May 29, 2003

Lender Liability for Environmental Risk Revisited*

Tetsuo Ono

Insitute of Policy and Planning Sciences, University of Tsukuba

Yasuo Maeda

Department of Economics, Keio University

Abstract

There have been opposing conclusions in the literature as to whether lender liability increases the probability of environmentally harmful accidents. This paper shows that s multiplicity of equilibria is the key to solve such contradictory conclusions.

Keywords: Environmental Risk, Lender Liability.

JEL Classification: K32.

*This paper was presented at APFA Finance Conference in 2002 held in Tokyo. For helpful comments on a previous version, authors wish to thank Gordon Roberts.

1 Introduction

There have been opposing conclusions as to whether lender liability increases the probability of environmentally harmful accidents. Pitchford (1995) has shown that an increase in lender liability for environmental risk would lead to an increase in the probability of environmental accidents. On the other hand, Heyes (1996) and Boyer and Laffont (1997) have shown the contradictory result. These two opposing results raise the following question: how do such seemingly contradictory conclusions emerge from otherwise very similar formal models?

Balkenborg (2001) has recently answered the above question by showing that the distribution of bargaining power between the lender and the owner is the key to the puzzle. Pitchford conclusion holds when the credit market is competitive (i.e., the bargaining power of the lender is not too high), while it does not when the market is imperfectly competitive (i.e., the power of the lender is high).

This paper provides a different framework from Balkenborg (2001), and then show two opposing consequences of lender liability under a perfectly competitive credit market. The key to the puzzle is a multiplicity of quilibria. The effect of lender liability on the accident probability is entirely different between the two equilibria.

2 The Model

A wealth-constrained owner with no initial wealth conducts a project yielding a gross return V after an initial investment K where $V > K > 0$. To finance the project the owner needs a loan from a lender in a competitive credit market, whom we assume to have deep pockets, i.e., not to be wealth-constrained. Both agents are risk neutral.

The project may cause an accident that generates total damage cost h to anonymous victims.

The probability of an accident depends on the owner's unobservable effort choice to prevent it. The owner can reduce the accident probability by expending nonpecuniary (or effort) costs according to a cost function $\phi(p)$. The cost function $\phi : [0,1] \rightarrow \Re_+$ is twice continuously differentiable on $(0,1)$, and satisfies the following properties.

Assumption 1: $\phi' < 0, \phi'' > 0, \lim_{p\rightarrow 1} \phi = 0, \lim_{p\rightarrow 0} \phi = \infty, \lim_{p\rightarrow 1} \phi' = 0$, and $\lim_{p\rightarrow 0} \phi = -\infty$.

Figure 1 depicts the graph of the function ϕ. The meaning of Assumption 1 is that, if a reduction in p is desired, cost rises. As p gets close to zero, cost becomes prohibitively high. Assumption 1 leads to the following result which will be used for showing the non-negative profit of the owner.

Lemma 1: $-(1-p)\phi'(p) - \phi(p) > 0 \forall p \in (0,1)$.

Proof: $-(1-p)\phi'(p) - \phi(p)$ is strictly decreasing in $p \in (0,1)$ since $d[-(1-p)\phi'(p) - \phi(p)]/dp = -(1-p)\phi''(p) < 0 \forall p \in (0,1)$. In addition, $\lim_{p\rightarrow 1}[-(1-p)\phi'(p) - \phi(p)] = 0$. Thus, $-(1-p)\phi'(p) - \phi(p) > 0 \forall p \in (0,1)$. ■

No effort will be exerted unless liability is imposed. In this paper, we study the consequences of a joint and strict liability rule which requires the owner and the lender jointly to pay liability $c \in [0,h]$. We assume that the owner is made liable with all his wealth firstly and that the lender has to add the remainder. Because the lender has deep pockets, he cannot evade the liability payment.

We assume that it is not possible for the owner and the lender to write a contract specifying p, because the lender lacks the appropriate monitoring technology, or more generally because it is too costly to describe in a contract the factors that determine p. We consider (pure) debt contracts, where the owner borrows an amount K and is required to make a repayment RK where R is a gross rate of interest on loan.

