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TO REDUCE THE COST OF  
REGULATORY MONITORING

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**A NEW METHOD OF RANDOM SAMPLING TO REDUCE  
THE COST OF REGULATORY MONITORING**

Robert J. Jackson, Jr. \* and David Rosenberg \*\*

Abstract

This Article proposes a new method of reducing the costs administrative agencies incur in monitoring regulatory compliance by a firm that operates multiple sources of risk, such as air-polluting smokestacks. The expense of individually monitoring such sources directly may consume a large share of the agency's enforcement budget. Under our proposal, regulators would instead randomly select one of the firm's sources of risk, determine the firm's liability at that source, and apply that outcome performance as determinative of liability at all of the sources. The proposal significantly reduces monitoring costs because agencies need to monitor only one source of risk to replicate the deterrence generated by the source-by-source approach that regulators currently use. To indicate the potential benefits, we apply the proposal to EPA monitoring of compliance with regulations limiting pollution under the Clean Air Act. We also address potential risk-bearing and judgment-proof costs associated with the use of our proposal and explain how both problems can be solved.

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# A NEW METHOD OF RANDOM SAMPLING TO REDUCE THE COST OF REGULATORY MONITORING

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## I. INTRODUCTION

This Article proposes a method of reducing the costs administrative agencies incur in monitoring regulatory compliance by a firm that operates multiple sources of risk, such as air-polluting smokestacks. The expense of individually monitoring such sources directly (a common enforcement strategy we refer to as “iterative monitoring”) may consume a large share of the agency’s enforcement budget. At some point, as the number of regulated sources increases, budgetary constraints may force the agency to choose between allocating resources to iterative monitoring or to other enforcement priorities. If both courses of action would yield a net enforcement benefit, the agency’s choice of one over the other necessarily sacrifices socially desirable deterrence.<sup>1</sup>

To remedy this problem, we propose a new method of random sampling that an agency can use in place of iterative monitoring to achieve the same level of deterrence at a fraction of the cost.<sup>2</sup> Specifically, under our proposal regulators would randomly select for monitoring only *one* source from among the total number that the firm operates.<sup>3</sup> Upon determining the amount of liability at the selected source, the agency would apply that outcome perforce as determinative of liability for all regulated sources—the unselected sources as well as the selected source.<sup>4</sup> Our method confronts the firm with the same aggregate expected liability across all regulated sources as it would face if those sources were monitored iteratively. Both strategies thus provide the firm with the same incentives for compliance; but, in determining liability at only one among many sources, our proposal achieves this deterrence result at a fraction of the cost of iterative monitoring.

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<sup>1</sup> The notion that enforcement costs impede agencies’ ability to achieve optimal enforcement has been well-developed in previous work. *See, e.g.*, A. Mitchell Polinsky & Steven Shavell, *Enforcement Costs and the Optimal Magnitude and Probability of Fines*, 35 J. L. & ECON. 133, 135-39 (1992); Colin S. Diver, *The Assessment and Mitigation of Civil Money Penalties by Federal Administrative Agencies*, 79 COLUM. L. REV. 1435, 1466-68 (1979).

<sup>2</sup> The principal focus of the paper is on regulation of risk by means of deterrence: by threatening a firm with liability to provide it with financial incentives to comply with regulatory standards. We do not consider other modes of law enforcement such as imprisonment, seizures, and injunctions.

<sup>3</sup> To be precise, our proposal would apply the determination of liability at the selected source only to sources at the firm that the agency would otherwise subject to iterative monitoring. For convenience, we refer to these as “regulated sources.”

<sup>4</sup> We use the term “liability” to encompass taxes, fines, compensatory damages, and other forms of monetary sanctions.

Consider a firm operating a fleet of five trucks subject to a regulation requiring that all trucks have commercial registrations. Assume that an agency imposes liability of \$100 upon the firm for each unregistered truck, and that two of the firm's trucks are unregistered. The agency could choose to iteratively monitor the firm's trucks, *i.e.*, inspect each for the appropriate registration; given that two are unregistered, it would assess total liability of \$200. Instead, under our proposal, the agency could randomly select a single truck, determine the firm's liability for that truck, and apply that outcome as determinative of liability for all five trucks. If the agency randomly selected an unregistered truck, the firm would bear total liability of \$500 (\$100 x 5 trucks); if the agency selected a registered truck, the firm would bear total liability of \$0. Notably, using our approach, the firm would be subjected to the same aggregate expected liability of \$200—a 40% chance of \$500 in total liability and a 60% chance of \$0 in total liability—as it would via iterative monitoring, but the agency would only have to inspect one truck to produce that result.

Our proposal, which we call “single-outcome sampling” (“SOS”), can replace iterative monitoring without compromising deterrence, while saving considerable administrative expense. The key to this result is that the firm faces the same aggregate expected liability under SOS as it would under iterative monitoring.<sup>5</sup>

SOS is an application to the administrative context of the standard theory of law enforcement according to which it may be socially optimal to reduce enforcement cost by lowering the probability of detecting violations while raising the magnitude of sanctions to maintain deterrence.<sup>6</sup> Agencies have applied this theory to reduce monitoring cost without sacrificing deterrence principally by randomly sampling multiple sources to impose a statistically appropriate level of average liability<sup>7</sup> or by offsetting a lower

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<sup>5</sup> We assume throughout that reducing the number of monitored sources will reduce monitoring costs, and proceed to analyze the benefits of SOS on this assumption. Thus, whether or not the agency is optimally policing compliance by iteratively monitoring, we assume that SOS will save monitoring cost by reducing the number of sources the agency monitors without compromising the level of deterrence the agency would achieve through iterative monitoring. Where deterrence is suboptimal as a result of high monitoring costs, SOS may also improve incentives for regulatory compliance. *See infra* text accompanying note 49.

<sup>6</sup> *See* Gary S. Becker, *Crime and Punishment: An Economic Approach*, 76 J. POL. ECON. 169 (1968). For an application of this theory in the civil-liability context, *see, e.g.*, A. Mitchell Polinsky and Yeon-Koo Che, *Decoupling Liability: Optimal Incentives for Care and Litigation*, 22 RAND J. ECON. 562, 562 (1991); STEVEN SHAVELL, FOUNDATIONS OF ECONOMIC ANALYSIS OF LAW 479-484 (2004); *id.* at 491 (summarizing the literature on this point); *see also* Robert Cooter & Ariel Porat, *Total Liability for Excessive Harm*, at 2-3 (forthcoming in *Journal of Legal Studies* 2007) (describing a proposal that would hold firms liable for all excessive harm caused by an activity). An early application of this literature to the administrative context was set forth in Diver, *supra* note 1, at 1467.

<sup>7</sup> For example, when considering an application for approval to market a new drug, the Food and Drug Administration generally requires that applicants provide evidence of the drug's efficacy, including results of clinical trials evaluated by measures of statistical significance. *See* 21 C.F.R. § 314.126(b)(7). In addition, as a condition to the receipt of federal funds, the Department of Health and Human Services requires that states conduct a statistically adequate number of “random, unannounced inspections” to determine whether stores are in compliance with laws restricting the sale of tobacco products to minors.

probability of detection with increased sanctions.<sup>8</sup> Under the former, the agency must determine the statistically appropriate size of the sample, while the latter requires it to determine the appropriate ratio between the sanction and the probability of detection. In contrast, SOS duplicates incentives for compliance without placing any additional informational or decisional burden on the governing agency.<sup>9</sup>

SOS is readily generalizable across a variety of regulatory regimes. The proposal applies whether the criterion for determining liability is strict liability or a negligence-type cost-benefit analysis. SOS also applies whether regulatory standards result in the firm taking standardized or customized compliance measures. The advantages of SOS hold whether the regulatory requirement is set for each source individually or for all sources in the aggregate. And, in addition to reducing the number of sources of risk monitored at a particular point in time, SOS can reduce the frequency of such monitoring.

In Part II, we describe the mechanics of SOS and its various basic applications. To indicate the potential benefits of SOS, in Part III we apply the proposal in the context of EPA monitoring of compliance with regulations limiting pollution under the Clean Air Act.<sup>10</sup> The EPA relies on direct inspection of sources of such pollution to determine whether firms are in compliance with emissions standards, but the agency monitors far fewer sources with far less frequency than Congress authorized and EPA regulations mandate.<sup>11</sup> We show that, by adopting SOS, the EPA could not only secure the same compliance at lower cost, but also substantially expand its regulatory program.

In Part IV, we consider potential costs of applying SOS to cases in which SOS might confront a firm with the possibility of incurring substantial total liability. In

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*See* 45 C.F.R. § 96.130(c). The Department of Justice has also successfully proposed consent decrees requiring random sampling of telephone conversations to aid in the detection of securities violations. *See United States v. Alex Brown & Sons*, 963 F. Supp. 235, 237 (S.D.N.Y. 1997). For an application of statistical sampling in the civil liability context, *see, e.g., Hilao v. Estate of Marcos*, 103 F.3d 767, 786 (9th Cir. 1996) (approving the use of a random sample of class claimants to establish damages for the class).

