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MINIMUM ASSET REQUIREMENTS

Steven Shavell

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1050 Massachusetts Avenue

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ABSTRACT

Requirements that parties have assets of at least a minimum level in order to participate in an activity are frequently imposed. A principal rationale for minimum asset requirements is considered in this article—potential injurers have stronger incentives to prevent harm, or not to engage in harmful activities, provided that they have at least the required level of assets at stake if they are sued for causing harm. The optimal minimum asset requirement generally reflects a tradeoff between this advantage and the disadvantage that some parties with assets below a required level ought to engage in the activity (because the benefits they would obtain exceed the expected harm they would cause). Additionally, it is emphasized that minimum asset requirements are socially desirable only when the victims of harm are not customers of firms. When victims of harm are customers of firms, minimum asset requirements are socially undesirable.

Steven Shavell
Samuel R. Rosenthal Professor of Law and Economics
Harvard Law School
Cambridge, MA 02138
and NBER
shavell@law.harvard.edu

1. Introduction

Requirements that parties have assets of at least a minimum level in order to participate in an activity are frequently imposed. Business entities must satisfy minimum asset requirements to engage in a wide range of enterprises, including transportation of hazardous wastes, building of homes, pesticide application, insurance activity, and banking operation, and individuals must sometimes meet financial responsibility requirements as well.¹ In this article, a principal rationale for minimum asset requirements is considered: Potential injurers have stronger incentives to prevent harm, or not to engage in harmful activities, provided that they have at least the required level of assets at stake if they are sued for causing harm.²

Minimum asset requirements are first investigated here employing a standard model in which individuals choose whether to engage in a harmful activity, individuals are able to reduce the risk of harm by exercising care, and individuals are held liable for harm caused. If individuals have assets at least equal to the harm they might create, their incentives will be optimal: They will engage in the activity if and only if their benefits would exceed the expected harm caused; and if they engage in the activity, they will choose the optimal level of care. If individuals' assets are less than the potential harm, however, they will engage too often in the harmful activity, as they will not then face expected liability equal to the full expected harm, and they will similarly lack incentives to take optimal care.

A minimum asset requirement alleviates the problems that individuals might engage in the activity too often and that they would take inadequate care when doing so. However, a minimum asset requirement has a disadvantageous effect: Some of the individuals with assets below the required level ought to engage in the activity, because the benefits they would obtain exceed the expected harm they would cause, even though this harm is higher than is optimal due to their dulled incentives to take care. The optimal minimum asset requirement reflects the tradeoff between this disadvantageous effect and its advantages.

Minimum asset requirements are then examined when firms that produce a good or service (as opposed to individuals who engage in an activity) are the potential injurers, and when the victims of harm are strangers to firms, such as victims of pollution from the spill of a hazardous waste. In this case, minimum asset requirements have analogous advantages to those just mentioned; they lead to lower and more appropriate levels of production, because the asset requirement implies that expected liability payments are higher than otherwise, and hence that product prices are higher; and the asset requirement means that firms that produce exercise greater care in the process. But minimum asset requirements also exert a disadvantageous effect; they prevent production by some relatively efficient firms with low assets that ought to produce because their costs plus accident losses generated are less than value consumers place on their

¹On hazardous wastes, see for example FLA. STAT. Ch. 403.724 (2002); on building of homes, see for example WIS. ADMIN. CODE §5.31 (2002); on pesticide application, see for example MASS. REGS. CODE tit. 333, §10.13 (2002); on insurance activity, see Jackson and Symons 1999, pp. 443-445; and on banking operations, see Jackson and Symons 1999, pp. 184-207. It should be noted that parties are often allowed to obtain liability insurance (or to post a bond) in lieu of satisfying a minimum asset requirement, as is generally the case with drivers' licenses; see Jerry 1996, pp. 859-63. I discuss minimum liability insurance requirements in the concluding section.

²Another rationale for minimum asset requirements is to increase victims' ability to gain compensation through suit for their losses, on which I comment in the concluding section.

output. The optimal minimum asset requirement reflects a balancing of these factors.

Then minimum asset requirements are studied when firms are the injurers and the victims are the customers of the firms. In this case, minimum asset requirements are generally socially undesirable. The underlying reason is that because customers bear any losses that firms with assets less than harm are unable to pay in liability judgments, a customer will not make a purchase unless the value obtained exceeds the social cost. In particular, a firm with low assets that would take little care and produce a risky good, such that the full cost of the good including expected losses exceeds its value to a potential customer, would not be purchased by the customer -- meaning that the customer does not need a minimum asset requirement to protect him. At the same time, a minimum asset requirement would prevent certain efficient firms with low assets from producing, so that it is socially undesirable.

The details of this argument, and whether a first-best outcome is obtained in equilibrium, depend on whether product risks are or are not observable and on whether the assets of firms are directly observable. It is assumed that, if assets are not directly observable, they can be credibly revealed by a firm (for instance, through an accountant's certified report). As is emphasized, when firms' assets are not directly observable, they will be voluntarily revealed in equilibrium. High asset firms will have an incentive to reveal their assets in order to obtain a better price (high asset firms can pay more if liable for causing harm, and also have an incentive to produce less risky goods, so customers will pay a higher price to such firms). That high asset firms want to reveal their assets causes an "unraveling" phenomenon among firms that would otherwise be silent about their assets, so that in equilibrium essentially all firms reveal their assets.

