). Thus, to avoid excessive incentives to delay, prejudgment interest should be computed at a company's cost of debt.[50]

C. Increasing the Probability of Detection

Perhaps the clearest problem that emerges from DuPont's case is the extreme information asymmetry. Policymakers should focus on improving the flow of information about the toxicity of products from inside chemical companies to the outside world (regulators and affected communities), as well as the flow of information inside the company.

1. Introducing an Environmental Qui Tam

Increasing the severity of sanctions ex-post will not necessarily stop chemical companies from suppressing information ex-ante (as Section IV.A explained, it may actually incentivize more suppression). One tested method to break the information monopoly is to incentivize whistleblowing. The divergence between social and private incentives to divulge information is not unique to pollution, but rather common to fraud of all types. For fraud against the government, the information problem has been mitigated by the 1986 False Claim Act, which empowers individuals to sue fraudsters in the name of the Government (*Qui Tam* suits). If the Qui Tam suit is successful, those who voiced the concern are entitled to 15% of the fine imposed on the fraudsters. As Dyck, Morse and Zingales (2010) show, the False Claim Act proved effective in motivating employees who become aware of fraud to come forward. The whistleblowing mechanism has been successfully extended to tax fraud in 2007, and to securities markets fraud with the Dodd-Frank Act in 2010. How can the DuPont case help us think about the desirability of extending the whistleblowing mechanism to toxic pollution as well?

The internal documents detailed in Part I show that scores of scientists, lawyers, and businesspersons inside the company knew about C8's potentially disastrous effects. And our calculations from Part II show just how much societal costs could have been saved had one of these individuals blown the whistle in real-time. As Dyck, Morse and Zingales (2010) show, whistleblowers face enormous personal costs. Applied here, one DuPont insider explicitly admitted in retrospect: "I wasn't about to go against the paycheck that supported my family. So I

[50] One could even argue that the prejudgment interest should exceed the cost of the company's debt, because creditors are able to impose dividend covenants, while tort claimants are not. Without these restrictions, a defendant would have strong incentives to pay high dividends and delay the day of reckoning. In alternative to higher prejudgment interest, trial judges should impose dividend (and stock repurchases) restrictions on defendant firms before any liability is established.

shut my mouth" (Blake 2015). DuPont's market power increased the costs of blowing the whistle. When a giant corporation is one of the only viable employers in town, the threat of retaliation becomes bigger. More generally, the more concentrated the labor market is, the less likely insiders are to burn bridges with their current companies by blowing the whistle.

If these insiders could have gained tens of millions of dollars by airing out information about the health effects of C8, we conjecture that one of them would probably have, and would have perhaps saved irreversible damage to human health and the environment.

An important design choice when setting a whistleblowing mechanism for pollution is whether to leave the enforcement in the hands of the relevant regulator (as in the Dodd-Frank model) or let the insider herself pursue legal action (as in the False Claims model). The decision should turn on the likelihood that the relevant regulator is captured by the industry (see generally Zingales 2012). The DuPont-C8 case is suggestive in that regard: recall that victims and their attorneys have tried to enlist the regulators' help for decades, but the latter was too slow to react. Choosing the False Claims model, which is less susceptible to regulatory capture, thus seems like a better choice in our context, all else being equal.

2. Recalibrating Director Oversight Duties

Any attempt to solve the failure of deterrence observed in DuPont should address the perverse incentives of top decision-makers to remain ignorant. It is well established that knowledge is fragmented inside giant corporations (Vaughn 1999, 277). Knowledge of unethical behavior (here: the adverse effects of C8) tends to be pushed down the organizational ladder, while credit for success (here: the profits from using C8) is claimed up the latter (Jackal 1988, 20). This fragmentation of knowledge creates plausible deniability, which dilutes legal and nonlegal deterrence. In the C8 case, while the internal documents we reviewed were signed and addressed by top scientists, engineers, and lawyers inside DuPont, we have not located evidence of active involvement by DuPont's directors. What can be done to reverse these plausible-ignorance dynamics and ensure greater involvement of directors and top managers in risk oversight?

