

# The Efficiency of Bargaining under Divided Entitlements

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## INTRODUCTION

Ever since Professor Guido Calabresi and A. Douglas Melamed published their seminal article *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*,<sup>1</sup> the question of how to best define property rights has been a central question in the legal literature.<sup>2</sup> Calabresi and Melamed highlighted the fact that, if bargaining is impossible, a liability rule (in which an individual can take another's entitlement by paying damages) can make the allocation of the entitlement depend on the taker's privately-known valuation.<sup>3</sup> Thus, they argued, while simple property rights are preferable when bargaining is possible, liability rules can serve a market-mimicking role in cases in which it is not.<sup>4</sup> Indeed, by setting damages equal to the plaintiff's expected value for the entitlement, the defendant would be induced to take precisely when his valuation was greater than this expectation, thus enhancing efficiency over what could be achieved with a simple property right held by the plaintiff.<sup>5</sup>

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<sup>1</sup> See generally Guido Calabresi and A. Douglas Melamed, *Property Rules, Liability Rules, and Inalienability: One View of the Cathedral*, 85 Harv L Rev 1089 (1972).

<sup>2</sup> Calabresi and Melamed's work explored and expanded upon ideas presented by Ronald Coase in his famous 1960 article. See generally R.H. Coase, *The Problem of Social Cost*, 3 J L & Econ 1 (1960).

<sup>3</sup> See Calabresi and Melamed, 85 Harv L Rev at 1108–10 (cited in note 1).

<sup>4</sup> See id at 1106. See also Ian Ayres and Eric Talley, *Solomonic Bargaining: Dividing a Legal Entitlement to Facilitate Coasean Trade*, 104 Yale L J 1027, 1032 (1995).

<sup>5</sup> See Louis Kaplow and Steven Shavell, *Property Rules versus Liability Rules: An Economic Analysis*, 109 Harv L Rev 713, 773 (1996). The same issues arise in contract law with the comparison of specific performance and damage remedies for breach of contract. For simplicity, throughout the Article we will refer only to property rules and liability rules, but the analysis applies more broadly.

Subsequently, scholars beginning with Professors Ian Ayres and Eric Talley and Professors Louis Kaplow and Steven Shavell began to question the presumption that simple, undivided property rights are always best when bargaining is possible.<sup>6</sup> Noting that when bargaining is perfect, the Coase Theorem indicates that all forms of entitlements achieve a first-best outcome, they asked whether certain forms of entitlements such as liability rules might perform better than simple property rights when bargaining is possible but inefficient due to asymmetric information.<sup>7</sup> As Kaplow and Shavell suggested, liability rules might be expected to perform better because of their “head start,” the fact that they outperform property rules when bargaining is impossible.<sup>8</sup> Ayres and Talley argued that, moreover, liability rules provide an “information-forcing” benefit by encouraging victims to reveal their harm truthfully.<sup>9</sup> To date, however, the literature has considered this question using very particular examples and bargaining procedures.

In this Article, we address the “horse race” between property rules and liability rules by taking a mechanism-design approach.<sup>10</sup> In particular, we ask what the best form of entitlements is given that bargaining always takes a form that is “optimal” given the informational constraints that are present.

Through most of our analysis, we do so by focusing on a benchmark measure of bargaining efficiency, the subsidy that would be required for the parties to achieve an efficient outcome

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<sup>6</sup> See Ayres and Talley, 104 Yale L J at 1098–99 (cited in note 4); Kaplow and Shavell, 109 Harv L Rev at 773 (cited in note 5). See also Louis Kaplow and Steven Shavell, *Do Liability Rules Facilitate Bargaining? A Reply to Ayres and Talley*, 105 Yale L J 221, 233 (1995). For a more limited challenge to the notion that either damages or an injunction is categorically better in situations in which bargaining is possible, see generally A. Mitchell Polinsky, *Controlling Externalities and Protecting Entitlements: Property Right, Liability Rule, and Tax-Subsidy Approaches*, 8 J Legal Stud 1 (1979). See also A. Mitchell Polinsky, *Resolving Nuisance Disputes: The Simple Economics of Injunctive and Damage Remedies*, 32 Stan L Rev 1075, 1103–06 (1980).

<sup>7</sup> See generally Coase, 3 J L & Econ 1 (cited in note 2). See also Ian Ayres and Eric Talley, *Bargaining in the Shadow of Different Regimes*, in Ian Ayres, *Optional Law: The Structure of Legal Entitlements* 142, 145–52 (Chicago 2005).