In the concluding section several issues relevant to the analysis are discussed, including the observability of assets and the regulation of liability insurance coverage.

2. Injurers are Individuals

Assume that injurers are risk-neutral individuals who may choose to engage in an activity from which they would obtain a gain but that might also result in harm, with a probability depending on their level of care. Define the following notation.

g = gain to an individual from engaging in the activity; $g \geq 0$;
 $w(g)$ = probability density of g across individuals; and $w(g) > 0$;³
 x = level of care exercised by an individual; $x \geq 0$;
 $p(x)$ = probability of harm; $p'(x) < 0$; $p(x) > 0$;
 h = level of harm; $h > 0$.

Social welfare S is the gains that individuals obtain from engaging in the activity minus the cost of care⁴ exercised by them and expected harm caused; that is, social welfare is the integral of $g - (x + p(x)h)$ over all individuals who engage in the activity.

Socially optimal behavior is easily described: If an individual engages in the activity, he should choose x to minimize the costs of care plus expected harm,

³A particular individual's gain is certain; different individuals obtain different gains.

⁴The term "cost" of care will be used interchangeably with "level" of care.

$$(1) \quad x + p(x)h,$$

so that if x is positive, it should satisfy

$$(2) \quad 1 = -p'(x)h;$$

that is, the marginal cost of care should equal the marginal expected reduction in harm. Denote the optimal x by x^* and assume that it is positive.⁵ A person should engage in the activity if and only if⁶

$$(3) \quad g \geq x^* + p(x^*)h.$$

Suppose that individuals are held strictly liable⁷ for causing harm: A person who causes harm h is supposed to pay h to the victim. However, an individual may not have assets sufficient to pay for the harm he caused. Specifically, assume that individuals differ in their holdings of assets; let

y = level of assets of an individual;
 $f(y)$ = probability density of assets across individuals, where $y \geq 0, f(y) > 0$,

and where, for simplicity, it is assumed that the distributions of assets y and of gains g are independent. If a person causes harm h , he can pay only y if his assets are lower than h . Hence, a person's cost of care plus expected liability payments if he engages in the activity equal⁸

$$(4) \quad x + p(x)\min(y, h) \tag{4}$$

Denote the person's choice of x that minimizes (4) by $x(y)$. We have,⁹

⁵That is, assume that $1 < -p'(0)h$, or, equivalently, that $h > -1/p'(0)$.

⁶If (3) holds with equality, social welfare is of course unaffected by whether the person engages in the activity, but for concreteness I make the assumption that he ought to engage in it in this case. (I will not bother to make similar comments about other cases of equality below.)

⁷If liability were instead based on the negligence rule, the thrust of the conclusions would not be altered, as is discussed in section 4.

⁸Note that because it is assumed that a person can pay his assets y , it is implicitly assumed that his cost of care is not a monetary cost but instead a utility cost: for if care involves a monetary expenditure, then the assets that a person would have available to pay in a liability judgment would be only $y - x$. If x is monetary, complications that are distracting for the purposes of this paper would be introduced into the analysis. Namely, because expenditures on care would be expenditures of money that might otherwise have to be paid as liability judgments, care effectively becomes cheap; this raises the possibility that a person with low assets would exercise excessive care, even if the normal expectation would be that his care would be inadequate; on these issues, see Beard 1990.

⁹The point that when assets are less than harm, liability does not result in optimal deterrence is first

PROPOSITION 1. If an individual's assets y are less than the harm h that he might cause, he may engage in the harmful activity when that is socially undesirable (that is, when $g < x(y) + p(x(y))h$) and, if so, will exercise inadequate care (that is, $x(y) < x^*$).

Notes. This proposition (and others below) is proved in the appendix to the article. The reason for it is clear: If a person's assets are less than harm, expected liability is less than expected harm, so a person will not bear the full social cost of his activity; hence he may decide to engage in it when his gain g is less than $x(y) + p(x(y))h$. Relatedly, because his expected liability is less than expected harm, the marginal benefit to him of taking more care is less than the social marginal benefit, implying that $x(y)$ is less than x^* .

Now suppose that the state can regulate entry into the activity by use of a minimum asset requirement: Individuals cannot engage in the activity unless their assets are at least \underline{y} . Social welfare S as a function of the asset requirement \underline{y} is

$$(5) \quad S(\underline{y}) = \int_{\underline{y}}^h \int_{x(y)+p(x(y))h}^g \{ [g - (x(y) + p(x(y))h)] f(g) dg \} w(y) dy$$

because, for every permitted y , an individual will engage in the activity if his gain is at least equal to (4). Denote the optimal \underline{y} by \underline{y}^* . We then have the following.

PROPOSITION 2. It may be desirable to impose a positive minimum asset requirement. A necessary and sufficient condition for this to be true, for $\underline{y}^* > 0$, is that the mean gain that individuals would obtain from the activity is less than the expected harm when no care is exercised, that is, $E(g) < p(0)h$. Also, the optimal requirement \underline{y}^* is less than the harm h .

