Conflicts of Entitlements in Property Law: The Complexity and Monotonicity of Rules

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ABSTRACT: In property law, and especially in the law of nuisance, the simple Calabresi–Melamed scheme of property and liability rules experience significant transformations, mainly through their recombination—which results in rules that are a combination of the elementary rules—and less frequently through the interplay between the rules and public regulatory standards. The result of these combination processes and the interaction between private law rules (property and liability) and public law standards is a set of complex rules in which some threshold acts as a switch that triggers a given property or liability rule to change into a different rule. In this respect, the negligence rule can be seen as a composite rule, consisting of a pure strict liability rule favoring the victim, and a property rule favoring the injurer, with the variable of due care acting as the switch between the two. Sometimes, the number of switches, and thus, the complexity of the rules, increase to two and, eventually, to a larger number.

The above explanation implies that property law, the area of the law that most conspicuously (albeit not exclusively) deals with the protection of entitlements

is, in fact, much more structurally complex than most current law and economics analyses have assumed.

We also explore how the switches between elementary rules move along the variables typically involved in situations of conflict of entitlements: measures of care taken by parties in conflict, investments made by the parties, and uses of such investments. We identify how rules appear to be (using, with some conceptual abuse, the mathematical notion) monotonic in all those variables: The sequence of elementary rules and switches combined in complex rules does not allow "reversals of ordering" as choice variables increase or decrease. We conjecture that new developments and new forms of property would conform to the monotonicity property we identify and that informal coordination between the agents involved, instead of heavy reliance on formal legal enforcement, would play a large role in the choice of the structure of rules protecting entitlements through future property forms.

I. INTRODUCTION

A. *THE COMPLEXITY OF SCENARIOS IN CONFLICTING USES OF PROPERTY AND NUISANCE LAW*

The extensive law and economics literature that jointly analyzes property rules and liability rules as legal means to allocate and protect entitlements[1] in the nuisance context typically consider relatively simple forms of property rules and liability rules. In more recent years, scholars' exploration of more complex rules, especially in the form of put-option-like alternatives, has raised considerable interest.[2] The related law and economics literature dealing with the control of externalities[3] typically adds regulation and taxes to the simple property rules and liability rules as instruments for controlling harmful externalities.

When one examines in detail the rules in place in the law of nuisance—one of the classical building blocks of property law, and one that directly addresses conflicting uses by entitlement holders over neighboring tracts of land—the picture seems to get less structured and more complicated.[4] At least in many European jurisdictions (for instance, in Germany and Spain, along

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1.   *See generally* Lucian Arye Bebchuk, *Property Rights and Liability Rules: The* Ex Ante *View of the Cathedral*, 100 MICH. L. REV. 601 (2001) [hereinafter Bebchuk, *The* Ex Ante *View of the Cathedral*]; Richard R.W. Brooks, *The Relative Burden of Determining Property Rules and Liability Rules: Broken Elevators in the Cathedral*, 97 NW. U. L. REV. 267 (2002); Guido Calabresi & A. Douglas Melamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 HARV. L. REV. 1089 (1972); Keith N. Hylton, *Property Rules and Liability Rules, Once Again*, 2 REV. L. & ECON. 137 (2006); Louis Kaplow & Steven Shavell, *Property Rules Versus Liability Rules: An Economic Analysis*, 109 HARV. L. REV. 713 (1996); Lucian Arye Bebchuk, Ex Ante *Investments and* Ex Post *Externalities* (Harvard Olin Discussion Paper No. 397, 2002) [hereinafter Bebchuk, Ex Ante *Investments and* Ex Post *Externalities*], *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=297091.

2.   *See generally* IAN AYRES, OPTIONAL LAW: THE STRUCTURE OF LEGAL ENTITLEMENTS (2005); Ronen Avraham, *Modular Liability Rules*, 24 INT'L REV. L. & ECON. 269 (2004); Ian Ayres & J.M. Balkin, *Legal Entitlements as Auctions: Property Rules, Liability Rules, and Beyond*, 106 YALE L.J. 703 (1996); Ian Ayres & Paul M. Goldbart, *Optimal Delegation and Decoupling in the Design of Liability Rules*, 100 MICH. L. REV. 1 (2001); Lee Anne Fennell, *Property and Precaution*, 4 J. TORT L. 1 (2011); James E. Krier & Stewart J. Schwab, *Property Rules and Liability Rules: The Cathedral in Another Light*, 70 N.Y.U. L. REV. 440 (1995); *see also* Yun-chien Chang, *Optional Law in Property: Theoretical Critiques*, 9 N.Y.U. J.L. & LIBERTY (forthcoming 2015), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2351651.

3.   For early examples, see generally R. H. Coase, *The Problem of Social Cost*, 3 J.L. & ECON. 1 (1960); A. Mitchell Polinsky, *Controlling Externalities and Protecting Entitlements: Property Right, Liability Rule, and Tax-Subsidy Approaches*, 8 J. LEGAL STUD. 1 (1979) [hereinafter Polinsky, *Controlling Externalities and Protecting Entitlements*]; A. Mitchell Polinsky, *Resolving Nuisance Disputes: The Simple Economics of Injunctive and Damage Remedies*, 32 STAN. L. REV. 1075 (1980) [hereinafter Polinsky, *Resolving Nuisance Disputes*].

4.   The relative complexity of nuisance law vis-à-vis other areas of property law, such as trespass, is a relevant dimension in the analysis of Thomas W. Merrill, *Trespass, Nuisance, and the Costs of Determining Property Rights*, 14 J. LEGAL STUD. 13, 23–26 (1985). Merrill conceives the law of nuisance as a judgmental—and not mechanical—entitlement determination scheme. *Id.*

with some others) and, we conjecture, in the United States as well,[5] the legal rules that actual legal systems deploy to resolve nuisance cases greatly depart from the simple property rules and liability rules considered by the standard law and economics literature (and also, by the way, from the put-option rules some of the more recent literature also explores).

As more specific references to the solutions actually in place will show, in the law of nuisance, the simple property rules and liability rules of the Calabresi–Melamed framework are subject to significant transformations. These transformations take place mainly through their combination and, eventually, recombination, resulting in rules that are composites following a given structure of the elementary ones and, through the interplay with public regulatory standards, dealing with the activities giving rise to the conflicting uses of land. The result of these combination processes, and the interaction between traditional private law rules (property and liability) and public law standards, is a set of complex rules characterized by a distinctive structure.

What we often observe is that a certain threshold, legally defined in more or less precise terms and sometimes explicitly provided by the content of a public regulatory standard, functions as a "switch" that triggers one elementary rule to transform into, or give way to, a different one. Thus, the legal rule in place is a complex or composite one, where two (or more) elementary rules are linked together through one switch (possibly, more than one) defined over a certain variable of the interaction, determining which of the elementary rules should govern the conflict in uses. In this respect, one can see the negligence rule as a composite rule consisting of a pure or elementary strict liability rule favoring the victim and a property rule favoring the injurer, with the due care level, defined over the variable "care or precaution," acting as the switch between the two.

We do not pretend to be the first to have considered complex rules in the protection of entitlements nor even to have identified rules in the nuisance context that depart from the basic Calabresi–Melamed framework. For instance, Saul Levmore filled in gaps in the basic matrix—a scheme with only property rules and liability rules, with protecting the polluter or the polluttee as the only added relevant dimension in characterizing the rules.[6] Levmore added complications related to the timing of the remedy, the connection with restitution of gains, and the past or future character of the harm.

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    5.   For nuisance law in the United States, we have mostly relied on DAN B. DOBBS, THE LAW OF TORTS (2000); Keith N. Hylton, *The Economics of Nuisance Law, in* RESEARCH HANDBOOK ON THE ECONOMICS OF PROPERTY LAW (Kenneth Ayotte & Henry E. Smith eds., 2011) [hereinafter Hylton, *The Economics of Nuisance Law*]; Keith N. Hylton, *The Economic Theory of Nuisance Law and Implications for Environmental Regulation*, 58 CASE W. RES. L. REV. 673 (2008) [hereinafter Hylton, *The Economic Theory of Nuisance Law*].

    6.   *See generally* Saul Levmore, *Unifying Remedies: Property Rules, Liability Rules, and Startling Rules*, 106 YALE L.J. 2149 (1997).

Bell and Parchomovsky introduced the notion of "pliability rules," which they define as hybrid rules "combin[ing] their familiar cousins—property . . . and liability rules—in numerous combinations," and which contain within themselves their own conditions for change.[7] However, there is very little structure to the category: "A person who observes property rule or liability rule protection at a given point in time, and assumes that the property rule or liability rule protection encapsulates the true legal protection of an object, may be making a critical error."[8] And the basic examples provided confirm that "pliability rules" cover almost any variation in the legal protection of entitlements: copyright protection as a property rule that becomes a liability rule with zero compensation after the expiration of the copyright term;[9] fair use as the entitlement holder holding one type of rule protection against some potential users and a different type of rule protection with respect to other users;[10] title-shifting situations, as adverse possession, transforming property rule protection of one holder into property rule protection in the hands of another holder.[11]

Some of the categories within pliability rules ("classic pliability" and "loperty"), as they involve a shift from one elementary rule to another (property into liability; liability into property), resemble more closely our complex rule notion,[12] although neither the notion of triggers or switches over some defined variable nor the monotonocity in the structure of the rules is part of their analysis, as discussed in later Parts.

The complex rule structure that we analyze in this Essay is unrelated to the "higher-order liability rule" proposed by Ian Ayres.[13] In Ayres's usage, the term serves to designate rules that allow a series of reciprocal takings by the parties in conflict over the legal entitlement.

Our notion is also different from that of the "modular liability rules" developed by Ronen Avraham, who builds on the previous literature highlighting the importance of the options embedded in the elementary rules and envisages rules that would contain, instead of one option for the injurer or for the victim, a pair of options—one for each party—and thus harness the private information available to both sides, and not just one party to the manifested conflict between the uses of the injurer and the victim.[14]

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7. Abraham Bell & Gideon Parchomovsky, *Pliability Rules*, 101 MICH. L. REV. 1, 26 (2002).

8. *Id.* at 27.

9. *See id.* at 39–44.

10. *See id.* at 50–52.

11. *See id.* at 54.

12. *See id.* at 31–38, 53.

13. *See generally* AYRES, *supra* note 2.

14. Avraham, *supra* note 2, at 278–82.

Our taxonomy is related to, but separable from, the hybrid rule that Yun-chien Chang has identified in the context of access to landlocked land.[15] A hybrid rule is one that combines a liability rule up to a certain extent—up to a limit of passage rights to the landlocked owner over the neighboring property—and a property rule once the negotiation ground for the interested parties has been leveled to a certain degree at least; "*beyond the limited extent of passage (attainable under the liability rule) that the neighbors are forced to accept, the neighbors' entitlements are protected by the property rule.*"[16] This rule could be considered as one possible example of our entire family of complex rules for the protection of entitlements.

We must note that we do not intend to make an unqualified plea in favor of complex rules, neither in nuisance law nor generally. We are well aware of the trade-offs between an incentive provision and the administrative costs that added complexity brings to the functioning of legal systems.[17]

Our previous set of observations seem to imply, nevertheless, that the law of nuisance that most conspicuously deals with externalities and the protection of entitlements is, in fact, legally more intricate and populated by rules more complex than commonly assumed.

Of course, the structure of the problem in the typical nuisance case is complicated, and legal rules, in principle, ought to reflect this complexity. Several variables are at work when neighboring uses conflict. Four of these variables come to mind immediately when using the lens of an analogy of nuisance to tort:[18] (1) care of injurer; (2) care of victim; (3) activity level—or the use of the investment, as we characterize it below—of the injurer; and (4) activity level—use of the investment again—by the victim.

But the number of variables is not the whole story behind the complex structure of the legal rules in place in the nuisance context, as a simple comparison with tort confirms: Tort equivalents to extremely complex nuisance rules, such as those contained in section 906 German Civil Code

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15.   Yun-chien Chang, Access to Landlocked Land: A Case for a Hybrid of Property and Liability Rules 3–7 (July 26, 2013) (unpublished manuscript), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1986739.