<sup>8</sup> Kaplow and Shavell, 105 Yale L J at 225 n 12 (cited in note 6).

<sup>9</sup> Ayres and Talley, 104 Yale L J at 1100 (cited in note 4). But see Kaplow and Shavell, 105 Yale L J at 221–22 (cited in note 6) (offering four primary grounds for critiquing Ayres and Talley’s claim that liability rules are “information-forcing”).

<sup>10</sup> Ayres and Talley, 104 Yale L J at 1101 (cited in note 4) (describing a “Coasean horse race” between property rules and liability rules). For another mechanism design approach, see also Eric L. Talley, *Property Rights, Liability Rules, and Coasean Bargaining under Incomplete Information* \*4 (Stanford Law School, John M. Olin Program in Law and Economics Working Paper No 114, Aug 1994).

given the informational constraints they face. Under most conditions of asymmetric information, bargaining will fall short of achieving efficiency, regardless of the bargaining procedure parties follow.<sup>11</sup> The dual pressures of what economists call “incentive-compatibility” (bargainers’ inclination to understate or overstate their true benefit or harm when bargaining) and “individual rationality” (the fact that an injurer or victim can always refuse any proposed bargain and revert to his or her entitlement under the law) prevent always reaching an efficient outcome. Our benchmark measure is the subsidy that is needed to relax the individual-rationality constraints to a sufficient degree to permit efficiency if the best possible bargaining procedure were to be followed.

As a general matter, liability rules with unrestricted choices of damages must be weakly better than simple, undivided property rules—after all, a simple property rule can be viewed as a special case of a liability rule in which damages are infinitely large, or at least large enough to deter any taking. Thus, for there to be a horse race between property rules and liability rules, we must either be comparing general, unrestricted forms of property rules (in other words, allowing for what Ayres and Talley called “fractional property entitlements”<sup>12</sup>) or be considering a restricted class of liability rules (for instance, liability rules with damages equal to the expected harm). As noted by both Ayres and Talley and Kaplow and Shavell, fractional property entitlements are sometimes physically possible—an asset may be owned in partnership, or a firm may have the right to pollute up to some specified limit—and can also be created by legal uncertainty over who will be determined to be the proper holder of the entitlement.<sup>13</sup>

We begin in Part I by conducting the “unrestricted” horse race in which fractional property entitlements are compared to liability rules. We argue that, very generally, fractional property entitlements will outperform liability rules. Indeed, well-chosen fractional property entitlements can enable efficient bargaining, while efficiency is typically impossible under a liability rule.<sup>14</sup>

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<sup>11</sup> See Roger B. Myerson and Mark A. Satterthwaite, *Efficient Mechanisms for Bilateral Trading*, 29 J Econ Theory 265, 273 (1983).

<sup>12</sup> Ayres and Talley, 104 Yale L J at 1072 (cited in note 4) (quotation marks omitted).

<sup>13</sup> See *id.* at 1080–82; Kaplow and Shavell, 105 Yale L J at 222 n 5 (cited in note 6).

<sup>14</sup> This conclusion draws from prior works by the authors. See Ilya Segal and Michael D. Whinston, *Property Rights and the Efficiency of Bargaining* \*13–14 (Toulouse Network for Information Technology Working Paper, Aug 2012), online at

We illustrate this very general result using an example that we then carry through the rest of the Article.

We then turn to the “restricted” horse race, comparing undivided property entitlements to traditional liability rules with damages equal to the expected harm. In Part II, we consider the case of two-party disputes. We report a striking result for such settings: *the best (subsidy-minimizing) property right is the same as when bargaining is impossible*. This is true in several senses. First, an undivided property entitlement should go to the individual with the greatest average value for it. Second, regardless of who chooses under a liability rule, the optimal damage payment equals the expected harm—the average benefit or harm of the other party—exactly as when bargaining is impossible. Third, the party who should choose under a liability rule is the party who should choose under a liability rule when bargaining is impossible. Fourth, and finally, the best liability rule always requires a lower subsidy than the best undivided property entitlement.

In Part III, we extend our analysis to the case of situations involving more than two parties. We show that, in general, the correspondence between the best entitlement when bargaining is impossible and the one that minimizes the subsidy required to achieve efficient bargaining breaks down. We describe what determines the best entitlement in these settings and illustrate its determination in our example.