Notes. Imposing a minimum asset requirement \underline{y} has the advantage that it prevents individuals with the least wealth from engaging in the activity, and there is a double reason why it may be desirable to do so: These individuals would exercise the least care, meaning they would create the most risk if they engaged in the activity; and they would have the weakest liability-related incentives to take the expected harm they create into account in deciding whether to engage in the activity because their assets are lowest. In particular, the social welfare benefit from use of \underline{y} derives from preventing individuals from engaging in the activity who would otherwise have done so but should not have, that is, those for whom $x(y) + p(x(y))y < g < x(y) + p(x(y))h$. There is also a social welfare disadvantage from use of \underline{y} , due to its preventing individuals from engaging in the activity who would otherwise have done so and should have, that is, those for whom $x(y) + p(x(y))h < g$.

If $E(g) < p(0)h$, then the group with no assets are on average desirable to prevent from engaging in the activity, which suggests why this condition implies that a positive minimum asset requirement is advantageous. Also, observe that the social welfare benefit from use of \underline{y}

developed in Shavell 1986.

exists only for $y < h$, explaining why y^* cannot exceed h . To understand why y^* must be strictly less than h , note that if y is lowered marginally from h , those individuals who are led to engage in the activity who should not do so cause no first-order loss in social welfare (since their assets are essentially equal to h , their expected liability is essentially equal to expected harm, so their incentives are essentially optimal), but the individuals who are now permitted to engage in the activity who ought to do so generate a positive first-order gain in social welfare.

3. Injurers are Firms

Now assume that injurers are risk-neutral firms that may choose to produce and sell a good (or to perform a service) in a competitive industry. If a firm produces a good, it may cause harm with a probability depending on its level of care. Two cases are examined: when victims of harm are strangers to firms, and when victims are the customers of firms.

3.1 Victims are strangers

A firm is distinguished by its unit cost of production; define

$$k = \text{unit production cost (exclusive of the cost of care); } k > 0;$$

$$t(k) = \text{probability density of } k \text{ across firms; } t(k) > 0.$$

The lower is k , the more efficient a firm is. For simplicity, assume that if a firm produces, it produces only one unit. Let x , $p(x)$, and h be defined as before, so that the social cost of producing a unit is $k + x + p(x)h$. Assume also that

$$q = \text{quantity of the good produced by all firms;}$$

$$u(q) = \text{utility of consumers from quantity } q.$$

Social welfare is $u(q)$ minus the social costs of production, namely, the integral of $k + x + p(x)h$ over the q firms that produce.

The socially ideal outcome is clearly as follows. First, any unit that is produced should be produced at minimum social cost; hence the level of care should be x^* , minimizing $x + p(x)h$. Second, only firms with production costs k below some optimal threshold k^* should produce. Third the total quantity produced should be such that the marginal social value equals the marginal social cost of production; the optimal quantity q^* obeys

$$(6) \quad u'(q^*) = k^* + x^* + p(x^*)h.$$

To describe the outcome that occurs in the absence of minimum asset requirements, assume that firms have assets y that are distributed according to $f(y)$ as defined before¹⁰ and that firms are liable for harm that they cause. Thus, if a firm produces, it will choose x to minimize $k + x + p(x)\min(y, h)$, so it will choose $x(y)$, as described in section 2. Now let

¹⁰The distribution of y will for simplicity be assumed to be independent of the distribution of k .

r = price of the good.

As the industry is assumed to be competitive, each firm takes r as given and will produce a unit if and only

$$(7) \quad k + x(y) + p(x(y))\min(y, h) \leq r.$$

The quantity supplied is equal to the number of firms obeying (7); let

$$q_s(r) = \text{quantity supplied given } r.$$

Thus

$$(8) \quad q_s(r) = \int_0^{\infty} \int_0^{[x(y) + p(x(y))\min(y, h)]} t(k) dk w(y) dy,$$

since (7) determines when a firm produces. Also, let

$$q_d(r) = \text{quantity demanded given } r,$$

which must satisfy

$$(9) \quad u'(q_d) = r.$$

The quantity produced is determined by market equilibrium,

$$(10) \quad q_s(r) = q_d(r),$$

which for simplicity is assumed to be unique. The market equilibrium deviates from the socially ideal outcome, as described in

PROPOSITION 3. In market equilibrium, firms with assets y less than the harm h that they might cause may produce when that is socially undesirable and, if so, exercise inadequate care. Also, the total quantity produced is socially excessive.

*Notes.*¹¹ That the level of care $x(y)$ is less than x^* for firms with $y < h$ is clear, as in section 2, where injurers are individuals. That firms with $y < h$ may produce when they should not is also evident, for $k + x(y) + p(x(y))y \leq r < k + x(y) + p(x(y))h$ will sometimes hold. That total quantity produced is socially excessive follows because, at a price of $r^* = k^* + x^* +$

¹¹Against the background of the analysis done in section 2, these notes should be sufficient to establish the proposition for the reader, and its formal proof is omitted.

$p(x^*)h$, more firms produce than just those with $k \neq k^*$. Hence, the equilibrium price must be less than $k^* + x^* + p(x^*)h$, and thus the quantity produced exceeds q^* .

