Option Coverage Techniques for Environmental Projects

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Abstract: Environmental firms are faced both with the prospect of liability claims that may arise long after activities at a project have been completed and the impact of catastrophic events that can severely threaten a firm's financial resources. The inadequacy in most cases of site-specific data, the lack of scientific understanding of the complex processes' interaction at a contamination event, and the limited cost-effective technological solutions that exist compound the problem. This condition has led many environmental firms to explore alternatives for risk management through the use of innovative insurance policies, training and selection of specialized staff for high-risk projects, careful screening of potential projects and customers, self-funded risk pools, partial involvement in projects as members of a consortium, and option payments. Payment of a one-time amount for the option to limit a firm's maximum liability to a fixed amount has been used in many cases to facilitate financial transactions, mergers, and acquisitions and to set well-defined limits to future risks. This study focuses on the alternative of option payment as a method for managing risk. Two general methods to evaluate the maximum option amount are presented and illustrated with the use of a hypothetical numerical example. Consideration of an option alternative makes management teams sharply aware of future unknown remediation or liability costs and guides them in bracketing the range of these costs. Correspondingly, according to an environmental firm's risk tolerance, limits can be set on future potential liabilities and optioning out of payment.

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Introduction

Environmental projects often have a track record of cost overruns, schedule delays, auxiliary liabilities, and hidden risks (Yeo 1990; Moorhouse and Millet 1994; Jeljeli and Russell 1995). Assessing and properly managing short- and long-term liability risks is critical for the environmental industry because uncertainties in scientific evaluations (such as the proper assessment of the chemical, physical, and biological impacts of contamination events), improper waste disposal methods, inadequate risk management, and poor staff training can lead to excessive cleanup costs and legal and financial liabilities (Larson 1996; Voorhees and Woellner 1997; Tietenburg 1998; Paleologos and Fletcher 1999). Thus, for example, a 1996 survey of 33 environmental firms found that 21% of Phase I reports had underestimated potentially critical environmental issues, and in many cases, because of lack of documentation of a property's history, a realistic understanding of liability conditions was impossible (Dunn 1997). Moorhouse and Millet (1994) found that lack of disclosure of risks and poor staff training were the two major causes of failure in the environmental consulting industry.

Several major options are usually available to an environmental firm. First, the environmental firm can attempt to include in a contract with the regulatory authorities a limited liability clause for a specific period of time beyond which all liability reverts to the regulatory authority. Second, it may purchase some form of insurance to provide protection against claims that arise from (1) errors, omissions, or negligence by the environmental firm (professional liability); (2) physical activities such as construction, sampling, or remedial activities (contractor's pollution liability); (3) incomplete contamination cleanup of remediated properties (postremediation coverage); or (4) third-party suits for property damage and bodily injury from disposal sites used by the insured (off-site disposal coverage) (Herrmann 1995; Dixon 1996; Dunn 1997; Fletcher and Paleologos 2000). Insurance policies with high deductibles, relatively low and short time coverage limits, and provisions that may exclude coverage for potential releases of hazardous wastes (Ness 1992) have led some environmental consulting firms to the creation of self-funded risk pools. Frano (1991) and Paleologos and Fletcher (1999) have proposed risk retention strategies where potential liability costs of environmental projects are treated as legitimate business revenues priced into projects. These writers have suggested several weighted, risk-based premiums that are assigned to projects to generate a risk-reserve fund to meet potential future claims.

Finally, and of interest here, is the alternative of an option scenario. Consider the case of an environmental firm that is involved in the transport and burial of hazardous material or the cleanup of contaminated properties. Instead of paying an insurance premium every year against the chance of leakage or incomplete cleanup during the liability period, the consulting firm may elect to pay one-time amount for the option to limit its maximum liability to a fixed amount. Should no unpredictable event occur, then the company has expended only the amount paid for the original option. But should a major, unanticipated environmental liability arise, the firm has a fixed maximum liability plus the option cost. The remaining liability costs then have to be carried

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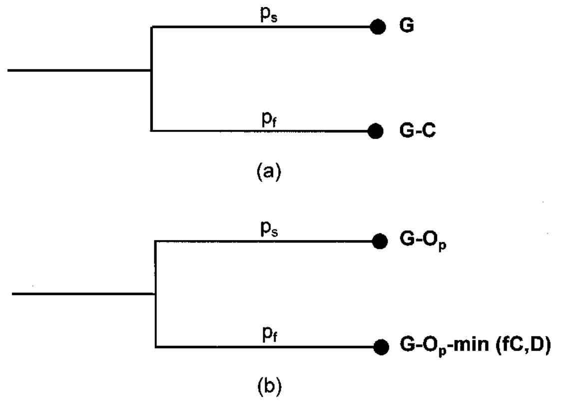

Fig. 1. Decision-tree diagram (a) when no option payment has been included, and (b) when option has been paid

by the agency with which the environmental consulting firm negotiated the option, which may be a partner corporation, an insurance company, or a regulatory authority.