The time structure of the model is as follows. (1) A social planner sets the joint and strict liability $c \in [0, h]$. (2) The lender and the owner make a contract to finance the investment in a competitive credit market. (3) The owner decides on the level of probability of accident, p. (4) The net returns from the project are realized. (5) An accident may or may not occur. If an accident occurs, the owner and the lender have to pay liability c.

In closing this section, we characterize a socially optimal level of the accident probability p^* such that social surplus is maximized. The expected social surplus $SW(p)$ is

$$SW(p) = V - K - ph - \phi(p),$$

where $V - K$ is the net social value of the project, ph is the expected cost of accident, and $\phi(p)$ is the cost of effort. The socially optimal level of the accident probability maximizing social surplus is $p^*(h)$ which is the solution for $\phi'(p) = -h$. We assume that $SW(p^*) > 0$, which implies that the project should be financed from the social point of view.

3 Contract and Equilibrium

3.1 Contract

This section considers the contract under joint and strict liability, and shows its consequences.

The owner achieves the value of the project V and discharges RK to the lender. The owner is made liable with his wealth $V - RK$ if the accident occurs. He can owe a full liability c if $V - RK - c \geq 0$. On the other hand, if he cannot pay a full amount of liability, a lender has to add the remainder $c - (V - RK)$. Thus, the expected profit of the owner $E\Pi$ is

$$E\Pi = V - RK - p\min\{c, V - RK\} - \phi(p). \tag{1}$$

The first term is the net value of the project for the owner,[1] the second term is the expected amount of liability, and the third term is the cost of effort. Given R, the owner chooses the probability p to maximize the expected profit.

The lender conjectures that the (unobservable) effort exerted by the owner will be p^E (where the superscript E means the lender's expectation). He lends to the owner provided that he finds it individually rational.

$$(R - 1)K - p^E \max\{o, c - (V - RK)\} \geq 0. \tag{2}$$

This is the participation constraint of the lender, which says that an expected profit is non-negative. The first term, $(R - 1)K$, is the net return of the loan, and the second term is the expected payment of liability. If the amount of liability c is greater than the net value of the project for the owner, $V - RK$, then the lender must pay the remainder $c - (V - RK)$. In a competitive credit market, the participation constraint (2) should be met with equality.

3.2 Equilibrium

Based on the behavior of the owner and the lender explained above, we introduce the concept of equilibrium as follows.

Definition 1: An *equilibrium* in this model is a pair $(\bar{p}, \bar{R})$ such that

(i) the owner's expected profit is maximized at $p = \bar{p}$ given $R = \bar{R}$ and is non-negative;

(ii) the lender's participation constraint holds with equality when $p^E = \bar{p}$ and $R = \bar{R}$.

[1] Note that $V - RK$ is the net value of the project for the owner whereas $V - K$ is the net social value of the project.

The form of the contract in this paper is different from that in Pitchford (1995) and Balkenborg (2001). They assume that the lender and the owner choose a pair of the accident (or the safety) probability and the amount of repayment, which maximizes the joint surplus (Pitchford (1995)) or the generalized Nash product (Balkenborg (2001)). Contrary to them, we assume that the amount of repayment (i.e., a gross rate of interest R on loan) is determined in a competitive credit market (Rajan (1992)). The lender decides whether to hold a contract to the owner, depending on the expectations of the unobservable accident probability chosen by the owner. This difference in the form of contracts will lead to a result that are not found in the previous studies.

In what follows, we consider the equilibrium under the following two cases: $c \leq V - K$ and $c > V - K$. In the case of $c \leq (>) V - K$, the net social value of the project is greater than or equal (less than) the joint liability.

Case: $c \leq V - K$

We first consider the case of $c \leq V - K$: the net social value of the project is greater than or equal to the joint liability.