Next, consider minimum asset requirements. For any minimum requirement \underline{y} , there will be a market equilibrium (which will be assumed to be unique) with quantity $q(\underline{y})$ and price $r(\underline{y})$, determined as described above, except that the supply function $q_s(r)$ is lower; it is now given by the number of firms that satisfy both $y \geq \underline{y}$ and (7), so that

$$(8N) \quad q_s(r) = \int_{\underline{y}}^4 \int_{r(y) - [x(y) + p(x(y))\min(y, h)]}^{\infty} t(k) dk w(y) dy$$

It is evident that $q'(\underline{y}) < 0$ and $r'(\underline{y}) > 0$, because as \underline{y} rises, the supply function $q_s(r)$ shifts to the left. Social welfare as a function of \underline{y} is

$$(11) \quad S(\underline{y}) = u(q(\underline{y})) - \int_{\underline{y}}^4 \int_{r(y) - [k + x(y) + p(x(y))h]}^{\infty} t(k) dk w(y) dy.$$

Note that in the inner integral, the upper limit of integration reflects (7), that a firm produces when $k \neq r(y) - [x(y) + p(x(y))\min(y, h)]$. Let \underline{y}^* be the optimal minimum asset requirement. We can then show

PROPOSITION 4. It may be desirable to impose a positive minimum asset requirement. A sufficient condition for $\underline{y}^* > 0$ is that the equilibrium price in the absence of such a requirement, $r(0)$, is sufficiently less than $E(k^*k \neq r(0)) + p(0)h$. Also, the optimal requirement \underline{y}^* is less than the harm h .

Notes. The explanation is analogous to that for Proposition 2. Imposing a minimum asset requirement \underline{y} has the advantage that it prevents firms with the least wealth from producing; these firms would exercise the least care and would have the weakest liability-related incentives to take the expected harm they create into account in deciding whether to produce. In particular, the social welfare benefit from use of \underline{y} derives from preventing firms from producing that would otherwise have done so but should not have, that is, firms for which $k + x(y) + p(x(y))y \neq r(\underline{y}) < k + x(y) + p(x(y))h$. The social welfare disadvantage from use of \underline{y} is due to its preventing firms from producing that would otherwise have done so and should have, that is, firms for which $k + x(y) + p(x(y))h < r(\underline{y})$.

The sum $E(k^*k \neq r(0)) + p(0)h$ is what the mean social cost of production would be among firms with no assets if there were no minimum asset requirement: such firms would exercise no care, and thus they would produce whenever their unit production cost k is less than the price $r(0)$. Since the social cost of production includes also the expected harm $p(0)h$, it would seem to be desirable to prevent these firms from producing when $E(k^*k \neq r(0)) + p(0)h$ exceeds $r(0)$, which of course equals the marginal utility of the good to consumers; however, raising the minimum asset requirement increases the price, which makes the sufficient condition for a

positive \underline{y}^* slightly different. That \underline{y}^* must be strictly less than h is explained essentially the same way as in Proposition 2.

3.2 Victims are customers

In this case the individuals who are victims are assumed to be the customers of firms. It will be assumed for simplicity that each customer places a (gross) value on having a single unit of the good and does not want more than one unit;¹² let

v = value of the good to an individual customer;
 $z(v)$ = probability density of v ; $z(v) > 0$.

Social welfare is the integral of v obtained by customers minus the social costs of production. The socially ideal outcome is thus as described in section 3.1.

We will now consider different assumptions concerning customers' information about risk and about the assets of firms. For each assumption, we discuss whether minimum asset regulation is socially desirable.

Customers can observe a firm's risk and its assets. Here the assumption is that customers can observe $p(x)$ and y for each firm. Thus, the price of the good can then depend on both $p(x)$ and y . We have

PROPOSITION 5. Suppose that customers can ascertain, for any firm, both the risk $p(x)$ of harm from the good sold by the firm and its assets y . Then the socially ideal outcome will be achieved and a minimum asset requirement is socially undesirable.

Notes. Firms with assets less than harm will have proper incentives to take care even though their expected liability will be less than the expected harm they cause. In particular, if a firm's assets y are less than harm h , customers will recognize that they will themselves bear expected losses of $p(x)(h - y)$ if they buy the good from the firm. Hence, if r is the price of the good when sold by firms with assets y at least equal to h (note that the customers of these firms do not bear any expected losses), then the price of the good when sold by a firm with assets $y < h$ will be $r - p(x)(h - y)$ in equilibrium. Hence, a firm with $y < h$ will have an optimal price-related incentive to lower risk and will choose x^* , as will firms with higher assets. Also, because customers know the expected losses that they bear when purchasing from firms with $y < h$, customers will take the full social cost of the good into implicit account and decide to make a purchase when and only when that is socially desirable. Because the outcome will therefore be ideal in the absence of a minimum asset requirement, imposition of such a requirement will lower social welfare. It will do this by preventing some firms with low assets from producing even though those firms would take optimal care and purchase decisions from them would be socially desirable.

¹²In the previous section, it was not necessary to specify demand for the good at the level of the individual, and $u(q)$ there could be interpreted as the utility from q units derived by different individuals or by a single individual.