<sup>8</sup> For a general description of this approach, *see, e.g.,* SHAVELL, *supra* note 6, at 480-81 & n.9. One illustration of this approach is the False Claims Act, 31 U.S.C. §§ 3279 *et seq.*, which authorizes treble damages against those found liable for defrauding the government, *see* 31 U.S.C. § 3279(a). The Act responded to “the absence of effective government resources to investigate and prosecute fraud against the government.” John T. Boese, *When Angry Patients Become Angry Prosecutors: Medical Necessity Determinations, Quality of Care and Qui Tam Law*, 43 St. Louis U. L.J. 53, 60 (1999).

<sup>9</sup> We proceed on the assumption that SOS provides a competitive alternative to imposing average liability derived from multi-source sampling or magnifying the sanction to offset a lower probability of detection. As we have explained, there are several reasons to think that SOS may be the lower-cost alternative in many administrative contexts. Whether this would be true in any particular administrative context, or as a general matter, is an empirical question that we do not attempt to resolve here.

<sup>10</sup> 42 U.S.C. §§ 7401 *et seq.*

<sup>11</sup> *See infra* Part III and sources cited therein.

particular, the prospect of incurring significant total liability might increase the firm's risk-bearing cost (to the extent that the firm is risk averse) or decrease its incentives for compliance (to the extent that the firm anticipates that it will be judgment-proof). We explain that the agency can address these problems by permitting wider sampling of the firm's sources. Part V concludes by describing possible extensions of our proposal to a variety of regulatory regimes and to the civil liability context.

## II. THE SOS MECHANISM

We begin by explaining how SOS replicates deterrence under iterative monitoring ("IM") for agencies determining compliance with regulations based on strict liability. We then demonstrate that the benefits of SOS extend to negligence-based regulations, whether such regulations call for standardized or customized precautions.<sup>12</sup> We also show that SOS applies whether the agency sets the negligence standard of compliance at each source individually or on a multi-source, aggregate basis. Finally, we explain how SOS can be used to further reduce monitoring costs by lessening the frequency of monitoring regulatory compliance.<sup>13</sup>

### A. *Strict Liability*

Strict liability provides a straightforward basis for demonstrating how SOS replicates the aggregate expected liability produced by iterative monitoring. While offering notable advantages over liability based on a negligence-type cost-benefit analysis,<sup>14</sup> strict liability is relatively infrequently used in the regulatory context.<sup>15</sup> The

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<sup>12</sup> We take negligence and strict liability to represent the basic norms aimed at affecting risk-taking behavior by means of imposing costs (including sanctions). For purposes of our discussion, negligence refers to norms that judge the reasonableness of risk-taking conduct by measuring its social costs and benefits. Strict liability refers to norms that impose liability on the fact of risk or harm alone. For simplicity, in this discussion we do not distinguish between a negligence rule *ex ante* mandating compliance with a standard of care (*i.e.*, a "command-and-control" standard) and an approach that assesses the reasonableness of precautions *ex post*. We also do not distinguish between negligence regulations that assess liability based on risk versus actualized harm. Rather, we use the "negligence" as a catch-all term referring to standards that determine the reasonableness of risk-taking conduct and related liability by measuring the social costs of the risk against its benefits.

<sup>13</sup> As we explain, *see infra* Part II.C., in certain regulatory contexts agencies determine that periodic monitoring with a particular frequency—for example, semiannual monitoring—is appropriate. Such agencies may use SOS by randomly selecting a particular monitoring period, determining the firm's liability during that period, and applying that liability determination *perforce* to other periods during which the firm is subject to monitoring. For additional discussion and an important caveat, *see infra* Part II.C.

<sup>14</sup> *See, e.g.*, A. MITCHELL POLINSKY, AN INTRODUCTION TO LAW AND ECONOMICS 50-51 (2d ed. 1989). The strict approach, for example, entails lower information costs, obviating the need for determining standards for risky conduct. *See, e.g.*, SHAVELL, *supra* note 6, at 219-220, 229. Strict liability is also likely to be more cost-effective in securing socially appropriate adjustments to the level of risky activity. *See, e.g., id.* at 197-99.

<sup>15</sup> *See, e.g., id.* at 204.

application of SOS to strict liability, however, will reduce its administrative costs and may therefore render the strict approach more attractive to regulators.<sup>16</sup>

To illustrate how SOS produces the same aggregate expected liability as would IM when assessing liability strictly, consider a firm operating two factories, A and B, each producing 10 and 20 units of a regulated chemical, respectively. Assume that, under IM, the agency monitors the output at each factory and imposes \$1 in liability for each unit of the chemical produced. The following table describes the aggregate expected liability (of \$30) imposed on the firm under IM:

Facility	Units Produced	Expected Liability
A	10	\$10
B	20	\$20
<b>Total</b>	30	\$30

SOS would replicate the firm's liability under IM in this case. Under SOS, if source A is selected, the firm expects aggregate liability of \$20; if source B is selected, the firm expects aggregate liability of \$40.<sup>17</sup> Expecting each result with 50% probability, the firm anticipates aggregate liability of \$30—the same as the firm expects under IM. Facing the same aggregate expected liability under IM and SOS, the firm has the same incentives to comply under both.

#### B. *Negligence*

Negligence is a ubiquitous administrative standard for determining liability<sup>18</sup> that entails a complex cost-benefit analysis.<sup>19</sup> Administrative enforcement of negligence-based liability for firms operating multiple sources of risk typically requires judgments about the reasonableness of source-specific precautions and corresponding benefits. Typically, negligence-based regulations are enforced by means of iterative monitoring.<sup>20</sup>

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<sup>16</sup> For a discussion of this point in the environmental-regulation context, *see infra* Part III and text accompanying notes 53-55.

<sup>17</sup> If source A is selected, the liability determination at that source (\$10) will be applied to source B, for total liability of \$20; if source B is selected, the \$20 liability determination at that source will be applied to source A, for total liability of \$40.

<sup>18</sup> *Cf.* W. KIP VISCUSI ET AL., *ECONOMICS OF REGULATION AND ANTITRUST* 35-37 (3d ed. 2001) (describing cost-benefit approaches to establishing regulatory norms).

<sup>19</sup> For a helpful discussion of the cost-benefit analysis generally attendant to the negligence standard and its concomitant administrative costs, *see, e.g.*, SHAVELL, *supra* note 6, at 180-81, 185-189.

<sup>20</sup> For an example in the environmental regulation context, *see infra* note 40.

SOS can replace iterative monitoring and achieve the same deterrence effects even when liability is determined under a negligence standard. Because SOS portends the same aggregate expected liability as the firm faces under IM, the firm’s incentives for compliance will be the same under SOS.

As we explain below, SOS applies to a variety of negligence-based regulatory regimes. First, we show that the proposal applies to a negligence regulation that would lead the firm to take standardized compliance measures across all of its regulated sources. We then explain how SOS applies to a negligence regulation that would lead the firm to take source-specific or customized compliance measures. Finally, we show how, with a minor modification, SOS applies to a negligence regulation that evaluates all of the firm’s risky activity against an aggregate standard of reasonableness.

1. *Standardized Compliance*

First, consider a negligence-based regulation resulting in the firm taking the same compliance measures at all of its regulated sources. Assume that it would be socially optimal for a firm operating two sources of risk to install a safety device at each costing \$8 to prevent harm of \$9, and that the agency will impose liability of \$9 for each instance of non-compliance.<sup>21</sup> The firm’s aggregate expected liability and corresponding total expected cost of compliance given various levels of compliance are set forth below:

<b>Safety Devices Installed</b>	<b>Compliance Cost</b>	<b>Aggregate Expected Liability</b>	<b>Total Expected Cost<sup>22</sup></b>
2	\$16	\$0	\$16
1	\$8	\$9	\$17
0	\$0	\$18	\$18

Under IM, the agency inspects both sources to determine the firm’s level of compliance, and would impose aggregate liability of \$0, \$8, or \$16 based on findings of full, partial, or zero compliance, respectively. Under SOS, the agency inspects only one randomly selected source; but by automatically applying the liability outcome to both regulated sources it would impose aggregate liability of \$0, \$8, and \$16 based on findings of full, partial, or zero compliance, respectively.<sup>23</sup>

<sup>21</sup> We assume throughout our analysis that the agency has set liability at the social optimum, *i.e.*, equivalent to the social harm caused by the firm’s failure to take precautions. *See, e.g.*, SHAVELL, *supra* note 6, at 182-86. However the agency calibrates liability to harm, SOS will replicate the firm’s aggregate expected liability under iterative monitoring.

<sup>22</sup> We use “total expected cost” throughout our examples to refer to the sum of the costs of compliance and any liability imposed by the agency. We highlight the firm’s aggregate expected liability for purposes of comparing IM and SOS, but of course the firm’s incentives for compliance derive from the fact that taking the prescribed precautions minimizes its expected total costs.

