NBER WORKING PAPER SERIES

IS POLLUTION VALUE-MAXIMIZING? THE DUPONT CASE

Roy Shapira
Luigi Zingales

Working Paper 23866
http://www.nber.org/papers/w23866

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
September 2017

We thank Asher Schechter for research assistance, John Matsusaka, Cary Coglianese and Effi Benmellech for very useful comments, and participants in conferences and seminars in University of Chicago Booth School of Business, University of Chicago Law School, the American Law and Economics Association, The Society of Environmental Law and Economics Scholars, European Law and Economics Association, Israeli Law and Economics Association, IDC, Case Western University, and Columbia University. Financial support from the Stigler Center at the University of Chicago is gratefully acknowledged. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

Is Pollution Value-Maximizing? The DuPont Case
Roy Shapira and Luigi Zingales
NBER Working Paper No. 23866
September 2017
JEL No. K32,L21,Q52

ABSTRACT

DuPont, one of the most respectable U.S. companies, caused environmental damage that ended up costing the company around a billion dollars. By using internal company documents disclosed in trials we rule out the possibilities that this bad outcome was due to ignorance, an unexpected realization, or a problem of bad governance. The documents rather suggest that the polluting was a rational decision: under reasonable probabilities of detection, polluting was ex-ante optimal from the company's perspective, even if the cost of preventing pollution was lower than the cost of the health damages produced. We then examine why different mechanisms of control – legal liability, regulation, and reputation – all failed to deter a behavior that was inefficient from a social point of view. One common reason for the failures of deterrence mechanisms is that the company controls most of the information and its release. We then sketch potential ways to mitigate this problem.

Roy Shapira
IDC
Kanfei Nesharim
Herzliya, 4610101
Israel
rshapira@sjd.law.harvard.edu

Luigi Zingales
Booth School of Business
The University of Chicago
5807 S. Woodlawn Avenue
Chicago, IL 60637
and NBER
luigi.zingales@ChicagoBooth.edu

In February 2017 DuPont settled a multi-district litigation to the tune of $670M (DuPont 2017). The litigation concerned DuPont's emissions of a toxic chemical named C8, which DuPont used in the making of Teflon® in its West Virginia plant. For these C8 emissions DuPont had already paid tens of millions in previous litigations and some of the biggest regulatory fines ever imposed in such matters. In all, C8 pollution is bound to become one of the costliest environmental debacles, for DuPont, the nearby communities, and the environment. The irony is that such a disaster was caused by one of the most respected American companies. DuPont has "a track record of long-term investment and better-than-typical treatment of constituencies other than stockholders," as Justice Strine (2017) put it, and is a known leader in toxicological and occupational safety research. How could the C8 debacle happen to such a good company? Did DuPont simply not know the potential health consequences of C8? Was it an accident? The consequence of a bad corporate governance system?

We use a trove of internal company documents disclosed in trials to trace back DuPont's decision processes in handling C8 emissions. The internal documents help us rule out the possibility of lack of awareness. In 1984 DuPont's executives sat for a key meeting in the company's headquarters in Delaware, and the minutes show a careful cost-benefit analysis. By 1984 DuPont knew that C8 is toxic, does not break down in the environment, accumulates in human blood, travels from pregnant mothers to their babies, and seeps into local drinking water supplies. The executives acknowledged that the legal and medical departments would recommend stopping the usage of C8 altogether. They also considered investments in abatement measures. Yet the business side ultimately overruled these recommendations and opted to continue (in fact, double) C8 emissions.

We then examine the possibility that continuing production was an efficient decision from a societal point of view. If the only choice was between continuing using C8 in the production of Teflon and stopping its use altogether, the answer is ambiguous. But the 1984 minutes contain a third option, namely, investing in incineration techniques that would have mitigated many of the damages caused to the community and the sanctions later paid by DuPont. Since the incineration option was relatively cheap,

the cost of preventing pollution was lower than the cost of the health damages produced. Thus, a simple cost-benefit analysis suggests that continuing production without any abatement was socially inefficient.

We also rule out the possibility that not investing in abatement was merely due to bad corporate governance. We construct a counterfactual, in which DuPont executives in 1984 seek to maximize shareholder returns, and have rational expectations, knowing just how costly the C8 debacle will end up being. Would they have decided differently and invest in abatement? The surprising answer is no. By comparing the present value of DuPont's actual legal liabilities with the present value of the abatement costs, we estimate that it was value-maximizing to pollute if the probability of getting caught was less than 19%. While subjective probabilities can never be proven right or wrong, the extreme set of coincidences that led to the current state of affairs suggests that it was very reasonable for DuPont's executives to take the risk. In other words, the decision to pollute was ex-ante optimal for DuPont's shareholders.

If the decision to pollute is not a product of incompetence or myopic fly-by-night companies, but rather a calculated, rational decision by a reputable company, perhaps socially harmful corporate behavior is more endemic and less solvable than we acknowledge. Are the dynamics in the DuPont-C8 case merely the exception, or can we identify some more fundamental, generalizable drivers of socially harmful decisions that go beyond a single case?

To help answer these questions we flesh out the ways in which the various mechanisms designed to deter excessive pollution failed in this case. We start with legal liability. Internal memos show that the possibility of paying large legal liabilities was considered in real time, at every key juncture. Yet, the threat of legal liability did not act as a sufficient deterrent. This is not because the company executives were expecting small fines (they were rather warned that C8 could turn into the company's "biggest tort issue"), but probably because they were counting on their ability to minimize the probability of having to pay damages, or at least to delay the damages by decades.

The threat of regulatory intervention was similarly discounted. DuPont had to know that the statutory framework left regulators at the mercy of chemical companies, since they did not have the

ability to monitor toxic emissions in real time. Even when regulators received alarming information, they do not seem to react promptly. When the regulators eventually fined DuPont for suppressing information, they touted a $16.5M settlement as the largest fine ever collected by them. Yet, the regulatory fine was merely a fraction of what the regulators were authorized to impose. It did not penalize the company for delaying the release of information. Nor was it sizable enough, given the societal costs or the company benefits, to effect change.

Finally, DuPont explicitly considered the prospect of losing reputation if news about how they handled C8 broke. Even this fear failed to deter pollution. One reason is the gap between organizational- and individual-level reputations: bad news about the company does not necessarily hurt individual managers. We show that none of the company's top decision-makers suffered reputational damages for the company's early handling of C8. In fact, some of them were hailed as environmental visionaries. Even from a corporate reputation perspective, bad information does not automatically translate into reputational sanctions. DuPont's executives could count on their ability to limit the certification, attribution, and diffusion of damning information, in ways that significantly reduced the reputational sanction suffered by the company.

The overarching theme across these failures of deterrence is the control of information. For decades only DuPont and other chemical companies knew the adverse effects of C8 emissions. Yet, DuPont had powerful incentives to hide that information, or selectively release parts of it to the outside world. By controlling information, DuPont was able to co-opt regulators, delay enforcement, and limit the ability of academics or journalists to chime in. Without breaking such information monopolies, it is difficult to see how problems like the C8 one can be resolved. We speculate what changes in regulation and in the information ecosystem would be necessary to make regulation more effective, and/or for shareholders' value maximization to coincide with social efficiency.

Our paper connects several strands of literature. First, we offer a new critical perspective on the theory of deterrence (Becker, 1968). We show that companies do not take expected sanctions as given, but dilute them and delay them (see also Gleaser and Shleifer, 2003). Second, our analysis of the

company's efforts to suppress and distort information relates to a relatively nascent literature on academic capture (Zingales, 2014), "bending science" and "manufacturing doubt" (McGarity & Wagner 2008; Oreskas & Conway 2010; Nestle 2015).

Finally, there exist various accounts of failures of the various deterrence mechanisms: tort law (Dewees & Trebilcock 1992), regulation (Shwartz & Soo 1996; King & Sutinen 2010), and reputational sanctions (Karpoff, 2012). Our account differs in at least two aspects. First, we focus on the joint failure of all these deterrence mechanisms. Second, we are able to document the actual decision-making process, as in the Ford-Pinto case several decades ago (Gioia 1992).

Section 1 introduces the background: how DuPont started using C8, and the dilemma it faced once it realized the potential risks that come with the chemical. Section 2 uses the internal documents revealed during trial to rule out three potential explanations for DuPont's behavior: ignorance, socially optimal pollution, and bad governance. Section 2 concludes that the decision to continue emitting C8 was rather a rational, shareholder-value-maximizing decision ex ante, albeit one with large negative externalities. Section 3 examines why the external systems of control – legal liability, reputation, and regulation – all failed to deter this socially harmful pollution. Section 4 fleshes out one overarching theme in the failure of systems of control: the ability of companies to reduce sanctions by controlling the information environment. Section 5 sketches some potential remedies to better align incentives. We then conclude.

1. Background: DuPont and the Use of C8

DuPont is one of the oldest American companies, continually operating since 1802 in Wilmington, Delaware. 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 2014). To this day DuPont is referred as "one of the most distinguished of any U.S. corporation" (George 2015), and scores highly on both environmental and corporate governance metrics. 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.

In the 1930s a DuPont scientist accidentally created a substance that would later be known as Teflon®, when experimenting with refrigerants (Lyons 1994). DuPont would go on to manufacture Teflon with the help of a chemical known as PFOA, or C8, used to smooth out lumps in the Teflon products. A combination of carbon and fluorine made C8 very stable to heat and repellent to water, and thus great for industry. But it also made the chemical potentially very dangerous to the environment and humans, as it is extremely persistent in the environment and accumulative in human blood.

From 1951 to 2000 DuPont received C8 from a supplier (the Minnesota Mining & Manufacturing Company, later renamed 3M). They handled the material in their Washington Works plant, which is 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 (cf. Paustenbach et al. 2007 (detailing the amounts of emissions); Vieira et al. 2013 (detailing the geography of emissions)). C8 emission came in three forms: poured from the 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).

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 Tennants approached the company and then the local regulators, who brushed the farmers off. The Tennants were told that their cattle were dying because they simply did not take good care of them (Rich 2016a). The Tennants were not aware of C8 and its effects at the time; in fact few outside the 3M and DuPont labs were. As long-time farmers they only knew that something was wrong, and so they got a lawyer and sued. Little did they know that their individual lawsuit (hereinafter: The Tennant Litigation) was about to spotlight a much bigger story. The discovery process in the Tennant Litigation and subsequent trials unearthed a large amount of alarming information about C8's effects on health and the environment, which was known to DuPont but had been kept from public scrutiny. The

discovery process also provided a unique glimpse into the inner workings of a large company like DuPont.