The answer could come from recent developments in corporate law's director oversight liability doctrine. This so-called "*Caremark* doctrine" (named after Delaware's leading precedent) imposes on directors the duty to be proactive about their firm's compliance (*In re* Caremark Int'l. Inc. Derivative Litig., 698 A.2d 959 (Del. Ch. 1996)). Directors must install a system that monitors compliance issues and reports them back, and they must react to red flags that such a monitoring

system generates. Historically, that doctrine did little to reverse the incentives of top-level decision-makers to remain ignorant, because of its procedural stance (an insurmountable "pleading hurdle"). Plaintiffs had to show smoking-gun indications of what the directors knew in real-time, and they had to do it without having access to discovery. But in recent years there has been a shift: Delaware courts are now increasingly willing to apply enhanced oversight duties when the issue concerns a "mission critical risk" (one that touches the core business activity of the company). Delaware courts are also increasingly willing to provide outside shareholders with access to internal company documents in order to investigate potential failure-of-oversight (Shapira 2021). In the Boeing-737 Max case, for example, plaintiffs gained access to 44,000 internal documents related to how the company handled air safety issues (*In re* Boeing Co. Derivative Litig., No. 2019-0907, (Del. Ch. Sep. 7, 2021)).

One could argue that such extensive discovery would only aggravate companies' incentives to not document, of the kind that was evident in the DuPont case. Yet, the courts have clarified that any document not produced could be used as pleading-stage evidence against the defendant directors (Teamsters Local 443 v. Chou, No. 2019-0816-SG, (Del. Ch. Aug. 24, 2020)). In other words, directors can no longer point to a lack of documentation as evidence that they were not aware of the problem, and so should be let off the hook. Lack of documentation can serve as evidence of a lack of needed follow-up actions on the part of the board to remedy potential oversight issues. This newfound emphasis on creating paper trails could carry prophylactic value. Going forward, directors and their legal advisors will attempt to create a proper record of their efforts to monitor and address safety issues. This, in turn, will force directors to ask others in the organization to prepare written materials for them, thereby bringing thorny issues to the fore.

The main lesson that the DuPont case adds here is the need to keep extending the *Caremark* framework so that it also applies to giant corporations. The Blue Bell case that signaled the new *Caremark* era did so in the context of monoline, smaller companies that only sell one product (Marchand v. Barnhill, 212 A.3d 805 (Del. 2019); see also *In re* Clovis Derivative Litig., No. 2017-0222-JRS, (Del. Ch. 2019)). It is intuitive to argue that if directors of a company that only sells ice-cream never discussed issues of food safety, they were not trying hard enough to meet their oversight duties. It is less intuitive to fault directors of giant corporations with multiple divisions (such as DuPont), for not discussing one out of their numerous products or chemicals. But as our discussion throughout has demonstrated, the fragmentation of knowledge and plausible

ignorance problems are more pronounced inside giant chemical organizations. Carefully applying the director oversight duty doctrine to our context can therefore add much value. Promoting whistleblowing could improve inside-out information flows, and recalibrating director oversight duties could improve bottom-up information flows.

3. Introduce Medical Monitoring and Other Knowledge Doctrines

As Part II detailed, the legal fight against DuPont and PFOAs would not have proceeded past the Tennant case if it was not for the possibility of medical monitoring claims, which had just been introduced in West Virginia in 1999 (Bilott, 2020, 130). Medical monitoring is a tort law claim that allows people who have been exposed to a hazardous substance to recover "the economic costs of the extra medical check-ups that [the plaintiff] expects to incur as a result of his exposure" to the defendant's product (Metro-North Commuter Ry. Co. v. Buckley, 521 U.S. 424, 438 (1997)). It was thanks to medical monitoring that Bilott was able to collect the blood sample of 65,000 of the 70,000 residents of six water districts contaminated by DuPont's West Virginia plant. Without this sample, it would have been impossible to discover the cumulative effects of low-level exposure to C8.

As of 2023, most U.S. states still do not recognize medical monitoring claims. Several legal scholars have recently advocated for wider acceptance of medical monitoring, and more generally for a shift toward "knowledge remedies" in tort law (Lahav 2020; Wagner 2022). Our analysis lends credence to these calls. The internal documents show that the realization that C8 could end up causing DuPont large legal sanctions did not push the company to come clean, but rather incentivized it to further suppress information. The case therefore illustrates how tort law as currently construed incentivizes companies to avoid testing ("wait until we get sued" was how DuPont's businesspersons answered the scientists who requested further testing), so as not to put a target on their backs and allow plaintiffs to establish causation. A shift toward knowledge remedies, which do not focus on compensating past harms but rather on funding future research, could reverse these deliberate ignorance dynamics.