Customers can observe a firm's risk but cannot observe a firm's assets unless the firm discloses this. Now assume that although customers can observe the risk $p(x)$ for a firm, they cannot directly observe a firm's assets y . However, firms are able to disclose their assets in a credible way (notably, by hiring an accountant to make a certified statement). The equilibrium market price can thus depend on $p(x)$ and, if y is disclosed, on it as well. We have

PROPOSITION 6. Suppose that customers can ascertain, for any firm, the risk $p(x)$ of harm from the good sold by the firm, but not its assets y unless y is disclosed by the firm. Then firms will be led to disclose their assets, the socially ideal outcome will be achieved, and a minimum asset requirement is socially undesirable.

Notes. If firms are led to disclose their assets, the situation will be essentially identical to that just discussed, so the explanation for Proposition 5 will apply. That all firms will be induced to disclose their assets follows from an unraveling argument. In particular, suppose that there is a silent-about-their-assets group of firms (for which the risk is $p(x)$) that contains a subgroup with $y < h$. Then customers who buy from a firm in this silent group will bear positive expected losses, for some firms in the group will be unable to pay h . Thus, the price of the good from the silent group will be lower by the mean expected losses than r , the price of the good when customers bear no expected losses. This will cause firms with high assets within the silent group to disclose y in order to obtain a higher price (since then customers would know that they would bear lower expected losses buying from it than from the silent group). This implies that in equilibrium there cannot be a silent group containing firms with $y < h$. There also cannot be an equilibrium with silent firms containing only firms with $y \geq h$, for then firms with $y < h$ would want to be silent to obtain a higher price of r .

Customers cannot observe a firm's risk but can observe a firm's assets. In this case, customers cannot observe the risk $p(x)$ of a firm but do know its assets y , so that the price r may depend on y . We have

PROPOSITION 7. Suppose that customers cannot observe the risk $p(x)$ of harm from the good sold by a firm but can observe a firm's assets y . Then the outcome will not be optimal; firms with assets less than the harm will take less than optimal care. But a minimum asset requirement is socially undesirable.

Notes. Firms with assets y less than harm will have inadequate liability-related incentives to take care, and will not be rewarded by a higher price for taking more care because customers cannot observe $p(x)$; thus such firms will take suboptimal care. Because customers can observe assets y , they know the risk associated with the product sold by firms with assets y , so that customers make optimal purchase decisions. This means that preventing firms with assets below \underline{y} from selling will lower social welfare, because any sale that would have been made would have raised welfare.

Customers cannot observe a firm's risk and cannot observe a firm's assets unless it discloses them. In this case, customers cannot observe the risk $p(x)$ of a firm and does not know

its assets y unless the firm chooses to disclose y , in which case the price r may depend on y . We have

PROPOSITION 8. Suppose that customers cannot observe the risk $p(x)$ of harm from the good sold by a firm and cannot observe a firm's assets y unless it discloses them. Then firms will disclose their assets and the outcome will be identical to that in Proposition 7: firms with assets less than the harm will take less than optimal care; but a minimum asset requirement is socially undesirable.

Notes. Firms will be led to disclose their assets due to an unraveling argument similar to that explaining Proposition 6. Hence, the situation will be as in Proposition 7, so it will hold.

4. Discussion.

In conclusion, let me comment on several issues of relevance to the analysis.

(a) *Observability of assets.* A conclusion from the analysis was that when the victims of harm are customers, minimum asset requirements are undesirable if assets are observable or can be credibly disclosed, since a minimum asset requirement can then only interfere with welfare-enhancing purchases from low asset firms. It is apparent, though, that if assets are not observable or disclosable, a minimum asset requirement might be desirable, for otherwise the presence of low asset firms selling products with high risks could effectively prevent some firms with high assets and low risks from selling their products despite the desirability of such transactions.¹³ However, for a minimum asset requirement to be enforced, the state presumably must be able to observe assets, and if the state can do that, the state can announce the assets of firms and raise social welfare by dispensing with a minimum asset requirement.

(b) *Endogeneity of assets.* It was assumed in the analysis that the assets of individuals and firms are fixed, but assets are in fact to some degree variable; firms can decide on asset size when establishing themselves, and individuals and firms can shield their assets. The major effect of allowing for the endogeneity of assets on the conclusions is to increase optimal minimum asset requirements, because the variability of assets diminishes the efficiency losses associated with asset requirements. For example, if an efficient firm can obtain high assets by finding more investors, it might not be barred from operating by an asset requirement that it would otherwise

¹³Suppose for example that there are four firms, two with no assets that would each sell a product with a risk of 50% of causing a harm of 100, and the other two firms with assets of over 100, that would be induced to spend 10 per unit on care, reducing the risk of harm to zero. The production cost of the product exclusive of care is 5. There are two customers, who each place a value of 20 on the product. In the absence of a minimum asset requirement, there does not exist an equilibrium in which the product is produced: For the high asset firms to produce, the price must be at least 15 (to cover the production cost of 10 plus the cost of care of 5). But at a price of 15, the low asset firms would produce (their cost is only 10). Yet if the low asset firms produce, creating an expected loss of 50 for their products, the average product risk is 25 (customers cannot distinguish between the low asset and the high asset firms). This means that the full price of a product would be at least 40. Since the value placed on a product is 20, customers would not make purchases. However, if there is a positive minimum asset requirement, then only the two high asset firms would produce, and at any price in between 15 and 20, the two firms would make profits and the customers would purchase the good, raising social welfare.

be unable to satisfy.