<sup>23</sup> Under SOS, if the firm chooses noncompliance at one source, it faces aggregate expected liability of \$9. If the agency selects the noncompliant source, it will assess liability of \$9 at that factory and impose the same liability perforce at the unselected factory for a total of \$18. If the agency selects the compliant source, it will assess zero liability. Facing each outcome with equal probability of 50%, the firm expects



Note that SOS and IM confront the firm with the same aggregate expected liability corresponding to each level of compliance, but in contrast to IM, SOS achieves this result without requiring the agency to determine the firm’s compliance at both sources.<sup>24</sup> Because the firm faces the same aggregate expected liability under IM and SOS, both approaches motivate the firm to take the same level of compliance (in this example, compliance at both sources), for doing so minimizes the firm’s aggregate expected liability as well as total expected costs.<sup>25</sup>

## 2. Customized Compliance

Now consider a negligence-based regulation that results in the firm customizing compliance at one or more sources of risk. Assume, for example, that the firm in the above example is subject to regulation requiring compliance measures costing \$6 at source A and \$10 at source B to prevent harm of \$8 and \$12 at each source, respectively. Assume also that the agency will impose liability of \$8 if the firm fails to take precautions at source A and \$12 if the firm fails to do so at source B. The firm’s aggregate expected liability and corresponding total expected cost of compliance at each level of compliance are described in the following table.

Source(s) in Compliance	Compliance Costs	Liability	Total Cost
A and B	\$16	\$0	\$16
A only	\$6	\$12	\$18
B only	\$10	\$8	\$18
None	\$0	\$20	\$20

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total liability of \$9, or the sum of  $(50\% \times \$18)$  and  $(50\% \times \$0)$ . If the firm chooses noncompliance at both sources, it faces expected liability of \$18, as the regulator will with certainty select a noncompliant source and impose total liability of \$18. Thus, under SOS—as under IM—the firm minimizes expected total liability by full compliance.

<sup>24</sup> For example, under SOS the agency confronts the firm *ex ante* with aggregate expected liability of \$17 for partial compliance, even though it is possible that the randomly selected source will be judged in compliance and the agency will therefore impose aggregate liability *ex post* of \$0.

<sup>25</sup> Under SOS, a firm choosing noncompliance at one source faces expected total costs of \$17. The firm faces a 50% probability that the agency will select the noncompliant source and impose \$18 in liability; added to the \$8 the firm spends at the compliant source, the firm faces \$26 in total costs given this outcome. The firm also faces a 50% probability that the agency will select the compliant source, and thus impose \$0 in liability; in this situation the firm’s total costs are \$8. The firm’s total expected costs are equal to the sum of  $(50\% \times \$26)$  and  $(50\% \times \$8)$ , or \$17. If the firm chooses noncompliance at both sources, the agency will select a noncompliant source with certainty, and the agency will assess \$9 in liability at that source and \$18 in total liability; having spent nothing for compliance, the firm expects total costs of \$18. Finally, if the firm selects full compliance, because the agency will select a compliant source with certainty, the agency will assess \$0 in liability; added to \$16 the firm spends in compliance at both sources, the firm expects total costs of \$16.

Under IM, the firm minimizes its exposure to negligence liability (to \$0) by full compliance, *i.e.*, by taking the required customized precautions at both sources. Partial compliance results in liability of \$12 or \$8 (for compliance at only source A or only source B, respectively), and noncompliance results in liability of \$18. Because the firm also minimizes total expected costs (to \$16) by complying at both sources, the firm will be led to comply fully with the regulation under IM.

The firm faces the same expected liability and total costs, and thus will be induced to take the same compliance measures, under SOS. Under SOS, the firm minimizes aggregate expected liability (to \$0) by full compliance.<sup>26</sup> The firm also minimizes total expected cost under SOS by complying with the regulation at both sources.<sup>27</sup>

Because SOS imposes greater liability for noncompliance at the randomly selected source than would IM for non-compliance at that source, it might be thought that the firm would be led to invest excessively in compliance at that source. But while SOS imposes greater liability than IM at such a source *ex post*, both SOS and IM generate the same *ex ante* expected liability and hence the same incentives for compliance at each source and for the firm in the aggregate. For example, if the firm in this example chooses to comply at source A only, under IM it faces liability of \$12. The same is true under SOS. A firm complying only at source A faces the prospect that the agency will impose \$24 in liability in the event that the agency randomly selects the non-compliance source B. This result does not lead the firm to take greater precautions at source B, however, because under SOS the firm internalizes that outcome with a 50% probability. Because it also internalizes the 50% chance that the agency will select the compliant source A and impose \$0 in liability, the firm anticipates aggregate liability of \$12 for its failure to comply at source B.

Thus, under SOS—as under iterative monitoring—the firm minimizes its liability and its total costs by complying fully with a regulation requiring customized precautions

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<sup>26</sup> If the firm complies at source A only, it faces a 50% chance that the agency will select A (imposing \$0 in liability) and a 50% chance that the agency will select B (imposing \$24 in liability), and therefore expects \$12 in aggregate liability (the sum of  $(50\% \times \$0)$  and  $(50\% \times \$24)$ ). Similarly, if the firm complies at source B only, the firm will face a 50% chance that the agency will select source A (imposing \$16 in liability) and a 50% chance that the agency will select source B (imposing \$0 in liability), and thus will expect aggregate liability of \$8 (the sum of  $(50\% \times \$16)$  and  $(50\% \times \$0)$ ). Finally, if the firm complies at both sources, it expects—as it does under IM—that no liability will be imposed.

<sup>27</sup> As explained above, *see supra* note 26, if the firm complies at source A only, it expects liability of \$12; including \$6 in compliance costs, the firm expects total costs of \$18. If the firm complies only at source B, it expects liability of \$8; including \$10 in compliance costs, the firm again expects total costs of \$18. If the firm chooses total noncompliance, it faces expected liability—and total costs, as it pays nothing in compliance costs—of \$20. Finally, if the firm complies with the regulation at both sources, it expects no liability; including the costs of compliance at both sources, it expects total costs of \$16.

at the firm's sources of risk. In addition, use of SOS does not lead the firm to take different precautions than it would under iterative monitoring.

### 3. *Aggregate Liability*

Aggregate liability refers to regulations in which the agency *ex ante* specifies the reasonable level of risk collectively for all sources, and *ex post* iteratively monitors the risk output at each source to assess liability by comparing the total to the collectively specified level.<sup>28</sup> Aggregate liability regulation is generally thought to reduce the costs of regulatory compliance because it permits the firm to select the most efficient means of meeting the aggregate risk standard for all sources covered by the regulation.<sup>29</sup> While reducing the costs of *compliance* with regulatory standards, however, aggregate liability does not reduce the costs of *monitoring* whether a firm is in compliance, for regulators must still engage in an *ex post* measurement of risk at each source, sum the risk levels at all covered sources, and compare the total to the regulatory standard.

A slightly modified version of SOS can replace *ex post* iterative monitoring as a means of monitoring compliance with aggregate liability regulations. The modification requires the firm to specify, at some point before the agency randomly selects a source for monitoring, the risk output at each of the firm's sources that will result in compliance with the agency's cumulative limit.<sup>30</sup> Under SOS, regulators would randomly select a source, determine liability at that source based upon the difference between the specified and observed risk, and apply that liability outcome perforce to all regulated sources.<sup>31</sup>

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<sup>28</sup> The aggregate-liability approach is essentially a variation on the negligence rule. We address this approach separately because some agencies, and particularly the EPA, consider it an efficient alternative to individual-source, negligence-based regulation. *See infra* text accompanying notes 58-59. The approach is often referred to as "bubble" treatment of multiple sources; the term is commonly associated with EPA regulations in the emissions context. *See Chevron v. Nat'l Res. Def. Council, Inc.*, 467 U.S. 837 (1984). It should be noted that aggregate liability does not imply use of iterative monitoring; the agency could assess the total risk *ex post* and compare it to its aggregate benchmark.

<sup>29</sup> The firm need not comply with agency specified technology and risk limits at individual sources; instead, it must only ensure that its total risk from all covered sources does not exceed the standard set forth by regulators. The firm will therefore reduce the risk at sources where the marginal cost of reducing risk is lowest and increase risk where marginal costs are high, reducing compliance costs. *See generally* TOM TIETENBERG, ENVIRONMENTAL AND NATURAL RESOURCE ECONOMICS 349 (2d ed. 1988); *see also* TOM TIETENBERG, EMISSIONS TRADING: AN EXERCISE IN REFORMING POLLUTION POLICY 52 (1985).

<sup>30</sup> The specification requirement under SOS will not impose costs on firms beyond those already incurred under IM because firms must determine the risk output at each source as a necessary step to determining the least-cost means of complying with the aggregate risk limit set by the agency. In practice, agencies employing aggregate liability regulation generally require firms to disclose expected risk outputs at each regulated source as a condition for agency authorization to engage in the risky activity. For a discussion of this point in the EPA context, *see infra* note 59.