Proposition 1: *Suppose that $c \leq V - K$ holds. There exists an equilibrium such that $(\bar{p}, \bar{R})$ satisfies $-c - \phi'(\bar{p}) = 0$ and $\bar{R} = 1$.*

Proof: Set $\bar{R} = 1$. Then the lender's participation condition (2) is satisfied for any value of p with $p \in [0, 1]$. Under $\bar{R} = 1$, the borrower's expected profit (1) becomes

$$E\Pi = V - K - pc - \phi(p).$$

The first-order condition of the borrower's profit maximization problem is calculated as

$$-c - \phi'(p) = 0.$$

Let $\bar{p}$ be the solution for the above problem. The final task is to show that $E\Pi(\bar{p}) \geq 0$ under conditions $c \leq V - K$, $-c - \phi'(\bar{p}) = 0$, and $\bar{R} = 1$. We have

$$\begin{aligned}
E\Pi &= (V - K - \bar{p}c) - \phi(\bar{p}) \\
&\geq (1 - \bar{p})c - \phi(\bar{p});\ \text{since } c \leq V - K \\
&= -(1 - \bar{p})\phi'(\bar{p}) - \phi(\bar{p});\ \text{since } -c - \phi'(\bar{p}) = 0 \\
&\geq 0;\ \text{from Lemma 1.}
\end{aligned}$$

This proves the proposition. ■

When $c \leq V - K$ holds, the owner can pay the full liability c; the lender holds no liability. It is immediately shown that $\bar{p} \geq p^*$ holds and that $\bar{p}$ is decreasing in c. Thus, if $c \leq h \leq V - K$, setting $c = h$ leads to social optimum (see Figure 2).

Case: $c > V - K$

We next consider the case of $c > V - K$: the net social value of the project is less than the joint liability.

Proposition 2: *Suppose that $c > V - K$ holds. An equilibrium $(\bar{p}, \bar{R})$, if it exists, is characterized by*

$$\bar{R} = \frac{K + \bar{p}(c - V)}{(1 - \bar{p})K}, \tag{3}$$

$$-(V - K) + \bar{p}c = (1 - \bar{p})\phi'(\bar{p}). \tag{4}$$

Moreover, it holds that $\bar{p} > p^*$.

Proof: Guess $\bar{R} > 1$. Then, $c > V - K$ implies that $c > V - \bar{R}K$. The participation constraint (2) is rewritten as

$$\bar{R} = \frac{K + p(c - V)}{(1 - p)K}. \tag{5}$$

It is clear that the value of the above equation is greater than 1 which is consistent with the initial guess (see Figure 3).[2]

The expected profit of the firm becomes $E\Pi = (1-p)(V - \bar{R}K) - \phi(p)$. The first-order condition for the maximization problem of the owner is $-(V - \bar{R}K) - \phi'(p) = 0$. With (5), this first-order condition is reduced to

$$-(V-K) + pc = (1-p)\phi'(p), \tag{6}$$

or

$$\frac{(V-K) - pc}{1-p} = -\phi'(p), \tag{7}$$

which characterizes the equilibrium level of p.

Next, we will show that $E\Pi \geq 0$ under (5) and (6).

$$\begin{aligned} E\Pi &= (1-\bar{p})(V - \bar{R}K) - \phi(\bar{p}) \\ &= V - K - \bar{p}c - \phi(\bar{p});\ \text{since (5)} \\ &= -(1-\bar{p})\phi'(\bar{p}) - \phi(\bar{p});\ \text{since (6)} \\ &\geq 0;\ \text{from Lemma 1.} \end{aligned}$$

Finally, we will show that $\bar{p} > p^*$. With $c > V - K$, (4) is $(1-\bar{p})\phi'(\bar{p}) > -(1-\bar{p})c$ or $\phi'(\bar{p}) > -c \geq -h = \phi'(p^*)$ which implies $\bar{p} > p^*$. ■

Multiple Equilibria Here, we examine the case of multiple equilibria. Define

$$F(p) \equiv \frac{(V-K) - pc}{1-p}.$$

Then, we have

$$F'(p) = \frac{1}{(1-p)^2}[-c(1-p) + \{(V-K) - pc\}] = \frac{1}{(1-p)^2}[(V-K) - c] < 0,$$

[2] Under the assumption $c > V - K$, we have $p(c - V + K) > 0 \Leftrightarrow K + p(c - V) > (1-p)K \Leftrightarrow \frac{K + p(c-V)}{(1-p)K} > 1$.