Importantly, the information revealed during the Tennant Litigation led to a separate class action against DuPont, for contaminating the nearby area's drinking water (hereinafter: the Class Action) (Young 2016). As part of settling the 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 Probable Links Report 2012). Some 3,500 of the 70,000 individuals drinking the contaminated water were diagnosed as suffering from the enumerated diseases.[1]

By 2013 DuPont had stopped using C8, replacing 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 (Lerner 2016a).[2]

Our focus is on decisions DuPont made, starting in the mid-1980s, to keep using C8 even in the face of alarming information they got about the potential consequences of C8 emissions. Among the papers emerging from trial discovery is a long memo about a meeting that took place at the company's headquarters in May 1984 (the concluding page is reported in Figure 1). The 1984 memo allows us to deduce the several options that were on the table: stopping using C8 altogether; continuing using C8 but investing in abating measures; reducing production; and continuing using C8 (in fact doubling the production), while monitoring as before without investing in abatement measures. DuPont chose the latter option: to continue production with no investment in abatement. The fundamental question is why. In retrospect, we know that the option of abating C8 was relatively cheap, and could have prevented many of

[1] 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.

[2] Lerner (2015 and 2016) is the main public source that reports the court documents, thus we quote her rather than the court documents, but we checked the original sources.

the damages to the community as well as the legal and reputational damages paid by DuPont. How come the company chose the option that seems worse for society and for the company itself?

2. Why DuPont Opted to Keep Emitting C8

We start with three potential explanations for DuPont's behavior. First, *ignorance*: the possibility that DuPont simply did not know that emitting C8 would end up damaging the community and greatly costing DuPont. Second, *social optimum*: the possibility that the benefits from continuing using C8 and having smooth non-stick pans exceeded the human health costs of pollution. Third, *bad governance*: the possibility that the decision to continue using C8 was bad for the company but good for individual decision-makers – the doing of myopic decision-makers. The internal documents revealed during trials allow us to trace back the state of knowledge and conduct a cost-benefit analysis, thereby ruling out all three potential explanations. DuPont's decision, it seems, was a case of "rational wrongdoing": a decision that maximizes shareholder value ex ante, even though it is socially inefficient.

2.1 Ignorance?

The internal documents revealed during trial allow us to rule out the possibility of ignorance. By 1984 DuPont had already accumulated a lot of alarming information about C8. By the early 1960s the company became aware that C8 is *toxic* and should be "handled with extreme care" (sources appendix, item 1). During the 1960s and 1970s they received indications that exposure to C8 causes *adverse health effects in animals* (sources appendix, item 2). By the early 1980s they received indications that the substance is *bio-accumulative*, meaning it accumulates in human blood, building up and remaining in the human body for years; and *bio-persistent*, meaning it does not break down in the environment (sources appendix, item 5).

In 1981 DuPont further learned that C8 may travel from pregnant mothers to their babies and cause *birth defects in humans*. At first 3M notified DuPont of a study where rat fetuses whose mothers were exposed to C8 developed eye defects (Figure 3).This memo, called Karrh Memo from the doctor who wrote it, was addressed to Carl De Martino, "group vice president" and head of the business unit producing Teflon.

DuPont sent scientists to review the 3M study, and concluded that it was valid (sources appendix, item 3). The company immediately proceeded to monitor the babies of its female workers who worked with C8 and were pregnant in the relevant time frame. They found detectable C8 levels in the umbilical cord blood, indicating that C8 can indeed travel through the human placenta. Furthermore, 2 of the 7 monitored babies were born with birth defects in their eyes and nostrils (EPA 2005; see also Figure 4).[3] DuPont decided to transfer 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 (sources appendix, item 4). The company did not, however, alert the regulator or the nearby community to the new findings.

The impetus for the 1984 meeting came when DuPont sent employees to quietly sample drinking water in nearby communities: tap water in one employee's home, public water fountains in a gas station, and so forth. Several samples came back with detectable levels of C8 (EPA 2005; see also Figure 2). Against this background the company called a top-level meeting at its headquarters in Wilmington, Delaware, in May 1984, to discuss how to proceed with C8 (sources appendix, item 6; Figure 1). At that point, then, the executives making the decision had evidence that the company emitted a potentially dangerous substance into community drinking waters.

Documents from after May 1984 complete the picture and help us further rule out ignorance. Alarming information about C8 continued coming to DuPont executives' attention. By 1986 at the latest they became aware that the plant's methods of handling C8 were inappropriate, as their provider (3M) explicitly warned them that C8 should either be incinerated or dumped in a commercial landfill (sources appendix, item 7). DuPont did neither. Then starting in 1988 DuPont learned that C8 is an animal carcinogen and a potential human carcinogen (sources appendix, item 9). The company indeed initially upgraded its internal classification of C8 accordingly. In the late 1980s and early 1990s DuPont set a threshold for C8 presence in drinking water of 1 part per billion (ppb). It then detected C8 levels above

[3] 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.

this threshold in several samples (EPA 2005; sources appendix, items 10–11). Here too, they opted to continue using C8, while not alerting the outside world.

To be sure, the 1984 minutes and other documents we reviewed do *not* necessarily support a story of a company making conscious decisions to harm individuals. There seems to be a lot of uncertainties regarding the exact effects of C8, or what would be a safe-enough level of exposure.[4] Yet it should be noted that in May 1984 DuPont already suspected that C8 is a substance that is accumulative and persistent. As a result, DuPont had to suspect that even exposure to very low doses could end up creating adverse health effects, since the substance does not break down in the environment and builds up in human blood over time.[5] In other words, the documents support a story of a company opting to err on the side of ignoring warning signs.

Moreover, DuPont's treatment of its own employees indicates just how much they were aware of the risks involved. As mentioned, DuPont initially pulled all female employees of child-bearing age from the C8 unit once they had suspicions, and throughout the years they continued monitoring employees (Bartlett transcripts, Vol. 4, p. 162). The 1984 memo contains explicit discussion of acceptable exposure levels (AEL) for employees, and an assurance that current levels were safe. Yet nowhere in the memo do we find *community* exposure guidelines (CEG). Nor do we find any indication that the current community exposure was at safe levels.

Furthermore, while the internal documents provide little evidence of DuPont's executives explicitly acknowledging that C8 would harm nearby communities, they provide ample evidence of DuPont's executives being warned that the C8 decisions could come back to haunt the company itself with great legal and reputational liabilities. The 1984 memo states very clearly that the "legal and medical [departments] will most likely take a position of total elimination," but this position is dismissed as "they

[4] Similarly, it should be noted that even the plaintiff's expert did not fault DuPont for setting the CEG at 1 ppb. The arguments against DuPont were rather directed at not alerting the outside world once they found C8 levels above their own threshold (Bartlett transcripts, Vol. 4, pp. 40, 94).

[5] Cf. EPA 2005, describing how the Environmental Protection Agency (EPA) published in 1978 clarifications regarding the relevant reporting requirements, which put special emphasis on persistent and accumulative chemicals; Swanson et al. 1997, voicing the scientific approach, according to which persistent and accumulative chemicals are perennial red flags.

have no incentive to take any other position." The memo further acknowledges that the "issue deciding further action is one of corporate image and of corporate liability." Post-1984 documents corroborate the notion of the executives' awareness. In 1986 an internal letter suggests that the "Wilmington management" was very concerned with the potential liabilities arising from C8 (sources appendix, item 8). In 1992 another internal letter suggests that C8 may turn into DuPont's "biggest tort issue" (sources appendix, item 12; Bartlett transcripts, Vol. 4, p. 90). In a private email from 2000, reported as Figure 5, DuPont's in-house lawyer admits that DuPont's story of handling C8 is "not a good one" (Bartlett transcripts, Vol. 4, p. 96).

2.2 Socially Optimal?

The most benign explanation for continuing to use C8 would be that production of C8 was socially optimal. [6] Pollution comes with costs – but the optimal level of pollution is not zero. One should also consider, among other things, the benefits from using the chemical, such as a better cooking experience. To estimate whether this was the case at the time, we derive the costs and benefits as of 1984.

2.2.1 The Societal Benefits of Using C8

DuPont's executives estimated that replacing or stopping using C8 altogether would have jeopardized between $100M and $200M 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%), and add a risk premium of 8% (thus assuming a beta of 1), for a discount rate of 17.1%. We assume that the profits will grow at the expected rate of inflation (at the time 4.2%). With these assumptions, the present value of profits is between $760 and $1500 million.

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.[7] While it is unlikely that consumer surplus is zero,

[6] The DuPont-C8 case is unlike cases such as cigarette smokers versus big tobacco. With cigarettes, one line of argument was that the smokers made an informed tradeoff: they knew that smoking is bad for them, but engaged in it anyhow. In the C8 case, the harmed individuals living nearby DuPont's plant did not know or make an informed decision to drink C8 from their tap water.

conservatively we are going to set the societal benefit of C8 use at the level of DuPont's profits from the product – around $1.1bl. As we will discuss shortly, this underestimation does not affect our main conclusion.

2.2.2 The Societal Costs of Using C8

We narrow our measure of societal costs to human health costs, ignoring damages to the environment. We further narrow our scope to the six water districts near the West Virginia plant. This gives us a group of 70,000 people, who lived in an area with relative high exposure to C8 emissions. When quantifying the human health costs for these 70,000 people, we consider only costs associated with the specific six 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 (C-8 Medical Monitoring Program 2012).[8]

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 (C-8 Medical Monitoring Program 2012).

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 – the above-mentioned 1984–2013 period.

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 turns to be a fuzzy, challenging endeavor (see generally Dolan 2000; Rowen & Brazier 2011). For cancer cases, we subsume the reduction in the

[7] 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.

[8] For incidence and prevalence rates of the enumerated diseases, see also Kappelman et al. 2013; National Center for Health Statistics 2015; Vanderpump 2011; National Cancer Institute 2016.

quality of human life into the value of a lost life.[9] The estimates of the value of statistical life (VSL) vary greatly. The EPA set VSL in 2009 at $9.1M (Appelbaum 2011). An earlier meta-analysis of the VSL literature in the U.S. generates a median of around $7M (Viscusi & Aldi 2003). To be conservative we use the latter.

In 1984 terms, the present value of societal costs generated by the continuing use of C8 is around $350M (see Appendix A and Table 1).