<sup>31</sup> The SOS modification is necessary because, without a basis for evaluating liability at each source, SOS will not replicate deterrence under IM where the SOS procedure results in a risk outcome below the aggregate-liability standard set by the agency. To see this, consider a firm with two sources, A and B, each

Consider again a firm with two facilities, A and B, each producing a regulated chemical. Assume that the agency sets the aggregate limit for production at 16 units, that the regulator imposes liability of \$1 per unit in excess of that limit, and that the firm specifies that it will produce 8 units of risk at each factory.<sup>32</sup> Finally, assume that the firm has three alternatives with respect to its level of precautions, with correspondent chemical outputs and liability costs. These factors and the firm's total expected costs related to each production choice are summarized in the following table:

Compliance Alternative	Investment in Precautions		Chemical Production (Units)		Expected Liability	Total Costs
	Source A	Source B	Source A	Source B		
1	\$7	\$7	8	8	\$0	\$14
2	\$7	\$0	8	25	\$17	\$24
3	\$0	\$0	25	25	\$34	\$34

Under IM, the firm faces aggregate expected liability of \$0 if it chooses full compliance; \$17 if it complies at only one source; and \$34 if it does not comply at either source. We assume that a rational, profit-maximizing firm will choose the level of compliance that minimizes its total costs. In this example, such a firm will comply fully in order to minimize its aggregate expected liability and hence total costs.

The firm faces identical aggregate expected liability in each compliance scenario under SOS. If the firm complies fully, it faces expected liability of \$0; if it complies at one source, it expects liability of \$17, and if it chooses total noncompliance, it expects that the agency will impose \$34 in liability.<sup>33</sup> Under SOS, the firm minimizes its

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producing 10 and 5 units of risk, respectively, subject to an aggregate-liability limit of 15 units of total risk, and supervised by an agency that will impose \$1 in fines for risk in excess of that limit. Under IM, the firm expects aggregate liability of \$0. Under SOS without specification, the agency would apply the risk outcome at the selected source as determinative of risk at unselected regulated sources. Thus, under SOS without specification, the firm would face a 50% probability that the agency will select source A, find 5 units of excess risk (applying the risk at source A, or 10, to source B, for total risk of 20, five units above the aggregate standard), and impose \$5 in liability; and a 50% probability that the agency will select source B and impose \$0 in liability. The firm's aggregate expected liability would be \$2.50, greater than its aggregate expected liability under IM. This problem could also be addressed by requiring regulators to pay or credit firms where the SOS procedure results in a total risk determination less than the cumulative standard set by the agency. Whether this approach or the specification modification would be less expensive for firms and regulators is an empirical question beyond the scope of this Article.

<sup>32</sup> Rational, profit-maximizing firms will have little to gain from inaccurate *ex ante* specifications where firms are required to specify risk levels that comply with the total cumulative standard set forth by the agency. Any other approach will increase the firm's costs in the event that the regulator selects a noncompliant source.

<sup>33</sup> If the firm complies fully, the regulator will with certainty select a source in compliance, determine that there is no liability at that source, and impose total liability of \$0. If the firm chooses compliance at one source, the firm faces a 50% chance that the agency will select the noncompliant source and impose \$17 in liability at that source and \$34 in total liability, and a 50% chance that the agency will select the compliant source and impose \$0 in liability at that source and total liability of \$0. Thus the partially compliant firm

aggregate liability and hence its total costs by complying fully.<sup>34</sup> Thus, as under IM, the firm facing SOS would be led to select full compliance. Note, however, that SOS results in the firm choosing an identical compliance strategy as it selects under IM while requiring monitoring of just one source of risk.

C. *Frequency of Liability Determination*

In addition to setting the method for determining liability and the magnitude of liability, regulators in many contexts also choose the frequency with which liability will be assessed. SOS replicates the firm’s expected liability over a series of monitoring periods while reducing the frequency of monitoring. To apply SOS in this context, regulators would determine the firm’s liability at a particular point in time and apply that determination perforce to all other time periods during which the firm would otherwise be subject to iterative monitoring.

To see this, consider a firm operating a single source of risk, and assume that the level of risk at that source varies over time: at  $t=1$ , the source creates 10 units of risk, while at  $t=2$ , the source creates 20 units. Assume, too, that regulators will impose liability of \$1 for each unit of risk at each point in time.<sup>35</sup> The following table describes the firm’s expected liability under iterative monitoring:

Monitoring Period	Level of Risk	Expected Liability
1	10	\$10
2	20	\$20
<b>Total</b>	30	\$30

Under SOS, rather than monitor at both  $t=1$  and  $t=2$ , regulators will randomly select one time period, determine the firm’s liability at that point in time, and apply that liability determination to both periods. If the regulator monitors at  $t=1$ , it will impose liability of \$10; applying that result to time 2 as well, it will impose total liability of \$20. If the agency monitors at  $t=2$ , it will impose \$20 in liability and thus impose liability of \$40 for both periods. Anticipating each outcome with 50% probability, the firm’s

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expects aggregate liability of \$17. Finally, if the firm chooses total noncompliance, it expects with certainty that the regulator will select a noncompliant source and impose \$17 in liability at that source and \$34 in total liability—and thus the firm expects aggregate liability of \$34.

<sup>34</sup> The firm’s total costs under SOS are identical under each compliance alternative to the firm’s total costs under IM. If the firm chooses full compliance, its total costs are \$14, including \$14 in compliance costs and \$0 in expected liability. If the firm chooses partial compliance, its total costs are \$24, including \$7 in compliance costs and \$17 in expected liability. Finally, if the firm chooses total noncompliance, its total costs are \$34, including \$0 in compliance costs and \$34 in aggregate expected liability.

<sup>35</sup> For ease of illustration, we assume that the regulator imposes liability strictly based on the level of risk during each monitoring period. We note, however, that SOS could also be used to reduce the frequency of negligence-based determinations of liability.

aggregate expected liability under SOS is \$30—precisely the same as under iterative monitoring.

The application of SOS to periodic monitoring will be straightforward in cases in which the agency can randomly select a any time period in the relevant series – first, last or any interim interval – and impose liability without distorting the firm’s incentives for compliance. If, however, the agency randomly selects any time period before the last and the firm is able to alter its compliance strategy for the ensuing period(s),<sup>36</sup> there is some risk that the firm will lack optimal incentives for compliance thereafter, given that its liability for the future period(s) has been determined by monitoring that has already taken place.

An agency can address this problem in two ways. First, where reliable records are available during all relevant periods, the agency can wait to the last period in the series and then randomly select one of the periods for monitoring and apply the liability determination to all periods. Where such records (or functional equivalent) are not available, the agency could apply the liability outcome during a randomly selected period only to preceding periods of time.<sup>37</sup>

Whether agencies should assess liability at individual sources or in the aggregate; whether they should employ a negligence-based or strict-liability approach to determine liability; or whether monitoring is calibrated in sources, time periods, or otherwise are matters beyond the scope of this Article. Our point is simply that SOS can replicate the deterrent effect of IM regardless of how the agency might resolve those questions. As we explain below in Part III, SOS does so at lower regulatory cost to firms as well as agencies such as the EPA.

### III. BENEFITS OF SOS: THE CASE OF THE EPA

The principal benefit of SOS is a significant reduction in the cost of monitoring compliance with regulatory standards without affecting incentives for compliance. SOS generates substantial cost savings for a straightforward reason: under SOS, the regulator monitors only *one* source, while under the corresponding regime of IM it must monitor

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<sup>36</sup> Of course, the firm must also be *aware* that the agency has selected a previous period as determinative of liability. In many regulatory contexts, the firm may not know or may be kept unaware of the period of time selected for monitoring.

<sup>37</sup> Alternatively, the agency could randomly choose to monitor each period in the series with a 50% probability (or with any other probability), and offset the reduced chance of detection by multiplying any liability imposed during the selected periods by 2 (or 1/.5, the reciprocal of the given probability selection). *Cf.* David Rosenberg & Steven Shavell, *A Simple Proposal to Halve Litigation Costs*, 91 VA. L. REV. 1721 (2005) (describing a system in which half of civil cases would be dismissed and damages would be doubled in remaining cases).

every regulated source operated by the firm. The cost savings generated by SOS can be reduced to the simple expression  $1-(1/n)$ , where  $n$  represents the total number of sources controlled by the firm. Thus, the benefits associated with SOS increase in a linear fashion as the number of sources controlled by each firm increases. These savings may generate additional enforcement gains if regulators redeploy resources freed up by SOS for other pressing, but underserved, regulatory priorities.

We expect that agencies employing SOS will significantly reduce the monitoring costs they face under iterative monitoring. In this Part, we briefly examine the savings SOS would generate if used by the Environmental Protection Agency (“EPA”) in regulating emissions from “stationary sources” of airborne pollutants, such as industrial smokestacks.<sup>38</sup> In general, the EPA specifies the type of precautions required at each source based on a negligence-type, cost-benefit analysis,<sup>39</sup> and ensures compliance with these precautions by iteratively monitoring each regulated source.<sup>40</sup>

Monitoring every source of potential pollution in the United States, however, would in all probability be prohibitively expensive. As a result, Congress has limited EPA oversight to “major” sources, defined as “any stationary facility or source of air pollutants which directly emits, or has the potential to emit, one hundred tons per year of any air pollutant.”<sup>41</sup> There are approximately 22,000 such sources in the United States.<sup>42</sup> On average, a single firm operates approximately four major stationary sources,<sup>43</sup>

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<sup>38</sup> 42 U.S.C. § 7502(c)(5). In practice, most monitoring of compliance with this mandate is conducted by state officials, who propose, promulgate, and enforce state implementation plans pursuant to the Clean Air Act. For simplicity, however, we refer jointly to the state and federal authorities charged with monitoring compliance with the Clean Air Act as the “EPA,” or “regulators.”