Environmental insurance and option payments have been used to facilitate merger and acquisition transactions because they translate liability responsibilities into finite, fixed costs of the transaction (Milligan 1998). In many instances buyers of industrial, property require long-term guarantees that any potentially undiscovered contamination at the site will be paid by the seller. In addition, it is common for buyers to request indemnity agreements and guarantees against liability claims arising from historic contamination of the site. Such conditions are usually unacceptable to a selling corporation because it will have to carry on its balance sheet an unlimited cleanup cost overrun item and a high amount of contingent environmental liability for third-party claims that will severely limit the corporation's prospects in future financial transactions (Taylor 1998).

This study is concerned with the use of option payments in decision-making situations in the environmental industry. Two procedures are discussed and illustrated numerically by a hypothetical example for the evaluation of the maximum amount of options in the case of projects of burial of hazardous wastes.

Maximum Option Payments

Consider a hazardous material disposal site project that, if successful, would return a net profit G to an environmental firm. By "successful" is meant that no leakage occurs during the period prior to which liability reverts to the regulatory authorities. If unsuccessful (that is, if leakage occurs), then let the liability costs of site remediation be C. Let the probability of success be estimated at p_s, and so the probability of a failure (leak) is given by $p_f = 1 - p_s$. Estimates of such probabilities can be obtained by expert opinion, historical records of similar projects that the corporation has been involved in, or records of such projects from the whole environmental industry.

If the environmental firm does not take out an option, then it is responsible for the total remediation costs. In this case, as shown in Fig. 1(a), the expected value of the project to the firm, E_0, is

$$E_0 = G - p_f C \qquad (1a)$$

with a variance, σ_0^2, given by

$$\sigma_0^2 = p_s p_f C^2 \qquad (1b)$$

If the environmental firm does pay an option amount, O_p, then it limits liability during the period prior to reversion to regulatory authorities (or to the insurance agency that has underwritten the option contract) to a fraction f of the total remediation costs C, up to a maximum amount D. For any amount above D, the corporation is not liable, but instead the option holder is responsible for the excess cost. Thus the decision-tree diagram is now changed, as shown in Fig. 1(b). Effectively, the corporation lowers its net profit, if no leakage occurs, from G to $G - O_p$ in order to option against the fiscally damaging effects of unlimited liability for remediation should leakage occur.

In this case, the expected value of Fig. 1(b), E_1, of the project to the environmental firm is

$$E_1 = G - O_p - p_f \min(fC, D) \qquad (2a)$$

with the variance, σ_1^2, given by

$$\sigma_1^2 = p_s p_f [\min(fC, D)]^2 \qquad (2b)$$

There are several ways to assess the option amount to be paid for protection against unlimited liability, depending on corporate philosophy. Here we consider two of the more common approaches.

Mean Value Assessment of Option Costs

The simplest, but not necessarily the best, method to determine the option amount to be paid to an insurance agency is to require that the expected project worth with optioning be greater than without

$$E_1 \geqslant E_0 \qquad (3a)$$

which requires that

$$O_p \leqslant p_f C[1 - \min(f, D/C)] \qquad (3b)$$

Thus, two factors determine the amount of option to be paid. First is the fraction, f, of total remediation cost negotiated; second is the maximum acceptable liability, D, relative to the remediation costs C. The most difficult task, of course, is to estimate the potential remediation costs (and/or other liabilities) a priori in the event of leakage; should they prove to be truly excessive, then the ratio D/C will be smaller than the negotiated fraction, f. In this case, the maximum option amount that should be paid is limited to

$$O_p \leqslant p_f (C - D) \qquad (4a)$$

Eq. (4a) can be rearranged to provide the option amount as a fraction m of the total profit G as

$$m \leqslant p_f \left(\frac{C}{G} - \frac{D}{G} \right) \qquad (4b)$$

It is clear from expression (4b) that the fraction m is controlled primarily by two factors: the probability of failure, and the ratio of remediation (or liability) costs to the profit amount, both of which are highly unpredictable.