2.2.3 Costs of Reducing C8 Pollution

The 1984 meeting included a discussion of the possibility of continuing using C8, while limiting the costs imposed on society by adopting precautionary measures that reduce emissions. The memo specifically reports the estimates of the cost of incinerating C8. Incineration would imply an up-front cost of $1M and an operating cost of roughly $1M a year (exhibit 1). In 1984 present-value terms – investment in incineration would be equal to $18.8M (see Appendix A).

[9] For studies measuring the costs of the enumerated diseases see, e.g., Cohen et al. (2010); Pourat et al. (2013); Medical Expenditure Panel Survey (2014).

DuPont decided against incineration. In a 2017 trial – the last trial before settlement – DuPont raised a new claim, namely, that the decision not to incinerate was actually meant to reduce risks to the environment and the community. According to DuPont's argument, incineration runs the risk of releasing a different toxic chemical into the air. The claim did not prove successful in court, however, as company documents showed that in real time cost saving was mentioned as a reason for rejecting incineration. Internal documents also included detailed plans to design the incineration facility in ways that prevent the alleged release of new toxic chemicals. Finally, testimonies of DuPont's own executives suggest that incineration would have been the best option to limit the societal costs of C8 pollution (Bartlett transcripts, Vol. 7, pp. 163–173; Vigneron transcripts).

2.2.3 Cost Benefit Analysis

If the choice is between producing and not producing, producing seems to dominate from an aggregate welfare perspective, since the present value of the benefit is $1.1bl, while the present value of the cost is only $350 million. This conclusion depends on several 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 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. 2016 (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. There are wide standard errors around each number, but given the differences in scale, one can crudely assume that producing is the optimal choice.

Yet, such debate becomes irrelevant once the option to contain pollution is considered. Here it is very clear that the abatement option vastly dominates the other two. Assuming that the incineration program eliminates much of the pollution (Bartlett transcripts, Vol. 7, pp. 163–173), the societal cost of abatement (less than $19 million) is greatly inferior to the human health costs of pollution (at least $350

million). Since the abatement costs are also greatly inferior to the benefits of production, from a societal perspective the efficient course of action is to keep producing C8, with the prescribed abatement process.

2.3 Bad Governance?

Assume that a shareholder-wealth-maximizing manager with rational expectations is faced with the 1984 decision.[10] Would she opt to stop using C8, continue using without abating, or continue using while investing in incineration techniques? 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. The expected sanction, in turn, is a function of the probability of getting caught and the magnitude of 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 because its stakeholders will think less highly of it. 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 computed the benefits of producing Teflon at $1.1B, and the benefits of avoiding investment in abatement at $19M. All these benefits accrue directly to the shareholders. We now move to calculate the legal liability in case of detection. Since DuPont was detected, we use the actual costs incurred (on the use of lagged actual sanctions for polluting as a proxy for perceptions of expected sanctions see Gray & Shimshack 2011).

[10] 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.

2.3.1 Legal Liability

To quantify the sanctions imposed on DuPont we simply count the various publicized regulatory fines and damages paid along the timeline, and then discount them to their 1984 values.

The first sanction came in 1997, when the West Virginia regulator slapped DuPont on the wrist for damaging the Tennants' land and animals, to the tune of $200k (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 $107M (Janofsky 2005), while agreeing to finance an epidemiological study and medical monitoring valued at around $350M (Young 2016). In 2005 the company settled the enforcement action the U.S. regulator brought against it for failing to disclose alarming information, for $16.5M (EPA 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 $670M. DuPont reached the settlement after losing the first bellwether cases: the court ordered DuPont to pay $1.6M for a breast cancer case (Bartlett v. DuPont 2015); $5.6M for a testicular-cancer (Freeman v. DuPont 2016); and $12.5M for another testicular-cancer case (Vigneron v. DuPont 2016).

Assuming that the magnitude of legal sanctions are not correlated with the economy, we can discount them at the 1984 risk-free rate (9.8%). This puts the 1984 value of future legal fees at around $100M.[11]

2.3.2 Break-Even Probability

Let us temporarily set the reputational costs to zero. Then, we can easily infer what probability of detection makes a DuPont shareholder indifferent between producing and abstaining. Given the numbers computed in the previous sections, if the only choice is between producing and not producing, shareholders will find it optimal to produce and pollute. In fact, if they produce and pollute they expect to

[11] Jurors who assign punitive damages focus on the defendants' ability to pay (Vigneron transcripts, vol. 25), thus the magnitude of legal sanctions is likely to 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.

receive $1.1B in profits and if caught they will have to pay fines that (at present value) are only $100M. So, even if eventually they are caught, they are happy to do it, as long as this event is sufficiently distant in the future. Remember that the first detection was in 1997 and as of early 2017 the bulk of money has still not been paid. Thus, DuPont's shareholders greatly benefitted from the ability of the company to delay damages payments.

A similar calculation can be made for the probability of detection that makes a DuPont shareholder indifferent between abating the C8 through incineration and not doing so. Given the numbers computed in the previous sections, shareholders will find it optimal not to spend the money to incinerate C8 if the probability of detection is less than 19%.

The next sub-section provides several clues to suggest that a shareholder-wealth-maximizing manager in 1984 had all the reasons in the world to perceive the probability of detection as way below 19%.

2.3.3 The Ex-Ante Probability of Detection

It took a rare combination of low-probability events for DuPont to be forced to pay legal liability the way it did. While it is impossible for us to come up with a precise probability for each of these events, each of them is fairly unlikely. Since several of them are mostly independent, the compounding of these probabilities easily leads to an ex-ante probability of detection below 19%. After all, the joint probability of four equally likely events is 6.25% and the compound probability of three events with a probability of 40% each is 6.4%.

The first low-probability event we wish to highlight is the fact that plaintiffs were represented by a defendant-side lawyer, named Robert Bilott. Typical plaintiff lawyers tend to have a high discount rate. They are relatively less well funded, and prefer to spread their risks over several cases rather than heavily invest in one case, if only because they do not bill by the hour. As a result, typical plaintiff lawyers prefer to settle quickly, rather than draw out a long battle, like Bilott did in the DuPont-C8 case. Most cases of this ilk would have been over after the first settlement in the Tennant litigation, back in 2001. The only reason the Tennants were able to land a top environmental lawyer like Robert Bilott, who worked for a

big law firm (Taft, Stettinius, & Hollister LLP) representing the industry, was a family connection. As a kid Robert Bilott used to spend the summers at his grandmother's, who lived close to and had mutual friends with the Tennants. Bilott initially accepted the job just out of deference to this old friendship (Rich 2016a; Blake 2015). Bilott's unique background and makeup also made him able to identify a needle in a haystack: a reference (out of thousands of documents) to a then-opaque C8 chemical.

Bilott's ability, however, would not have been so useful if there had not been some mistakes on the part of the defendants. Even though DuPont's lawyers held workshops inside the company on how to avoid creating a paper trail regarding C8 effects (Lerner 2015a), the discovery process yielded numerous internal memos documenting the extent of the problem caused by C8 as well as emails documenting the systematic suppression of information. The first batch of documents was probably revealed because the DuPont legal department had not yet centralized the collection and storage of documents, and so the plant's lawyer did not fully appreciate the importance of the documents. These were the documents that attracted Bilott's attention and allowed him to pursue the case. A second batch of emails were probably transmitted because in the early days of laptops and hand-held devices, legal counselors did not understand that even personal emails sent from their blackberries or company laptops would be stored on the company's server and become discoverable (cf. Lerner 2015b).

The third low-probability event (albeit some may attribute it to Bilott's talent) is that the class action was filed in West Virginia, one of the few states where courts accept a medical monitoring claim. The medical monitoring doctrine allows plaintiffs to continue with a class action simply by showing that a group was exposed to a chemical that puts the group at risk, without proving actual physical harm. To understand just how much the doctrine contributed to the way the DuPont-C8 case unfolded, one can simply look at the equivalent 3M-C8 case. 3M were DuPont's providers, and one could claim they were in as much trouble as DuPont in terms of how they handled C8. Yet 3M's lawsuit was handled in Minnesota, whose courts do not accept medical monitoring claims. As a result, the 3M lawsuit did not make it to full trial. Unlike DuPont, 3M was not forced to pay damages in courts, nor was it exposed so extensively in the media (Lerner 2016b).

The fourth event (although here as well Bilott's talent may have played a role) came after a settlement was reached in the class action. In our case DuPont agreed to a settlement whereby it accepted the conclusions of an appointed science panel regarding linkage between C8 emissions and diseases. Presumably, DuPont agreed to give away some of its ability to question findings, because it was well aware that there was no preexisting hard evidence the scientists could rely upon, as epidemiological studies of such scale are extremely hard to execute properly.[12] Yet in our case the plaintiffs' lawyers employed another innovative strategy: instead of using the $70M that was put aside in the settlement for health monitoring to cut small checks to the group members, they invested the money in incentivizing 70,000 affected people to participate in the study (drawing blood, interviewing, and so forth), by offering $400 to each participant (Blake 2015; Lerner 2015b). This unique strategy led to an unprecedented large-scale human study. The study was then analyzed by the independent science panel, which established the links between DuPont's C8 emissions and the six above-mentioned diseases.[13]

The combined probability of all four above-mentioned events alone is likely below 19%. In fact, the likelihood of the first event – landing an experienced defendant lawyer to try your case – is in itself an event with a probability of less than 19%.

Another indication that the probability of detection must have been low ex ante comes from actual data. When in 1991 the EPA announced a limited "amnesty period" whereby chemical companies could report retroactively on risks without incurring full sanctions, 11,000 reports came from the industry. It was four times more than all the reports submitted in the 15 years prior to the amnesty period combined (Coglianese et al. 2004, 310; McGarity & Wagner 2008, 119). So, we can safely say that there had been chronic under-reporting (and under-detection and enforcement) at the time the decision was taken. Indeed, the U.S. Government Accountability Office and the Office of Management and Budget have both

[12] To be sure, the company could claim that such decision shows their (misguided) confidence that they did nothing wrong.

[13] Such legal innovations were not lost on legal scholars, who now recommend adopting them in other cases as well (e.g., Wagner 2010, 1327-1328; Young 2016). With an independent science panel, the idea is to level the playing field, whereas normally the determination of health effects of opaque chemicals is left to judges or jurors, who lack the needed expertise and information.

assessed the EPA's ability to monitor chemicals as limited (Wagner 1997; Gray & Shimshack 2011). DuPont's executives must have anticipated that most alarming information goes unreported, without meaningful repercussions.