<sup>39</sup> See, e.g., TIETENBERG, ENVIRONMENTAL AND NATURAL RESOURCE ECONOMICS, *supra* note 29, at 367.

<sup>40</sup> EPA and state officials engage in site visits that permit direct monitoring of compliance at stationary sources. See EPA, CLEAN AIR ACT STATIONARY SOURCE COMPLIANCE MONITORING STRATEGY 7-8 (2001) (on file with authors) [hereinafter STATIONARY SOURCE COMPLIANCE] (describing the type and frequency of visits recommended by the EPA). Where a violation of relevant emissions standards are detected, the EPA imposes liability following guidelines that measure, *inter alia*, the actual or possible harm, the toxicity of the pollutant, and the size of the firm. See EPA, CLEAN AIR ACT STATIONARY SOURCE CIVIL PENALTY POLICY pt. II.A (on file with authors); see also David B. Spence, *The Shadow of the Rational Polluter: Rethinking the Role of Rational Actor Models in Environmental Law*, 89 CALIF. L. REV. 917, 937 (2001) (describing EPA procedures for imposing liability).

<sup>41</sup> 42 U.S.C. § 7602(j); see also 40 C.F.R. § 52.21(b)(1)(i) (defining “major stationary source”).

<sup>42</sup> See EPA, Part 64 Compliance Assurance Monitoring Rule Regulatory Impact Analysis, at 23 (1997) (on file with authors).

<sup>43</sup> See EPA OFFICE OF THE INSPECTOR GENERAL, REPORT OF EPA’S OVERSIGHT OF STATE STACK TESTING PROGRAMS 2-3 (2000) [hereinafter OVERSIGHT OF STATE STACK TESTING] (stating that, in a representative sample of six states, the EPA identified 1,179 facilities containing 4,642 major stationary sources).

although the distribution of sources among firms likely varies by industry, geography, and scale of the firm.

The burden of iteratively monitoring thousands of major sources has led the EPA to reduce the frequency of such monitoring. Currently, the agency aims to test each source at least once every five years.<sup>44</sup> Even given this reduced monitoring frequency, however, the EPA's schedule calls for spending more than \$130 million per year.<sup>45</sup> Nevertheless, the EPA has failed to keep up with even this prolonged schedule.<sup>46</sup>

It is apparent, then, that the EPA could reap substantial benefits by replacing its iterative monitoring of stationary sources with single-outcome sampling. Indeed, given the EPA's estimated average of four sources per firm,<sup>47</sup> SOS would reduce monitoring costs by 75%, or approximately \$98 million per year.<sup>48</sup> SOS would therefore free agency

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<sup>44</sup> See EPA, STATIONARY SOURCE COMPLIANCE, *supra* note 40, at 7-8. In order to manage monitoring costs, the EPA also uses a number of statistical thresholds to dictate whether and when cost-intensive, on-site monitoring is necessary. For example, the EPA recommends that state investigators conduct a "full compliance evaluation" of any facility with a major stationary source within 20% of the maximum emissions authorized by regulatory standards. See *id.* at 6. Moreover, to reduce monitoring costs the EPA reviews compliance materials provided by the firms themselves, relying on those estimates for "reasonable assurance of compliance with applicable requirements." EPA, *Compliance Assurance Monitoring*, 62 FED. REG. 54,900, 54,902, 54,938 (1997). Note also that the EPA reserves its most expensive (and precise) form of monitoring—continuous monitoring via equipment installed directly in stationary sources—for the most harmful types of emissions. See A. DENNY ELLERMAN ET AL., *MARKETS FOR CLEAN AIR: THE U.S. ACID RAIN PROGRAM* 248-50 (2000).

<sup>45</sup> Our estimate assumes that the average expense of directly monitoring a stationary source is \$30,000, see *OVERSIGHT OF STATE STACK TESTING*, *supra* note 43, at 2-3 (estimating the costs of such monitoring at \$10,000 to \$50,000 per source), that 22,000 sources are subject to such monitoring, and that each source is monitored once every five years. EPA and state regulators pass these costs on to regulated firms, see *id.* at 3, who are statutorily required to pay for the reasonable costs of enforcing permits issued under the Clean Air Act, see 42 U.S.C. § 7410(a)(2)(K). Because firms must themselves prepare for on-site inspections as well as reviewing the regulators' findings, the costs of iterative monitoring of emissions compliance may well be higher than those described here.

<sup>46</sup> According to a recent study, only 14% of major sources were tested even once within a 10-year period. See *OVERSIGHT OF STATE STACK TESTING*, *supra* note 43, at 10 (drawing this conclusion from an analysis of EPA's nationwide stack-testing database); see also EPA OFFICE OF THE INSPECTOR GENERAL, *REGION SIX'S OVERSIGHT OF NEW MEXICO ENFORCEMENT DATA* 7 (1998).

<sup>47</sup> See *supra* note 43.

<sup>48</sup> The precise magnitude of the savings, of course, may be greater depending on whether larger-scale firms operate more sources than the average described here. In any event, these savings should prove significant for an agency frequently described as "desperately short" of enforcement resources. See, e.g., Rena I. Steinzor, *Devolution and the Public Health*, 24 HARV. ENV'T'L L. REV. 351, 354 (2000) ("The simple truth is that EPA and the states are desperately short of money, with statutory mandates that far exceed their administrative and enforcement capabilities.").



resources to ensure that the EPA adheres more closely to its stated schedule for inspections<sup>49</sup> or to fund other enforcement priorities that are currently underserved.

SOS may also permit the EPA to make greater use of strict liability or aggregate-liability regulations. Notwithstanding the apparent efficiencies of these modes of regulation in comparison to negligence-based, source-specific regulation,<sup>50</sup> Congress and the EPA have confined use of strict<sup>51</sup> and aggregate liability (or “bubble”)<sup>52</sup> regulation.<sup>53</sup> Commentators have noted that significant monitoring costs attendant to such regulations may have caused the EPA to refrain from making greater use of strict liability and aggregate-liability regulations.<sup>54</sup> By reducing the monitoring costs associated with strict liability and aggregate-liability regulations, SOS may permit the EPA and lawmakers to consider wider use of these enforcement approaches.

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<sup>49</sup> Of course, SOS could also be applied to reduce the frequency of EPA’s inspection while replicating deterrence under the current enforcement approach. *See supra* Part II.C.

<sup>50</sup> Several commentators have argued that the cost-benefit, command-and-control regulatory structure of most EPA regulations is administratively burdensome. *See, e.g.,* Shi-Ling Hsu, *Fairness Versus Efficiency in Environmental Law*, 31 *ECOLOGY L.Q.* 303, 379 (2004) (describing the administration of the EPA’s “traditional ‘command-and-control’ regulatory structure” as “difficult, time-consuming, and costly,” and noting that EPA is responsible for setting discharge standards for more than twenty-seven different types of pollution sources under one provision of the Clean Water Act alone).

<sup>51</sup> Despite analysis urging wider use of the strict approach, *see, e.g.,* Robert A. Pulver, *Liability Rules as a Solution to the Problem of Waste in Western Water Law*, 76 *CAL. L. REV.* 671, 707 n.153 (1988), Congress has limited this approach to a small set of cases involving highly hazardous substances, *see* Comprehensive Environmental Response, Compensation, and Liability Act, 42 U.S.C. §§ 9601 *et seq.*; *see also* *New York v. Shore Realty Corp.*, 759 F.2d 1032, 1041 (2d Cir. 1985) (“CERCLA is not a regulatory standard-setting statute such as the Clean Air Act. . . . Congress intended that responsible parties be held strictly liable”).

<sup>52</sup> In the EPA context aggregate-liability standards are applied principally to “bubble” treatment of multiple stationary sources of emissions, *see* *Chevron v. Nat’l Res. Def. Council, Inc.*, 467 U.S. 837, 846-53 (1984); *see, e.g.,* Robert W. Hahn & Gordon L. Hester, *Where Did All the Markets Go? An Analysis of EPA’s Emissions Trading Program*, 6 *YALE J. ON REG.* 109, 123 (1989). Under this approach, “instead of trying to meet the emission limit set for a specific [source], a plant is allowed to arrange its emission controls such that the facility satisfied its *aggregate* permitted amount for a specific pollutant.” Kathryn C. Wilson, *The International Air Quality Management District: Is Emissions Trading the Innovative Solution to the Transboundary Pollution Problem?*, 30 *TEX. INT’L L.J.* 369, 381 (1995).

<sup>53</sup> The EPA’s regulations are almost exclusively “standard-setting,” such as those under the Clean Air Act, *see* *Shore Realty Corp.*, *supra* note 51, at 1041; CERCLA is an exception to this general rule. *See id.* Similarly, bubble regulations apply to just 1% of the stationary sources in the United States. Thus, notwithstanding the significant benefits of “bubble” treatment of multiple sources, *see supra* note 29, several commentators have concluded that “the net impact of bubbles on environmental quality has not been significant.” Hahn & Hester, *supra* note 52, at 129; *see also id.* at 129 n.105 (describing internal EPA analysis noting that “bubble” treatment has generated surprisingly small benefits).