16.   *Id.* at 4 (emphasis added).

17.   For a discussion of this trade-off, see RICHARD A. EPSTEIN, SIMPLE RULES FOR A COMPLEX WORLD 21–49 (1995).

18.   The use of a common analytical framework for nuisance—and even property disputes more generally—and tort is favored by an extensive literature. *See generally* Robert Cooter, *Unity in Tort, Contract, and Property: The Model of Precaution*, 73 CALIF. L. REV. 1 (1985); Lee Anne Fennell, *Property and Half-Torts*, 116 YALE L.J. 1400 (2007); Fennell, *supra* note 2; Hylton, *The Economics of Nuisance Law, supra* note 5; Hylton, *The Economic Theory of Nuisance Law, supra* note 5; Polinsky, *Resolving Nuisance Disputes, supra* note 3. This view is not shared by others, however. *See generally* Henry E. Smith, *Exclusion and Property Rules in the Law of Nuisance*, 90 VA. L. REV. 965 (2004) [hereinafter Smith, *Property Rules in the Law of Nuisance*]; Henry E. Smith, *Property and Property Rules*, 79 N.Y.U. L. REV. 1719 (2004) [hereinafter Smith, *Property and Property Rules*].

("BGB") and articles 546-13 and 546-14 of the Catalan Civil Code, do not seem to exist in real world tort systems.

B.   *THE PROBLEM IN THE EXISTING LITERATURE AND OUR CONTRIBUTION*

The rules scholars traditionally consider as the legal (at least in private law) alternatives for nuisance cases are the following: a property rule in favor of the injurer, a (strict or negligence-like) liability rule favoring the victim, or a property rule in favor of the victim.[19] But scholars have not compared the performance of these particular rules with the complex rules that typically govern nuisance cases, and the rules result from an interaction with different switches and thresholds, sometimes determined by public law. More recently, the two property rules and the two call-option liability rules (including the Calabresi–Melamed addition) have been complemented by put-option rules, by which the party favored by the rule is entitled to force the transfer of the resource at a price determined by an outside authority, typically a court.[20]

Existing literature on externalities and the legal protection of entitlements have extensively analyzed the above rules in a variety of settings. More relevant to our purposes, Bebchuk shows in two important companion papers that, in a setting that resembles the bargaining scenario that we consider more appropriate, no simple rule can induce first-best behavior of both the injurer and victim when investment levels and care are non-contractible, and thus, Coasean bargaining is restricted to the use of

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19.   Since the pathbreaking contribution of Calabresi and Melamed, *see supra* note 1, the existence of a fourth simple rule has been recognized. This rule, which is sometimes called Rule 4 and could be formulated symmetrically to the strict liability of the injurer, would amount to a sort of strict liability of the victim. The victim could stop pollution or emissions, but would then have to pay damages to the injurer or polluter. Some claim that the American case *Spur Industries, Inc. v. Del E. Webb Development Co.*, 494 P.2d 700 (Ariz. 1972), is an actual embodiment of this very rule. The fact is, though, that there are little traces of the adoption of such a rule in nuisance law in real-world legal systems, so for the sake of brevity and simplicity, we have decided to omit its treatment. Our framework, nevertheless, would perfectly allow the analysis of such a rule and its progeny. A relevant portion of the literature has argued against the existence—and desirability—of such a rule. Richard A. Epstein, *A Clear View of the Cathedral: The Dominance of Property Rules*, 106 YALE L.J. 2091, 2102–05 (1997); Levmore, *supra* note 6, at 2164–68 (addressing Krier and Schwab's put-option version of liability protection of the injurer which is sometimes referred to as Rule 5); Smith, *Property Rules in the Law of Nuisance*, *supra* note 18, at 1010–11. To be clear, we do not claim that protecting the party that could intuitively be considered the injurer through a liability rule is unfounded in property or other areas of the law. In fact, in Roman Law, rules on *accessio*—still very much in force in most civil codes in Europe and Latin America—it is possible to find illustrations of such a rule allowing the victim of encroachment to keep the improved property, subject to paying damages to the *bona fide* encroacher or injurer. *See, e.g.*, CÓDIGO CIVIL art. 361 (Spain); CODI CIVIL DE CATALUNYA arts. 542-5 to -7. For an efficiency look on these issues, see EPSTEIN, *supra* note 17, at 116–18; Yun-chien Chang, *Property Law with Chinese Characteristics: An Economic and Comparative Analysis*, 1 BRIGHAM–KANNER PROP. RTS. CONF. J. 345, 358–59 (2012).

20.   *See generally* AYRES, *supra* note 2; Avraham, *supra* note 2; Ayres & Goldblat, *supra* note 2; Krier & Schwab, *supra* note 2.

investments.[21] Bebchuk further shows that no simple rule is superior to the others with respect to all four variables.

Since the pioneering work by Shavell, law and economics literature has given considerable attention to the simultaneous use of liability rules and regulation.[22] Other contributions include Kolstad, Ulen, and Johnson;[23] Burrows;[24] and Schmitz.[25] The focus of this literature, however, has been the analysis of the conditions in which the joint use of liability and regulation might be socially advantageous and the optimal design of both instruments when legal systems jointly use liability and regulation. But this literature does not address the added complexities involved in nuisance cases (so it rules away property rules and bargaining) nor does it consider the use of switches from one rule (be it property or liability) to another.

In nuisance contexts, scholars have analyzed some complex doctrines—such as coming to the nuisance—from an economic perspective.[26] But complexity arises in this literature based on the time dimension of the parties' investment decisions, and not from the presence of complex rules combining elementary rules through thresholds and switches among rules, as we do here.

We have disregarded the time dimension, not because we believe it is unimportant in reality, but because parties can conceptually substitute the time dimension through the contractibility or non-contractibility of their initial investments. In fact, Pitchford and Snyder can be viewed as a special case of our framework, in which the investment, use of the investment, as well as the abatement costs by the victim are all fixed.[27] Thus, Pitchford and Snyder's conclusion that liability rules favoring victims are superior to other rules crucially depends on the fact that, due to the aforementioned

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21.   *See generally* Bebchuk, Ex Ante *Investments and* Ex Post *Externalities*, *supra* note 1; Bebchuk, *The* Ex Ante *View of the Cathedral*, *supra* note 1.

22.   *See generally* Steven Shavell, *A Model of the Optimal Use of Liability and Safety Regulation*, 15 RAND J. ECON. 271 (1984); Steven Shavell, *Liability for Harm Versus Regulation of Safety*, 13 J. LEGAL STUD. 357 (1984).

23.   *See generally* Charles D. Kolstad et al., Ex Post *Liability for Harm vs.* Ex Ante *Safety Regulation: Substitutes or Complements?*, 80 AM. ECON. REV. 888 (1990).

24.   *See generally* Paul Burrows, *Combining Regulation and Legal Liability for the Control of External Costs*, 19 INT'L REV. L. & ECON. 227 (1999).

25.   *See generally* Patrick W. Schmitz, *On the Joint Use of Liability and Safety Regulation*, 20 INT'L REV. L. & ECON. 371 (2000).

26.   Robert Innes, *Coming to the Nuisance: Revisiting* Spur *in a Model of Location Choice*, 25 J.L. ECON. & ORG. 286 (2008); Rohan Pitchford & Christopher M. Snyder, *Coming to the Nuisance: An Economic Analysis from an Incomplete Contracts Perspective*, 19 J.L. ECON. & ORG. 491 (2003); Michelle J. White & Donald Wittman, *Long Run Versus Short Run Remedies for Spatial Externalities: Liability Rules, Pollution Taxes, and Zoning, in* ESSAYS ON THE LAW AND ECONOMICS OF LOCAL GOVERNMENTS 13 (Daniel L. Rubinfeld ed., 1979); Donald Wittman, *First Come, First Served: An Economic Analysis of "Coming to the Nuisance,"* 9 J. LEGAL STUD. 557 (1980).

27.   *See generally* Pitchford & Snyder, *supra* note 26. They use the term "second party" to designate the party we call the victim, but this is due to their focus on the sequence of actions, and it is just a matter of labeling. *Id.* at 494.

restrictions, bargaining never takes place under liability rules, just under property rules. Our approach shows how bargaining under liability rules makes them less efficient in the context of nuisance and externalities than what is commonly considered. Innes has extended the Pitchford and Snyder approach, but focuses on location and not on investment decisions, showing an overall advantage of first-party liability rules over second-party rights (in all forms) and over property rights favoring the first party.[28] Innes does acknowledge the overinvestment problem that we highlight for non-contractible *ex ante* investments, but "solves" it through a damages setting that makes the payoff for the investing party invariant to the second party moving and fixes damages at the efficient level of investment.

We think that a setup with two parties who may invest and decide—both about the use of their investments and precautions affecting losses from the conflict of uses, adding bargaining by the two agents in the stylized nuisance conflict—is the appropriate one to characterize the equilibria and the interaction under the elementary rules. This setup also works well under several first-order and higher-order complex rules that may be observed in various legal systems when dealing with nuisance cases.

In this Essay, we try to do a number of things. First, we present our notion of complex rules, and illustrate how nuisance law uses these complex rules. However, we believe the complexity we identify in the rules is deeply connected with the existence of a property conflict, regardless of the setting, and thus, one can also find this complexity outside of nuisance law. Second, we delve into the effects of complex property rules and liability rules (and of their simpler counterparts as well) on the four different variables typically present in nuisance cases: care of the injurer and victim, as well as activity levels—use of investment—of the injurer and victim. In addition, given that bargaining between the parties implies a more interesting environment to analyze the legal rules protecting entitlements, we will rely heavily on the Coase theorem to determine care. We will show how inefficiencies under the different legal regimes (all elementary and first-order complex rules, as well as other higher-order rules) arise due to the strategic use of investments to improve the bargaining position when bargaining under the shadow of the legal rules protecting entitlements takes place.

In our analysis of the strategic nuisance interaction under simple and complex legal rules, we do not consider the "qualities" of activities involved in the conflicting uses dispute. We acknowledge that this qualitative dimension may be particularly important for nuisance, since in reality some uses conflict and others do not. However, one could abstractly interpret different qualities also as activity levels if we order the alternative qualities of activities according to their profitability. We concede that this does not perfectly solve the problem, since the order according to profitability will usually be different

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28.   *See generally* Innes, *supra* note 26.

from the order according to the degree of conflict—i.e. according to the amount of damages or the minimal total of damages and avoidance costs. Therefore, we cannot disregard the possibility that much of the complexity of legal rules in the nuisance context may be due to such additional complications that we do not directly address. However, we think that our framework sheds new light both on the taxonomy of legal rules protecting entitlements and on the intricacies of nuisance law.

Third, and finally, we link our category of complex rules to the notion of "monotonicity," in the sense that the structure of complex rules that involve a sequence of simple or elementary rules does not allow "reversals of ordering" as choice variables increase or decrease from certain levels. In Part IV, we elaborate on the notions of "incentive monotonicity" and "switch monotonicity" and hypothesize how new developments in property law, dealing with conflicting entitlements or uses, would make use of complex rules that conform to the monotonicity properties that we characterize. Thus, the emergence of new property forms and solutions will not be devoid of a recognizable pattern or structure—one that typically would facilitate parties to adjust their reciprocal behavior with less reliance on formal legal enforcement mechanisms and more reliance on informal coordination.

II.   LEGAL RULES ON NUISANCE

A.   *A TAXONOMY OF THE COMPLEX LEGAL RULES GOVERNING NUISANCE DISPUTES*

Nuisance disputes typically involve one party (injurer or polluter,[29] male in what follows) negatively affecting the property of another party (the victim or pollutee, female in what follows). The typology of rules that legal systems use to resolve nuisance disputes is highly complicated. We observe that legal systems have "pure" or "elementary" rules in which the solution does not depend on the level of a given variable—for instance, the level of behavior fixed by a legal decisonmaker (be it the legislature, administrative regulator, or court).