In all, a monetary calculation of costs and benefits suggests that even a shareholder-value-minded manager would have chosen to pollute from an ex-ante perspective. We cannot attribute the decision to bad governance.

All indications therefore point to another possibility: producing 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 external systems of control – legal liability, regulation, and reputational concerns – did not kick in to deter such behavior.

3. Why Liability, Regulation, and Reputation Did not Stop DuPont from Emitting C8

3.1 Liability

3.1.1 Time Lag

At first sight, DuPont's C8 case appears the poster child for the working of the tort system. A private plaintiff uncovered the problem, holding DuPont accountable to the tune of hundreds of millions of dollars. In fact, we show that even the sizable ex-post fines imposed in this case are insufficient to deter pollution ex ante. The reason is the time lag and the time-value of money. DuPont paid the bulk of its liability in 2017, more than thirty years after the facts. Remember: DuPont's documents from the 1980s and 1990s contain warnings that C8 emissions may eventually end up costing the company sizable tort damages. DuPont's executives were apparently counting on the "eventually" to come several decades later – and they were right.

One could argue that if a low probability of detection makes the fine ineffective, we could simply raise the magnitude of the sanction. While proposals to raise the severity of sanctions should be taken seriously, they are hardly a panacea. The corporate deterrence literature has already discussed at length several limitations of such proposals (e.g., Polinsky & Shavell 1979). Furthermore, as the DuPont case

illustrates, the jurors who assign punitive damages focus on the defendants' ability to pay, not the amount that would have generated deterrence (Vigneron transcripts, vol. 25). More importantly, the optimal sanction is a function of the probability of detection and of enforcement, but these probabilities are affected by the magnitude of the sanction: raising the sanction may end up incentivizing avoidance and distortive efforts on the part of the companies even more (Glaeser & Shleifer 2003). Thus, it is important to study how in equilibrium these probabilities are influenced by corporate decisions.

3.1.2 Path Dependency

When DuPont made the 1984 decision, the company had already released large quantities of C8 into the environment in the preceding decades. On paper, the liability for past damages is sunk and therefore should not affect the decision to continue production after 1984. Indeed, the 1984 memo explicitly defines liability as "the incremental liability from this point on if we do nothing." In reality, past liability could affect future decisions by removing the benefit of secrecy. A major initiative to contain the environmental damages of C8 could alert the public to the potential dangers of C8, increasing DuPont's chances of being punished for past pollution (cf. Graham 1991 (discussing the possibility that design improvements may be used against the company as admission of past wrongdoing)).

The existing liability regime may therefore help some victims ex post, but as currently designed it creates bad incentives ex ante. Companies face incentives to suppress potentially damaging information, so as to keep the plaintiff lawyers away. As legal scholars have noted elsewhere, companies that report early suspicions get very little reward and a lot of risk (McGarity & Wagner 2008).

3.2 Regulation

3.2.1 Regulatory Framework: : Difficulties in Extracting Information

Some of the delay in detecting C8 issues is due to the regulatory framework that was in place. The Toxic Substances Control Act (TSCA) was enacted in 1976, when C8 was already in use. As a result, C8 was grandfathered by TSCA along with tens of thousands of other chemicals. Grandfathered chemicals were presumed safe until proven otherwise, and TSCA limited the regulator's ability to probe into these

chemicals. In effect, for a chemical to be proven other than safe adverse information would have to come from the chemical producers themselves (U.S. Government Accountability Office Report 2000).[14]

Chemical producers face strong incentives to err on the side of under-reporting, and the regulatory framework – designed in part by the industry itself – did not help. For example, Section 8(e) of TSCA required manufacturers to 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 takes decades until enough hard evidence builds and the case for substantial risk is clear-cut, chemical producers had an easy way out. Another legal mechanism to prevent/delay detection was to meet the TSCA reporting requirements only nominally, as in reporting about substantial risk but using a trade-secret claim to disguise basic details such as the name of the chemical itself (McGarity & Wagner 2008).

3.2.2 Bad Enforcement: Soft Capture

Even when alarming information is detected and reaches regulators, companies can still fight back and erode the enforcement actions. In the 1990s, when the Tennants started voicing concern, the local West Virginia regulators were slow to hold DuPont accountable (Lerner 2015b). We later learned that the West Virginia environmental agency director, who signed the initial consent agreement with DuPont, joined the consulting company that got paid by DuPont to implement the agreement (Lerner 2015c). And three attorneys handling C8 issues for DuPont became regulators of C8 in the West Virginia environmental protection agency (Lyons 2007). Then in the 2000s, after the Tennant lawsuit flushed out the C8 debacle and got the federal regulator involved, DuPont assembled a team to handle communications with the federal regulator, and recruited Michael McCabe, who was up until 2001 the U.S. EPA's deputy administrator, and then his EPA successor – Linda Fisher.

To emphasize: companies can erode regulatory enforcement even without suitcases with unmarked dollar bills exchanging hands. The U.S. EPA failed to stop C8 pollution in time not necessarily because of explicit or implicit bribes, but rather because of fuzzier notions such as conflict avoidance

[14] Unless a material is considered unsafe to begin with and is regulated, the regulator cannot conduct independent tests and regulate it.

(Joskow 1974), information overload (Wagner 2010), and asymmetric monitoring (Levear 2009). Notably, federal regulators were spurred to intervene only by episodes of national media coverage (as happened, for example, around 2015 when the Flint, Michigan debacle turned public attention to the inept regulation of pollution).

There is a broader point here. Regulators face high levels of uncertainty and complexity when asked to regulate opaque chemicals. As a result, they tend to err on the side of doing nothing or on the side of the industry. Doing nothing makes sense when mistakes against the industry are more likely to be spotlighted than mistakes against the public (cf. Leaver 2009). The DuPont case therefore pokes holes in the conventional wisdom in political science, according to which environmental regulation is an area that is relatively less susceptible for capture by industry (Wilson 1976).[15]

3.3 Reputation

3.3.1 Individual Reputational Concerns

Managers are supposedly disciplined by the threat of damage to their labor-market reputation. In Fama (1980), for example, market participants take a bad news about a company as a signal that the quality of the company's managers is low and they revised downward the managers expected contributions and, thus, their wages. The DuPont case fleshes out one condition under which Fama's settling-up process is less likely to work: a big time lag between the moment a decision is made and the moment information about the decision becomes public. To illustrate, consider DuPont's executives back in 1984.

Several executives signed the memos and minutes from the 1984 meeting. To identify possible reputational costs we looked for articles on the Lexis News and Proquest databases during the 1984–2015 period mentioning the names of these executives along with terms associated with the C8 debacle, such as "PFOA," "C8," "carcinogenic," "Washington Works," and "Teflon." We did not find indications of their names getting dragged through the mud (see Table 2).[16] That should not surprise us, as almost two

[15] The reason they cite is increased public saliency and more policy entrepreneurs, which in turn balance the inherent advantages of special interest groups (compare Wilson 1976 with Olson 1965). What the conventional wisdom misses is problems with information flows.

[16] There was one exception: one of the DuPont's executives signing some of the above-cited memos was Bruce

decades have passed between the decision (1984) and the time that mainline media started seriously scrutinizing the C8 debacle (2003). By that time, the DuPont executives who were mentioned and reached out to for response were those who had replaced the 1980s decision-makers.

We went beyond the named executives and also examined all DuPont's 1984 directors. The corporate governance literature usually focuses on directors as the target for reputational sanctions. After all, the board is more exposed than lower-level executives, and directors have incentives to monitor corporate behavior so as to prevent bad news about the company from being attributed to them. From DuPont's 1984 proxy statement we learn that DuPont's board back then was composed of 29 members. In Table 2 we compile a list of all directors and their post-DuPont careers. The table shows that by the time serious media attention was directed at the C8 debacle (2003), 19 of the 29 directors had already died or retired not only from DuPont's board, but also from any other professional activity. When bad news broke, labor-market reputation had therefore already stopped being a concern of most of the directors.

Even for the 10 directors still engaged in some professional activity in 2003, labor-market reputation was not likely to be a large concern. This is because the media had not associated and attributed the C8 debacle to them.[17] We ran the same media search on directors, and here too found no indications of directors' names getting dragged through the mud. To the contrary, we found some articles celebrating these executives as environmental visionaries. For example, Ricard Heckert – CEO between 1986 and 1989 – was remembered in a *Wall Street Journal* obituary as the one 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)

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.

[17] The name of Richard Heckert, former director and then CEO of DuPont, was mentioned in an online article of Alternet.org on PFOA in January 2016, after his death. His name was mentioned indirectly, however, in the context of telling the reader how TSCA rules were designed by the industry lobby itself in the 1970s under Heckert's leadership.

The upshot is that managers at DuPont interested only in their monetary payoff would have rationally chosen to pollute even if they had perfect foresight about future events. For these managers, dropping C8 or investing in abatement would have come with some immediate, clear costs in terms of reduced income. In theory, the managers could have weighed the benefits from maintaining a good reputation against these costs. In reality, given the time lag and difficulty to attribute problems to specific individuals, the need to maintain good reputation probably did not feature prominently in decision-makers' considerations.[18]

3.3.2 Corporate Reputational Concerns

The economic literature assumes a straightforward process whereby the need to maintain a good reputation disciplines corporate behavior. Whenever bad news breaks, the argument goes, company stakeholders downgrade their willingness to do business with the company, and as a result the company's bottom line suffers. But in order to understand why the threat of reputational sanctions did not work in DuPont's case, we need to introduce some nuance. Bad information does not automatically translate to reputational damages. The information has to go through a process of certification, attribution, and diffusion. It has to be certified as credible in order for stakeholders to update their beliefs based on it. It has to be attributed to deep-seated flaws that are likely to reoccur in the future in order for stakeholders to act on it. And it has to be widely diffused to a critical mass of stakeholders in order for the company to truly feel it.[19] In cases such as ours, however, large companies can minimize diffusion, certification, and attribution – thereby effectively reducing the expected reputational sanction.

[18] Thus far our analysis has focused on DuPont's 1984 decision-makers. The dynamics change when considering decision-makers in the 2000s, when news about C8 started to break. May 2000 in particular is a watershed, because DuPont's C8 provider – 3M – publically announced then that they would stop produce the material, citing concerns. DuPont responded by doubling down on C8, building a plant to manufacture C8 on their own. DuPont's then-current decision makers, and in particular its CEO – Chad Holliday – were frequently mentioned and reached out to for response in media coverage during that time. Holliday had a strong preexisting reputation of being a "green" CEO (e.g., Holliday 2001), and he stood firmly behind DuPont's C8 decisions. Anecdotal evidence suggests that Holliday's strong CSR reputation did not suffer from his involvement with the C8 issue: after stepping down from his position at DuPont in 2009, Holliday kept receiving environmental accolades, and was appointed chairman of the board at Bank of America and Shell, specifically citing his commitment to green conscience (BBC 2014).