<sup>54</sup> *See, e.g.,* DANIEL H. COLE, *POLLUTION & PROPERTY* 82 (2002).

In particular, the EPA has long resisted calls<sup>55</sup> for expanded use of strict liability in the form of taxes calculated on the basis of units of pollution or risk.<sup>56</sup> One objection has been that the benefits of such a regime would be outweighed by its administrative costs, including the cost of iteratively monitoring to assess the tax at every source of risk rather than only those sources presenting a readily identifiable breach of the prescribed regulatory standard.<sup>57</sup> Application of SOS to strict liability taxes will, as we have shown, maintain deterrence at the level achieved by IM, but reduce monitoring cost by orders of magnitude. This should render such taxes a more palatable regulatory alternative.

EPA use of aggregate-liability, or “bubble,” regulation also appears to have been curtailed due to the significant costs of iterative monitoring.<sup>58</sup> Use of SOS would permit the EPA significantly to reduce these costs; and, because under current law firms seeking bubble treatment of multiple sources must disclose target emissions at each source,<sup>59</sup> SOS would impose no additional costs on regulators or firms. Switching to SOS would reduce the costs of monitoring compliance with bubble-based emissions limits without altering firms’ incentives for compliance with those limits. This reduction in cost should make bubble regulation far more attractive as an enforcement strategy.

In sum, the EPA’s use of SOS rather than its current practice of iterative monitoring would produce three significant benefits. First, SOS would reduce the costs of monitoring compliance under the predominant enforcement strategy of negligence-type, individual-source regulation. Second, the agency could reallocate these resources to address underserved regulatory objectives. Finally, by reducing monitoring cost, SOS may enable the EPA to extend its use of alternative modes of regulation, including strict taxes and bubble-based regulation. In the next Part, we consider potential costs of adopting the SOS solution.

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<sup>55</sup> See, e.g., Hsu, *supra* note 50, at 400 (proposing, but recognizing the “political realities” counseling against, the use of Pigouvian taxation by the EPA).

<sup>56</sup> We distinguish such taxes, commonly referred to as Pigouvian taxes, see A.C. PIGOU, *WEALTH AND WELFARE* 164 (1912), which are imposed on the basis of the *ex ante* risk created, from the more traditional conception of strict liability, *i.e.*, liability imposed strictly based upon an *ex post* analysis of the harm imposed.

<sup>57</sup> See, e.g., DAVID M. DRIESEN, *THE ECONOMIC DYNAMICS OF ENVIRONMENTAL LAW* 68-70 (2003) (expressing the view that the EPA would be administratively incapable of implementing such a tax or establishing the appropriate rate).

<sup>58</sup> See, e.g., COLE, *supra* note 54, at 82 (noting that the success of bubble regulation of emissions has been limited by the cost of “adequately monitor[ing] point-source emissions”).

<sup>59</sup> Before regulators approve a group of sources for bubble treatment, the firm is required to disclose the means of compliance with the bubble’s limit. See EPA, *Alternative Emission Reduction Options Within State Implementation Plans*, 44 FED. REG. 71,780, 71,781 (1979) (indicating that firms seeking bubble treatment must “propose” “a mix of controls” that meets total output limits, and that the firms must “come forward with alternative abatement strategies”).

#### IV. POTENTIAL COSTS OF SOS

In this Part, we address risk-bearing and judgment-proof costs associated with the use of SOS. Both costs arise from the possibility that SOS may in some cases produce highly variable liability outcomes, which might include the threat of an outlier result imposing so much total liability as to consume much or even all of the firm's wealth. First, the prospect of large total liability relative to its assets may burden a risk-averse firm with increased risk-bearing costs.<sup>60</sup> Second, if total liability might exceed the firm's assets, use of SOS may compromise deterrence because the firm, anticipating that it might be judgment proof from some liability outcomes, may have less incentive for compliance. The potential for such problems to arise is context-specific, depending, for example, on the firm's degree of risk aversion and asset holdings relative to expected liability,<sup>61</sup> and most importantly, on whether they would raise the total costs of SOS above those of the corresponding IM regime. Both problems are, as we explain, amenable to the same solution: wider sampling.

##### A. *Risk-Bearing Cost*

The prospect that SOS might result in the imposition of significant total liability could increase the firm's risk-bearing costs. For two reasons, we think these costs unlikely to be substantial. First, firms are generally structured to minimize the impact of risk on firm assets.<sup>62</sup> Second, insurance for regulatory liability is generally available.<sup>63</sup> Nevertheless, these approaches to managing firm risk may prove expensive, raising risk-bearing costs in some cases, perhaps forcing the firm to reduce its liability exposure by inefficiently over-investing in compliance.

The agency can address this problem by providing the option to have the firm's liability determined on the basis of wider sampling. Specifically, this option would be exercisable by the firm; it could choose to have the agency randomly select and

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<sup>60</sup> We think it is unlikely that the agency would be risk-averse with respect to the opposite outcome, *i.e.*, that no liability will be imposed as a result of random selection of a single source. The mechanical nature of SOS would likely shield the administrator from any political costs associated with such a result.

<sup>61</sup> They will also depend on the nature and structure of the regulatory regime as well as on the , and the degree to which liability outcomes may vary under the particular application of SOS.

<sup>62</sup> *See, e.g.*, David Meyers & Clifford W. Smith, Jr., *On the Corporate Demand for Insurance*, 55 J. BUS. 281 (1982).

<sup>63</sup> In the environmental context, such insurance is generally available, at least for regulatory liability incurred accidentally. *See, e.g.*, EPA, *Environmental Insurance Policy Coverage and Terms*, available at [www.epa.gov/brownfields/insurance/ei\\_insurance\\_coverage\\_12405.pdf](http://www.epa.gov/brownfields/insurance/ei_insurance_coverage_12405.pdf) ("most" insurers offer policies covering "[d]amages (including pollution liability) for acts, errors, or omissions" related to compliance). Although the maximum coverage provided by such a policy would have to be higher for a firm facing SOS than under IM, the premiums paid for such coverage should not rise, because under SOS the prospects for both higher *and* lower liability outcomes offset each other.

determine liability at any number of its regulated sources.<sup>64</sup> In the event the firm chooses to have the agency conduct wider sampling, the average of all liability determinations at the selected sources will automatically determine the firm's liability at all of the firm's regulated sources.<sup>65</sup>

Two conditions should govern the availability of this option. First, the option should be made available only *before* the regulator has randomly selected any source for monitoring. If the firm is permitted to elect wider sampling after it has learned what source the agency has randomly selected in the normal course of applying SOS, the firm might opt for wider sampling opportunistically, diluting deterrence.<sup>66</sup>

Second, the firm must pay the cost incurred by the agency in monitoring additional sources.<sup>67</sup> This condition prevents the firm from unnecessarily exercising the option. Charging firms for additional sampling also relieves the agency of the costs of determining whether wider sampling is needed, and promotes deterrence by requiring the firm to internalize enforcement costs associated with its risky activity.<sup>68</sup> In short, the firm will exercise the option for wider sampling only when doing so is socially appropriate.

To illustrate the value of this option to a risk-averse firm, consider a firm with sources A, B, and C. Assume that the sources produce risk of 10, 20, and 30 units at each source respectively, and that the governing agency will assess liability of \$1 per unit of

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<sup>64</sup> Or, where SOS is used to reduce the frequency of monitoring, the number of periods selected.

<sup>65</sup> For convenience, we refer to this modification as providing the firm with an option to have "wider sampling" conducted. For precision, we note that wider sampling under SOS should be distinguished from *statistical* sampling required by other approaches to reducing monitoring cost, *see supra* note 7. Statistical sampling, unlike SOS, requires the regulator to determine the appropriate size of the statistical sample and the acceptable probability of error in estimating the mean outcome in the sampled population. In contrast, wider sampling under SOS requires only that the agency randomly monitor some, pre-chosen number of additional sources of risk.

<sup>66</sup> For example, the firm would request wider sampling only when the initially selected source would generate above-average total liability, and would not request wider sampling when the initially selected source would generate below-average total liability. Using this strategy, the firm would be confronted *ex ante* with lower aggregate expected liability than it would face under the corresponding IM regime.

<sup>67</sup> Of course, to require firms to internalize the social costs of risky behavior, the firm may also be required to pay the costs of monitoring even a single source under SOS. *See*, SHAVELL, *supra* note 6, at 178, 411 (discussing the social optimality of internalization of enforcement costs).