Granted, introducing knowledge remedies would come with its own set of costs, such as increasing the administrative burden on courts. But the merits of introducing such doctrines for toxic torts is especially pronounced in a country like the United States, without universal health insurance and with very strong protection of the privacy of patients. The combination of these two elements makes it very difficult to identify the long-term health effects of pollution. By contrast,

in Scandinavian countries, with universal health insurance and fewer privacy concerns, such studies can be done at no extra costs for polluting companies (see, e.g., Andersen et al. 2023).

D. Taxing Secret Settlements?

The DuPont-C8 case helps us rethink yet another well-debated institution, namely, secret settlements. In our case, it was litigation that broke the information monopoly and alerted the world to the dangers of C8 emissions. This seems to be a recurring pattern: as Shapira (2018) showed, most prizewinning investigative journalism projects rely heavily on "legal sources" (such as documents exchanged in discovery, judicial opinions, and regulatory investigation reports). The information that comes out in litigation is thus a positive externality, helping third parties who did not pay for litigation.

This also means that the disputants do not fully internalize the benefits of public dispute resolution. The DuPont case is an exception that illustrates the rule in that regard. It took Sisyphean efforts by Tennant's attorney (Bilott), who fought legal battles to be able to share with regulators and journalists the information that he discovered during litigation (Bilott 2020). In other cases, plaintiffs usually use defendants' willingness to pay for secrecy to extract higher settlement awards for themselves, not caring whether relevant information leaks out and warns others (Shavell 1997). But as Levmore and Fagan (2018) point out, the higher awards obtained in confidential settlements could actually help deterrence. In the limit, if the plaintiff can extract the full value of all future liabilities (including reputational fallouts), secret settlements retain the deterrence effect while reducing litigation's administrative costs.

The DuPont-C8 case, however, illustrates the limits of this argument. First, the optimal deterrence argument explicitly assumes symmetric information. That is, plaintiffs need to be able to appreciate the extent of future liabilities the defendant would face. Yet, this is decidedly not the case when the harms are opaque, widely dispersed, and latent, as is often the case with manmade chemicals such as C8.

Second, the optimal deterrence argument implicitly assumes zero spillovers. But in reality, information revealed in litigation against one polluting company can lead to lawsuits and media scrutiny of other companies using similar pollutants. Information coming from the Tennant litigation has spawned not just thousands of additional lawsuits against DuPont for the same misbehavior (emitting C8 while producing Teflon in West Virginia), but also lawsuits against 3M

and other users of C8 polluters around the globe; and lawsuits against companies using other chemicals of the same family. There are currently 12,034 known variants of the PFAS family (Gaber et al. 2023). DuPont would not have agreed to pay anything to avoid the liabilities of other companies. Accordingly, a secret settlement in the DuPont case would have greatly reduced deterrence. To generalize, the case against secret settlements becomes stronger in cases of chemical pollution or harmful drugs, where information about one product can shed light on the lack of safety of an entire family of products.

One way to address the externality of secret settlements is to impose a sort of a tax on them. Another (more direct) way is to require not just defendants but also plaintiffs to share any adverse effects of chemicals and drugs discovered in litigation. More generally, the DuPont case illustrates the need to rethink the enforceability of mandatory arbitration and gag provisions that big corporations with market power tend to force on their employees and customers. In the context of hazardous chemicals, such provisions generate a sizeable informational externality by effectively eliminating public dispute resolution.

E. Changing the Regulatory Default?

Our discussion of potential solutions has thus far focused on increasing the expected sanction for polluting. We would be remiss if we did not discuss the other way to curb pollution, namely, introducing regulatory requirements that prevent the usage of certain chemicals ex-ante. On the one hand, requiring chemical companies to undertake long-term effect studies before commercializing each new substance (think about the process that pharmaceutical companies undergo before marketing drags), would likely chill innovation. On the other hand, the system that allowed the C8 debacle – whereby tons of toxic substances are dumped into the environment until clear evidence of their adverse effects surfaces – does not seem optimal either.