[19] Cf. Hoffman & Ocasio 2001 (the chemical industry increases its responsiveness as a function of media coverage).

Consider *diffusion* first. When dealing with large firms, diffusion of information can happen only through intermediaries such as mass media (cf. Mahon 2002). Yet in our case, both local and national media were very slow to hold DuPont accountable for C8.

On the one hand, local journalists are closer to information sources and have stronger incentives to rectify wrongdoing that hurts the community they are a part of. 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. Furthermore, scrutinizing the biggest employer in town ran the risk of upsetting their Parkersburg readers. It is no wonder that the few victims who came forward reported that when they tried to enlist the help of local journalists they were turned down because no journalist wanted to touch the issue (Lerner 2015a). Even after the bad news broke nationally, the Parkersburg-area media seemed to shy away from holding DuPont accountable (Rich 2016a; Rich 2016b). The few reporters who did go after the C8 debacle aggressively were either not part of an established media outlet, or reputable reporters from outside the Parkersburg area.

National media, by contrast, are less dependent on a single company for information and advertising revenues (Dyck et al.; 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. In the DuPont case, periods of national media attention to C8 were few and far between: a surge around 2003, and another one starting in late 2015. Why then? It seems that two conditions have to materialize before we get wide diffusion of information: someone needs to feed national media reporters with credible information, and someone needs to convince national reporters that the information is newsworthy. In 2003 and 2015 alike, existing litigation provided reporters with *information subsidies* – feeding them with credible, readymade, shielded-from-liability quotes and documents. And in both points there existed strong NGO activity, convincing the media that the C8 story had national implications (cf. Wagner et al. 2011 (providing systematic evidence of the link between

public interest groups' activity and media attention to environmental issues)). National media is good at spotlighting an already existing smoking gun; but it cannot be counted on to reveal the smoking gun, or to stick with a story over the long run.

Next consider *certification*. Since the 1970s there were data on C8 that warranted further research. Nevertheless, relatively few academic studies about C8 were published until 2008 (Grandjean & Clapp 2015). One reason for this delay is straightforward. In-house scientists, who have access to data on chemicals that their companies produce, have little interest in producing research that might jeopardize the commercial viability of those products. Outside experts, who can be more independent, do not have access to the data about opaque chemicals.

Other reasons for the delay are of a fuzzier nature, such as potential pressures on those who try to publish research that can hurt industry interests. In 2004, Dr. James Dahlgren and a group of coauthors attempted to publish a paper on the adverse effects of C8.[20] It was one of the first studies to examine the effects on community members rather than on employees. The authors claimed to have found that exposure to C8 increases risks of various types of cancer. 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. Dahlgren maintains that when he presented a draft of his findings in a 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.

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. When we talked with other contributing editors of the journal at the time, all they could relay was that the editor who accepted the paper was known to be open to critical papers that challenged industry interests. The effects of retracting an already accepted paper,

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

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 the findings (Bartlett transcripts, vol. 5, p. 125; cf. McGarity & Wagner 2008, 140).

Another DuPont-related 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).

To be sure, it seems unlikely that companies can capture the whole academic process. Our claim is a more modest one: experts face incentives to stay away from research that goes against strong economic interests. The upshot is fewer chances to get credible damning information on corporate behavior.

A third factor in diluting reputational sanctions comes from large companies' ability to affect *attribution* – that is, to disassociate the company from the wrongdoing. In July 2015, just as legal sanctions were about to come down, DuPont was pressured by an activist investor to spin off its Performance Chemicals unit that dealt with C8 to a new company named Chemours. DuPont spun off not just its chemical assets but also its chemical liabilities. The spinoff raised questions regarding the ability of 3,500 plaintiffs to collect damages from the new company, which had shallower pockets than DuPont (Mordock 2016b). Yet, it was unlikely that DuPont could avoid legal sanctions by spinning off liabilities. Indeed, Judge Sargus, who presided over the litigation, ordered DuPont to clarify who would pay what (News & Sentinel 2016). An understudied question, which remains open even after the conclusion of litigation, is how the spinoff affects DuPont's *reputational* liability. A cursory look at DuPont's media strategy since the spinoff suggests that the company tries to disassociate itself from the C8 debacle. DuPont is constantly referring any media inquiry on the issue to Chemours, refusing to comment further, while pointing out that it is not DuPont's business any longer.

Shortly after the spinoff, DuPont announced its intentions to merge with Dow Chemicals and break up the merged company into smaller divisions. As a first step, DuPont would lose its distinctive name. As a second intended step, the merged company is to be broken into three separate and rebranded entities. Changing names and passing responsibility to a separate company may serve to distance DuPont from the C8 debacle. A nascent literature suggests that it is possible, even plausible, that such changes will allow DuPont eventually to reduce the associations that stakeholders make between DuPont's offspring and the C8 debacle (cf. Lei et al. 2008, 121).

Yet another way for companies to manage attributions is by investing in projecting a good image. 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 et al 2010, 87).[21] DuPont has traditionally invested heavily in its corporate social responsibility (CSR) image, and apparently further ramped up its efforts since the C8 bad news broke. In 2008, just three years after it paid the EPA $16.5M for the alleged failures to report on C8, DuPont opened a PR campaign titled "Open Science" (Young & Dhanda 2013, 330). An open question for future research is whether investing in CSR is a better insurance mechanism against reputational damage than actually investing in abatement measures.

4. What Is Wrong With the Standard Theory of Deterrence

The ability to draw generalizable lessons from a single case study is usually limited. Yet our analysis here is based on what the qualitative methodology literature calls "crucial, least likely case," whereby the researcher can use the case to expose holes in existing theories (Given 2008). DuPont is hailed as one of the companies that takes its reputation very seriously and takes extremely good care of it (Alsop 2004). DuPont was also the first company to have a full-blown, internal, scientific lab (Bartlett transcripts, Vol. 4, p. 167). It has traditionally been known as "the scientists' company," employing

[21] 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).

10,000 scientists. Indeed, a critical mass of honest research and well-documented studies of C8 were generated in-house. These scientists seemingly tried to instill in DuPont a corporate culture of the highest standards in that regard, as is evident from the words of Bruch Karrh, DuPont's medical director and vice president in the relevant time frame (since 1983):

> "to maintain credibility and good relations with our customers, employees and the public, DuPont management feels that it is not only a matter of the duty or corporate ethics to report pertinent health information, but it is also good, sound business practice. To do less would be both morally irresponsible and in many cases economically irresponsible… A company cannot risk the possibility of being placed in the compromising position of withholding information, making a false judgement about who should know and what. It is the duty of every company's management to discover and reveal the unvarnished facts about health hazards" (Bartlett transcripts, Vol 4, pp. 133-134)

Thus, ex ante DuPont was the least likely company one would expect to suppress information. That is exactly what makes the DuPont-C8 case a good case to identify holes in existing deterrence theories, which treat the probability of detection as largely exogenous.

The DuPont case illustrates how chemical companies can use their informational advantage to delay liability, fend off regulators, and cast doubts in ways that limit a reputational sanctioning process.

4.1 Hiding Information

To understand our claim, it may be useful to go back to Becker's (1968) model. In the traditional model, both the probability of enforcement and the size of the legal liability are exogenous. We slightly extend the model to reflect the fact that a company can work very effectively to reduce the probability π of detection and minimize the penalty. Thus, according to this framework a company would pollute if

$$B > \min_e \{\pi(\mathrm{e})[L(\mathrm{e}) + R(\mathrm{e})] + \mathrm{C}(\mathrm{e})\},$$

where *e* is the effort exerted to avoid sanctioning and C(e) the cost of this effort in dollar terms. One of the simplest ways for a large company to minimize the right-hand side is to prevent damning information from coming out. With chemical products in particular, the producers have the advantage of creating these chemicals and enjoying much more information than any outside party about the nature and risks of

the products. They can even (and often do) use confidentiality claims through trade-secrets law to limit the ability of outsiders to gather information (McGarity & Wagner 2008).

DuPont's C8 case provides plenty of examples of information that existed in house being suppressed. For one, the general counsel was holding workshops on what *not* to document and share in regards to C8 (Lerner 2015b). And when a white paper about C8 was prepared and sent to top officials in 1994, the copies were numbered and the recipients returned them for shredding afterwards (Lerner 2015a). A former senior employee who worked in government affairs told journalists about a detailed internal report on all the different waste sites and their contents. Yet, when the journalists inquired the report was nowhere to be found (Lerner 2016c). One employee told a reporter: "I wasn't about to go against the paycheck that supported my family. So I shut my mouth" (Blake 2015).

Equally importantly, the production of damning information in-house was designed to avoid red flags to begin with, such as when the company rejected scientists' recommendations to further investigate problematic aspects of C8. The minutes of a 1991 meeting cite an interesting reason for refusing scientists' requests to examine how C8 exposure affected workers: "Do the study after we are sued" (Lerner 2015a). In other words, the executives did not want to generate damning information that would later be used against them in the courtroom or the court of public opinion.

On the other side, the victims, who have all the incentives to identify misbehavior, have very little way to do so. They are often at a loss to understand what caused their harm (like the Tennant family). Without knowledge of the risky substance, it is like searching for a needle in a haystack.

Another important yet underappreciated factor is the social pressures that are often exerted on victims not to produce damning information. Virtually every victim that tried to fight DuPont had to face not just legal costs, but also heavy social costs such as ostracism by their neighbors. The farmers who filed the Tennant litigation suffered social exclusion: they had to change their church more than once, and people would walk out of a restaurant when they entered (Rich 2016a; Blake 2015). Similarly, the gym teacher who was behind the subsequent 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). There was apparently a code of silence to protect the biggest employer in town. Everyone who broke it faced consequences.

4.2 Not All Corporate Misbehavior Is Created Equal

It is always useful to go beyond the “on average” claims and look at the cross-sectional variation. While liability, regulation, and reputation were not enough in the DuPont-C8 case, they do work in other cases. And companies’ ability to control the information environment and reduce the expected sanctions is limited to certain sets of circumstances.