$\lim_{p\to 1} F(p) = -\infty$, $F(0) = (V-K)$, and $F(p) = 0$ at $p = \frac{V-K}{c} < 1$. Hence, Figure 4 depicts the graph of (7) that characterizes the equilibrium level of the accident probability p. Thus, (7) could have multiple solutions as shown in Figure 4. We denote e^L (e^H) as the equilibrium with low (high) p.[3]

The effect of liability on the accident probability is entirely different between the two equilibria. When an amount of liability c increases, the function $F(p)$ turns in a clockwise direction, while the curve $-\phi'(p)$ is unchanged. Thus, an increase in liability c leads to an increase (a decrease) in the accident probability at e^L (e^H) equilibrium; Ritchford's result is supported at e^L equilibrium but not at e^H equilibrium. Moreover, since $p^* < \bar{p}$ holds, an increase in liability is harmful (beneficial) when the economy attains the e^L (e^H) equilibrium. Therefore, liability leads to opposing effects on social surplus as well as the accident probability between the two equilibria.

---

[3] For example, let us specify the cost function as $\phi(p) = 1/p - 1$. This function satisfies Assumption 1. It is immediately shown that $(1-p)\phi'(p)$ is strictly increasing and strictly concave in p. Thus, there could be a critical level of c, $\hat{c} \in (0, h)$, such that (6) has no solution for $c > \hat{c}$ and two solutions for $c < \hat{c}$. In case of $c > \hat{c}$, a large amount of liability leads to the collapse of the credit market, which is consistent with the empirical result (Schidheiny et al. (1998)). In case of $c < \hat{c}$, multiple equilibria emerge.

References

Balkenborg, D., 2001, How Liable Should a Lender Be? The Case of Judgement-Proof Firms and Environmental Risk: Comment, *American Economic Review* **91**, 731-738.

Boyer, M., and Laffont, J-J., 1997, Environmental Risks and Bank Liability, *European Economic Review* **41**, 1427-1459.

Heyes, A.G., 1996, Lender Penalty for Environmental Damage and the Equilibrium Cost of Capital, *Economica* **63**, 311-323.

Pitchford, R., 1995, How Liable Should a Lender Be? The Case of Judgement-Proof Firms and Environmental Risk, *American Economic Review* **85**, 1171-1186.

Rajan, R.G., 1992, Insiders and Outsiders: The Choice between Informed and Arms-Length Debt, *Journal of Finance*, 1367-1400.

Schmidheiny, S., and Zorraquin, F.J.L. with the World Business Council for Sustainable Development, 1998, Financing Change: The Financial Community, Eco-efficiency, and Sustainable Development, MIT Press.