<sup>68</sup> This requirement applies to firms subject to EPA regulation. *See* 42 U.S.C. § 7410(a)(2)(K) (requiring firms to pay reasonable costs of EPA compliance monitoring).

risk.<sup>69</sup> Finally, assume that the firm starts with wealth of \$100, and that it is risk averse and therefore attaches diminishing marginal utility to money.<sup>70</sup>

Under IM, the firm expects aggregate liability of \$60.<sup>71</sup> Under SOS, of course, the firm's aggregate expected liability is identical: with probability of 33%, it expects liability of \$30, \$60, or \$90 if source A, B, or C is selected, respectively.<sup>72</sup> Thus, the firm's aggregate expected liability under SOS is also \$60.<sup>73</sup> Under SOS, however, the firm is exposed to the possibility that the agency will impose \$90 in liability, leaving it with just \$10 in wealth.<sup>74</sup> Suppose that the possibility of the \$90 total liability outcome increases the firm's risk-bearing costs relative to those it would incur under IM.<sup>75</sup>

Now assume that this increase in risk-bearing costs would render SOS less administratively efficient than IM, so the agency provides and the firm exercises an option to have the agency randomly select more than one source for monitoring, in this example, the firm chooses two sources. Despite exercising the option, the firm faces the same aggregate expected liability of \$60.<sup>76</sup> However, the possible liability outcomes of

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<sup>69</sup> For simplicity we assume here that the agency imposes liability strictly, but, as we have explained, *see supra* Part II.B., application of SOS extends to negligence-based regulation as well.

<sup>70</sup> To represent a risk-averse firm's diminishing marginal utility of wealth, we can equate the welfare derived from a given amount of money with the square root of that amount. This simply reflects the assumption that the same marginal increase in wealth results in a smaller marginal increase in utility as wealth rises. This approach provides a helpful means of measuring the effects of SOS on the firm's expected welfare, *see infra* notes 75-79.

<sup>71</sup> Because the firm knows with certainty that the agency will monitor all three sources and assess liability of \$60, the firm expects that its total wealth will be reduced to \$40, and thus its expected welfare under IM will be equal to 6.33.

<sup>72</sup> Applying the liability determination at the selected source to all of the firm's sources, including both the selected source and those not selected, a liability determination of \$10 results in aggregate liability of \$30; a liability determination of \$20 results in aggregate liability of \$60; and a liability determination of \$30 results in aggregate liability at all three sources of \$90.

<sup>73</sup> This is simply the sum of  $(33\% \times \$30)$ ,  $(33\% \times \$60)$ , and  $(33\% \times \$90)$ .

<sup>74</sup> Because the firm expects aggregate liability of \$60 under IM, we would expect that the other possible liability outcomes under SOS, *i.e.*, \$30 or \$60, would not cause the firm to bear excessive costs of risk.

<sup>75</sup> Using the standard assumption with respect to the firm's utility, *see supra* note 70, we can calculate the firm's expected welfare under SOS. If the agency selects source C and imposes liability of \$90, this would reduce firm wealth to \$10 and welfare to 3.16. If the agency selects source B and imposes liability of \$60, this would reduce firm wealth to \$40 and welfare to 6.33. Finally, if the agency selects source A and imposes liability of \$30, this would reduce firm wealth to \$70 and welfare to 8.37. Expecting each state of the world with 33% probability, the firm's expected welfare under SOS is 5.95, lower than the firm's expected welfare of 6.33 when IM is used to reach the same aggregate expected liability.

<sup>76</sup> If the agency selects sources A and B, assessing liability of \$10 and \$20, respectively, and applying the \$15 average liability determination to source C, it will impose \$45 in total liability. If the agency selects

\$45, \$60, and \$75 no longer present the firm with the risk that it will be exposed to \$90 in liability, eliminating the risk-bearing costs<sup>77</sup> associated with that possibility.<sup>78</sup>

Whether this firm will choose to have one, two, or three sources randomly sampled will depend, of course, on the relationship between its utility under each alternative and the cost of additional sampling.<sup>79</sup> By providing the firm with the option to choose the number of sources sampled, however, the agency ensures that the firm internalizes the costs of its risk-producing activity without imposing any additional informational or decision costs on regulators.

## B. *Judgment-Proof Cost*

As SOS is an application of standard enforcement theory explaining that monitoring cost may be reduced by increasing the quantum of sanctions,<sup>80</sup> SOS is susceptible to a common problem associated with such proposals: that total liability calculated under SOS may exceed the firm's assets and liability insurance. This judgment proof problem can compromise deterrence. If the firm anticipates being unable to pay certain high-liability outcomes under SOS, it may reduce investments in regulatory compliance.<sup>81</sup>

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sources B and C, assessing liability of \$20 and \$30, respectively, and applying the \$25 average liability determination to source A, it will impose \$75 in total liability. Finally, if the agency selects sources A and C, assessing liability of \$10 and \$30, respectively, and applying the \$20 average liability determination to source B, the firm expects aggregate liability of \$60. The firm expects each outcome with 33% probability, and thus its aggregate expected liability is \$60, or the sum of  $(33\% \times \$45)$ ,  $(33\% \times \$75)$ , and  $(33\% \times \$60)$ .

<sup>77</sup> To see this in terms of the utility calculus described above, *see supra* note 75, we can calculate the firm's utility under SOS with two sources sampled. If the firm exercises its option to have two sources sampled, it will be exposed either to liability of \$45, reducing wealth to \$55 and welfare to 7.42, liability of \$75, reducing wealth to \$25 and welfare to 5.00, or liability of \$60, reducing wealth to \$40 and welfare to 6.33. The firm expects each outcome with 33% probability, and thus its expected welfare is 6.25, or the sum of  $(33\% \times 7.42)$ ,  $(33\% \times 5.00)$ , and  $(33\% \times 6.33)$ . Note that the firm's expected welfare is higher under SOS when two sources are sampled than when a single source is sampled, *see supra* note 75, because the sampling of an additional source decreases the variability of the firm's aggregate expected liability.

<sup>78</sup> If the firm remained concerned about the prospect of \$75 in liability—still a possibility under SOS where the firm exercises its option to have two sources selected—the firm could elect to have all three sources selected to ensure that its liability would be exactly \$60.

<sup>79</sup> In terms of the utility calculus described above, *see supra* notes 75-77, the firm will compare the marginal costs of the additional sampling with the increase in expected welfare provided by such sampling to determine whether to exercise its option to have two sources sampled. In this case, the firm can pay as much as \$3.50 for sampling of the second source and still expect total welfare higher than its welfare when a single source is sampled. If the cost of the second sample were \$3.60, however, the firm's expected welfare would fall to 5.94, and the firm would prefer sampling of a single source, *see supra* note 75.

<sup>80</sup> *See supra* text accompanying note and note 6.

<sup>81</sup> We distinguish between this type of judgment-proof problem arising because of variance in liability outcomes, *see* Rohan Pitchford, *How Liable Should a Lender Be? The Case of Judgment-Proof Firms and*

This problem is unlikely to arise often.<sup>82</sup> Agencies may minimize the likelihood that a firm will be judgment-proof by determining liability on the basis of risk rather than actualized harm.<sup>83</sup> Moreover, small firms—those most likely to have limited assets available—will likely have few regulated sources, reducing the likelihood that SOS will result in the imposition of high total liability.<sup>84</sup> Further, the problem may be mitigated in cases where the frequency of agency inspections effectively reduces the number of sources subject to monitoring at one time.<sup>85</sup> Regulators may also have authority to institute safeguards against the judgment proof problem, for example through minimum-asset and liability-insurance regulations.<sup>86</sup> Finally, of course, regulatory liability may not be of sufficient magnitude to raise the possibility that the firm will be judgment-proof.<sup>87</sup>

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*Environmental Risk*, 85 AM. ECON. REV. 1171 (1995), from the type arising because firms deliberately judgment-proof themselves, for example by encumbering assets with secured debt, *see* Lynn LoPucki, *The Death of Liability*, 106 YALE L.J. 1, 14-15 (1996). Here we address only the former, *i.e.*, judgment-proof problems created by the variance in liability outcomes generated by the SOS mechanism. Solutions to deliberate judgment-proofing efforts are well-developed in the literature. *See, e.g.*, SHAVELL, *supra* note 6, at 232.

<sup>82</sup> Although we describe here a number of factors that persuade us that judgment-proof firms are unlikely to be a significant problem under SOS, we acknowledge that the empirical questions underlying these considerations remain open. We are unaware of any studies or datasets that would permit closer empirical analysis of the question at this time.

<sup>83</sup> *See, e.g.*, SHAVELL, *supra* note 6, at 232 (explaining that one benefit of a Pigouvian tax is that it is less susceptible to judgment-proof problems because it determines liability on the basis of risk rather than actualized harm).

<sup>84</sup> Because SOS calls for the application of a single liability determination to all of the firm's regulated sources, firms with fewer sources will be exposed to less variability in liability outcomes and thus a lower probability that very substantial liability will render the firm judgment-proof. For example, to determine liability for a firm with just two sources, regulators multiply the liability determination at the selected source by a factor of only two. For a firm with ten sources, however, the liability determination at the selected source is multiplied by a factor of ten to determine the firm's aggregate liability.

<sup>85</sup> The EPA's policy of inspecting major stationary sources once every five years, *see supra* text accompanying note 44, where the sources are subject to monitoring on different schedules, could result in monitoring of a large firm's sources in small groups. For example, a firm operating 20 sources that have come online in different time periods, might be divided into five classes for purposes of the EPA's 5-year inspection schedule would not be exposed to the liability outcome at any particular source multiplied by 20; rather, the firm would annually be exposed to the liability outcome at any source to be monitored that year multiplied by 4.