Take airplane crashes, for example. Studies show that the day after a crash, the media already knows with great precision what happened and how it happened, and responsibility gets attributed quickly (Mitchell & Maloney 1989). The damage is immediate enough, and the victims visible enough, to make airplane crashes salient. As a result, stock prices of the airline company drop significantly, as a function of the company’s responsibility for the crash. Post-facto regulatory enforcement, legal liability, and market reaction (reputational sanctions) tend to be swift and total with airplane crashes. The health consequences of opaque chemicals, by contrast, are much less immediate, discernible, or attributable.

Even in a single company such as DuPont, you find variation. In some instances DuPont was leading environmental company. In 1988, for example, DuPont voluntarily abandoned the production of chlorofluorocarbons, or CFCs, which were used as propellants in aerosol cans and were suspected of destroying Earth’s ozone layer. The following year DuPont withdrew from the Savannah River site, where it had produced plutonium and tritium for nuclear weapons. Thus, the same managers who decided to continue emitting toxic C8 instead of investing a few million in incinerating costs were very environmentally friendly in other contexts. How come?

We suspect that the answer lies in the different levels of public awareness of each issue. The ozone layer and nuclear waste problems had gained international attention. When DuPont’s CEO chose to embrace the ban on production he gained worldwide acclaims for himself and the company (Miller 2010).

By contrast, even the existence of C8 was unknown to most, let alone its toxicity. Thus, there was no public opinion pressure to contain C8 pollution at the time, and no environmental credit to be gained. The upshot is that public visibility of a problem makes a huge difference. Yet, public visibility is easier when the problem affects everyone (like the ozone) or is already very salient (like the nuclear waste).

4.3 The Interactions between Systems of Control

What is particularly notable about the DuPont case is how systems of deterrence move together (cf. Komesar 2001). We already know that each mechanism in isolation can fail: noncompliance in regulation (e.g., Shwartz & Soo 1996; King & Sutinen 2010); under-deterrence in environmental tort law (Dewees & Trebilcock 1992); and lack of reputational sanctions for environmental pollution (e.g., Karpoff 2012). Yet, for effective deterrence is sufficient that at least one of these mechanisms work in every situation. Unfortunately, in the DuPont case *all* deterrence mechanisms failed simultaneously. Is this joint failure just the result of bad luck?

In the DuPont case we can attribute this joint failure to a common cause: DuPont's ability to companies have on the diffusion of information. The clearest example comes from the way DuPont was able to stave off for years the threat of legal or reputational sanctions.

By capturing the regulators companies are able not only to slow down or prevent enforcement, but also to use the regulator as a shield against allegations in the courtroom and in the court of public opinion. They fight allegations of misbehavior by arguing that the regulator's decision not to intervene is tantamount to evidence that nothing is wrong. Even a cursory review of DuPont's communications reveals frequent mentions of how C8 is under the watchful eyes of the regulator, and so the public has nothing to worry about (Lerner 2015a, 2015b, 2015c).

A related tactic is to use the regulator as a validator: having the company's version bear the letterhead of a public official assures that it will be better received by stakeholders. At one point DuPont's VP told his colleagues, "In our opinion, the only voice that can cut through the negative stories, is the voice of EPA. We need EPA … to quickly (like first thing tomorrow) say the following: Consumer products sold under the Teflon brand are safe" (Lerner 2015c). The company acted on this strategy:

before DuPont entered the consent agreement with the EPA over phasing out C8, it asked the regulator to issue a reassuring press release. And indeed, when the EPA announced the phasing off agreement it included with it the following statement: "To date EPA is not aware of any studies specifically relating current levels of PFOA exposure to human health effects." DuPont followed up on the same day with its own press release simply containing the regulator's words (Lerner 2015c; Bartlett transcripts, Vol. 4, pp. 79–80).

DuPont was not just reiterating what the regulator said; it told the regulator what to say. The process of drafting quotes to be attributed to regulators was customary. Indeed, when one affected water district sent information to the citizens about the presence of C8 in their drinking water, DuPont got to review and amend the document (Lerner 2015b). The broader phenomenon of companies drafting press releases for regulators was spotlighted in a 2014 Pulitzer-winning investigative reporting piece (Lipton 2014).

5. Lessons

There are two clear findings in this case. The first one is that polluting pays off, even when a company anticipates all the legal consequences of its behavior. While the specifics are very case-contingent, the reasons why pollution was optimal does not appear to be.

The second finding is that the main way corporations succeed in reducing their expected liability is by suppressing and distorting information. Once again, while the specific ways in which this takes place are very case-contingent, the idea applies broadly.

What can be done, then, to realign private incentives with social incentives? While we do not purport to offer a detailed plan, below we sketch a few ways to approach the problem. Instead of focusing on the oft-analyzed option of further raising the severity of sanctions, we focus on the more understudied solutions, namely, to attack problems having to do with the information environment.

5.1 Promote Whistleblowing

One proven way to promote the revelation of hidden information is to offer monetary rewards to whistleblowers. Such a system was introduced in 1986 for fraud against the government, extended in the early 2000s to major tax evasion cases, and extended again in 2010 to corporate fraud. In all these cases it has proven effective (e.g., Dyck et al. 2010). Extending such reward systems to environmental liability issues would have arguably made it difficult for DuPont to keep the information about health effects of C8 secret for long, given that its employees could have gained tens of millions of dollars by disclosing it. Thus, creating a version of the False Claims Act for toxic emissions would be a potential mechanism for avoiding a repeat of the DuPont case.

5.2 Penalize Gag Settlements

The main investigation of the health effects of C8 was made possible by the Tennants' initial litigation and the documents discovered during subsequent litigations. Importantly, many of the documents that were produced in these trials were not sealed, thus making possible subsequent litigation, media coverage, and even enforcement actions in other countries.

Settlements are generally regarded as an efficient way to end litigation. Yet, what is efficient for the parties involved is not necessarily efficient for society. If the underlying documents are kept confidential, the costs – not warning the public – are externalized. In fact, the bigger the informational externality, the more the defendant will be willing to pay the plaintiff to insure that documents remain sealed (Shavell 1997). A fundamental principle in public finance is that any divergence between private and social incentives can be alleviated through a tax or a subsidy. This is no exception. A differential taxation of sealed cases is a way to induce the parties involved in a litigation to internalize – at least in part – the information externality.

5.3 Penalize Delays

One unexpected effect emerging from the calculations of the costs and benefits of pollution regards the size of the effect of time delay. Given the long delay between the damage and the penalty, even sizeable penalties pale in comparison to the benefits of pollution (recall how an expected sanction of

close to $1B turned, in present value terms, into $100M). Understanding this effect, defense lawyers will try any tactic to delay as long as possible the moment of payment, making pollution more attractive. One simple way to mitigate this problem could be to increase the rate of interest at which damages awards are capitalized.

5.4 Allocate Responsibility

One of the interesting aspects of the DuPont-C8 case is the "faceless crime" element. Even though the company suffered negative media coverage, none of its top managers were dragged through the mud. The lack of personal accountability seems to be a feature of emissions of opaque chemicals, given, among other factors, the lack of a specific action attributed to specific individuals, and the length of time that passes until the outside world realizes the consequences. A potential way to mitigate faceless crime dynamics is to designate specific managers to vouch – under the credible threat of sanctions – for their companies' policies and state of knowledge over time.

Such a certification requirement already exists in other contexts. Following a string of corporate debacles in the early 2000s, section 302 of the Sarbanes–Oxley Act of 2002 (SOX) requires CEOs and CFOs of publicly traded companies to certify the appropriateness of their companies' reports. Closer to our context, the federal Clean Air Act requires the person in charge of submitting information to the regulator to certify the information, and subjects the certifier to possible jail time if the information turns out to be false. Such certification requirements can help mitigate the existing incentives to create plausible deniability by erecting Chinese walls inside organizations. One policy that might raise the personal stake of the corporate executives is to require a C-suite executive to sign the TSCA report.

6. Conclusion

C8 has been phased off. But the misalignment between companies' and societal goals lives on. This paper is not about a specific chemical or a specific company. Nor is it a paper about extremely unusual and immoral decisions. It is rather a paper about why even the best companies pollute the environment. C8 emissions and the suppression of information about it were not an evil plan or an accident. They were the

natural course of action of a profit-maximizing company, which fully utilized the tools available under then-current laws. As we show, the result was socially inefficient: not just ex post, but also ex ante.

The regulatory framework (TSCA) has since been modified (Berzon & Harder 2016), but there is no evidence that the problems highlighted in this study have been fixed. There is even a question of whether they can possibly be fixed if we maintain a rigid profit-maximization framework. As Hart and Zingales (2017) show, when a prosocial activity (avoiding pollution) and a profit-maximizing activity (producing) are not separable, shareholders' wealth maximization does not even lead to shareholders' *welfare* maximization, let alone to maximization of social welfare. In other words, the problems cited here are not just with governance procedures, but also governance objectives. The solution that Hart and Zingales propose, however, is not easily implementable in this particular case, since the primary problem here is the informational gap that affects not only outside regulators, but also the company's own shareholders.

Thus, an effective system to prevent inefficient pollution needs to rethink the interactions between corporate governance, environmental regulation, litigation, and the information environment.

REFERENCES

Ronald J. Alsop, *The 18 Immutable Laws of Corporate Reputation* (2004).

BBC, *Royal Dutch Shell Appoints Charles Holliday as Chairman*, Oct. 30, 2014, http://www.bbc.com/news/business-29829332.

Binyamin Appelbaum, *As U.S. Agencies Put More Value on a Life, Businesses Fret,* N.Y. Times, Feb. 16, 2011.

Gary S. Becker, *Crime and Punishment: An Economic Approach*, 76 Journal of Political Economy 169 (1968).

Jeremy Bentham, *An Introduction to the Principles of Morals and Legislation* (1823).

Alexandra Berzon & Amy Harder, *House Passes Sweeping Chemical Safety Bill*, Wall St. Journal, May 24, 2016, wsj.com/articles/house-passes-sweeping-chemical-safety-bill-1464125287.

Mariah Blake, *Welcome to Beautiful Parkersburg, West Virginia: Home to One of the Most Brazen, Deadly Corporate Gambits in U.S. History*, Huffington Post (2015), http://highline.huffingtonpost.com/articles/en/welcome-to-beautiful-parkersburg/.

Bryan Blissmer et al., *Health-related Quality of Life Following a Clinical Weight Loss Iintervention among Overweight and Obese Adults: Intervention and 24-Month Follow-up Effects*, 4 Health and Quality of Life Outcomes 43 (2006).