Figure 1. Cost of Effort

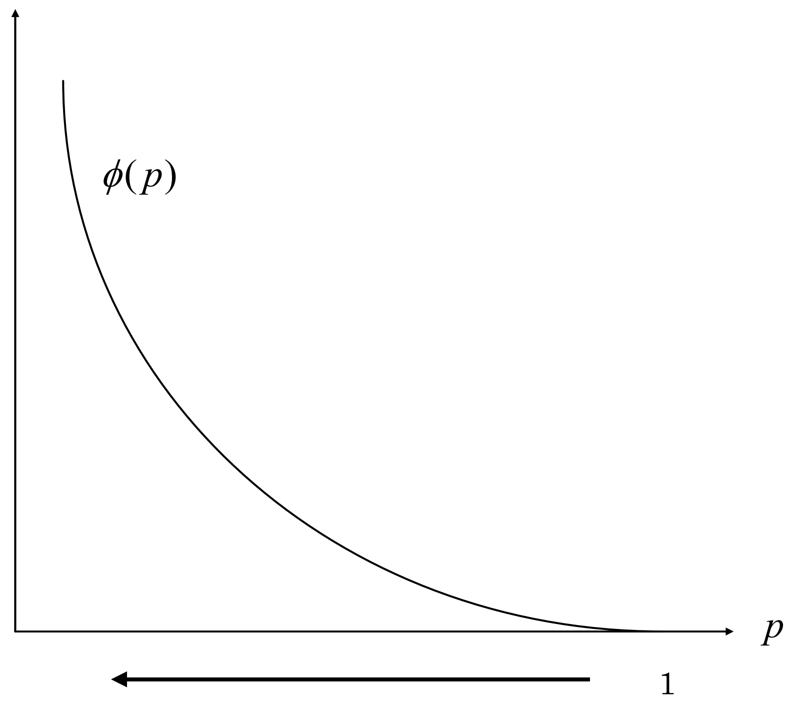

Figure 2. The Equilibrium in Case of $c \leq V - K$

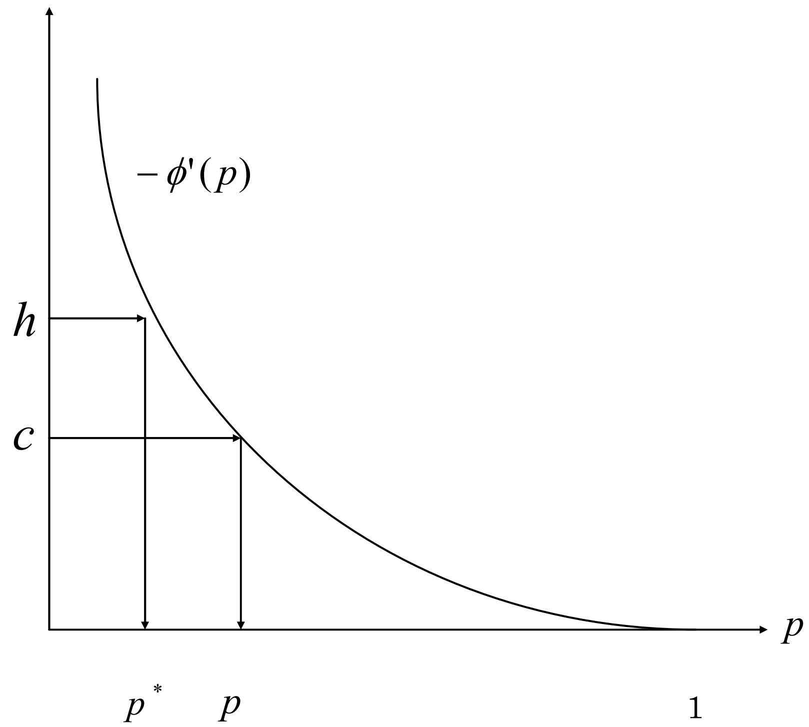

Figure 3. The Interest Rate in Case of $c > V - K$

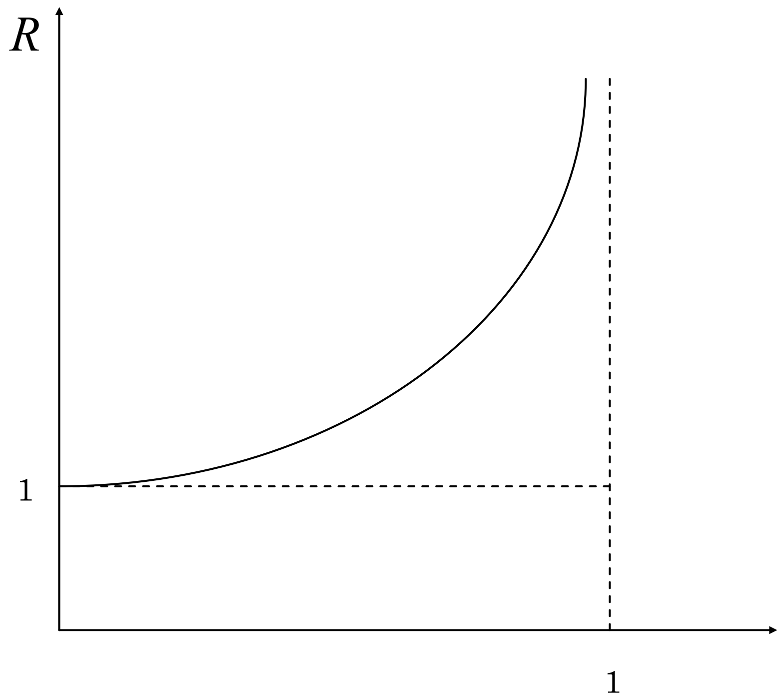

Figure 4. The Equilibria in Case of $c > V - K$