<sup>86</sup> *See, e.g.*, SHAVELL, *supra* note 6, at 232. *See also* The Safety Act, 6 U.S.C. §443 (requiring firms that produce designated anti-terrorism technologies to carry reasonable amount of liability insurance).

<sup>87</sup> For example, for violations of the Clean Air Act, the EPA may not impose more than \$25,000 per day per violation, and administrative penalties may not exceed \$200,000 total. 42 U.S.C. §§ 7413(b)-(c); *see* Michael Herz, *Structures of Environmental Criminal Enforcement*, 7 FORDHAM ENVTL. L. J. 679, 711 n.108 (1996) (noting that, in practice, administrative penalties imposed for Clean Air Act violations are relatively small). In fiscal year 1994, for example, the EPA imposed 1,596 administrative penalties totaling

Nevertheless, if a judgment-proof problem arises in a particular case, the agency can again address it by providing an option for the agency to sample more than one source. Here, it would be the agency's option, exercisable before any sampling occurs, to determine the number of sources to be sampled.<sup>88</sup> In the event that the agency exercises this option, the average liability determination at sampled sources would be applied perforce as determinative of liability to all of the firm's regulated sources. The firm would be required to pay for costs additional sampling.<sup>89</sup>

In the same way that wider sampling reduces risk-bearing costs for firms, sampling additional sources reduces the likelihood that a firm will be judgment-proof. By exercising its option for wider sampling, the agency can avoid imposing liability that would exceed the firm's assets. Consider again the hypothetical firm in the previous example with three sources, A, B, and C, producing risk of 10, 20, and 30 units, respectively, and assume that the firm is strictly liable for \$1 for each unit of risk. Assume further that the firm has \$80 in assets. Under IM, aggregate expected liability is \$60; because the firm has adequate assets to pay for its total liability, its incentives for compliance are undiluted. Under SOS, the firm anticipates fines of \$30, \$60, or \$90 when sources A, B, and C are randomly selected, respectively; because it anticipates each outcome with 33% probability, its aggregate expected liability remains \$60. But if source C is selected, the firm will be unable to pay the \$90 fine, and will pay only \$80. Thus under SOS the firm internalizes aggregate expected liability of \$56.67,<sup>90</sup> and its incentives for compliance may be diluted by the possibility that it will be judgment proof.

Now assume that the agency provides and exercises an option for it to choose more than one source for random sampling. Based upon the variance of the firm's

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\$151 million, for an average penalty of just over \$94,000. *See id.* at 711; EPA, FISCAL YEAR 1994 ENFORCEMENT AND COMPLIANCE ASSURANCE ACCOMPLISHMENT REPORT 4-2 (on file with authors).

<sup>88</sup> Moreover, to the extent that the agency's determination will be based upon information about the firm's wealth and variance in its outcomes, and the firm will be paying for wider sampling required by the agency, the firm will likely be forthcoming with data on their ability to pay liability outcomes available under SOS.

Where both the firm and the agency elect wider sampling, the agency to avoid the judgment proof problem and the firm to address risk-bearing costs, as a functional matter the agency will select the minimum number of sources to be sampled subject to the firm's option for still wider sampling. For example, where the agency has exercised its option to sample three sources, the firm could elect even wider sampling of four sources, but would not be permitted to choose sampling of just two sources. This ensures that the agency will be able adequately to address judgment-proof problems by opting for wider sampling.

<sup>89</sup> As we have noted, this is consistent with existing regulatory practice in the EPA context—which requires firms to pay for any reasonable monitoring costs, *see supra* note 68—and we do not anticipate that the agency will have incentives to require wider sampling unless the judgment proof problem requires such sampling for deterrence purposes.

<sup>90</sup> This is simply the sum of (33% x \$10), (33% x \$30), and (33% x \$80).



liability outcomes and firm wealth,<sup>91</sup> the agency could recognize that the firm's expected liability outcomes may reach \$90, exceeding the firm's assets of \$80, and require sampling of at least two sources.

As explained in Part IV.A. above, when two sources are sampled the firm faces liability outcomes of \$45, \$60 and \$75.<sup>92</sup> By increasing the number of sources to be randomly sampled to two, the agency ensures that no outcome exceeds the \$80 maximum the firm is able to pay.<sup>93</sup> Thus, sampling two sources in this case eliminates the judgment-proof problem. By giving regulators the option to require additional sampling to mitigate the judgment-proof problem, agencies can implement SOS without risk of diluting deterrence.

## V. CONCLUSION

In this Article, we have proposed a simple mechanism for reducing the costs of monitoring firms' compliance with regulatory standards. The proposal permits agencies to duplicate the deterrence created by cumbersome, expensive iterative monitoring at a fraction of the cost of the current system. We have also shown that SOS applies whether a regulation imposes liability on the basis of strict liability or negligence; whether the regulation sets forth a standard of care for a single source of risk or for a group of such sources; and may reduce the frequency with which sources of risk are monitored.

We have argued that the benefits of SOS will outweigh potential risk-bearing costs associated with the proposal, and that minor modifications to the SOS mechanism can address any such costs. In addition, we conclude that any dilution of deterrence effects as a result of judgment-proof firms can also be addressed with minor modifications to the SOS procedure. In view of the substantial benefits associated with SOS, we do not think these costs provide a persuasive basis for using expensive and unnecessary iterative monitoring as the exclusive means of monitoring compliance.

Although we have explored the merits of our proposal in general terms, we expect that SOS may reduce the costs of monitoring compliance with a wide range regulatory mandates. For example, SOS could be used by the Internal Revenue Service to reduce the number of tax returns monitored or the frequency with which returns must be reviewed.<sup>94</sup> And, in view of the limitations of the Food and Drug Administration's

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<sup>91</sup> We do not expect that this modification will impose additional information costs on regulators or firms, as many firms must disclose both their assets and potential regulatory liability in securities or other disclosures required to obtain financing.

<sup>92</sup> See *supra* notes 77-78.

<sup>93</sup> Of course, if the firm instead had total assets of only \$70, the agency could require sampling of all three sources in order to eliminate the possibility that \$75 in liability will be imposed.

<sup>94</sup> The IRS has long employed sampling of tax returns to determine statistically significant estimates of compliance rates among certain subpopulations of taxpayers. Using SOS to reduce the number of tax returns monitored or the frequency with which returns are monitored would further reduce monitoring

monitoring resources,<sup>95</sup> SOS could permit the FDA to more effectively evaluate compliance with public-health standards. Similarly, SOS could be used by antitrust authorities to reduce the costs of monitoring compliance with antitrust regulations.<sup>96</sup> In addition, SOS might be used by the Securities and Exchange Commission to reduce the costs of reviewing disclosures provided by public firms.<sup>97</sup>

Similarly, SOS could be applied to the civil liability context, reducing litigation costs by permitting courts to determine liability in a single case and apply the results perforce to other cases pending against the same firm. Consider application of SOS to traffic accident suits brought under the Federal Tort Claims Act against the U.S. Post Office.<sup>98</sup> SOS could also promote class actions by overcoming the management problems presented by cases involving significant legal and factual differences among class members' claims.<sup>99</sup>

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costs. See, e.g., General Administration Office, *Tax Administration: IRS' Use of Random Selection in Choosing Tax Returns for Audit* 18 (1998), at <http://www.unclefed.com/GAORReports/ggd98-40.pdf>.

<sup>95</sup> See, e.g., Luke McFarland, *Insufficient FDA Resources: Leveling the Playing Field and Reducing Fraud by Altering Incentives*, at 10 (2001) (unpublished manuscript on file with authors) (“[I]nsufficient FDA resources result in incomplete enforcement of FDA regulations.”).

<sup>96</sup> Reviewing the legality of merger activity is consuming a substantial fraction of enforcement budgets. See, e.g., Hearings on Antitrust Enforcement Agencies, House Committee on the Judiciary, at 82 (1997) (Statement of Robert Pitofsky, Chairman, Federal Trade Commission) (“[W]e review twice as many mergers now as we did 5 years ago, yet the agency is roughly the same size. . . . I worry that we’re slighting non-merger work, because we have so many merger cases that we have to review . . . .”); *id.* at 18-30 (Statement of Joel I. Klein, Assistant Attorney General, Antitrust Division, Department of Justice) (“To effectively continue to carry out our mission we need increased resources.”).

<sup>97</sup> Several commentators have argued that the SEC’s limited enforcement resources have reduced compliance monitoring to suboptimal levels. See, e.g., Shalini M. Aggarwal, *The SEC’s Evolving Strategy for Regulating the Capital Markets*, 2003 COLUM. BUS. L. REV. 581, 588 (2003).

<sup>98</sup> See, Federal Tort Claims Act, 28 U.S.C. §1346(b).

<sup>99</sup> See, e.g., *In re Bridgestone/Firestone, Inc.*, 288 F.3d 1012, 1018-19 (7th Cir. 2002), *cert. denied*, 537 U.S. 1105 (2003).