The DuPont-C8 case highlights one point that can inform our thinking about this difficult tradeoff, namely, the distinction between bio-persistent and bio-degradable substances. Damages created by the latter are temporary, whereas damages created by the former are irreversible. In the tradeoff between chilling innovation and protecting from harm, we should therefore err on the side of caution when it comes to bio-persistent substances. The idea is to preserve the "option value:" the price society should be willing to pay to maintain flexibility about an uncertain future. One way to do so is by flipping the burden: new substances that are not degradable should be presumed

toxic until proven safe.[51] And if a company learns mid-stream that a substance is persistent, it should halt production until fully studying the chemical's effects.

The C8 case provides a somber reminder of the costs of not being extra-cautious with persistent chemicals. More than seven decades have passed since C8 was introduced, yet we are still learning about new detrimental effects: from reducing male fertility (Di Nisio 2018), to reducing fetal growth, to impairing vaccine response (Gaber et al. 2023). With C8 detected in the blood of 99% of Americans (Bilott 2020), the potential ramifications are troubling.

F. Changing the Corporate Objective?

One could claim that the main problem in the DuPont C8 case was not one of corporate governance procedures but rather one of corporate *objectives*. Our analysis in Part II assumed that companies maximize shareholders' value. What if, as Hart & Zingales (2017) propose, companies maximize shareholders' *welfare* rather than value, where welfare includes other pro-social objectives that shareholders care about? Could it be that in today's world, with ESG considerations gaining more and more traction, a company facing the same inflection point would have decided differently? As Broccardo et al. (2022) show, in the presence of a large shareholder (as was the case for DuPont in 1984), it is unlikely that even factoring in shareholders' pro-social incentives would have been enough to prevent pollution. Granted, their analysis reveals that small, diversified shareholders do not need to be very pro-social to desire a reduction in pollution. Yet here as well the problem is information asymmetry: management with high-power incentive schemes is unlikely to share information that would lead shareholders to make decisions that reduce profits.

CONCLUSION

An effective system to deter companies from externalizing their costs is essential to the proper working of a capitalist economy. In this paper, we study an example of a major case of externalization of costs to understand what went wrong. We learn that when it comes to toxic substances with long-term health effects, all three major mechanisms – litigation, regulation, and

[51] The decision becomes more complicated with biodegradable substances, where chilling innovation by flipping the burden of proof may prove too costly. Instead, we can perhaps consider a small tax on introducing untested substances, proportional to the quantity of these substances being produced. Without getting into details, we can envision a scheme whereby the proceeds of such new-substance tax would be used to reward companies that provide proof of having disposed of substances in an environmental-friendly way. Alternatively, the proceeds can be used to finance independent research on the environmental costs of such substances.

reputation – are susceptible to failure. This problem does not seem to be limited to C8 or DuPont but (under the above conditions) is rather pervasive. And as our quantification here illustrates, it generates high societal costs.

We advance a series of proposals to address this major shortcoming. A pollution-related form of whistleblower rewards could improve information flows from inside the company to the outside world, thereby reducing the lag from pollution to detection. A recalibration of directors' oversight duties could ensure that crucial information reaches the top of an organization, negating directors' incentives to remain ignorant. A change in the regulatory default for approving bio-persistent substances (so that they are presumed toxic until proven otherwise) could reverse companies' incentives to delay research into manmade substances. A more aggressive application of prejudgment interest could reverse companies' incentives to delay litigation once damning information about their substances surfaced. Most importantly, a willingness to adopt innovative "knowledge doctrines" such as medical monitoring could help all of the above.

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Appendix A – Social Cost of Pollution

A.1 Incidence and Prevalence of Diseases Linked to C8 Pollution

We base our calculations on the findings of the C8 medical monitoring program screening tests, as published on their website,[52] henceforth "the panel." The panel estimates the increase in new cases of the six linked diseases for a community of a given size, for a given level of increased exposure to C8.

The panel reports ranges of incidence of various diseases associated to high exposure of C8. For example, high exposure to C8 yields 5 to 20 new cases of disease X per year. Since not all the 70,000 people are exposed to a high level of C8 and we do not have a detailed map of population-weighted exposure, we always choose the lower bound of the scientists' forecasts.

Testicular Cancer: The largest exposure to C8 increases the risk of males to develop testicular cancer by 3 to 6 times. This led the panel to estimate that in a community of 200,000 people, C8 exposure would cause from 6 to 15 additional cases each year. Thus, in a sample of 70,000 people, we assume 1.05 extra cases of testicular cancer a year.