(c) *Rule of liability.* It was assumed in the analysis that strict liability applied — that the injurer is required to pay for harm caused regardless of the level of care — rather than the negligence rule — under which the injurer must pay for harm only if his level of care was below a due care standard. However, the thrust of the conclusions about minimum asset requirements would be the same under the negligence rule, for as under strict liability, parties will not be induced by the threat of liability to take proper care if their assets are too low. Moreover, when parties assets are low enough that they will decide not to take due care and thus to be negligent, they will in effect become strictly liable, in which case the analysis of minimum asset requirements would closely resemble that above.

(d) *Liability insurance.* Although it was assumed that injurers are risk neutral, if they are risk averse, they may want to purchase liability insurance. This possibility would complicate the analysis and leads to the question whether it would be desirable to regulate liability insurance coverage along with, or instead of, assets. Notably, if parties with assets less than harm purchase full liability insurance coverage, then their insurance premiums will reflect expected harm, so that injurers' levels of activity and product prices will tend to be desirable. Moreover, if insurers can observe insureds' levels of care, insurance policy terms will tend to lead insureds to exercise optimal care. These observations suggest that, at least when insurers can observe levels of care, requirements to purchase liability insurance coverage may be desirable. However, when insurers cannot observe insureds' levels of care, the mandated purchase of liability coverage may dilute incentives to take care, possibly exacerbating the incentive problems due to low assets. In this case, it may be desirable to limit or prohibit the purchase of liability insurance, not require it.¹⁴

(e) *Minimum asset requirements as a means of assuring victims' compensation.* As noted in the Introduction, the use of minimum asset requirements is common, including for firms when their typical victims would be their customers. The explanation for the use of such requirements may well lie primarily in the view that the requirements assure victims that if they sue, the injurers will have at least the required level of assets to pay them.¹⁵ This, however, appears to be a socially undesirable method of assuring victims compensation due to the high costs of use of the legal system.¹⁶ Thus, it may well be better for such use of minimum asset requirements to be curtailed, and for the requirements to be imposed only where victims of harm are not customers.

¹⁴See Shavell 1987, pp. 240-243, 257-259, and Shavell 2000, on the regulation of liability insurance when parties' assets are less than the harm that they might cause (but not taking into account the possible use of minimum asset requirements).

¹⁵However, asset requirements that are imposed on banks (and certain other financial institutions) are sometimes said to be justified by a species of externality: that if a particular bank, fails, that may create a fall in confidence leading to the failure of other banks.

¹⁶For example, a recent study, Tillinghast-Towers Perrin 2002, p. 12, reports that victims received only 42 per cent of payments made by defendant parties in a nationwide survey of the tort system (in other words, over half of all payments were absorbed by others, notably, by lawyers).

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APPENDIX

Proof of Proposition 1. If $y < h$, then by (4) an individual will choose x to minimize $x + p(x)y$, so that

$$(A1) \quad 1 > p'(x^*)y,$$

implying that $x(y) < x^*$. Also, if $y < h$, we know from (4) that an individual will engage in the activity if and only if

$$(A2) \quad g \geq x(y) + p(x(y))y.$$

But since $y < h$, (A2) may hold even though $x(y) + p(x(y))h > g$.

Proof of Proposition 2. Differentiate (5) to obtain

$$(A3) \quad S'(\underline{y}) = \int_{x(\underline{y}) + p(x(\underline{y}))\min(\underline{y}, h)}^4 \{ [x(\underline{y}) + p(x(\underline{y}))h] - g \} f(g) dg \} w(\underline{y}),$$

which can be rewritten as

$$(A4) \quad S'(\underline{y}) = \int_{x(\underline{y}) + p(x(\underline{y}))\min(\underline{y}, h)}^{x(\underline{y}) + p(x(\underline{y}))h} \{ [x(\underline{y}) + p(x(\underline{y}))h] - g \} f(g) dg - \int_{x(\underline{y}) + p(x(\underline{y}))h}^4 \{ g - [x(\underline{y}) + p(x(\underline{y}))h] \} f(g) dg \} w(\underline{y}).$$

The first integral is the marginal social gain from preventing those individuals who should not engage in the activity from doing so, and the second integral is the marginal social loss from preventing those who should engage in the activity from doing so. At $\underline{y} = 0$, since $x(0) = 0$, (A4) is

$$(A5) \quad S'(0) = \int_0^{p(0)h} \{ (p(0)h - g) f(g) dg - \int_{p(0)h}^4 \{ g - p(0)h \} f(g) dg \} w(0) = p(0)h \{ E(g) - p(0)h \},$$

where $E(g)$ is the mean of g . Hence, a sufficient condition for $\underline{y}^* > 0$ is $E(g) < p(0)h$. To show that this condition is necessary for $\underline{y}^* > 0$, observe that the term in braces in (A3) declines as \underline{y} rises in $[0, h)$, for the lower limit of integration rises with \underline{y} and $[x(\underline{y}) + p(x(\underline{y}))h]$ falls with \underline{y} . Hence, if $S'(0) \neq 0$, then $S'(\underline{y}) < 0$ for all \underline{y} in $(0, h)$. Therefore, if $\underline{y}^* > 0$ holds, then $S'(0) > 0$, but this implies that $E(g) < p(0)h$.