Finally, while our subsidy formula provides one possible benchmark for measuring the efficiency of entitlements when imperfect bargaining is possible, in many—perhaps most—settings, no such subsidy is available. If so, a more useful benchmark may instead be the surplus that can be achieved, absent any subsidy, through the best possible bargaining procedure. Determining the best entitlements by this criterion is considerably harder. In Part IV we analyze an example that again maintains one striking finding from our subsidy analysis: the best liability rule again sets damages equal to the expected harm.

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[http://www.tse-fr.eu/images/doc/tnit/property\\_rights\\_rargaining\\_aug\\_2012\\_v2.pdf](http://www.tse-fr.eu/images/doc/tnit/property_rights_rargaining_aug_2012_v2.pdf) (visited Mar 2, 2014). See also Ilya Segal and Michael D. Whinston, *A Simple Status Quo That Ensures Participation (with Application to Efficient Bargaining)*, 6 *Theoretical Econ* 109 (2011).

## I. THE UNRESTRICTED HORSE RACE

We first consider the “unrestricted” horse race and ask which is better, the best fractional property entitlement or the liability rule involving the best possible damage level.

In our previous work we showed that in a wide range of circumstances, efficient bargaining can be achieved if property rights take the form of a fractional property entitlement in which each individual’s entitlement equals his average holding in the efficient allocation.<sup>15</sup> What it means for efficient bargaining to be achievable is that there is some bargaining process (in economist’s lingo, some “mechanism”) whose outcome is always efficient that is “incentive compatible” (so individuals always choose the strategies that maximize their payoffs), “individually rational” (so individuals are always willing to participate, regardless of their level of benefit or harm), and budget balanced (so what one individual pays, the other receives).<sup>16</sup> In our previous work, we showed that efficient bargaining can be achieved if and only if a particular type of mechanism (known as a “Vickrey-Clarke-Groves (VCG) mechanism” in the economics literature) does not require a subsidy to get individuals to participate rather than simply stick with their entitlement.<sup>17</sup>

The reason a divided entitlement can help achieve efficiency has been noted by Ayres and Talley: it makes the parties unsure of whether they want to be a buyer or a seller and so helps limit incentives for misrepresentations of benefits and harms while bargaining.<sup>18</sup> As it turns out, such divisions can be extremely effective in a wide range of circumstances.

As an example, suppose that Alpha Corporation can put up to one ton of pollutants into a river that flows by Ms. Smith’s fishery and Alpha’s benefit  $x$  from polluting is uniformly distributed between \$0 and \$100 per ton. Alpha’s average benefit from pollution is therefore \$50. Smith’s harm is also between \$0 and \$100, however it averages more than \$50. In particular, we assume that the probability (density) of harm  $y$  is  $ay^{a-1}/100^a$ ,

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<sup>15</sup> See generally Segal and Whinston, 6 *Theoretical Econ* 109 (cited in note 14).

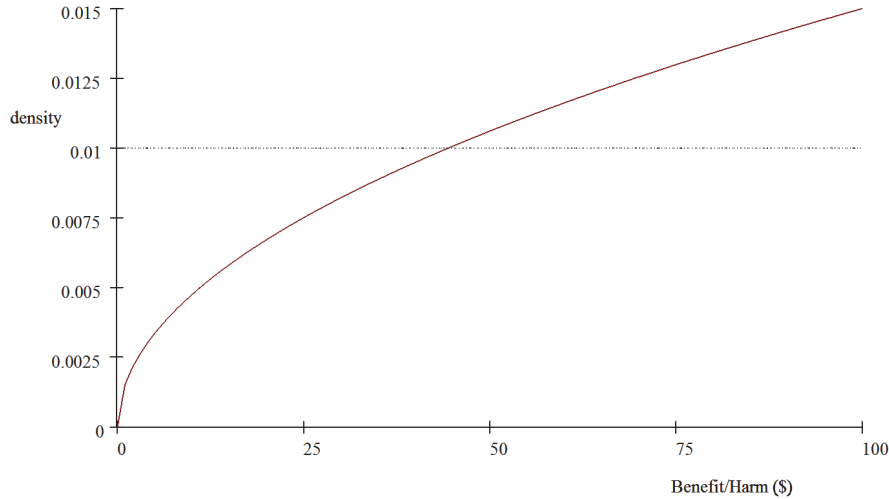
<sup>16</sup> This approach follows that of the seminal 1983 paper by Professors Myerson and Satterthwaite. See generally Myerson and Satterthwaite, 29 *J Econ Theory* 265 (cited in note 11). The first paper to investigate the effect of dividing entitlements in the Myerson and Satterthwaite setting was Peter Cramton, Robert Gibbons, and Paul Klemperer, *Dissolving a Partnership Efficiently*, 55 *Econometrica* 615 (1987).