There are three pure or elementary rules that legal systems actually use in the nuisance context:[30] strict liability of the polluter or injurer, property right of the victim, and property right of the polluter.

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29.   We have opted, for reasons of simplicity and familiarity, to use the injurer/victim or polluter/pollutee terminology as it is common usage in the economic analysis of nuisance. Obviously, other more "modern" examples would fit into our interaction, and other terms would be more appropriate for these. High trees and solar panels installed in a neighboring plot provides one example. *See* Lee Anne Fennell, *Property and Precaution*, *supra* note 2, at 5. Windmills and noise production affecting nearby residents is a similar illustration.

30.   Recall that we are not considering Rule 4 in the framework of Calabresi and Melamed, *see supra* note 1, given that we have not found traces of its actual presence in dealing with conflicting uses of land.

L-rule: Strict liability rule of the injurer, requiring the injurer to pay damages to the victim for any harm resulting from his emissions, regardless of his level of precaution in emitting.

PI-rule: Property rule in favor of the injurer, which allows the injurer to emit regardless of the harmful effects that his activity may entail for the victim.[31]

PV-rule: Property rule in favor of the victim, which allows the victim to enjoin the injurer from emitting any level of pollution (which implies in most cases that the injurer, having made any investment towards the polluting activity, must not use his investment at all).

In addition to these three pure or elementary rules, legal systems use more complex rules created by the combination of the simpler ones. These more complex rules (or at least those most relevant for nuisance interactions) result from the introduction of a switch that leads from one of the elementary rules to a different one. The switch operating the transition from one simple rule to another may consist of a given level of precautionary behavior on the part of the injurer or the victim, or a level of a different relevant variable—such as, for instance, the level of investments on either side of the nuisance conflict. The switch is set by a legal rule (statutory provision, regulatory standard, or judicial determination).

Under this light, a negligence rule is one of these complex rules. It is of the first-degree type, since the legal system only uses one threshold to determine the transit of one elementary rule to another. A negligence rule could be construed as a combination of the property right (or the entitlement, protected with the *PI*-rule in the sense described above) of the injurer and strict liability, with due care acting as the switch between both pure rules: if the injurer takes due care, he has the property right to emit without paying damages and disregarding the consequences; if he takes less than due care, he has to pay all damages as subject to a strict liability rule. That the injurer fails to have the right to forbid the victim to suffer harm does not affect, we believe, his "property-like" entitlement to invest in a polluting

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31.   Part of the literature considers that the entitlement corresponding to the injurer is not a true legal right, but merely (in Hohfeldian terms) a privilege. *See* Fennell, *supra* note 18, at 1415–17; Smith, *Property Rules in the Law of Nuisance, supra* note 18, at 1011–16; Chang, *supra* note 2, at 14. Thus, it would not be admissible for a polluter or prospective polluter to seek court protection in assisting his privilege, which would produce a fundamental asymmetry (due in large part to the availability of self-help actions for the victim that would be immune to the legal action of the injurer) between entitlements corresponding to the injurer and entitlements corresponding to the victim. Although we believe that in various circumstances it is not unimaginable for an injurer to obtain the court's assistance in securing that the injuring activity is carried out without interference from the victim, we do not want to take a stance on this general point. For the purposes of this Essay, it is sufficient that under the *PI*-rule if the victim desires that the injurer abstains from, or reduces to any extent, the use of the investment by the injurer, or that the injurer takes any level of abatement effort larger than zero, the victim needs to bargain with the injurer in order to make this happen. *See infra* Part III.B (describing our framework).

activity, decide to use fully his investment, and choose with only his welfare in mind the level of care in carrying out the activity.

Negligence liability, however, is not the only manifestation of these kinds of complex rules in the context of nuisance law. Paragraph 906 of the BGB and articles 546-13 and 546-14 of the Catalan Civil Code both contemplate a complex rule by which the victim can enjoin the injurer if the level of emission exceeds regulatory standards, albeit the victim is only entitled to claim damages when the injurer is in compliance with public law requirements, especially as to the type and nature of emissions, given the location, and as to abatement efforts.

The regimes under paragraph 906 of the BGB and articles 546-13 and 546-14 of the Catalan Civil Code are tantamount to a complex rule that combines strict liability and property right of the victim, with the regulatory standard operating as a switch between the two. Even the rule in *Boomer v. Atlantic Cement Co.* might be thought of as an example of a similar rule, with a switch from strict liability to property right of the victim—a sort of aggregate social benefit of the emission or substantial nuisance threshold.[32]

Initially, we will consider three[33] of these first-order (or one-switch) complex rules with precautionary effort or investment levels as a switch. When we use precautionary care as the switch, elementary rules are ordered within each complex rule as the injurer's care increases: (1) strict liability/property right of the injurer (the negligence rule); (2) property right of victim/strict liability (arguably, under a limited interpretation of them, the rules on non-intentional nuisance in the BGB and the Catalan Civil Code); and (3) property right of the victim/property right of the injurer:

PIL-rule: A conditional liability rule, which allows the injurer to emit any amount, but requires him to pay all damages if, and only if, the level of the switch variable is below some threshold. If precautionary care is the switch variable and its due level is the threshold, the *PIL*-rule is equivalent in this context to the negligence rule.

LPV-rule: A rule consisting of the strict liability rule if the switch variable is above the threshold and the property rule in favor of the victim if the switch variable is below.

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    32.   Boomer v. Atl. Cement Co., 257 N.E.2d 870 (N.Y. 1970).

    33.   Not that other rules are theoretically unimaginable. Let's think of a complex rule in which both property rules are combined but in this rather awkward manner: property rule of the victim if precautionary behavior of the injurer is higher than the due care or the regulatory standard, and property right of the injurer thereunder. Such a rule is possible in strictly logical terms, but we anticipate that it would be hard to trace in reality. The reason is that such a complex rule would be non-monotonic in the relevant dimension—precautionary effort of the injurer. *See infra* Part IV.

PP-rule: A rule consisting of the property rule in favor of the injurer if the switch variable is above the threshold and the property rule in favor of the victim if it is below.[34]

But there are still rules with a higher degree of complexity. On the one hand, there are rules that consist of two elementary rules, but use two (or more) switches to define the range in which the one elementary rule applies instead of the other. On the other hand, there are rules in which not just two, but three elementary rules combine with (at least) two switches triggering the transition from one elementary rule to another. One could obviously design an almost arbitrarily large number of such complex rules, but deploying them in a real setting of a nuisance conflict in terms of a governing rule is a different matter. As will become clear for the reader in the following Part, where we present a stylized summary of actual rules in real world legal systems, we will discuss these higher-degree complex rules on the basis of one example.

PLP-rule: Property rule in favor of the injurer if he takes a level of care above the higher standard, strict liability rule if his level of care violates this standard, and property rule in favor of the victim if his level of care violates the lower standard.

B.   A BRIEF OVERVIEW OF LEGAL REGULATION OF NUISANCE IN GERMANY, SPAIN, AND THE UNITED STATES

1.   Germany

In Germany, the Property Reform Act of 1994 added a second sentence to the first point of section 906 of the Bürgerliches Gesetzbuch ("BGB"), which had a declared aim to avoid the potential conflict between public law and private law requirements for externalities affecting neighboring tracts of land. In this vein, the amended provision establishes that the injured party may not claim that nuisances in compliance with the maximum or recommended levels of pollution or emissions provided by public law are substantial nuisances and, therefore, only allows the injured party to claim damages, but not enjoin the polluting party.

Section 906 of the BGB now reads:

> (1) The owner of a plot of land may not prohibit the introduction of gases, steam, smells, smoke, soot, warmth, noise, vibrations and similar influences emanating from another piece of land to the extent that the influence does not interfere with the use of his plot of land, or interferes with it only to an insignificant extent. An insignificant interference is normally present if the limits or targets

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34.   As in the two previous cases, there are not so clear examples of this rule. The rule contained in a California statute requires unreasonable operation by an industry to find such activity a nuisance if it operates in an expressly permitted zone. This might (but only might) be considered a case of the rule at hand, where the due care standard (reasonable operation) acts as the switch between property right of the injurer and property right of the victim.

laid down in statutes or by statutory orders are not exceeded by the influences established and assessed under these provisions. The same applies to values in general administrative provisions that have been issued under section 48 of the Federal Environmental Impact Protection Act and represent the state of the art.

(2) The same applies to the extent that a [material] interference is caused by a use of the other plot of land that is customary in the location and cannot be prevented by measures that [users of this kind can be reasonably expected to bear from an economic perspective]. Where the owner is obliged to tolerate an influence under these provisions, he may require from the user of the [other] plot of land reasonable compensation in money if the influence impairs a use of the owner's plot of land that is customary in the location or its income beyond the degree that the owner can be [reasonably] expected to tolerate.

(3) Introduction through a special pipe or line is impermissible.[35]

Section 906 of the BGB regulates the admissibility of nuisances and the kind of legal action and remedies available to the victim against the defendant's activity. As for the admissibility in the first place, section 906 of the BGB separates those interferences linked to a special regulation differently from the basic remedy of injunction available in a typical action for interference with property (section 1004 of the BGB). Broadly speaking, section 906 of the BGB includes non-trespassory nuisances emanating from a piece of land, which typically injure, at least, another piece of land.

Section 906 of the BGB overtly distinguishes between significant and insignificant nuisances. As for the latter, the injured owner lacks any action or remedy. As to significant interferences, section 906 of the BGB distinguishes between those in conformity with local custom and those contrary to the customary standards. The injured owner can use an injunction against a nuisance not in line with local custom. Finally, section 14 of the Federal Emission Protection Statute establishes that a legally authorized installation meant to abate or regulate emissions must be regarded as an installation in line with the local customs, but this fact may not limit damages claims or remedies in order to mitigate the interference.

A further distinction emerges when an injurer acts in a way that generates a nuisance and local custom covers that action. In that instance, the party affected by a nuisance that the defendant would be able to avoid "by measures that users of this kind can be reasonably expected to bear from an economic perspective"—that is, reasonable abatement measures for a polluting agent of

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35.   BÜRGERLICHES GESETZBUCH [BGB] [CIVIL CODE], Jan. 2, 2002, BUNDESGESETZBLATT [BGBL] I at 42, as amended, § 906 (Ger.), *available at* http://www.gesetze-im-internet.de/englisch_bgb/englisch_bgb.html#p3702.

its kind (size, type of activity, perhaps duration of presence at location, etc.)—can claim injunctive relief. On the other hand, the victim must tolerate unavoidable nuisances. The injured party may demand compensation when a nuisance that she should tolerate—one that cannot open the way for injunctive relief—is so serious that it "impairs a use of the owner's plot of land that is customary in the location or its income beyond the degree that the owner can be reasonably expected to tolerate." Courts and scholars do not clearly delineate whether the concept of "proportionality" also applies in determining which measures the defendant should have adopted to avoid the interference. Both cases are partially linked to a deprivation of the economic outputs of the plaintiff and the defendant, respectively.

In the German Supreme Court's Bundesgerichstof ("BGH") case law, the concept of "proportionality" in the impairment of the use of the land for both sides is generally translated into subtle distinctions (first by BGHZ 30, 273, 280), or is rejected (from BGHZ 64, 220, 223 and f., 229). Nevertheless, it is possible to find formulations showing that the BGH intends to interpret both meanings of "proportionality" as analogous.[36]

The undeniable complexity of the normative structure of section 906 of the BGB may be graphically displayed as in Table 1, which includes in the last column the economic interpretations of the rule.