Also, note that, for any $\underline{y} \leq h$, (A4) reduces to the second term, and since $x(\underline{y}) = x^*$ for such \underline{y} , we have

$$(A6) \quad S'(\underline{y}) = - \int_{x^*+p(x^*)h}^4 (g - [x^* + p(x^*)h])f(g)dg \} w(\underline{y}) < 0,$$

so that \underline{y}^* must be less than h .

Proof of Proposition 4. Differentiate (11) to obtain

$$(A7) \quad S'(\underline{y}) = u'(q(\underline{y}))q'(\underline{y}) + \int_0^{r(\underline{y}) - [x(\underline{y}) + p(x(\underline{y}))\min(\underline{y}, h)]} [k + x(\underline{y}) + p(x(\underline{y}))h]t(k)dkw(\underline{y}) \\ - \int_{\underline{y}}^4 r'(\underline{y}) [r(\underline{y}) + p(x(\underline{y}))\min(\underline{y}, h)]t(r(\underline{y}) - [x(\underline{y}) + p(x(\underline{y}))\min(\underline{y}, h)])w(\underline{y})d\underline{y}.$$

The first term is the decline (recall that $q'(\underline{y}) < 0$) in marginal utility from consumption of the product due to an increase in \underline{y} , and the other two integrals comprise the change in social production costs due to an increase in \underline{y} .¹⁷ Also, note from (8) that we can write

$$(A8) \quad q'(\underline{y}) = - \int_{\underline{y}}^4 r'(\underline{y}) - [x(\underline{y}) + p(x(\underline{y}))\min(\underline{y}, h)]t(k)dkw(\underline{y})d\underline{y}$$

so that

$$(A9) \quad q'(\underline{y}) = - \int_0^{r(\underline{y}) - [x(\underline{y}) + p(x(\underline{y}))\min(\underline{y}, h)]} t(k)dkw(\underline{y}) + \int_{\underline{y}}^4 r'(\underline{y}) [r(\underline{y}) - [x(\underline{y}) + p(x(\underline{y}))\min(\underline{y}, h)]]w(\underline{y})d\underline{y}.$$

Now let us evaluate (A7) at 0. We have

$$(A10) \quad S'(0) = u'(q(0))q'(0) + \int_0^{r(0)} [k + p(0)h]t(k)dkw(0) \\ - \int_0^4 r'(0) [r(0) + p(0)h]t(r(0))w(\underline{y})d\underline{y}.$$

Using (A9) and the fact that $u'(q(0)) = r(0)$, we can rewrite (A10) as

¹⁷The first integral is the production costs that society saves because firms with assets \underline{y} are prevented from producing. The second integral is the production costs that society incurs because the rise in the equilibrium price $r(\underline{y})$ leads more firms with assets above \underline{y} to produce.

$$(A11) \quad S\mathbb{N}(0) = \int_0^{r(0)} t(k) dk w(0) + \int_0^4 r\mathbb{N}(0) t(r(0)) w(y) dy$$

$$\begin{aligned} & + \int_0^{r(0)} [k + p(0)h] t(k) dk w(0) - \int_0^4 r\mathbb{N}(0) [r(0) + p(0)h] t(r(0)) w(y) dy \\ = & w(0) \int_0^{r(0)} [(k + p(0)h) - r(0)] t(k) dk - \int_0^4 r\mathbb{N}(0) p(0) h t(r(0)) w(y) dy. \end{aligned}$$

Hence, $S\mathbb{N}(0)$ will be positive, and thus $y^* > 0$, if the first integral is sufficiently large, which is the first claim that we need to demonstrate.

Now let us evaluate $S\mathbb{N}(y)$ at $y = h$ and show that it is negative; this will establish that $y^* < h$. For such y , since $x(y) = x^*$, (A7) is

$$(A12) \quad S\mathbb{N}(y) = u\mathbb{N}(q(y))q\mathbb{N}(y) + \int_0^{r(y) - [x^* + p(x^*)h]} [k + x^* + p(x^*)h] t(k) dk w(y) - \int_y^4 r\mathbb{N}(y) [r(y) - [x^* + p(x^*)h]] w(y) dy.$$

However,

$$(A13) \quad \int_0^{r(y) - [x^* + p(x^*)h]} [k + x^* + p(x^*)h] t(k) dk w(y) < \int_0^{r(y) - [x^* + p(x^*)h]} r(y) t(k) dk w(y)$$

since $[k + x^* + p(x^*)h] < r(y)$ for all k less than $r(y) - [x^* + p(x^*)h]$. Hence

$$(A14) \quad S\mathbb{N}(y) < u\mathbb{N}(q(y))q\mathbb{N}(y) + \int_0^{r(y) - [x^* + p(x^*)h]} r(y) t(k) dk w(y) - \int_y^4 r(y) [r(y) - [x^* + p(x^*)h]] w(y) dy = r(y)q\mathbb{N}(y) - r(y)q\mathbb{N}(y) = 0.$$

Note that we used (A9) in deriving the first equality in (A14).