C8 Medical Monitoring Program Report, http://www.c-8medicalmonitoringprogram.com/docs/med_panel_education_doc.pdf.

C8 Probable Links Report, Oct. 2012, http://www.c8sciencepanel.org/prob_link.html.

Susan Chaplinsky & Felicia Marston, *DuPont Corporation: Sale of Performance Coatings*, University of Virginia Darden School Case Study (2014).

R. D. Cohen et al., *Systematic Review: The Costs of Ulcerative Colitis in Western Countries*, 31 Alimentary Pharmacology & Therapeutics 693 (2010).

Cary Coglianese et al., *Seeking Truth for Power: Informational Strategy and Regulatory Policymaking*, 89 Minnesota Law Review 277 (2004).

Don Dewees & Michael Trebilcock, *The Efficacy of the Tort System and Its Alternatives: A Review of Empirical Evidence*, 30 Osgoode Hall Law Journal 57 (1992).

Paul Dolan, *The Measurement of Health-Related Quality of Life for Use in Resource Allocation Decisions in Health Care*, in: Handbook of Health Economics (2000).

DuPont Website, *DuPont Reaches Global Settlement of Multi-District PFOA Litigation*, Feb. 13, 2017, http://investors.dupont.com/investor-relations/investor-news/investor-news-details/2017/DuPont-Reaches-Global-Settlement-of-Multi-District-PFOA-Litigation/default.aspx.

Alexander Dyck, Adair Morse, Luigi Zingales, *Who Blows the Whistle on Corporate Fraud?*, 65 Journal of Finance 2213 (2010).

Alexander Dyck, David Moss, Luigi Zingales, "Media vs. Special Interests," *Journal of Law and Economics,* 2013, 56(3), 521-553.

Eugene F. Fama, *Agency Problems and the Theory of the Firm*, 88 Journal of Political Economy 288 (1980).

Given, ed., *The Sage Encyclopedia of Qualitative Research* (2008).

Bill George, *The DuPont Proxy Battle is a Battle for the Soul of American Capitalism*, Nov. 5, 2015,

Huffington Post, http://www.huffingtonpost.com/bill-george/the-dupont-proxy-contest_b_7256490.html.

Edward L. Glaeser & Andrei Shleifer, *The Rise of the Regulatory State*, 41 Journal of Economic Literature 401 (2003).

Graham, J. D., *Product Liability and Motor Vehicle Safety*, in: The Liability Maze (Huber & Litan, eds., 1991)

Philippe Grandjean et al., *Serum Vaccine Antibody Concentrations in Adolescents Exposed to Perfluorinated Compounds*, Environmental Health Perspective (Advance Publication, 2016).

Wayne B. Gray & Jay P. Shimshack, *The Effectiveness of Environmental Monitoring and Enforcement: A Review of the Empirical Literature*, 5 Review of Environmental Economics and Policy 3 (2011).

Henrich R. Greve et al., *Organizations Gone Wild: The Causes, Processes, and Consequences of Organizational Misconduct*, 4 Academy of Management Annals 53 (2010).

Andrew J. Hoffman & William Ocasio, *Not all Events are Attended Equally: Toward a Middle-Range Theory of Industry Attention to External Events*, 12 Organization Science 414 (2001).

Chad Holliday, *Sustainable Growth, the DuPont Way*, 79 Harvard Business Review 129 (2001).

Michael Janofsky, *DuPont to Pay $16.5 Million for Unreported Risk*, Dec. 15, 2005, N.Y. Times, http://www.nytimes.com/2005/12/15/politics/dupont-to-pay-165-million-for-unreported-risks.html?_r=1.

Paul L. Joskow, *Inflation and Environmental Concern: Structural Change in the Process of Public Utility Price Regulation*, 17 Journal of Law and Economics 291 (1974).

Michael D. Kappelman, *Recent Trends in the Prevalence of Crohn's Disease and Ulcerative Colitis in a Commercially Insured US Population*, 58 Digestive Diseases and Sciences 519 (2013).

Tiffany Kary & Denise Trowbridge, *DuPont Shares Rise as Jury Awards Limited Punitive Damages*, Jul. 8, 2016, Bloomberg, https://www.bloomberg.com/news/articles/2016-07-08/dupont-must-pay-500-000-in-punitive-damages-for-man-s-cancer.

Dennis M. King & Jon G. Sutinen, *Rational Noncompliance and the Liquidation of Northeast Groundfish Resources*, 34 Marine Policy 7 (2010).

Neil K. Komesar, *Law's Limits* (2001).

Philip Kotler & Waldemar Pfoertsch, *Ingredient Branding: Making the Invisible Visible* (2010).

Jonathan M. Karpoff, *Does Reputation Work to Discipline Corporate Misconduct?*, *in* The Oxford Handbook of Corporate Reputation (Timothy G. Pollock & Michael L. Barnett, eds., 2012).

Clare Leaver, *Bureaucratic Minimal Squawk Behavior: Theory and Evidence from Regulatory Agencies*, 99 American Economic Review 572 (2009).

Jing Lei et al., *Negative Spillover in Brand Portfolios: Exploring the Antecedents of Asymmetric Effects*, 72 Journal of Marketing 111 (2008).

Sharon Lerner, *The Teflon Toxin: DuPont and the Chemistry of Deception*, The Intercept, Aug. 11, 2015, https://theintercept.com/2015/08/11/dupont-chemistry-deception/.

Sharon Lerner, *The Teflon Toxin: The Case Against DuPont*, The Intercept, Aug. 17, 2015, https://theintercept.com/2015/08/17/teflon-toxin-case-against-dupont/.

Sharon Lerner, *The Teflon Toxin: How DuPont Slipped Past the EPA*, The Intercept, Aug. 20, 2015, https://theintercept.com/2015/08/20/teflon-toxin-dupont-slipped-past-epa/ .

Sharon Lerner, *New Teflon Toxin Causes Cancer in Lab Animals*, The Intercept, Mar 3, 2016, https://theintercept.com/2016/03/03/new-teflon-toxin-causes-cancer-in-lab-animals/.

Sharon Lerner, *Lawsuits Charge that 3M Knew about the Dangers of Its Chemicals*, The Intercept, Apr. 11, 2016, https://theintercept.com/2016/04/11/lawsuits-charge-that-3m-knew-about-the-dangers-of-pfcs/.

Sharon Lerner, *DuPont May Dodge Toxic Lawsuits by Pulling a Disappearing Act*, The Intercept, Jun. 15, 2016, https://theintercept.com/2016/06/15/dupont-may-dodge-toxic-lawsuits-by-pulling-a-disappearing-act/.

Eric Lipton, *Energy Firms in Secretive Alliance with Attorneys General*, N.Y. Times, Dec. 6, 2014, http://www.nytimes.com/2014/12/07/us/politics/energy-firms-in-secretive-alliance-with-attorneys-general.html?_r=1.

Richard D. Lyons, *Roy J. Plunkett is Dead at 83; Created Teflon While at DuPont*, May 15, 1994, N.Y. Times, http://www.nytimes.com/1994/05/15/obituaries/roy-j-plunkett-is-dead-at-83-created-teflon-while-at-du-pont.html.

Callie Lyons, *Stain-Resistant, Nonstick, Waterproof, and Lethal* (2007).

John F. Mahon, *Corporate Reputation: A Research Agenda Using Strategy and Stakeholder Literature*, 41 Business & Society 415 (2002).

Arvin Maskin et al., *Medical Monitoring: A Viable Remedy for Deserving Plaintiffs or Tort Law's Most Expensive Consolation Prize*, 27 William Mitchell Law Review 521 (2000).

Stephen Miller, *Former Du Pont CEO Aided Safety Efforts*, Wall St. J., Jan 21, 2010.

Jeff Mordock, *Taking on DuPont: Illness, Deaths, Blamed on Pollution from W. Va. Plant*, Delaware Online, Apr. 1, 2016, http://www.delawareonline.com/story/news/2016/04/01/dupont-illnesses-deaths-c8/81151346/.

Jeff Mordock, *DuPont or Chemours: Who Will Pay the Costs of C8 Lawsuits?*, Delaware Online, Apr. 3, 2016, http://www.delawareonline.com/story/news/2016/04/03/dupont-chemours-who-pay-costs-c8-lawsuits/81746064/.

National Cancer Institute, SEER Cancer Statistic Review (1975-2013), http://seer.cancer.gov/csr/1975_2013/.

The Value of Statistical Life: A Meta-Analysis (OECD study, 2010), available at http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=ENV/EPOC/WPNEP(2010)9/FINAL&doclanguage=en.

Opensecrets.org, Toxic Substances Control Act page (last visited Sep. 2016), http://www.opensecrets.org/news/issues/chemical/.

Dennis J. Paustenbach et al., *A Methodology for Estimating Human Exposure to Perfluorooctanoic Acid (PFOA): A Retrospective Exposure Assessment of a Community (1951–2003)*, 70 Journal of Toxicology and Environmental Health 28 (2007).

Mitchell Polinsky & Steven Shavell, *The Optimal Tradeoff between the Probability and Magnitude of Fines*, 69 American Economic Review 880 (1979).

Nathaniel Rich, *The Lawyer who Became DuPont's Worst Nightmare*, N.Y. Times, Jan. 6, 2016, http://www.nytimes.com/2016/01/10/magazine/the-lawyer-who-became-duponts-worst-nightmare.html.

Nathaniel Rich, *The Story Behind the E.P.A.'s Contaminated Water Revelation*, N.Y. Times, May 27, 2016, http://www.nytimes.com/2016/05/27/magazine/the-story-behind-the-epas-contaminated-water-revelation.html?_r=4.

Donna Rowen & John Brazier, *Health Utility Measurement*, in: The Oxford Handbook of Health Economics (Glied & Smith, eds., 2011).

Kenneth B. Schwartz & Billy S. Soo, *Evidence of Regulatory Noncompliance with SEC Disclosure Rules on Auditor Changes*, 71 The Accounting Review 555 (1996).

Roy Shapira, *Corporate Philanthropy as Signaling and Co-optation*, 80 Fordham Law Review 1889 (2012).

Steven Shavell, *The Fundamental Divergence between the Private and the Social Motive to Use the Legal System*, 26 J. Legal Stud. 575 (1997).

Suraj Srinivasan, *Consequences of Financial Reporting Failure for Outside Directors: Evidence from Accounting Restatements and Audit Committee Members*, 43 Journal of Accounting Research 291 (2005).