Kidney Cancer: The panel estimates that the highest exposure to C8 doubles the risk of developing kidney cancer. Since the baseline rate of incidence of this type of cancer is 3 per 10,000 people, in the affected community the panel estimates 21 additional cases per year.

Thyroid Disease: The panel found that exposure to a high level of C8 yields between 20 and 40 new cases of thyroid disease per 10,000 people each year. Thus, taking the lower limit this estimate implies 140 new cases per year in our sample.

Ulcerative Colitis: About 200 people in a city of 100,000 people have ulcerative colitis (UC) and 1 to 20 new cases develop each year. The Science Panel found that greater exposure to C8 was related to higher rates of UC. The Science Panel estimated that with the highest exposure to C8 the risk of developing UC doubles. This finding means that if the entire sample at risk were exposed to the maximum C8 level,

[52] http://www.c8medicalmonitoringprogram.com/docs/med_panel_education_doc.pdf.

the number of new UC cases would be between 0.7 and 14 cases per year. Thus, we assume the value of 0.7.

High Cholesterol: For high cholesterol the Science Panel provides data only on prevalence, not incidence. The Panel's research shows that – when exposed to the highest level of C8 – about 2,100 out of 10,000 people would have high cholesterol vs. an average of 1500 out of 10,000 in communities with regulator exposure. Therefore, high exposure to C8 would result in 600 additional adults with high cholesterol per 10,000 or 4,200 in our sample.

Pregnancy-Induced Hypertension: The medical monitoring panel estimated that high exposure to C8 increases the risk of getting high blood pressure and preeclampsia. According to the Panel, the risk is 20% to 30% higher in women with the highest exposure to C8. Thus, 750 pregnant women rather than 600 women per 10,000 would experience high blood pressure as a result of exposure to a high level of C8. The number of cases of preeclampsia out of 10,000 pregnancies would be about 500 women rather than 400 women. Since at any time 4% of the women are pregnant, high exposure to C8 can account for 35 additional cases.

A.2 Loss estimates

For each disease we consider both the medical cost of treating it and the probability of dying. For the cost of treating it, we use estimates provided by the web site http://www.costhelper.com/, which we then translate to 1984 dollars using the CPI price index. For the cost in terms of life loss, we take the probabilities of survival from the American Cancer Association. We take an average between the best and the worst survival rate for the disease. We then multiply this probability by the value of statistical life expressed in 1984 dollars. Because we use 2010s' survival rates, our estimates likely underestimate the number of lives lost.

A.3 Discount Rate

Since we have all the figures in 1984 dollars, we are going to use a real discount rate. The 10-year T-bond in May 22, 1984 (when the meeting took place) was 13.5%. At the same time, the University of Michigan Inflation Expectation was 4.2% (https://fred.stlouisfed.org/series/MICH).

Figure 1: Memo of the 1984 DuPont Meeting on C8

5/23/84

cc. R. E. PUTNAM

PERSONAL & CONFIDENTIAL

TO: T. M. KEMP
T. L. SCHRENK

FROM: J. A. SCHMID

C-8 MEETING SUMMARY
5/22/84 - WILMINGTON

THE REVIEW WAS HELD WITH BESPERKA, BENNETT, RIDDICK, GLEASON, HEGENBARTH, SERENBETZ, RAINES, KENNEDY, VON SCHRILTZ, AND INGALLS IN ATTENDENCE. COPIES OF THE CHARTS USED ARE ATTACHED.

THERE WAS A CONSENSUS THAT C-8, BASED ON ALL THE INFORMATION AVAILABLE FROM WITHIN THE COMPANY AND FROM 3M, DOES NOT POSE A HEALTH HAZARD AT LOW LEVEL CHRONIC EXPOSURE.

THERE WAS AGREEMENT THAT A DEPARTMENTAL POSITION NEEDED TO BE DEVELOPED CONCERNING THE CONTINUATION OF WORK DIRECTED AT ELIMINATION OF C-8 EXPOSURES OFF PLANT AS WELL AS TO OUR CUSTOMERS AND THE COMMUNITIES IN WHICH THEY OPERATE.