Another approach is to try to provide a limit for O_p (or m) based on the requirement that E_1 is positive, which yields

$$O_p \leqslant G - p_f \min(fC, D) \qquad (5a)$$

With unknown remediation costs, a firm will often choose a maximum payment of less than the worst liability, so that

$$m \leqslant 1 - p_f \frac{D}{G} \qquad (5b)$$

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provides an absolute maximum that should be paid under any conditions if the expected value E_1 is to remain positive. Expression (5*b*) is of little practical value because for catastrophic events ($p_f \ll 1$), it translates to $m \approx 1$ (or $O_p \approx G$), which does not allow any profit to a firm.

Probabilistic Assessment of Option Costs

For a project with a mean value E and a variance σ^2, the cumulative probability, P_+, of making a profit greater than or equal to zero is provided by the equivalent Gaussian expression

$$P_+ = (2\pi)^{-1/2} \int_{-q}^{\infty} \exp(-u^2/2)\, du \tag{6}$$

where $q = E/\sigma$. If q is large and positive, then $P_+ \to 1$ as $q \to \infty$, while if q is large and negative, then $P_+ \to 0$ as $q \to -\infty$. Thus for positive expected values, P_+ is always greater than 50%. The degree to which P_+ then exceeds 50% is determined by the ratio of E/σ. If there is great uncertainty about the expected value such that $E/\sigma \ll 1$, then P_+ is only slightly above 50; while if $E/\sigma \gg 1$, then P_+ is close to 100%. One should note that Eq. (2), which relates to Fig. 1(b), indicates that E_1 depends on the option amount, whereas the variance, σ_1^2, is independent of that amount. These facts can be used to assess the amount of option payment as follows:

For any option amount one can write Eq. (6) in the form

$$P_+ = (2\pi)^{-1/2} \int_{-Q}^{\infty} \exp(-u^2/2)\, du \tag{7a}$$

where

$$Q = \frac{G - O_p - p_f \min(fC,D)}{\min(fC,D)\sqrt{p_s p_f}} \tag{7b}$$

Varying the option cost, O_p, entering expression (7*b*) influences the cumulative probability of making a profit in Eq. (7*a*). Corporations often require that no matter what costs are entailed, a project should have a minimum probability of realizing a profit [in the oil industry this is referred to as the minimum acceptable chance (MAC) of making a profit (Lerche and MacKay 1999)]. Each corporation has its own internal risk tolerance and sets a MAC value accordingly. Thus, one equates expression (7*a*) with the corporate-determined MAC value and then finds Q and the maximum option amount that allows a profit probability of MAC or greater to be achieved. For example, if MAC=0.5 (50% chance of some profit) is set, then

$$O_p \leq G - p_f \min(fC,D) \equiv O_{50} \tag{8a}$$

while if MAC=0.84 (84% chance of profit), then

$$O_p \leq G - \sqrt{p_s p_f}[1 + \sqrt{p_f/p_s}]\min(fC,D) = O_{84} \tag{8b}$$

Note that $O_{84} < O_{50}$, so that the higher the probability of profit a firm insists on having, the smaller the maximum option amount the firm is prepared to pay to avoid a catastrophic event. Alternatively, if the option amount that a firm is prepared to pay is fixed, then for a mandated 50% probability of making a profit, the potential gains must satisfy

$$G \geq O_p + p_f \min(fC,D) \equiv G_{50} \tag{9a}$$

while if the mandated probability of profitbearing is 84%, then the gains must be higher at

$$G \geq O_p + \sqrt{p_s p_f}[1 + \sqrt{p_f/p_s}]\min(fC,D) = G_{84} > G_{50} \tag{9b}$$

Numerical Illustrations

Consider a hypothetical environmental project for which a firm estimates total gains of \$7 million. The firm estimates a 99% probability that there will be no leakage of hazardous material during its management of the project, prior to liability reverting to the regulatory authorities. However, if leakage were to occur, environmental remediation costs are estimated to range up to a maximum of \$100 million. The firm is interested in evaluating the utility of signing an agreement with an insurance company according to which the corporation will pay 10% of the actual remediation costs up to a maximum of \$5 million.

In this case the parameters of the problem are $p_s = 0.99$, $p_f = 0.01$, $C \leq \$100 \times 10^6$, $D = \$5 \times 10^6$, $G = \$7 \times 10^6$, and $f = 0.1$. What is unknown is the actual cost of remediation. The insurance company has asked for a premium of \$6 million to cover the corporate liability limit, and it is prepared to absorb all remediation costs over \$5 million. Note that when the corporate liability limit of \$5 million is charged, then, at 10%, the total remediation costs will have already reached \$50 million. The insurance company would then be responsible for the remaining \$45 million (and above) in costs. However, if the corporation has agreed to the option amount of \$6 million, then the insurance company can use this amount to offset its total charge. Effectively, then, the firm would pay a total of \$11 million maximum, while the insurance company would be paying for costs of \$39 million and above. To assess whether the \$6 million option is reasonable, the firm first performs mean value calculations.