Proof of Proposition 5. If $y = h$, an individual who makes a purchase knows that he will be compensated in full for losses of h that he might bear. Thus, if the individual buys from such a

firm, only the price of the good matters to him; consequently, in equilibrium there must be a single price r for all firms with $y \geq h$. If an individual purchases from a firm with $y < h$, he will pay a market price $r(p(x), y)$ that may depend on $p(x)$ and y , and he knows he will bear expected losses of $p(x)(h - y)$; thus the full price of the good will be $r(p(x), y) + p(x)(h - y)$. In equilibrium, customers must be indifferent between purchasing the good from firms with different levels of assets, so that

$$(A15) \quad r = r(p(x), y) + p(x)(h - y), \text{ or } r(p(x), y) = r - p(x)(h - y).$$

All firms will choose the optimal level of care x^* . Firms with $y \geq h$ sell at a fixed price r , so will choose x to maximize profits of $r - [k + x + p(x)h]$, so they will minimize $x + p(x)h$, so they will select x^* . Firms with $y < h$ will choose x to maximize their profits of

$$(A16) \quad r(p(x), y) - [k + x + p(x)y] = r - p(x)(h - y) - [k + x + p(x)y] = r - [k + x + p(x)h],$$

so they also will choose x^* .

Purchase decisions will be optimal because a customer will make a purchase if and only if $v \geq r$ (note from (A15) that this condition applies for a firm whether or not $y \geq h$). The total quantity produced will be optimal because a firm will produce if and only if $k + x^* + p(x^*)h \leq r$ (note from (A16) that this condition applies whether or not $y \geq h$), which is to say, if and only if $k \leq k^*$, where $k^* = r - (x^* + p(x^*)h)$.

We have shown that the socially ideal outcome will be achieved in the absence of a minimum asset requirement. Because a positive minimum asset requirement would alter the equilibrium, a requirement would reduce social welfare. In particular, this would occur because a requirement would prevent firms with assets y below \underline{y} from producing even though it would be desirable for the efficient firms (those with $k < k^*$) among them to produce and they would do so in the absence of a requirement.

Proof of Proposition 6. If firms are led to disclose their assets, the situation will be essentially identical to that just discussed, so the proof for Proposition 5 will apply.

To show that all firms will be induced to disclose their assets, suppose that there is a silent group of firms for which the risk is $p(x)$ and that contains firms with $y < h$.¹⁸ Customers who buy from a firm in this group will bear expected losses of $p(x)(h - E(y^*|\text{silence}, p(x))) > 0$, where $E(y^*|\text{silence}, p(x))$ is the mean assets of firms in the silent group for which the risk is $p(x)$. Hence, if r is the price of the good when sold by firms known to have assets y at least equal to h , the price that firms in the silent group will obtain in equilibrium is $r - p(x)(h - E(y^*|\text{silence}, p(x)))$. This cannot be, however, for the silent firms with the greatest assets would always want to disclose their assets. In particular, there must be firms in the silent group with $y > E(y^*|\text{silence}, p(x))$, and if such a firm discloses its assets, it will be able to obtain a higher price (of r if $y \geq h$ and of $r - p(x)(h - y)$ otherwise).

Accordingly, if there is a silent group, it must be comprised entirely of firms with $y \geq h$.

¹⁸By "all" firms, I mean all firms except possibly for a set of measure zero, and by "firms with $y < h$ " I mean a set of such firms of positive measure (and I will not repeat similar qualifications below).

But this cannot be, for if it were true, the price silent firms would obtain would be r . Then, however, a firm with $y < h$ that discloses y (because the maintained hypothesis is that silent firms are only those with $y \geq h$) and thus that obtains a price of $r - p(x)(h - y)$ could obtain r by keeping silent. This upsets the supposed equilibrium.

Proof of Proposition 7. Let $r(y)$ be the price firms with assets y obtain, and note that it is independent of $p(x)$ since this is not observable. A firm will thus choose x to maximize $r(y) - [k + x + p(x)\min(y, h)]$, so will choose $x(y) < x^*$ if $y < h$ and $x(y) = x^*$ for $y \geq h$. Customers know $p(x(y))$ in equilibrium, so a customer will buy make a purchase when

$$(A17) \quad v \geq r(y) + p(x(y))(h - y).$$

On the other hand, by (7), a firm with assets y will produce only if $r(y) \geq k + x(y) + p(x(y))y$. Hence, if a customer makes a purchase,

$$(A18) \quad v \geq k + x(y) + p(x(y))h,$$

so that customer purchases can only raise social welfare. Hence, a minimum asset requirement can only lower social welfare. (It will definitely lower social welfare if (A18) is sometimes strict, which must be the case if the price $r(y)$ is positive since $t(k) > 0$ for all positive k .)

Proof of Proposition 8. There cannot be a group of silent firms, by essentially the argument given in the proof of Proposition 6. Hence, the proof of Proposition 7 applies.