THERE WAS CONSENSUS REACHED THAT THE ISSUE WHICH WILL DECIDE FUTURE ACTION IS ONE OF CORPORATE IMAGE, AND CORPORATE LIABILITY. LIABILITY WAS FURTHER DEFINED AS THE INCREMENTAL LIABILITY FROM THIS POINT ON IF WE DO NOTHING AS WE ARE ALREADY LIABLE FOR THE PAST 32 YEARS OF OPERATION. CORPORATE IMAGE DISCUSSION CENTERED AROUND THE PERCEIVED DILIGENCE VERSUS OUR POLICIES IF WE ELECTED TO STOP WORK.

CURRENTLY, NONE OF THE OPTIONS DEVELOPED ARE, FROM A FINE POWDER BUSSINESS STANDPOINT, ECONOMICALY ATTRACTIVE AND WOULD ESSENTIALLY PUT THE LONG TERM VIABILITY OF THIS BUSSINESS SEGMENT ON THE LINE. FROM A BROADER CORPORATE VIEWPOINT THE COSTS ARE SMALL.

THE BASIS FOR A DECISION AT THIS POINT IS SUBJECTIVE AND IS MADE MORE DIFFICULT BY OUR CURRENT UNDERSTANDING OF TECHNOLOGY AND COST, AND THE IMPACT ON THE FINE POWDER BUSSINESS. IT'S NOT AN EASY AND OBVIOUS DICISION AS FOR EXAMPLE TBSA WAS.

EID602999

RJZ009986

Table 1: Social Cost of Pollution

In '000		Source
1. Testicular Cancer		
Incidence per year	2.1	6 additional cases per 200,000
Medical cost per unit	1.09	21.8 Million Medical Expenditure Panel Survey (2014)
Total medical costs	2.28	8,700 new cases https://seer.cancer.gov/statfacts/html/testis.html
Prob of dying	0.14	http://www.cancer.org/cancer/testicularcancer/detailedguide/testicular-cancer-survival-rates
Expected Life loss	1,058	
Total per year	**1,061**	medical cost + expected life cost
2. Thyroid Cancer		
Incidence per year	140	20 per 10,000
Medical cost per unit	0.49	The total cost ($9bn) from the 2014 Medical Expenditure Panel is divided by the total number of cases (20 M).
Total per year	**68**	Only 0.4 of the are cured http://www.thyroid.org/media-main/about-hypothyroidism/
3. Kydney Cancer		
Incidence per year	21	3 per thousand people
Medical cost per unit first year	19.95	46 : https://academic.oup.com/jnci/article/103/2/117/2568866/Pro
Next 4 years	7.92	6.255 for every continuing year
Total medical costs	585	https://academic.oup.com/jnci/article/103/2/117/2568866/Projections-of-the-Cost-of-Cancer-Care-in-the
Prob of dying	0.27	http://www.cancer.net/cancer-types/kidney-cancer/statistics
Expected Life loss	20,412	
Total per year	**20,997**	medical cost + expected life cost
4. Ulceritative colitis		
Incidence per year	0.7	1 per 100,000
Medical cost per unit	2.82	Cohen et al (2010) 6
Total medical cost per year	**2**	
5. Pregnancy-induced hypertension		
High blood pressure	21	extra 150 case per 10,000 pregnant women. 4% of 35,000 pregnant women
Preeclampsia	14	extra 100 case per 10,000 pregnant women. 4% of 35,000 pregnant women
Total incidence per year	35	
Medical cost per unit	70	Pourat et al (2013).
Total medical cost per year	**2,450**	
6. High cholesterol	4200	600 per 10,0000
Medical cost per unit	0.45	We obtain a 2014 estimate of 1.04 per person based on the fact that the Medical Expenditure Panel Survey (2014)
Total medical cost per year	**1,886**	reports an expenditure of 36.25bn for 35 million people with high cholesterol
		https://www.cdc.gov/cholesterol/cholesterol_education_month.htm. Translated into 1984 dollars, this yields 0,45
Total cost per year	**26,465**	sum of the total costs for the 6 diseases
Discount Rate	5.63	real rate = T-bill - inflation expectation
Value of Statistical Life	3,600	Viscusi (1992) in 1984 dollars
2014 dollars deflated by 1984	0.43	
Period	28	
Annuity factor	13.93	
Total	**368,647**	Total cost per year multiplied by annuity factor

Table 2: DuPont's Directors – History

(The following table lists all DuPont's directors in 1984. Aside from their names and roles, we detail whether the director was an insider or not; the length of his/her tenure; when did s/he stepped down from DuPont's board; approximately when did s/he "stepped down" from the labor market more generally (e.g., retired/died); and whether his/her name was mentioned in articles regarding C8 once the bad news broke. Remember: the first time serious media attention was directed to the C8 debacle was in 2003. Our purpose is to show the 1984 directors' status at the time the bad news breaks.)