Table 1. Structure of Cases in Section 906 BGB

Facts							Legal consequences	economic background
Nuisances	Easily tangible nuisances ('ponderabilities') and nuisances directed by a pipe or similar						→ Negatory action according to Section 1004 BGB	Property rule in favor of victim
	Physically measurable nuisances which typically spread ('imponderabilities')	Substantial harm	Resulting from use according to local custom					
			Resulting from use contrary to local custom	Economically avoidable				
				Economically not avoidable	affected land use is according to local custom	inflicting unreasonable burden on victim	Liability according to Section 906, 2, 2 BGB	Liability rule in favor of victim
						inflicting only reasonable burden on victim	No negatory action or liability	Property rule in favor of injurer
					affected land use is contrary to local custom			
		Non-substantial harm						
	Purely ideal nuisance							

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2. Spain

In Spain, the most detailed regulation—though certainly not the only regulation—of nuisance disputes is found in articles 546-13 and 546-14 of the Catalan Civil Code; both articles were heavily influenced by the earlier version of section 906 of the BGB. The first of such provisions reads: "*Nuisances involving smoke, noise, vapors, smells, vibrations, light, heat, electromagnetic waves and similar ones, produced by illegitimate behavior of the neighbor and causing harm to the property are prohibited, and give rise to legal liability covering all harm caused.*"[37]

Article 546-14 introduces the complex rules:

1. All property owners should tolerate a nuisance coming from neighboring properties when they are innocuous or produce only unimportant prejudice. Those that exceed indicative or maximum limits set out by law or regulation are generally deemed important.

2. Property owners should equally tolerate a nuisance causing substantial harm if they are a consequence of a normal use, according to applicable laws and regulations, of the neighboring property, and ceasing the nuisance would imply a disproportionate cost.

3. In the latter case, the property owner has the right to claim damages for past harm, and compensation mutually agreed or judicially determined, for future harm, if nuisance excessively affects the use of the property or the income therefrom, according to local custom.

4. Substantial nuisance coming from installations complying with all regulatory requirements allow the affected property owner to request the adoption of technically feasible and economically reasonable measures to avoid harm, and for damages covering harm already produced. For the remaining harmful consequences, the property owner is entitled to damages covering future harmful effects.

5. No property owner has to tolerate a nuisance specifically or artificially addressed towards her property.[38]

Interferences or nuisances causing substantial harm are not always enjoinable as the previous provisions show. Commentators in this area of the law think that the "normal use" criterion favors owners who cause nuisance to their neighbors and cause substantial harm, and especially the industrial owners because injured parties cannot enjoin their activity through an

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37. CODI CIVIL DE CATALUNYA art. 546-13.

38. *Id.* art. 546-14.

injunctionary remedy (the ancient Roman *actio negatoria*) and the plaintiff is only entitled to seek economic compensation.[39]

One should interpret "normal use" within the text of the provision with regard to local standards, in spite of the arguably important degree of uncertainty surrounding this notion. Moreover, a nuisance, the cessation of which would imply an excessive cost (article 516-14 (3))—which can be understood as abatement measures exceeding the due care level according to the Hand formula—cannot be enjoined. An injunction under such circumstances would deter firms' socially valuable economic activity and would eliminate their profits and, thus, impede production. As a consequence, the affected property owner should tolerate normal interferences that the injurer cannot abate except at a disproportionate cost.[40] Additionally, owners should tolerate nuisances emanating from installations that comply with regulatory requirements.[41]

3.   The United States

In a gross simplification of the complicated and varied legal landscape of nuisance law in the United States, one can claim, as a general statement, that for an invasion upon the owner's property to constitute a private nuisance, the invasion has to be both substantial (a condition that appears to be applicable across the common law–civil law divide) and unreasonable.

The reasonableness requirement seems to be at the core of nuisance law in many U.S. jurisdictions, and the fact that it is not a simple translation of the reasonable behavior test in tort law confirms the complexity of this reasonableness requirement. The search for the meaning of what amounts to an unreasonable interference in nuisance law requires considering several factors: the type of neighborhood in which the invasion takes place and the expectations of the residents about the kind of uses and interferences to be had (a factor in which compliance with regulatory requirements seems to play a major, albeit not entirely dominant, role); the level and intensity of the invasive activity; priority in time (that is, the well-known "coming to the nuisance" doctrine); and the social utility (or lack thereof) of the injurer's activity (a factor that seems extremely relevant for allowing an injunction or damages as the available remedy).[42]

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39.   LLUÍS PUIG I FERRIOL & ENCARNA ROCA I TRIAS, INSTITUCIONS DEL DRET CIVIL DE CATALUNYA VOLUM IV. DRET REALS [INSTITUTIONS OF CIVIL LAW OF CATALONIA. VOLUME. IV: PROPERTY] 294 (2007).

40.   JOAN EGEA FERNÁNDEZ, ACCIÓN NEGATORIA, INMISIONES Y DEFENSA DE LA PROPIEDAD [INJUNCTIONS, NUISANCE, AND PROTECTION OF PROPERTY] 135, 137 (1994); *see also id.* at 140–43 (detailing the notion of normal use).

41.   *See* PUIG I FERRIOL & ROCA I TRIAS, *supra* note 39, at 295.

42.   *See* DOBBS, *supra* note 5, at 1325–30.

Recent approaches to nuisance law that attempt to provide a consistent economic logic to its doctrines consider that section 520 of the Restatement (Second) of Torts is applicable in nuisance disputes:[43]

> In determining whether an activity is abnormally dangerous, the following factors are to be considered: (a) existence of a high degree of risk of some harm to the person, land, or chattels of others; (b) likelihood that the harm that results from it will be great; (c) inability to eliminate the risk by the exercise of reasonable care; (d) extent to which the activity is not a matter of common usage; (e) inappropriateness of the activity to the place where it is carried on; and (f) extent to which its value to the community is outweighed by its dangerous attributes.[44]

This brief overview of the legal regulation of nuisance in three different jurisdictions has thus shown that the legal approach to nuisance cases is far from a replica of the simple scheme of rules the law and economics literature usually considers in dealing with property rules and liability rules. Real-world legal systems primarily use complex rules in which bits and pieces of the elementary rules co-exist and combine—a scenario that can be approximated by the taxonomy presented in Part III more closely than through the Calabresi–Melamed framework of simple rules.

III. FRAMEWORK OF THE PROBLEM, SETTING, AND FINDINGS

A. THE PROBLEM

Similar to the central problem in tort law, the incentive problem in nuisance law can also be characterized as twofold: optimizing the parties' choices about what activity to pursue in a given location and how much to invest in it, as well as the way in which the activity is carried out. In terms already familiar due to the standard tort model, these characteristics boil down to (1) control of care; and (2) control of the parties' activity levels. As we know from economic analyses of Tort Law[45] neither negligence-based nor strict liability rules induce optimal care and optimal activity levels by both the

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43.   Hylton, *The Economics of Nuisance Law, supra* note 5, at 334–35; Hylton, *The Economic Theory of Nuisance Law, supra* note 5, at 682–83. Hylton argues that the first two factors in section 520 operate as a minimum requirement for nuisance, so when the interference is trivial and the injurer exercised reasonable care, nuisance law should not apply. *Id.* The common usage factors would relate to reciprocity of risks, where there would be no reason to deploy nuisance liability. The latter factors would refer to the balance of external costs and external benefits. The extent to which there may be external benefits from economic activities that could also have negative effects on neighboring properties is extensively analyzed in agglomeration economies literature. *See* Diego Puga, *The Magnitude and Causes of Agglomeration Economies*, 50 J. REGIONAL SCI. 203, 210–16 (2010).

44.   RESTATEMENT (SECOND) OF TORTS § 520 (1977).

45.   STEVEN SHAVELL, ECONOMIC ANALYSIS OF ACCIDENT LAW 29–31, 43–46 (1987); *see also* THOMAS J. MICELI, ECONOMICS OF THE LAW: TORTS, CONTRACTS, PROPERTY, LITIGATION 28–29 (1997).

injurer and the victim. Only if damages were conditioned by both the levels of care and the levels of activity could Tort Law induce optimal behavior along all relevant dimensions.

The structure of the problem is not too different in the nuisance setting: Harm arising from a nuisance depends on the level of abatement behavior of the injurer (but sometimes also of the victim) and on the level (and kind) of use of the respective properties by both the victim and the injurer. Very often, a certain level of activity requires some investments before a particular conflict between incompatible uses arises or becomes relevant. By analogy, one may infer that these investments will be sub- or supra-optimal, if damages exclusively depend on the level of care exerted by the injurer (and the victim, if relevant). In fact, part of our argument and findings will rely on reasons closely related to this idea.

An important difference between tort law and nuisance law, however, comes from the possibility of Coasean bargaining in many typical nuisance situations. While individual bargaining is impossible or nearly impossible in the case of many interactions under Tort Law, the parties may bargain about nuisances. We believe that, typically, bargaining between the parties may occur before the injurer undertakes abatement or other precautionary measures (that is, prior to decisions to emit more or less, or to install filters or other externality-reducing devices), but most likely after the injurer or victim has made investment decisions (that is, after a plant or a house has been built, for instance).

Besides Coasean bargaining, there are two other potential solutions to the nuisance problem: optimal liability rules conditioning liability on both care and investment levels, and optimal regulation. However, it is reasonable to think that the conditions for these two alternative solutions to operate in our setting are too exacting to be implemented in most real-life scenarios.

For Coasean bargaining, we have already claimed that injurers, as well as victims, tend to decide on their investments before the conflicting uses arise or even become predictable, and so, before any bargaining can take place. We will consequently assume that Coasean bargaining will take place only after both the victim and the injurer have made all of their investments and, thus, bargaining cannot refer to the level of investments. The reasons for this are threefold. First, investment decisions by the injurer and the victim often are, or tend to be in an abstract sense, simultaneous. Especially in new development areas, all parties are newcomers and their investment decisions can be, for all relevant purposes, deemed simultaneous. Second, even when, in chronological terms, there is a first-comer, the second-comer may very well be unaware of the possible conflicts arising from his investment, as well as of the relevant individual former investors (whether it is because he is unable to observe their identity, or because they do not observe his investment plans). Moreover, investment decisions tend to be only very imperfectly verifiable in

court, which makes them substantially noncontractible.[46] And last, the focus of our Essay does not lie on the first-comer–second-comer type of interaction, which would be most appropriate to analyze the entry and exit of polluters and victims, and rules such as the "coming to the nuisance" rule. Rather, the focus of our Essay lies in the interplay between care, activity, and noncontractible investments preparing activity.

Nevertheless, it is important to emphasize that we consider bargaining among parties in a nuisance conflict as very relevant for understanding the interaction, and that we allow Coasean bargaining a larger space than the one commonly granted in the standard law and economics treatment of nuisance situations. We assume that the injurer and victim can bargain not only over abatement behavior, but also on how both the injurer and victim use their own investments, although we exclude, as already argued, that parties bargain over the initial choice of their investment levels.

Such a setup, at least so we believe, reasonably approximates the scenarios in which the rules we want to explore are typically applied, while giving the possibility of Coasean bargaining between the parties the amplest room one can allow. In fact, somewhat surprisingly at first blush, the increased space for bargaining actually reduces the efficiency induced by the different legal rules—especially by liability rules—thus undermining the preference awarded to liability rules by previous literature, such as Kaplow and Shavell[47] and Pitchford and Snyder.[48]

In this Essay, we concentrate on the following stylized nuisance situation: an injurer (I) and a victim (V) invest in activities of which I's activity inflicts harm on V's activity. Before I and V decide on how much of their investment they will actually use, they bargain on the degree of use of their investment levels (their activity levels in the familiar tort landscape) and on their levels of care, all of it under the shadow of three types of rules: the classic elementary ones, the first-degree complex ones, and even some higher-degree complex rules.

In the following Subparts, we will summarize and explain informally the model and results that are more elaborately and formally presented, with all corresponding proofs, in the accompanying Working Paper version.[49]

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46.   This is the reason underlying the assumption found in other analyses of investments under property rules and liability rules, to the effect that the investment level is outside the scope of Coasean bargaining. Bebchuk, Ex Ante *Investments and* Ex Post *Externalities, supra* note 1, at 8; Bebchuk, *The* Ex Ante *View of the Cathedral, supra* note 1, at 620.