Leo E. Strine, Jr., *Corporate Power Is Corporate Purpose I: Evidence from My Home Town*, Oxford Review of Economic Policy (forthcoming, 2017).

Mary B. Swanson et al., *A Screening Method for Ranking and Scoring Chemicals by Potential Human Health and Environmental Impacts*, 16 Environmental Toxicology and Chemistry 372 (1997).

Mark P. J. Vanderpump, *The Epidemiology of Thyroid Disease*, 99 British Medical Bulletin 39 (2011).
Veronica M. Vieira et al., *Perfluorooctanoic Acid Exposure and Cancer Outcomes in a Contaminated Community: A Geographic Analysis*, 121 Environmental Health Perspectives 318 (2013).

W. Kip Viscusi & Joseph E. Aldy, *The Value of a Statistical Life: A Critical Review of Market Estimates Throughout the World*, 27 The Journal of Risk and Uncertainty 5 (2003).
Wendy E. Wagner, *Choosing Ignorance in the Manufacture of Toxic Products*, 82 Cornell Law Review 773 (1997).

Wendy E. Wagner, *Administrative Law, Filter Failure, and Information Capture*, 59 Duke Law Journal 1321 (2010).

Wendy Wagner et al., *Rulemaking in the Shade: An Empirical Study of EPA's Air Toxic Emission Standards*, 63 Administrative Law Review 99 (2011).

Elizabeth V. Young, *Outsourcing the Jury: Bartlett v. DuPont and the Role of Alternative Adjudication in Preserving Jury "Fairness" in Complex Scientific Litigation*, 77 Ohio State Law Journal 15 (2016).

Luigi Zingales, "Preventing Economists' Capture," in Preventing Regulatory Capture, D. Carpenter and D. A. Moss (eds.), New York: Cambridge University Press, 2014.

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 (http://www.c-8medicalmonitoringprogram.com/docs/med_panel_education_doc.pdf), 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, 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 the University of Michigan Inflation Expectation was 4.2%.

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

Figure 2: Sampling Results of the Water

C-8 SAMPLING (MARCH - JUNE 1984)

LOCATION	DISTANCE (MILES)	C-8 PPB (0.6 LIMIT)
PKSBG-HOME TAP	7.5 UPSTREAM	<
WW-DRINK FTN	---	<
DIST. CTR-WELL	0.25 DOWN	<
WASHINGTON-STORE TAP	0.25 DOWN	1.2,1.0
LUBECK-STORE TAP	0.25 DOWN	1.5
L. HOCKING-STORE TAP	3 DOWN	0.8,0.6
BELLEVILLE-PRIVATE WELL	12 DOWN	<
REEDSVILLE-STORE TAP	14 DOWN	<
RAVENSWOOD-STORE TAP	29 DOWN	<
RACINE-STORE TAP	50 DOWN	<
POINT PLEASANT-STORE TAP	74 DOWN	<
GALLIPOLIS-STORE TAP(*)	79 DOWN	<

(*) NEAREST COMMUNITY TO TAKE WATER DIRECTLY FROM OHIO RIVER.

Figure 3: Karrh Memo

B. W. Culpepper, M.D.
J. C. Bonnett, M.D.

PERSONAL & CONFIDENTIAL

TO: C. DE MARTINO

FROM: BRUCE W. KARRH, M.D. BWK March 25, 1981

AMMONIUM PERFLUOROOCTANOATE (FC-143)
C-8 COMPOUNDS

The fluorinated surfactant C-8 compound, which is used in Teflon® manufacture at Parkersburg and in other applications at Chambers Works, has been found to cause scarring of the eyes of rat fetuses following maternal exposures during pregnancy. The study was done by 3-M, the supplier of the material, and was reported by 3-M to EPA under Section 8e of TSCA on Monday, March 23. 3-M does not plan to inform its employees until the second week of April.

Effects were found in the fetuses of mothers exposed at feeding concentrations ranging from 25-150 mg/Kg body weight. A no-effect level has not been determined. Somewhat similar fluorinated alcohol compounds were found by 3-M to have similar teratogenic effects in studies reported to EPA in November 1980. The current study was done for a different reason and the teratogenic effect was an incidental finding. There is reason to question the validity of the study and Dr. R. E. Staples, Teratologist at Haskell Laboratory, is to meet with 3-M this week and review the study and its results. However, the study is probably valid.

At present, about 50 women employees have potential for exposure to C-8 compounds at Parkersburg and an undetermined number at Dordrecht, Chambers Works, and Japan. Of the 50 female employees at Parkersburg, three are pregnant now and 2 probably pregnant. The reproductive capability of the others is unknown at present. One employee who worked in the area had a miscarriage followed immediately by a normal pregnancy with a recent normal outcome. Her potential C-8 exposure throughout both pregnancies was described as "heavy." There was one recent abnormal pregnancy outcome with one female employee at the Plant, but she did not work where there was any possibility of exposure to C-8.

Of the employees presently pregnant, one is in her 7th month, one in her 5th month, one in her 3rd month, and 2 probably just pregnant. One complicating factor is that C-8 is retained in the body for a very long time after exposure ceases.

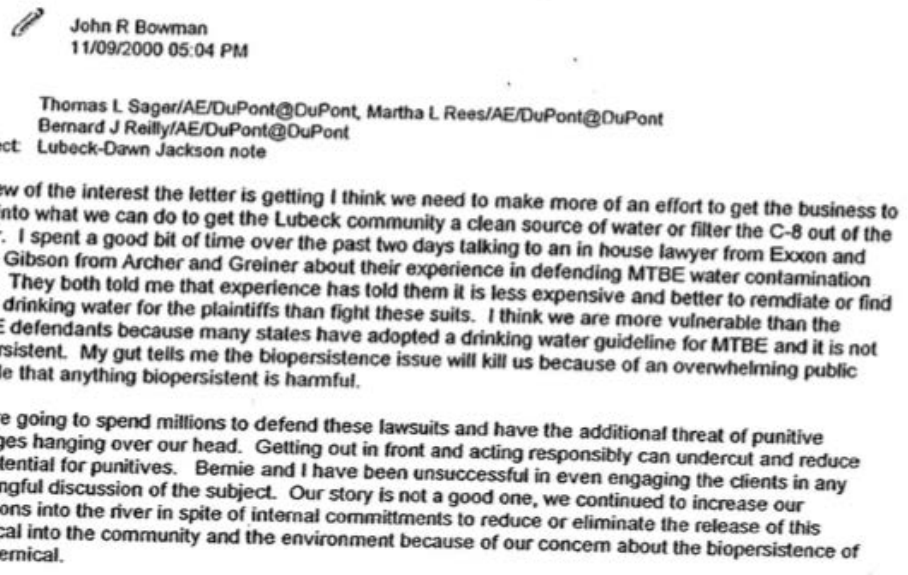
The plan at present is to convene a meeting after Dr. Staples reviews 3-M's work, probably by March 27. PPD, C&P, Haskell Laboratory, EEO Section, Labor Law Division, Medical Division, Textile Fibers, F&F, and General Legal will participate. If the 3-M study is valid, women of child-bearing potential will probably be excluded from jobs where there is potential for exposure to C-8 compounds, at least until a no-effect level is determined. Present plans are to communicate to employees no later than April 3 and an appropriate package is being prepared now. Haskell Laboratory will determine what additional testing needs to be done.

Please let me know if you need additional information.

BWK:ceb

EID096503

Figure 5: Bowman Memo



John R Bowman
11/09/2000 05:04 PM

To: Thomas L Sager/AE/DuPont@DuPont, Martha L Rees/AE/DuPont@DuPont
cc: Bernard J Reilly/AE/DuPont@DuPont
Subject: Lubeck-Dawn Jackson note

In view of the interest the letter is getting I think we need to make more of an effort to get the business to look into what we can do to get the Lubeck community a clean source of water or filter the C-8 out of the water. I spent a good bit of time over the past two days talking to an in house lawyer from Exxon and Chris Gibson from Archer and Greiner about their experience in defending MTBE water contamination suits. They both told me that experience has told them it is less expensive and better to remdiate or find clean drinking water for the plaintiffs than fight these suits. I think we are more vulnerable than the MTBE defendants because many states have adopted a drinking water guideline for MTBE and it is not biopersistent. My gut tells me the biopersistence issue will kill us because of an overwhelming public attitude that anything biopersistent is harmful.

We are going to spend millions to defend these lawsuits and have the additional threat of punitive damages hanging over our head. Getting out in front and acting responsibly can undercut and reduce the potential for punitives. Bernie and I have been unsuccessful in even engaging the clients in any meaningful discussion of the subject. Our story is not a good one, we continued to increase our emissions into the river in spite of internal committments to reduce or eliminate the release of this chemical into the community and the environment because of our concern about the biopersistence of this chemical.

Table 1: Social Cost of Pollution

In '000										
Total	**346,497**		**Source**							
Discount Rate	5.63		real rate = T-bill - inflation expectation							
Value of Life	3,333		OECD 3 Million in 1984 dollars							
2014 dollars deflated by 1984	0.43									
Period	28									
Annuity factor	13.93									
Total cost per year	**24,875**									
Testicular										
Incidence per year	2.1		6 additional cases per 200,000			2.1				
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-surviva							
Expected Life loss	980.01									
Total per year	**982.30**									
Thyroid										
Incidence per year	140		20 per 10,000							
medical cost per unit	0.49		9	bn total ex	Medical Expenditure Panel Survey (2014)					
Total per year	**68.30**		20	million	only	0.4	cured	http://www.thyroid.org/media-r		
Kydney										
Incidence per year	21		3 per thousand people							
medical cost per unit first year	19.95		46	: https://academic.oup.com/jnci/article/103/2/117/25						
next 4 years	7.92		6.255	for every continuing year			: https://academic.oup.com/jnci/article/10			
total medical costs	585.25									
Prob of dying	0.27		http://www.cancer.net/cancer-types/kidney-cancer/statistics							
Expected Life loss	18,900									
Total per year	**19,486**									
Ulceritative colitis										
Incidence per year	0.7		1 per 100,000							
medical cost per unit	2.82		Cohen et al (2010)		6					
total per year	**1.97**									
Pregnancy-indued 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 per year	**2450**									
Prevalence										
High cholesterol	4200		600 per 10,0000							
medical cost per unit	0.45		Total exp 36.25 bn		Medical Expenditure Panel Survey (2014)					
total per year	**1,886**		35 million		https://www.cdc.gov/cholesterol/cholesterol_education_month.					
			1.035714	in 2014						
			0.449151	in 1984						

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)	-