Insider?	Name	Role	Committee	Director since	Stepped down from board	Stepped down from Labor market	Media mentions
1	**Edward G. Jefferson**	Chief executive officer and chairman of the board	Executive committee, finance committee	1973	1992	Pre-2003 (Around 2002. Stepped down as CEO in 1986, when reaching retiring age. Died 2006)	-
1	**Ralph E. Bailey**	Vice chairman of the board	Executive committee, finance committee	1981	1987	post-2003	-
1	**Richard E. Heckert**	Vice chairman of the board	Executive committee, finance committee	1973	1994 (retired)	Pre-2003 (in 1994)	(only in relation to helping design TSCA)
1	**David K. Barnes**	Executive vice president	Executive committee	1981	1988	Died 1990	-
0	**Andrew F. Brimmer**	President of Brimmer & Company (economic and financial consulting)	Audit Committee	1974	1998	Remained a consultant post-2003. Died 2012	-

0	**Charles R. Bronfman**	Deputy chairman of the board at Seagram	Finance committee	1981	Before 2003	Post 2003	-
0	**Edgar M. Bronfman (Sr.)**	Chief executive officer and chairman of the board at Seagram	Compensation committee	1981	Before 2003	Post-2003	-
0	**Charles L. Brown**	Chief executive officer and chairman of the board at American Telephone and Telegraph (AT&T)	Finance committee, compensation committee	1976	1992	Died 2003	-
0	**Norman A. Copeland**	(part of DuPont family)		1972	1984	Pre-2003	-
R	**Joseph A. Dallas**	-	-	1968	1987	Retired pre-2003	-
0	**Louisa C. Duemling**	-	Audit Committee	1982	2006 (part of the DuPont Family)		-
0	**Edward B. duPont**	-	Audit Committee	1977 (	2005 (part of DuPont family)	Post-2003	-
0	**Irénée DuPont, Jr.**	-	Finance committee	1959	1988	Pre-2003	-
0	**George P. Edmonds**	Director, Wilmington Trust Company	Finance committee, compensation committee	1966	1987	Pre-2003	-

0	**Harold Fieldsteel**	Consultant at Seagram	Audit Committee	1982	**1985**	Died 1995	-
1	**Robert C. Forney**	Executive vice president, DuPont	Executive committee	1979	1989	Pre-2003	-
0	**Crawford H. Greene-walt**	-	Finance committee	1942	1988	Died 1993	-
1	**Howard W. Johnson**	MIT/ Honorary chairman of DuPont	Compensation committee, finance committee	1972	1994	Pre-2003	-
R	**Gilbert E. Jones**	-	Audit Committee	1977	1987	Pre-2003	-
R	**Edward R. Kane**	-	-	1969	1989	Pre-2003	-
0	**Margaret P. Mackimm**	Vice president of corporate affairs at Dart&Kraft Inc.	Audit Committee	1979	1995	Pre-2003	-
R	**Charles B. McCoy**		Finance committee	1961	1987	Died 1995	-
0	**Dean R. McKay**	Consultant at IBM	Audit Committee	1981	1992	Died 2005	-
1	**Constantine S. Nicandros**	Executive vice president, Du Pont	Executive committee	1983	1995	Died 1999	-
1	**Wilfred P. Schmoe**	Executive vice president, DuPont	Executive committee	1983	1987	Pre-2003	-
R	**Edward Shapiro**		-	1981	1987	Pre-2003	-

R	**Irving S. Shapiro**	Partner at Skadden, Arps, Slate, Meagher&Flom law firm	Finance committee, compensation committee	1970	1988	Died 2001	-
1	**H. Rodney Sharp III**	Manager at computer systems section, finance department of DuPont	-	1981	2006 (Part of DuPont Family)	2006	
1	**William G. Simeral**	Executive vice president, DuPont	Executive committee	1977	1987	Pre-2003 (Retired 1987; died 2009)	-
1	**Edgar S. Woolard Jr.**	Executive vice president, Du Pont	Executive committee	1982	2000 (was CEO till 1995)	Pre-2003 (Retired 2000)	-