47.   Kaplow & Shavell, *supra* note 1, at 718–20.

48.   Pitchford & Snyder, *supra* note 26, at 496.

49.   Georg von Wangenheim & Fernando Gomez, The Complex Economics of Nuisance Law: Bargaining Under Property and Liability Rules with Public Law Standards (2008) (unpublished manuscript) (on file with authors).

B.   *Structure of the Interaction and Socially Optimal Actions*

The specific setting we use to look into the effects of simple and complex rules in a nuisance context with bargaining between the injurer and victim can be described as follows. They can make investments (i and j) and also decide about the uses of their respective investments i and j to any amounts $y \in [0, i]$ and $z \in [0, j]$. Use of the investments yield I and V gross payoffs, which may be described by continuous twice-differentiable functions $U(y, \rho)$ and $V(z, \sigma)$, respectively, with ρ and σ being productivity parameters. It is noteworthy that the restrictions $y \in [0, i]$ and $z \in [0, j]$ imply that investments may be fully used or not, and that the injurer and the victim may even completely discard their investments. This assumption reflects the possibility of the law providing an injunctive remedy for the protection of property rights, because an injunction not to use an investment would be implicitly ruled out if the use of the investment was completely determined by the size of the earlier investment.

The payoff functions $U(\cdot)$ and $V(\cdot)$ have the standard properties. If both the injurer and victim use their investments at strictly positive amounts ($y > 0$ and $z > 0$), the interaction creates harm or losses for the victim. The losses inflicted are in the amount $\ell(w, x, y, z)$, where w and x are abatement efforts of I and V, respectively. For simplicity, we assume that the size of the losses is independent of the amount of investments both the injurer and the victim use as long as both use their investments in a strictly positive way and given by $\ell(w, x)$, and that losses are zero if the injurer or the victim refrains from using their investment. We further assume that the functional forms of $U(\cdot)$, $V(\cdot)$, and $\ell(w, x)$ are common knowledge.

The sequence of events and actions in our stylized nuisance interaction may be summarized as follows:

1. I and V decide on their investments i and j, respectively, and effectively carry out their investment decisions.

2. For the purposes of allowing maximum space to private arrangements and bargaining, we assume that the next stage is a bargaining process: I and V bargain on the amount to which they use their investments—y and x, respectively—and also on their levels of care or abatement efforts—w and x, respectively.[50] After successful bargaining, V gets the proportion $a \in (0, 1)$ of

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50.   The literature that explicitly considers bargaining over entitlements under alternative legal rules provides less space for private bargains and does not consider how bargaining may affect the use of investments already made or abatement and precautionary measures more generally. *See, e.g.*, Ian Ayres & Eric Talley, *Solomonic Bargaining: Dividing a Legal Entitlement to Facilitate Coasean Trade*, 104 YALE L.J. 1027 (1995); Hylton, *The Economics of Nuisance Law, supra* note 5; Kaplow & Shavell, *supra* note 1;. Bargaining over such matters is not only a theoretical possibility. A real-world example of bargaining on care levels is provided by the French case of the mineral water company Vittel (a brand of Nestlé). Vittel, after finding out that the water source was being polluted by neighboring farmers, struck a deal with 92% of them in order to impose the adoption of more environmentally friendly and less polluting farming practices. *See*

the bargaining surplus. We assume also, for the purposes of giving the largest role to Coasean bargaining between interested parties, that transaction costs of these bargains are zero,[51] hence bargaining is always successful whenever there is something to gain from bargaining.

3. I and V take care w and x, respectively, either according to the bargaining agreement, if there is one, or to whatever level of care is optimal for them.

4. I and V apply their investments to $y \in [0,i]$ and $z \in [0,j]$, respectively, either according to the bargaining agreement, if there is one, or to whatever degree is optimal for them.

5. The gross payoffs $U(y,\rho)$ and $V(z,\sigma)$ of the used investments, as well as the losses $\ell(w,x,y,z)$ that injurer's activity inflicts on the victim, are realized.

6. Courts enforce property rights and liability, as well as contracts resulting from the parties' bargaining.

The decisions and actions that are socially or jointly desirable depend on whether the injurer alone, the victim alone, or both should be using their investments in the activity that they are engaged in on their respective plots. More formally, and using a bar above the variables to denote the optimal strictly positive values of variables, the social optimum depends on whether the costs of foregoing the injurer's optimal investment ($\bar{U} - \bar{\iota}$) or the costs of foregoing the victim's optimal investment ($\bar{V} - \bar{\phi}$), or the costs of incurring the conflicting uses given the optimal levels of care ($\bar{L} \equiv \bar{w} + \bar{x} + \ell(\bar{w}, \bar{x})$) are the lowest. If the damages from conflict $\bar{L}$ are less than the net payoffs of both I and V, $\bar{U} - \bar{\iota}$ and $\bar{V} - \bar{\phi}$, respectively, then both I and V should invest and use their investment fully. Otherwise, only the party with the larger net payoff should invest and use his or her investment fully. Put another way, each party should invest unless his or her net payoff is smaller than both the other party's net payoff and the damages from the conflict. Table 2 and Figure 1 summarize these conditions and the ensuing socially optimal values (positive or zero, marked by an asterisk) of the relevant variables including social welfare W^*. It is important to note that one cannot reach this first-best optimum by pure Coasean bargaining, since the initial investments of injurers and victims are not open to bargaining, and therefore, the investment

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Christophe Depres et al., *Contracting for Environmental Property Rights: The Case of Vittel*, 75 ECONOMICA 412 (2008).

51. Toshihiro Tsuchihashi, Socially Efficient Scheme to Protect Property Entitlements: A Property Rule vs. Liability Rule 27 (2012) (unpublished manuscript) (on file with authors) (considering positive bargaining costs and alternative bargaining formats—ultimatum and sequential—in a simple setting of nuisance under property rules and liability rules). Moreover, we do not consider the possibility of the strategic creation of transaction costs by parties in order to frame the interaction in a setting with less (but more individually advantageous) alternative bargained-for outcomes. Jordan M. Barry et al., *Coasean Keep-Away: Voluntary Transaction Costs* 28–37 (San Diego Legal Studies, Working Paper No. 14-149, 2014), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2403839.

decisions will be strategically adopted in order to maximize payoffs following bargaining.

Table 2. Socially Optimal Values of the Relevant Variables

$\min(\overline{\mathcal{L}}, \overline{\mathcal{U}} - \overline{\imath}, \overline{\mathcal{V}} - \overline{\jmath})$	$i^* = y^*$	$j^* = z^*$	x^*	w^*	W^*	area
$\overline{\mathcal{L}}$	$\overline{\imath}$	$\overline{\jmath}$	$\overline{x}$	$\overline{w}$	$\overline{\mathcal{U}} - \overline{\imath} + \overline{\mathcal{V}} - \overline{\jmath} - \overline{\mathcal{L}}$	Ⓐ
$\overline{\mathcal{V}} - \overline{\jmath}$	$\overline{\imath}$	0	0	0	$\overline{\mathcal{U}} - \overline{\imath}$	Ⓑ
$\overline{\mathcal{U}} - \overline{\imath}$	0	$\overline{\jmath}$	0	0	$\overline{\mathcal{V}} - \overline{\jmath}$	Ⓒ

Figure 1. Socially Optimal Investments
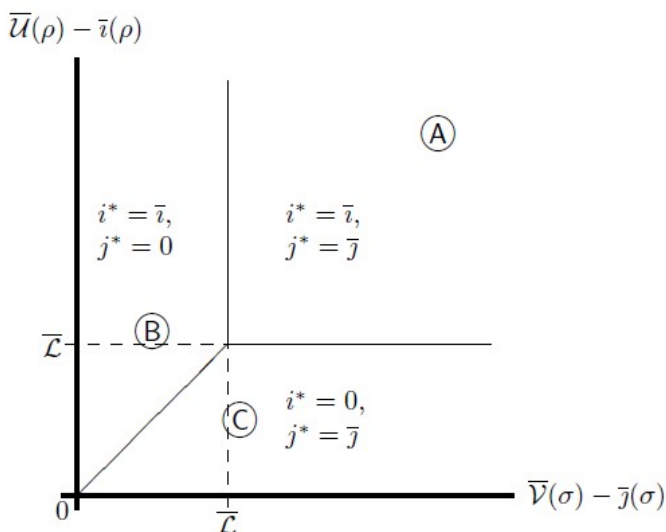
In the following Subparts, we will summarize our findings concerning the parties' choices and behavior under both the simple and the complex rules. We will also summarize how the behavior and the welfare effects compare to the first-best optimum.

C. *EFFECTS OF ELEMENTARY RULES*

With strict liability (the *L*-rule in the notation of Part II above), the injurer bears the costs of harm and the costs of his own care, unless bargaining allows him to transfer parts of these costs to the victim. The victim bears no costs of harm and only her own costs of care. Without bargaining, she would thus reduce her level of care to zero, which increases the injurer's costs of harm. Since bargaining on care is costless, both the injurer and the victim will agree to exert optimal care (given their levels of use of investments), and the injurer will bear the full costs of the optimal harm and care. In addition, the injurer will have to pay the victim's share of the bargaining surplus in order

to induce her to exert optimal care, rather than staying with zero care and being fully compensated for the resulting high damages.

Since the victim can guarantee herself a payoff of at least $\bar{V} - \bar{\emptyset} > 0$, she will always invest. Only if her productivity is so low that the injurer can compensate her for abandoning the investment with her share α of the bargaining surplus, will she be induced to abandon or not use her investment.[52] The injurer, on the other hand, will invest only if his net payoff $\bar{U} - \bar{\imath}$ is large enough either to cover $\bar{L}$ and the victim's share of the bargaining surplus, or the victim's gross payoff from her investment and the victim's share of the bargaining surplus.

Thus, in our setting, under the liability rule protecting the victim, the use of the investments and the choice of care or abatement measures will be ex-post efficient, since Coasean bargaining will take care of them. The liability rule will distort the investment decisions: the victim will overinvest, given that $\bar{V} - \bar{\emptyset}$ may be the lowest (that is, we may be in our B of Table 2 and Figure 1). Given that the injurer anticipates the strategic use of investments by the victim and the victim's lack of incentives to take any care and that the injurer will have to pay something to the victim, the injurer will not necessarily invest, even when his net payoffs are larger than the damages from the conflict or the victim's net payoffs, but only slightly so. The injurer will thus underinvest.

Under the property rule in favor of the injurer (the *PI*-rule in the notation of Part II above) and without bargaining, the injurer only bears the cost of his own care while the victim bears the costs of harm plus the costs of her own care. As under strict liability, both bear their own investment costs. From a strategic point of view, the property rule in favor of the injurer is thus perfectly symmetrical to the strict liability rule.

Now, under a property rule that favors the injurer who is now the party bearing no costs of harm, the injurer will reduce his care to zero unless he otherwise agrees differently in bargaining with the victim. He thus increases the victim's costs of harm. The costless bargaining on care (and on the use of investments) will induce the injurer to exert optimal care, but the victim will have to compensate him for these additional costs, and in addition, the victim will have to pay the injurer's share of the bargaining surplus. Hence, as was the case for the injurer under the injurer's strict liability rule, the victim will now bear more than the full costs of care and harm, and she will tend to underinvest. In symmetry with the strict liability rule, the injurer now bears no costs of harm (so, no costs of his own care) and can even extract some over-compensation (part of the bargaining surplus) when taking optimal care. He will thus invest even if he should abstain from doing so under social

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52.   In the French Vittel case, the water company actually purchased about 1500 hectars of farmland from the polluting farmers by offering attractive prices to farmers approaching retirement age. *See* Depres et al., *supra* note 50, at 417.

welfare considerations.[53] In fact, when his gross payoffs from investment are small enough, he may even invest only to build up a bargaining position, and then entirely abandon his investment after bargaining and obtaining his strategic gain.