<sup>17</sup> Segal and Whinston, 6 *Theoretical Econ* at 115, 118 (cited in note 14).

<sup>18</sup> See Ayres and Talley, 104 *Yale L J* at 1087–88, 1102 (cited in note 4).

where  $a = 3/2$ .<sup>19</sup> Smith's average harm with this distribution is \$60.<sup>20</sup> Figure 1 plots the two probability-density functions.

FIGURE 1. DENSITIES OF BENEFIT (DASHED) AND HARM (SOLID)



The efficient outcome has one ton of pollution if Alpha's benefit exceeds Smith's harm, and no pollution otherwise. It can be shown that this involves pollution occurring 40 percent of the time; the expected surplus, equal to the average of Alpha's benefit less Smith's harm when pollution occurs times the 0.4 probability of pollution occurring, is 11.4. So the result from our previous work described above implies that if Alpha has the right to pollute up to 0.4 tons, equal to Alpha's average level of pollution in the efficient outcome, efficient bargaining between Alpha and Ms. Smith is possible.<sup>21</sup>

What if instead a liability rule is used? In our previous work we derived a simple formula for the subsidy that enables efficient bargaining when the following two conditions hold:

- (1) It is possible that each individual may have a value for the entitlement (a "type") that makes it efficient for that individual to stick with his entitlement regardless of other individuals' values. We call such a type an "opt-out type."

<sup>19</sup> Note that if instead we had  $a = 1$ , then Smith's harm would have been uniformly distributed between \$0 and \$100.

<sup>20</sup> All calculations are shown in the Appendix.

<sup>21</sup> See Segal and Whinston, 6 *Theoretical Econ* at 123 (cited in note 14).

- (2) In the event that no deal is reached with an individual, all other individuals' collective payoff is lowest (in expectation) when the individual's type is his opt-out type. In that case, we say that this type is an "adverse opt-out type."

As an illustration, suppose that Alpha must pay Smith \$50 per ton in damages should it pollute. Then Alpha has an adverse opt-out type, which is when it has a benefit of \$100. In that case, it will always pollute under the liability rule and pollution is efficient regardless of Smith's harm. Moreover, since the \$50 damage is less than Smith's average harm of \$60, Smith is worse off when Alpha pollutes, so this type for Alpha is an adverse opt-out type.

Under this liability rule, Smith has an adverse opt-out type as well: that type has a harm of \$50, equal to the damage payment. To see why this is true, observe that when Smith's harm is \$50, under the liability rule Alpha's decision of whether to pollute is always efficient. Since Alpha's payoff is in fact unaffected by Smith's value under the liability rule, this is an adverse opt-out type for Smith.

For two-party disputes in which these conditions are met, so that each individual  $i$  has an adverse opt-out type, the required subsidy is:

$$V^* - V_1 - V_2, \quad (1)$$

where  $V^*$  is the efficient surplus and  $V_i$  is the expected payoff of individual  $i$  when a bargain is not reached and individual  $-i$  has its adverse opt-out type.<sup>22</sup> Intuitively, to induce efficiency, each party can be given all of the social surplus and charged a participation fee. Before the fees are collected, this creates a gross inflow to the parties equal to the efficient surplus,  $V^*$ . At the same time, each adverse opt-out type must be willing to participate, and so each adverse opt-out type is willing to pay a participation fee equal to the difference between  $V^*$  and what the party would earn by opting out. For each individual  $i$ , this difference can be shown to equal the other party's payoff when the adverse opt-out type opts out. So (1) represents the net subsidy required.<sup>23</sup> We

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<sup>22</sup> See Segal and Whinston, *Property Rights* at \*13 (cited in note 14).