While its name may suggest otherwise, the property rule in favor of the victim (the *PV*-rule in the above notation in Part II) is not a mirror image of the property rule in favor of the injurer. If the *PV*-rule is in place and bargaining fails to occur or to succeed, the injurer bears only the cost of his own care, while the victim bears the cost of harm and her cost of care (as was the case under the *L*-rule). However, the victim under this property rule is entitled to enjoin any harmful activity by the injurer. Thus, without exerting any care, the victim can guarantee to herself a payoff of at least $\bar{V} - \bar{\emptyset} > 0$, while the injurer would be forced to bear the costs of reducing the harm to zero. For these reasons, the strategic situation is parallel to that under the *L*-rule, except for the costs of harm and care that the injurer bears without Coasean bargaining: Under the *L*-rule, these costs amounted to the minimum costs of harm and care, given that the victim takes no care, but under the *PV*-rule, they amount to the costs of reducing the harm to zero. The latter costs are higher than the former, unless the damage function is such that reducing the harm to zero is the injurer's best reply to the victim's choice of zero care. In fact, in this special case, strict liability and property—both favoring the victim—are strategically equivalent in our setting.

In all other cases, such as when reducing the harm to zero is more expensive for the injurer than the minimized costs of care and the damages without any care of victim, moving from the *L*-rule to the *PV*-rule weakens the injurer's bargaining position by lowering his threat point. As a consequence, the injurer will invest less, and more often he will refrain from investing at all. On the other hand, the victim will invest more often, not only to abandon her investment after bargaining, but to use the investment because the injurer abstains from investing. Hence, the victim will overinvest to a larger degree. To summarize: The victim will invest at least as much as under the injurer's strict liability rule, and possibly more, while the reverse will happen to the injurer—that is, he will invest less or at most as much as under the *L*-rule.[54] Thus, in our setting, a liability rule protecting the victim is superior to a property rule also favoring the protection of the victim's entitlements.[55]

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53.   *See* Daniel B. Kelly, *Strategic Spillovers*, 111 COLUM. L. REV. 1641, 1652 (2011) (arguing that sometimes agents invest to produce negative externalities in order to extract payments from the victims of the externality in exchange for discontinuing the harmful activity).

54.   Pitchford & Snyder, *supra* note 26, at 511 (finding the same result in their more restrictive setting, in which their "second-party injunction right" is equivalent to our *PV*-rule); *cf.* Bebchuk, *The* Ex Ante *View of the Cathedral*, *supra* note 1, at 23–24 (obtaining a different result for the victim's investment incentives, but only because in that setting there was no possible bargaining over abatement measures).

55.   In our setting we do not consider a whole range of factors that have led other commentators to be skeptical about (or plainly opposed to) the superiority of a liability rule over

In our nuisance setting—that is, one involving: (1) the availability of Coasean bargaining on the level of care the parties may take and how the parties use the investments they make, but not on the level of investments that are sunk at the time of bargaining; (2) simultaneous decisions on the investments; and (3) common knowledge of the gross payoffs from the investments and the harm functions—the property rule protecting the victim is socially inferior to the strict liability rule protecting the injurer, while the relative social superiority of the strict liability rule and the property rule favoring the victim cannot be assessed generally and depends on the parameter constellations that are most relevant in the circumstances. None of these three elementary rules are capable of inducing the socially first-best behaviors for all parameter constellations.[56]

Figure 2 depicts which regions of the $(\bar{U} - \bar{\imath})$-$(\bar{V} - \bar{\varnothing})$-space the elementary rules we have discussed induce optimal behavior for both parties.

Figure 2. How the Elementary Rules Induce Optimal Investment

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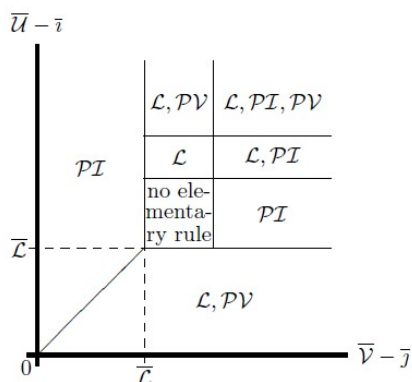
a property rule in a nuisance setting or more generally. *See, e.g.*, Epstein, *supra* note 19, at 2094 (discussing the risk of undercompensation of the entitlement holder under liability rules); Hylton, *supra* note 1, at 159–63 (describing subjective valuation on the part of entitlement holders that liability rules typically ignore); Smith, *Property Rules in the Law of Nuisance, supra* note 18, at 1021–27 (outlining information-cost savings that exclusionary rights fully delegated to owners may provide, but that will be lost if the internalization of externalities is delegated to courts implementing liability rules—even as in nuisance it is granted that, on the edges, some role for liability rules would be welcome). *But see* EPSTEIN, *supra* note 17 (acknowledging that liability rules should cover most nuisance situations, property rules only the residual). Although we would happily concede that courts, and the legal system more generally, would need to have more information to administer a liability rule instead of a property rule, it must be noted that our findings hold in a setting traditionally "hospitable" to property rules, namely one of ample room for Coasean bargaining and zero transaction costs preventing private arrangements over most of the variables relevant to the parties' interaction.

56. This last finding is consistent with those of Bebchuk. *See generally* Bebchuk, Ex Ante *Investments and* Ex Post *Externalities, supra* note 1; Bebchuk, *The* Ex Ante *View of the Cathedral, supra* note 1.

At the heart of our last finding lies the following insight: when the threat points of Coasean bargaining depend on sunk investments that are not covered by the bargain, the law should anticipate the result of Coasean bargaining to avoid investments that diverge from optimal levels. We will now consider if the complex rules we have identified as reflecting to some extent what some legal systems do in the nuisance context or other (probably even more complex) rules would be able to live up to the challenge posed by sunk investments prior to bargaining.

D.   *EFFECTS OF COMPLEX RULES*

We will start, for obvious reasons, by considering in our setting the performance of first-order complex rules. These are rules under which one elementary rule governs the conflict if one of the behavioral variables (precaution, or eventually investment) of either of the parties, or one of the variables describing the exogenous facts of the case (in our setting, for instance, the productivity levels), is below some critical value, and a different elementary rule if this behavioral variable is above the critical value. For continuity, we assume that one of these two elementary rules is also applied when the behavioral variable equals the critical value.

The critical value that operates as a switch may either be fixed or may be a (typically linear) function of other variables. We start our discussion with first-order complex rules based on care, and then briefly consider alternative rules employing one of the investment levels or productivity parameters as the relevant switch variable. We proceed like this for two reasons. First, rules using precaution or abatement costs as the variable over which to fix the rule switch are more familiar in the general discussion of legal rules protecting entitlements. Second, at least in the two European legal systems we have analyzed, the complex rules seem to look—though not exclusively—to switches linked to care or abatement measures, and not to investment and/or productivity (emission levels fixed by law or regulation, activity carried out in conformity with local custom, measures reasonably expected to avoid the interference with the victim's property, etc.).

An obvious first candidate would be (using the notation in Part II above) a *PIL*-Rule with due (or mandated, or reasonable, or locally normal) care as a switch. The most prominent example of such a complex rule would be the familiar negligence rule in tort, which one could also apply in the nuisance context.

The negligence rule is a special case of the *PIL*-rule, in which the level of care is the trigger to switch between the two rules: if the injurer's level of care is less than the socially optimal level of care,[57] then the liability rule in favor

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57.   We assume, as is standard in the economic treatment of negligence, that due care is set at the first-best optimal level of care. Deviations from this may happen due to courts' errors, but

of the victim will govern the conflict between the two parties. Otherwise, the property rule in favor of the injurer will govern the conflict between the parties. With this rule, the injurer bears the full cost of the conflict if he takes less than due care[58] and only his own costs of care if his care amounts to at least the due level.

From the vast literature on negligence in tort, the reader will immediately conclude that both the victim and injurer will take optimal care, even without any bargaining. Without bargaining, neither of the parties bear the full costs of the conflict among neighboring uses (costs of harm plus costs of care of both parties). Hence, both will invest when their gross payoff is large enough to cover investment costs plus the full costs of conflict because it is socially optimal.

When only one party should invest from a social point of view, it is still worthwhile for both to invest if the full costs of conflict are only slightly larger than the parties' net payoffs without conflict. Therefore, both parties tend to overinvest. Overinvestment need not find its end when the gross payoffs fail to cover the sum of a party's investment costs plus his or her costs of care, plus his or her share of the optimal harm. If such losses resulting from investment are minor, investment may become profitable due to subsequent bargaining: The party whose gross payoffs are smaller will abandon his or her investment, and the other party will compensate him or her and benefit from the saved costs of conflict. As was the case for the elementary rules, this may imply that the other party would not use his or her investment without bargaining.

Finally, one of the parties may also completely abstain from any investment. Whether and under what conditions these behaviors are sub-game perfect depends on the exact structure of the gross payoff functions and on the victim's relative bargaining power α.

Thus, the negligence rule in our setting induces overinvestment by both parties when only one should invest and none of the parties' net payoffs from investment without conflict is much smaller than the minimal costs of conflict. If at least one of the parties' net payoffs from investment without conflict is much smaller than the minimal costs of conflict, overinvestment of this party and underinvestment of the other party may result.

In fact, as the full-fledged model shows, any *PIL*-rule with switches between the property rule in favor of the injurer and the liability rule in favor

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also to efficiency considerations. Juan José Ganuza & Fernando Gómez, *Realistic Standards: Optimal Negligence with Limited Liability*, 37 J. LEGAL STUD. 577, 589–91 (2008).

    58.   We thus disregard the complications on the operation of the negligence rule regarding damages in terms of incorporating causation requirements that may lead to a reduction in the amount of damages to be paid by a negligent injurer. *See generally* Mark F. Grady, *A New Positive Economic Theory of Negligence*, 92 YALE L.J. 799 (1983); Marcel Kahan, *Causation and the Incentives to Take Care Under the Negligence Rule*, 18 J. LEGAL STUD. 427 (1989). We also disregard a possible limitation of damages to the gross value of the victim's investment. Incorporating this restriction into the analysis tremendously complicates it, but fails to add substantially to its insights.

of the victim on the basis of care levels either induces overinvestment at least by parties whose net payoffs are slightly less than the minimal costs of conflict, or induces the same inefficiencies as the strict liability rule or the property rule of the injurer working in isolation.

We now turn (again using the notation from Part II above) to a *PP*-Rule with care as the switch. We conjecture that only *PP*-rules based on injurer's care will be attractive for a lawmaker, while *PP*-rules based on the victim's care will not be attractive to a lawmaker, given that the latter would grant the victim the right to enjoin any nuisance if and only if she takes enough care as the victim. But this would mean that she has to take some care in order to make that very care futile through the injunction forbidding any activity leading to a level of harm different from zero—a legal rule which one can hardly imagine.

PP-rules based on the injurer's care, however, are very similar to *PIL*-rules based on the injurer's care. Similar to *PIL*-rules, *PP*-rules will induce the injurer to take due care since this bars the victim's ability to enjoin his activity or impose substantial costs on him (those necessary to reduce harm to the victim to a zero level). Beyond the due level of care, the injurer holds the right to carry on the activity that causes the nuisance under both rules, and therefore, has no incentive to take further precautions. Thus, in our setting, the effects of a *PP*-rule with due care as a switch will be the same as those of the negligence rule.[59]

Now we consider the *LPV*-Rule with care as a switch. We find this type of first-order complex rule with care as the switch as part of the complex rules in the German BGB: The *LPV*-rule uses the care of the injurer as a switch between the rules, but now between the property rule in favor of the victim and the strict liability rule, where the property rule protects the victim if the injurer fails to meet the due care standard. As was the case for the *PP*-rule, we consider that the care of the victim cannot cogently operate as the switch between the two rules, for the reasons already explained with regard to the *PP*-rule.

Under the *LPV*-rule, the injurer will meet the level of due care either to avoid unnecessary costs of care (if no bargaining occurs) or to improve his bargaining position. The injurer thus turns the legal situation into something that is close to the elementary strict liability rule inasmuch as investment and bargaining are concerned. The situation, nevertheless, is not necessarily identical under both rules. The *LPV*-rule induces the injurer to take care at least to the due care level. If this due level is not greater than the level of care

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59.   For due levels of care far greater than the optimal level of the injurer's care, the two rules may differ. Given that the *PV*-rule imposes higher costs on the injurer than the *L*-rule, the injurer will still comply with due levels of care under the *PP*-rule, which he would already ignore—and thus infringe—under the *PIL*-rule. However, such large due levels of care are either irrelevant for the main results, or substantially complicate the argument without seemingly providing further insights.

he would take under the simple strict liability rule without bargaining, he will of course further extend his care to this level. Then the *LPV*-rule induces the same effects as the the *L*-rule when that condition holds. However, if the due level of care is larger than the level of care that injurer would take under the *L*-rule without bargaining, the situation comes closer to the *PV*-rule, under which the victim could force the injurer to take any level of care until zero harm is reached, or the injurer abandons his investment in the harmful activity.

In sum, under the *LPV*-rule with the care of the injurer serving as a switch, investments are the same as under the strict liability rule protecting the victim if the due level of care is not too large. If the due level of care is very large, investments will deviate from those under the *L*-rule in the same direction as under the *PV*-rule, though to a lesser degree. Thus, the *LPV*-rule operates as the strict liability rule—or worse when due care standards are too large—but is preferable to the simple property rule protecting the victim.

Finally, it is interesting to consider first-order complex rules using a variable other than care or abatement measures as the switch—in particular, variables such as the investment level or investment productivity of one or both parties.[60] It seems to us that it would be wise to consider complex rules of this kind with the switch determining a transit between the two simple rules shown in the previous analysis to be undominated in terms of social welfare, namely the *L*-rule and the *PI*-rule.

The help of a graphical argument using Figure 2 above (recall that this figure shows the different areas of the parameters for which an elementary rule induces optimal investment) more easily shows the effects of a complex rule of this nature. First, consider a first-order complex rule based on investment productivities as the switch. Such a rule would be tantamount to a division of the $(\bar{U} - \bar{\iota})$-$(\bar{V} - \bar{\emptyset})$-space by a straight line on one side of which the *L*-rule is applied, while the *PI*-rule is applied on the other side. Mere inspection of Figure 2 shows that there is no such unique dividing line which avoids all over- and under-investment.

Alternatively, one could use the investment level of one party as a switch. Obviously, the best a legal system could do here is to compare actual investment to socially optimal investment. For example, one such rule could be to apply the *PI*-rule if the victim overinvests, and the *L*-rule otherwise. Or, equivalently, to apply the *PI*-rule if victim should not invest, and the *L*-rule otherwise. Again, mere inspection of Figure 2 shows that this will not induce socially optimal investments in all cases. In particular, the injurer will underinvest if his net payoff from investing is only slightly larger than the social costs of conflict.

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60.   We do acknowledge that the design and implementation of these kinds of switches would be very hard for lawmakers and courts, but we believe it is interesting theoretically to analyze the possibility.

In sum, in our setting, none of the natural (and some of the less natural) first-order complex rules achieve adequate investment incentives where bargaining refers to the parties' levels of care and uses of the investment, but investment levels cannot be bargained *ex ante.*

E. HIGHER ORDER COMPLEX RULES

In the previous Subparts, we concluded that none of the elementary rules nor any of the first-order complex rules lead to socially first-best incentives for at least two full regions as depicted in Figure 1. Consequently, resorting to even more complex rules may appeal as a potential source of inspiration for an efficiency-minded lawmaker. In fact, it is clear from looking at Figure 1 and Figure 2 that more than one switch has to be used to toggle between various rules according to the dividing lines in Figure 1.

From our previous discussion of the different rules so far, it would seem easy to derive the following highly complex rule:

"Apply the *L*-rule, when $\bar{U} - \bar{\iota} \leq \min\left[\bar{V} - \bar{\phi}, \bar{L}\right]$;

apply the *PI*-rule, when $\bar{V} - \bar{\phi} \leq \min\left[\bar{U} - \bar{\iota}, \bar{L}\right]$;

and apply the *PIL*-rule (or the *PP*-rule), with care as a switch,

when $\bar{L} \leq \min\left[\bar{U} - \bar{\iota}, \bar{V} - \bar{\phi}\right]$."

Notice that in the third portion of this high-order complex rule we use a first-order complex rule because no elementary rule induces socially first-best behavior for the entire upper right region in Figure 1. Also note that the dividing lines between the three cases are not straight but kinked.

Expressing such a highly complex rule in legal terms requires making numerous case differentiations of at least the level of complexity we have described—for example, in the German BGB and the Catalan Civil Code. Obviously, the exact content of these legal rules is different from the above proposition, but its degree of complexity is similar.

Adding more switches is not the only way to reach the necessary complexity to address the complex interaction that nuisance often entails. An alternative way would be to design rules that require more information from the court to tailor one of the elementary rules. An example could be a strict liability rule with damages being determined as the smallest amount of harm to which the victim could reduce actual harm by exerting appropriate care, given the care of the injurer plus the costs for the victim of this level of care.

Such a rule (the *L*-rule) gives incentives to the injurer to exert optimal care. At the same time, damages are independent of the victim's behavior and of actual harm so that the victim bears the full costs of harm. This induces her to also take optimal care and thus reduce the costs of care and harm she has to bear to the amount of damages payment she receives. Thus, bargaining on care does not take place. At the same time, under this type of rule, the injurer bears the full minimized costs of conflict. As a consequence, the victim will

always invest while the injurer will only invest when $\bar{U} - \bar{\iota} \geq \bar{L}$. As a result, the *L*-rule induces optimal investments of both parties, except when $\bar{V} - \bar{\phi} \leq \min\left[\bar{U} - \bar{\iota}, \bar{L}\right]$.

Even a precise and fine-tuned determination of damages such as this rule is unable to induce optimal behavior in all three regions depicted in Figure 1. The *L*-rule, regardless of its intrinsic complexity in terms of damages determination, would require being inserted into a first-order complex rule—in this case one having the *PI*-rule for $\bar{V} - \bar{\phi} \leq \min\left[\bar{U} - \bar{\iota}, \bar{L}\right]$ in order to ensure optimality in the remaining region.

IV. THE MONOTONICITY OF LEGAL RULES AND COORDINATION

The rules that legal systems employ in the context of conflicting uses of property do not fit into the schematic (though insightful) framework of rules to protect entitlements envisaged by Calabresi and Melamed. Rules actually in use seem greatly more complex than the elegant taxonomy of The Cathedral and its progeny. Especially, complex rules that combine two or more of the elementary rules through a system of transit switches, leading from the application of a given rule into the application of a different one, appear to be structures resembling some of the fine-tuned legal rules found in the laws of nuisance in several jurisdictions.

Our analysis in the preceding Subparts, however, clearly implies that these sorts of complex rules are no panacea for lawmakers and courts. None of the first-degree complex rules that use two simple rules as building blocks (such as the *PIL*-rule or negligence rule, the *LPV*-rule, or the *PP*-rule) nor even the most intuitive higher-degree complex rules (such as the *PLP*-rule) are able to induce adequate investment choice in a setting in which conflicting parties are able to bargain extensively over the investments they make in contemplation of a given activity in their property, and also over precautionary measures to accompany the operation of the activity.

The above does not mean that the use of complex rules (of the type characterized in this Essay) is a terrible idea. It may be the case that under certain circumstances the added complexity pays the extra burden and costs of the administrative complication, expense, and risk of error. The effects of the complex rules and their elementary building blocks are not the same. Thus, opting for a complex rule instead of a simple one is not a trivial matter, as it will affect incentives (and costs of administering the rule, to be sure) generated for the parties. For certain parameter constellations, a complex rule may be more desirable in terms of investment incentives for the parties.

Also, in other bargaining settings (with positive transaction costs, more limited scopes, or different sequences of action), a complex rule may alleviate some of the undesirable investment incentives produced by some of the elementary rules.

Additionally, if one simple rule (say, a property rule protecting the victim, the *PV*-rule) is in force in a given jurisdiction and cannot be easily

replaced by an alternative simple rule (for reasons of hysteresis, or due to political or interest group coalitions that the convincing force of efficiency gains cannot overcome), perhaps the less abrupt change to a first-degree complex rule that uses the current simple one as a building block is easier to implement, providing a more desirable outcome (as would happen in our setting if the *PV*-rule is replaced by the *LPV*-rule).

Once we have looked into the complex rules that various legal systems use in the nuisance context and we have analyzed the effects in our setting of both the simple rules and the complex rules that intuitively seem to be more appealing, we have identified a property in them that we believe to be common across legal systems. We refer to the idea of "monotonicity" in the sense that the structure of the elementary rules and switches acts as building blocks of possibly complex rules that do not allow "reversals of ordering" as choice variables increase or decrease. We acknowledge that the chosen term "monotonicity" implies some abuse of the mathematical notion, but we believe that it better captures the property that we would like to bring forward than other alternatives such as "consistency." All legal rules we have identified in this Essay correspond to a broad notion of consistent monotonicity, so our hypothesis is that the law, at least in our area of interest, seems reluctant to adopt non-monotonic rules.

By adopting a legal rule linked to a given variable, the law would be alert at preserving the ordering induced in the underlying variable by the sequence of elementary legal rules. What one would find in nuisance law and, we conjecture, in other areas of property law and in the law more generally, is that the elementary rules (valid for different ranges of the choice variables) and the switches between the rules will not decrease the incentives to change the choice variables towards their optimum values as the choice variables depart more from the optimum. Obviously, this claim has two separate aspects: first, the marginal incentive effects of the legal rules between the switches (i.e. for the ranges in which the incentive effects of the complex legal rules are differentiable); and second, the incentive effects of the switches (i.e. at the discontinuities of incentive effects of the complex legal rules). Both aspects require some order of the elementary rules. For the first, which we call "incentive monotonicity," the order is obvious. Without loss of generality, we consider a choice variable that, absent any conflict, would be costly for the controlling party. Then, if this party chooses more of this variable, the previously applicable elementary legal rule should not be replaced by another elementary legal rule with stronger incentives to further increase the choice variable. For a choice variable controlled by the injurer, *PV* should not replace *L* or *PI*, and *L* should not replace *PI*. For a choice variable controlled by the victim, *PI* should not replace *L* or *PV*, and *L* should not replace *PV*.

To be somewhat more precise, let us think of the elementary rules and the variable "care" or "abatement effort" on the part of the injurer—care and abatement obviously being costly to the injurer. The sequence $PI=L=PV$

increases in the amount of care induced by the rules when bargaining is not possible, since the elementary rules entail no incentives to increase care at all, incentives to increase care limited by the reduction in expected damages, and unlimited incentives to increase care to the level where damages are effectively excluded, respectively.[61] The incentive effects of this sequence would hold for every level of care. In other words, the three rules induce no care, optimal care, and enough care to avoid any harm (including abstention for using the investment as an extreme form of care), respectively. If the switches necessary to build the complex rules rely on the level of care, it seems natural that there should be monotonicity in the sense that increasing care beyond a switch should relieve the incentives for additional care: $PV \rightarrow L \rightarrow PI$ where $\rightarrow$ denotes the switch from the left to the right rule as care increases. Obviously, a legal rule does not necessarily have to employ all three of the elementary legal rules nor even two of them, but in case they are employed, the combination would observe the incentive monotonicity described above. A brief look at the description of complex rules governing nuisance disputes in the German and the Catalan Civil Codes would confirm this statement.

The second aspect of incentives induced by complex legal rules, which we call "switch monotonicity," implies an order that depends on the direction in which the choice variable departs from its optimal value. Here, it is intuitive to claim that no increase in the deviation from the optimum of the choice variable should entail a switch toward a legal rule that, at the switch and in its near neighborhood, gives higher payoffs to the individual controlling the choice variable. So when increasing a choice variable controlled by the injurer further, after it is already larger than its optimal value, PI should not replace L or PV, and L should not replace PV. The reason is clear upon reflection: With the PI-rule, the injurer will save all costs and reduce the choice variable to zero; with the L-rule, the injurer will bear the minimum of the sum of the costs of the choice variable and the losses resulting for the victim; and with the PV-rule, injurer will bear the care costs necessary to reduce the victim's losses to zero, which clearly is more than the aforementioned minimum of the sum of the costs of the choice variable and the resulting losses. Similarly, when further increasing a choice variable controlled by the victim after it is already larger than its optimum, PV should not replace L or PI, and L should not replace PI.