<sup>23</sup> For further information supporting and explaining this idea, see generally Segal and Whinston, *Property Rights* (cited in note 14).

showed in our previous work that this required subsidy is positive in a very wide range of cases.<sup>24</sup>

As an illustration, under the liability rule discussed above for Alpha and Smith, this subsidy formula takes the following form:

TABLE 1. REQUIRED SUBSIDY WITH LIABILITY RULE

Average Efficient Surplus	11.4
Less:	
Alpha Average Liability-Rule Payoff	12.5
Smith Average Liability-Rule Payoff When Alpha Has \$100 Benefit	-10
<i>SUBSIDY</i> =	8.9

This can be understood as follows: The efficient allocation has Alpha pollute when its benefit exceeds Smith's harm and results in an expected surplus of 11.4, as we noted above. Under the liability rule, in the event that no agreement is reached, Alpha chooses to pollute when its value exceeds \$50. This happens with probability 0.5, and when it happens Alpha's value is on average \$75. Subtracting the \$50 damage Alpha pays, it earns on average \$25 in these cases. Multiplying by the 0.5 probability, Alpha's average payoff is \$12.5. (Note that Alpha's average liability-rule payoff does not depend on Smith's harm.) Smith, on the other hand, receives \$50 under the liability rule when Alpha's value is \$100, since Alpha then always chooses to pollute. Her expected harm is \$60, for a net loss of \$10. The required subsidy is therefore \$8.9.

Thus, with this liability rule, a positive subsidy is required to achieve efficiency. In fact, as we will see in the next Part, *regardless of the damage payment and whether it is Alpha or Smith who chooses whether to exercise the pollution option*, a liability rule cannot achieve efficiency here, so there is always a divided fractional property entitlement that is better than any liability rule. Indeed, the same is true for any setting in which the

<sup>24</sup> More precisely, it is positive whenever the outcome in the event bargaining breaks down is inefficient. See *id.* at \*14.



identity of the efficient possessor of the entitlement is uncertain, including cases with more than two agents.<sup>25</sup>

## II. UNDIVIDED PROPERTY RULES VERSUS TRADITIONAL LIABILITY RULES WITH TWO PARTIES

We next compare traditional liability rules (with damages equal to the expected harm) with simple (undivided) property rules using our subsidy measure. Consider, first, simple property rules, which assign full ownership to one party. Who should be the owner, and what is the required subsidy to achieve efficient bargaining? As an illustration, should Alpha have the right to pollute, or should Smith have the right to a pollution-free environment?

Suppose, first, that Smith possesses the right to a pollution-free environment. Observe that with an undivided property entitlement an individual's payoff  $V_i$  when bargaining fails does not depend on the other party's benefit or harm—the payoff is simply the individual's expected benefit or harm at the default outcome. So, in this case, the required subsidy is:

TABLE 2. REQUIRED SUBSIDY WITH SMITH'S UNDIVIDED PROPERTY RIGHT

Average Efficient Surplus	11.4
Less:	
Alpha Average Payoff from No Pollution	0
Smith Average Payoff from No Pollution	0
<i>SUBSIDY</i> =	11.4

If, instead, Alpha has the right to pollute, the required subsidy is:

<sup>25</sup> A modified liability rule, however, in which there is a negligence standard, must be at least as good as a divided property entitlement, since a divided property entitlement is a special case of the liability rule with a negligence standard in which the damage payment is infinite for any additional pollution.

TABLE 3. REQUIRED SUBSIDY WITH ALPHA'S UNDIVIDED PROPERTY RIGHT

Average Efficient Surplus	11.4
Less:	
Alpha Average Payoff from Pollution	50
Smith Average Payoff from Pollution	-60
<i>SUBSIDY</i> =	21.4

So it is better for Smith, rather than Alpha, to possess an undivided property right.

More generally, with traditional undivided entitlements, formula (1) still applies but each  $V_i$  simply equals party  $i$ 's average value for the entitlement (that is, with traditional undivided entitlements, party  $i$ 's value from his entitlement does not depend on the other party's benefit or harm). So the best assignment of the entitlement will maximize  $V_1 + V_2$ , which amounts to choosing the entitlements that maximize the surplus at the default outcome. The way to do this is simply to give the undivided entitlement to the party with the larger average valuation for it. Thus, we see that we want to assign the entitlement exactly as if bargaining were impossible!