Incentive monotonicity and switch monotonicity do not always coincide. For example, consider a complex rule where switches depend on care. As depicted in Figure 3, when incentive monotonicity is satisfied, a switch from

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61.   Recall that *PV* typically implies the highest payoffs for the victim (since, at no cost, she can ensure no activity or zero harm from the injurer) and, conversely, the highest costs for the injurer. Then, *L* implies somewhat lower payoffs for the victim, because she is ensured of being compensated of residual harm (provided it is not larger than the costs for the injurer of no activity or zero harm production) and, conversely, somewhat lower costs for the injurer. *PI* implies the lowest payoffs to the victim and the lowest costs for the injurer.

L to *PI* might occur when injurer is already over-careful. Then, at the switch, further deviation from the optimum increases the injurer's payoff, which is a violation of switch monotonicity. We observe such switches in actual legal rules, for example, in tort rules where pure (unqualified by rules looking into the victim's care) strict liability is limited to all accidents that are not acts of nature beyond control. However, at least in nuisance law, we are unaware of actual legal rules which violate incentive monotonicity. So when actual legal rules take incentive monotonicity more seriously than switch monotonicity, they should be binding close to the optimum of a choice variable.

Figure 3. Incentive and Monotonicity Versus Switch Monotonicity
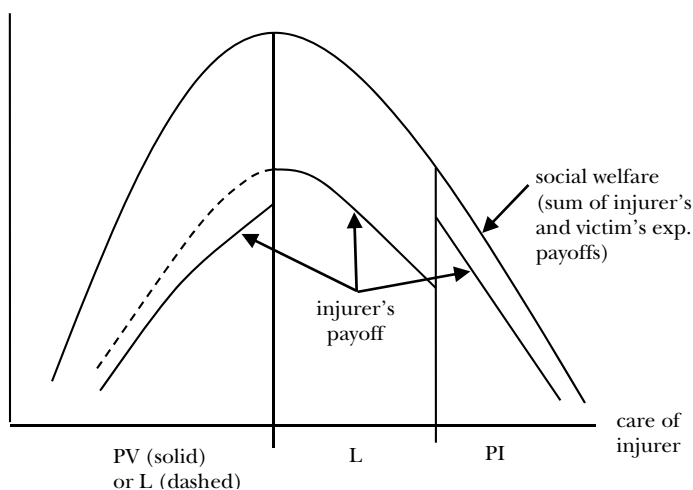
Instead of "the care of the injurer," if one would (and could) choose, for example, "the investment of the victim" as the choice variable upon which to set switches and produce transits of one elementary legal rule into another one, the expected sequence would similarly not imply a reversal of ordering. If the victim increases investment,[62] the switches could only be from *PI* to *L, L* to *PV*, or *PI* to *PV*, because *PV* gives more incentives to invest than *L*, which in turn gives more incentives to invest than *PI*. A complex rule that would move from *PV* to *L* if the victim decreases investment (or from *PI* to *L* if victim

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62.   Note that, absent any conflict, decreasing investment *lowers* payoffs and is thus costly (at least up to the individually optimal amount). So, the choice variable in terms of our incentive monotonicity claim would be "negative deviation of investment from no-conflict optimum."

increases investment) would violate this property and would result in a non-monotonicity of incentives.

We must emphasize that monotonicity has no necessary links to efficient allocations if we look at variables that neither of the parties can choose. On the one hand, incentive–monotonic complex rules may lead to inefficient allocations. The *PLP*-rule described in Part II would be such an example of an incentive–monotonic complex rule that fails to achieve efficiency for all cases in Figure 1, as may easily be seen from Figure 2. It is also true that it is possible to build complex rules that are non-monotonic in non-choice variables and, at the same time, are more efficient than monotonic ones. In Figure 2, we could construct an optimal complex rule which chooses the optimal elementary rule (*PI*, *L*, or *PV*) in the relevant areas characterized in the Figure, and then choose *PIL* only in the area marked "no elementary rule." Then, moving horizontally, or vertically, or in a diagonal manner leaves room for non-monotonicities. Moving horizontally to the right through the area marked "no elementary rule" would induce a switch from *PI* to *PIL*, and back again. And moving in a diagonal manner would imply non-monotonicity, even without running through the area marked "no elementary rule." We could have $PI \geq L \geq PI \geq L$. However, $(\bar{U} - \bar{\iota})$ and $(\bar{V} - \bar{\phi})$ are not choice variables—they are the maximal net payoffs the injurer and victim may achieve without conflict if they optimize i and j, respectively. $(\bar{U} - \bar{\iota})$ and $(\bar{V} - \bar{\phi})$ do not depend on actual choices of the parties, but only on the productivity parameters ρ and σ. In nuisance law at least, even if the link between monotonicity and efficiency is by no means general when observing real-world legal rules dealing with nuisance interactions, complex rules are composed from elementary rules or complex rules of a lower order in ways satisfying the monotonicity requirements.

The monotonicity property that we consider prevails in actual rules on nuisance, and probably well beyond it in property law, and has various advantages. A detailed examination of the attractive features of monotonic rules for courts and lawmakers to solve conflicts of entitlements in property should be left for further research, but we can sketch some of the factors here. For one, monotonic rules relieve legal systems from much ambiguity ensuing from multiplicity of optimal elementary rules. Additionally, compared to monotonic rules as a class, non-monotonic rules are more likely to distort the behavioral incentives that the rules are intended to produce.[63]

At this point, we would like to emphasize an additional rationale for the observed monotonicity property, namely the improved ability of monotonic rules to allow agents to easily observe the relevant levels of the choice variables affecting the legal outcomes and to resolve coordination problems in an informal way. That is, monotonic rules that use certain variables or switches

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63. Note that the claim does not extend individually to any potential example of a non-monotonic rule. For proof, simply recall the non-monotonic complex rule described above.

may facilitate parties to adjust their reciprocal behavior with less reliance on formal legal enforcement mechanisms.

It may be useful to recall that in nuisance law (at least in some jurisdictions), conformity of a given activity and a given level of precautionary effort with public regulatory standards in place at a given location may be very influential in determining the legal rule, and thus, the parties' payoffs (directly or indirectly through bargaining). The same is true with local usage and local norms affecting the choice and size of activity, as well as the way in which the activity is actually undertaken in terms of abatement efforts. One would imagine that potential parties to the conflict in land uses could easily access both locally applicable regulations and locally practiced customs regarding the type and mode of using assets.

Moreover, both publicly and openly adopted local (or locally implemented) regulations and local customs governing activities within the boundaries of private properties are likely to play a relevant and positive role in solving coordination problems at the local level. First, the local regulations and local informal norms may create focal points for members of the relevant community, so that the expectations of members would converge upon a reduced number of equilibria when many different ones would be possible. Second, the compliance and infringement of those levels may trigger informal consequences (positive or adverse) that may be less costly tools to guide and influence behavior than the formal institutions and mechanisms of the law. That is, the fact that the law openly adopts as relevant and legally meaningful those variable levels stemming from local regulations and local norms may trigger informal social rewards and sanctions that would economize on scarce resources by bypassing the setting in motion the formal legal apparatus. Additionally, the internalization of such standards by the potential parties in conflict—by providing cheap and effective enforcement—would tend to reduce the costs of conflict, and thus, improve outcomes.

All the above is admittedly speculative. But after looking into the actual choice of complex monotonic rules by legal systems to resolve issues of conflicting uses of land, and after our analysis of the effects of the rules in our Coasean bargaining setup, we have a strong impression that the set of rules and the nodes leading from one to the other are not at all causal.

This is likely to be relevant in areas in which new economic activities, technological innovations, or transformed assets and uses present opportunities for new conflicts between entitlement holders that require solutions from property law. Complex rules of the kind we identify in this Essay—combinations of elementary rules through nodes or switches over certain choice variables—would seem to us to be adept at addressing the incentive problems brought about by the emergence of new conflicts of entitlements, since the more complex structure allows for a more tailored and nuanced response than the elementary rules. At the same time, the monotonicity properties ensure that the added and valuable flexibility in the

applicable set of protective rules does not imply that the situations involving new entitlement conflicts will be devoid of a recognizable pattern or structure. And such pattern, as emphasized above on the recognizability of nodes and switches, would be well-designed to facilitate the parties' adjustment of their reciprocal behavior with less reliance on formal legal enforcement mechanisms and more reliance on informal coordination.

V. CONCLUSION

In this Essay, we have compared the complexity of existing legal rules on nuisance to the complexity which is necessary to induce socially optimal investment behavior of both the injurer and victim in a nuisance case when investment is not contractible, while care and the use of investment is contractible. We started with a brief review of the legal rules on nuisance and their complexity in Germany, Spain, and the United States. We then turned to a model with rather extreme informational assumptions.

We showed how elementary and first-order complex rules fail to induce socially optimal behavior under all relevant circumstances. Finally, we gave two examples of rules with a higher degree of complexity that are able to achieve this task. True, we do not claim that they are exactly mirrored by real-world legal systems, but only that some high-order complex rule is able to induce optimal behavior in the context of nuisance. This is not a plea for complexity in rules that need to address complex setups, but simply a reflection on the importance of fully considering the range of options and its possibly associated higher degree of complexity in structuring solutions.

Our findings lead us to think that the economic analysis of nuisance law and the protection of legal entitlements should, at least to a larger extent than it currently does, shift its focus from comparing and refining elementary rules to the study of complex rules. We believe that the taxonomy of elementary rules is reasonably well-known already, but much less is known of the complex rules that legal systems nevertheless display—sometimes prominently. Ours is a first step towards improving such knowledge. This would allow the economic approach to property and nuisance to contribute to the legal understanding of those complex rules that actually exist as they have evolved over time or have been legislated on the basis of experience with the variety of past cases. In some jurisdictions, the current legal discussion on nuisance rules does not even refer to the potential general applicability of any of the elementary rules, but is rather concerned with improvements of the switches between different elementary rules.

Our findings also point toward the importance of bargaining for the analysis of legal rules protecting entitlements. In a similar vein as Bebchuk,[64] we find that introducing or increasing the range of Coasean bargaining

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64.   *See generally* Bebchuk, Ex Ante *Investments and* Ex Post *Externalities, supra* note 1; Bebchuk, *The* Ex Ante *View of the Cathedral, supra* note 1.

actually hurts the *ex ante* behavioral incentives arising from legal rules, particularly from liability rules. This creates a normative implication from the negative effect of the strategic use of non-contractible actions to exploit bargaining advantages later on. The implication is that the design of legal rules should pay very close attention to the extent in which parties can enjoy or exploit opportunities to inefficiently manipulate the threat points of future bargaining by taking *ex ante* inefficient decisions, and thus, the need to introduce tests and checks in legal rules to mitigate these perverse incentives.

One may view the doctrine of mitigation of damages in contract law, or the leeway credited to regulatory takings in constitutional law, the doctrine of equivalents in patent aw, and other related doctrines in intellectual property, as schemes trying to place checks and balances on strategic investments to inefficiently influence bargaining positions of contracting parties, owners and regulators, or different inventors.

As a refinement of the treatment offered in this Essay, one could study the sensitivity of our results to several variations of our setup, such as reducing bargaining to care or to the use of investments only, or loosening the assumptions on the parties' information. Additionally, the monotonicity property that seems to characterize the rules in place in the nuisance setting appears to us worth exploring in other areas of property law—including intellectual property. Especially with respect to new forms of conflicting uses of valuable assets, the monotonic sequence that maps legal payoffs to underlying choices over the relevant variables may provide some clues about future developments in those new areas.