We now look at liability rules. We will next show that traditional liability rules are best; that is, the damage payment that minimizes the required subsidy is in fact equal to the expected harm—again, exactly as in the case without bargaining. Since any simple, undivided property rule is equivalent to a liability rule with an extreme damage (either zero or infinite) that either allows or prevents all takings, this fact will imply that traditional liability rules are better than simple property rules. (Although, as noted above, traditional liability rules will not achieve efficiency.)

To see that the optimal damage equals the expected harm, suppose the damage payment is  $D \leq 60$ . In this case, as before, Alpha's adverse opt-out type has a benefit of \$100. Using formula (1), the required subsidy is then:

TABLE 4. REQUIRED SUBSIDY WHEN ALPHA CHOOSES WITH A LIABILITY RULE HAVING  $D \leq 60$ 

Average Efficient Surplus	11.4
Less:	
Alpha Average Liability-Rule Payoff <sup>26</sup>	$\frac{(100-D)^2}{200}$
Smith Average Liability-Rule Payoff When Alpha's Benefit Is \$100	$(D - 60)$
<i>SUBSIDY</i> =	$71.4 - \frac{(100-D)^2}{200} - D$

This required subsidy is decreasing in  $D$  for all  $D \leq 60$  and is strictly positive for all such  $D$ .<sup>27</sup> If, instead,  $D \geq 60$ , Smith is worse off when Alpha chooses not to pollute, since the damage payment exceeds Smith's \$60 average harm. As a result, Alpha's adverse opt-out type now has a benefit of \$0. The required subsidy is then:

TABLE 5. REQUIRED SUBSIDY WHEN ALPHA CHOOSES WITH A LIABILITY RULE HAVING  $D \geq 60$ 

Average Efficient Surplus	11.4
Less:	
Alpha Average Liability-Rule Payoff	$\frac{(100-D)^2}{200}$
Smith Average Liability-Rule Payoff When Alpha's Benefit Is \$0	0
<i>SUBSIDY</i> =	$11.4 - \frac{(100-D)^2}{200}$

which is increasing in  $D$  for  $D \geq 60$  and is again strictly positive for all such  $D$ .<sup>28</sup> Thus, the lowest required subsidy occurs when  $D = 60$ , which equals Smith's expected harm!<sup>29</sup>

Since the two possible (undivided) property rules correspond to  $D$  equaling \$0 and  $D$  equaling \$100 (thereby leading Alpha to either always pollute or never pollute if bargaining breaks

<sup>26</sup> Regardless of Smith's harm, Alpha exercises its option to pollute with probability  $(100 - D)/100$  and, when it does so, its average gain is  $(100 - D)/2$ . So  $V_{Alpha}$  equals  $(100 - D)^2/200$ .

<sup>27</sup> The derivative of the required subsidy with respect to  $D$  is  $-\frac{D}{100} < 0$ .

<sup>28</sup> The derivative of the required subsidy with respect to  $D$  is  $1 - \frac{D}{100} > 0$ .

<sup>29</sup> Professor Yeon-Koo Che also derives this result. See Yeon-Koo Che, *Beyond the Coasian Irrelevance: Asymmetric Information IV* (2006), online at <http://www.columbia.edu/~yc2271/files/publications/Asymmetric%20Information.pdf> (visited Mar 2, 2014).

down), this already tells us that a traditional liability rule (with damages equal to the expected harm) is better than any simple property rule.

Finally, we now ask whether it is in fact Alpha, or might instead be Smith, who is the best chooser under a liability rule. In particular, what if Smith instead has the right to buy clean water in return for a payment  $D$ , with Alpha able to pollute otherwise? Now the payment that minimizes the required subsidy will be \$50, Alpha's expected benefit. To see this, suppose that  $D \leq 50$ . Then Smith's adverse opt-out type has a \$100 harm from pollution (in which case Smith will choose to pay Alpha  $D$ , which is less than Alpha's \$50 average benefit from polluting), while Alpha's adverse opt-out type has value  $D$ . The required subsidy is:

TABLE 6. REQUIRED SUBSIDY WHEN SMITH CHOOSES WITH A LIABILITY RULE HAVING  $D \leq 50$

Average Efficient Surplus	11.4
Less:	
Alpha Average Liability-Rule Payoff When Smith's Harm Is \$100	$D$
Smith Average Liability-Rule Payoff	$0.4D \left[ \left( \frac{D}{100} \right)^{3/2} - 5/2 \right]$
<i>SUBSIDY</i> =	$11.4 - 40 \left( \frac{D}{100} \right)^{5/2}$

so the required subsidy is decreasing in  $D$ . When  $D \geq 50$ , Alpha's adverse opt-out type still has value  $D$ , while Smith's adverse opt-out type switches to having a \$0 harm from pollution (so Smith never buys clean water if bargaining breaks down). The required subsidy is:

TABLE 7. REQUIRED SUBSIDY WHEN SMITH CHOOSES WITH A LIABILITY RULE HAVING  $D \geq 50$

Average Efficient Surplus	11.4
Less:	
Alpha Average Liability-Rule Payoff When Smith's Harm Is \$0	50
Smith Average Liability-Rule Payoff When Alpha's Benefit Is \$D	$0.4D \left[ \left(\frac{D}{100}\right)^{3/2} - 5/2 \right]$
<i>SUBSIDY</i> =	$11.4 - 50 - 0.4D \left[ \left(\frac{D}{100}\right)^{3/2} - 5/2 \right]$

This required subsidy is increasing in  $D$ . So  $D = 50$ , equal to Alpha's average benefit from polluting, is best.

Looking at the subsidy formulas above, and substituting the damage levels equal to the expected harms, we see that Alpha should be the chooser since that scenario involves a lower subsidy:

$$11.4 - 50 - 0.4(50)\left[\left(\frac{50}{100}\right)^{3/2} - 5/2\right] > 11.4 - \frac{(100 - 60)^2}{200}. \quad (2)$$

In fact, this comparison is *exactly the same* as the comparison when bargaining is impossible. To see this, observe that when bargaining is impossible and Alpha chooses facing a \$60 damage payment, the social surplus is simply equal to Alpha's expected payoff (since Smith is always exactly compensated for her expected harm):

$$\frac{(100 - 60)^2}{200}.$$

On the other hand, when Smith chooses whether to buy clean water facing a \$50 payment, social surplus is:

$$50 + 0.4(50) \left[ \left(\frac{50}{100}\right)^{3/2} - 5/2 \right],$$

where the first term is Alpha's payoff (it always gets a \$50 expected benefit, whether from polluting or the payment), and the second term is Smith's average payoff. So inequality (2) is equivalent to selecting the chooser who maximizes surplus in the absence of bargaining.

Finally, note that the required subsidy when Alpha is the chooser is positive; no liability rule can achieve efficiency here.

In summary, the subsidy-minimizing liability rule is exactly the same traditional liability rule as when bargaining is impossible,

and is better than any undivided property rule (and any other liability rule with damages not equal to the expected harm).

One can also use this type of analysis to consider other types of entitlements. Ayres, for example, discusses “dual-chooser rules,” in which one party is the default holder of the entitlement, but the entitlement can be exchanged for some fixed amount  $D$  if both individuals consent.<sup>30</sup> (The idea is that the defendant might take, but the plaintiff has a choice of getting either a damage payment  $D$  or having the entitlement returned.)<sup>31</sup> For example, suppose that Smith holds the initial entitlement, and the damage payment  $D$  is again \$50. Once again, both Alpha and Smith have adverse opt-out types. For Alpha it is the type with benefit \$0, and for Smith it is the type with harm \$100. (These are both the types that never trade in either the efficient outcome or the default dual-chooser outcome.) Now the required subsidy is:

TABLE 8. REQUIRED SUBSIDY WITH DUAL-CHOOSER RULE

Average Efficient Surplus	11.4
Less:	
Alpha Average Dual Chooser Payoff When Smith Has Harm \$100	0
Smith Average Dual Chooser Payoff When Alpha Has Benefit \$0	0
<i>SUBSIDY</i> =	11.4

Recalling our earlier discussion of undivided property rules,<sup>32</sup> we see that this dual-chooser subsidy is exactly the same as when Smith has a simple right to no pollution. In fact, this is a fully general result: the subsidy required with a dual-chooser rule is always identical (for any damage payment  $D$ ) to the subsidy required for the simple property rule in which the default entitlement holder in the dual-chooser rule is assigned an undivided right.

<sup>30</sup> Ayres, *Optional Law* at 54 (cited in note 7).

<sup>31</sup> Admittedly, this may not be feasible with pollution, since once polluted the river might not be (costlessly) returned to its original state as assumed here. It is a more natural possibility with other sorts of takings, or nuisance externalities.

<sup>32</sup> See Tables 2–3 and accompanying text.

## III. OPTIMAL ENTITLEMENTS WITH MORE THAN TWO AGENTS

We now consider the case in which there are more than two agents. For example, imagine that Mr. Jones also owns a fishery downstream from Alpha and has a harm  $z$  from pollution between \$0 and \$100, which is drawn with probability  $b(z/100)^{1-b}$ , where  $b = 2/3$ . Jones's average harm is then \$40. Assume also that Alpha now has a benefit from polluting that is uniformly distributed between \$0 and \$200.

In the case in which there may be more than two agents, the previous formula for the required subsidy generalizes to:

$$(N - 1)V^* - \sum_i V_{-i}, \quad (3)$$

where  $N$  is the number of individuals and  $V_{-i}$  is the average payoff of all parties other than  $i$  in the event that individual  $i$  has a benefit or harm equal to that of its adverse opt-out type and chooses not to participate in bargaining. Since the efficient surplus  $V^*$  is not affected by the choice of entitlements, minimizing the required subsidy amounts to maximizing  $\sum_i V_{-i}$ .

Let's investigate the best liability rule in our pollution example, when Alpha is the chooser. Let  $D_S$  and  $D_J$  represent the damage payments due to Smith and Jones, respectively, should Alpha pollute. We will consider values for each of these damages between \$0 and \$100.

To proceed, we need to say what happens when one of the parties refuses to bargain. We will assume, perhaps optimistically, that the remaining parties end up reaching an agreement that maximizes their joint payoff. Given this assumption, Smith's adverse opt-out type has a harm equal to  $D_S$ : with this level of harm, Alpha and Jones will decide that Alpha should pollute if and only if Alpha's benefit exceeds Jones's harm plus  $D_S$ , so if Smith's harm is actually  $D_S$  this outcome is always efficient. In a parallel fashion, Jones's adverse opt-out type has a harm  $D_J$ . Also, as in our discussion of the two-party case, Alpha's adverse opt-out type is \$200 if  $D_S + D_J \leq 100$  and is \$100 if  $D_S + D_J \geq 100$ , where \$100 is the average total harm for the two victims.

The calculation of the relevant coalition values is somewhat involved. We show in the Appendix, however, that any subsidy-minimizing choice of damages has  $D_S + D_J = 100$ . Thus, the total damages should equal the average total harm, exactly

as when bargaining is not possible. However, while only the total damage matters for efficiency when bargaining is impossible, when imperfect bargaining is possible the required subsidy can be affected by the division of damages among the victims. In the Appendix we show that setting damages for each victim equal to his or her expected harm is *not* optimal in this example—in fact, all damages should go to Jones.

#### IV. UNDIVIDED PROPERTY RULES VERSUS TRADITIONAL LIABILITY RULES WITH TWO PARTIES: SECOND-BEST COMPARISON

As noted in the Introduction, an alternative benchmark for comparing entitlements is the maximal potential expected surplus that can be achieved in the absence of a subsidy. Comparing entitlements using this criterion is, however, considerably harder than using the subsidy criterion we have discussed earlier. We have examined this criterion for one special case of the single-victim Alpha/Smith example above, in which Smith's harm is uniformly distributed between \$0 and \$100 (corresponding to  $a = 1$ ). Figure 2 shows the deadweight (efficiency) loss from various levels of  $D$  (measured in units of 100). Two facts are striking: First, the best liability rule sets  $D = \$50$ ; that is, it has damages equal to the expected harm. Second, for  $D$  very close to \$0 or \$100, the liability rule is worse than the simple property right it is close to. Note that, absent bargaining, any such liability rule would necessarily be better than the nearby property rule.<sup>33</sup> This must mean that a liability rule with these damage levels is detrimental to bargaining efficiency, in contrast to the arguments of Ayres and Talley.<sup>34</sup>

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<sup>33</sup> For example, absent bargaining, the derivative of expected surplus with respect to  $D$  when Alpha chooses facing a damage of  $D$  is  $-(D - \mathbb{E}[y])$ , where as before  $y$  is Alpha's harm, which is strictly positive for  $D$  below the average level of Smith's harm and strictly negative for  $D$  above it.

<sup>34</sup> See Ayres and Talley, 104 Yale L J at 1099 (cited in note 4).



FIGURE 2. DEADWEIGHT LOSS AS A FUNCTION OF THE DAMAGE PAYMENT  $D$