Mean Value Assessment of Option Costs

Inserting the parameter values into Eqs. (1*a* and *b*), one has (in millions of dollars)

$$E_0 = 7 - (C/100) \tag{10a}$$

and

$$\sigma_0 = 0.995(C/10) \tag{10b}$$

Eqs. (2*a* and *b*) allow calculation of the expected value and standard error of the worth of the project, taking into account the option amount

$$E_1 = 7 - O_p - 0.01\min(0.1C,5) \tag{11a}$$

$$\sigma_1 = 0.995\min(0.01C,0.5) \tag{11b}$$

For actual remediation costs less than \$700 million, the expected value is $E_0 \geq 0$; otherwise, it is $E_0 < 0$. Inspection of Eq. (11*a*) shows that for fractional remediation in excess of \$50 million, the corporate liability cap becomes effective, so that for this situation one has (in millions of dollars)

$$E_1 = 7 - O_p - 0.05 \tag{12}$$

In this case, in order that $E_1 \geq 0$, the option amount should be less than \$6.95 million. If the actual remediation costs range between \$50 million and \$0 million, then the option payment rises linearly from \$6.95 million to \$7 million for $E_1 \geq 0$. Thus, on the basis of requiring a positive expected value, an option payment of \$6 million is a good alternative for the environmental corporation.

Probabilistic Assessment of Option Costs

For a MAC of 0.5, the maximum option payment (in millions of dollars) can be calculated from Eq. (8*a*)

$$O_p \leq 7 - 0.01\min(0.1C,5) \equiv O_{50} \tag{13a}$$

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while for a mandated MAC of 84%, the maximum option (in millions of dollars), Eq. (8*b*), is

$$O_p \leqslant 7 - 1.095 \min(0.01C, 0.5) \equiv O_{84} \tag{13b}$$

For anticipated cleanup costs less than \$50 million, Eq. (13*a*) provides a maximum option cost (in millions of dollars) of

$$O_{50} = 7 - 10^{-3} \times C \tag{14a}$$

while for cleanup costs in excess of \$50 million, the corresponding option (in millions of dollars) is

$$O_{50} = 6.95 \tag{14b}$$

Equally, if the firm insists on an 84% chance of a profitable venture, then (in millions of dollars)

$$O_{84} = 7 - (1.095 \times C/100) \tag{15a}$$

if the remediation costs are less than \$50 million, while

$$O_{84} = 7 - 0.5475 = 6.4525 \tag{15b}$$

for remediation costs over \$50 million. Thus, the option offer from an insurance company of \$6 million to limit liability appears acceptable.

Alternatively, if the firm has no negotiating power in the determination of the amount of option payment, then it can ask how large the gains should be in order to satisfy the corporate-mandated risk tolerance. At $O_p = \$6$ million, a MAC of 50% then requires gains in excess of (in millions of dollars)

$$G_{50} = 6 + 0.01 \min(0.1C, 5) \tag{16a}$$

while for a MAC of 84%, one would require gains in excess of (in millions of dollars)

$$G_{84} = 6 + 1.095 \min(0.01C, 0.5) \tag{16b}$$

Discussion and Conclusions

Environmental projects are burdened both by the prospect of liability claims that may arise long after activities at a site have been completed and the impact of low-probability but high-cost events. This situation is accentuated by the incomplete scientific information that is available at most sites and the limited technological solutions that exist to address remediation tasks in a cost-effective way. This condition has led many environmental companies to explore alternatives for risk reduction through the use of innovative insurance policies, partial involvement in projects as members of a consortium, and so on. Payment of a one-time amount for the option to limit a corporation's maximum liability to a fixed amount has been used in many cases to facilitate financial transactions, mergers, and acquisitions and to set well-defined limits to future risks. Should no unpredictable, catastrophic event occur, then the environmental firm has expended only the amount paid for the original option. But should a major, unanticipated environmental liability arise, the firm has a fixed maximum liability charge plus the option cost. The remaining liability costs then have to be carried by the agency with which the environmental firm negotiated the option, which may be a partner corporation, an insurance company, or a regulatory authority.

While the option example presented in this paper was specifically chosen for simplicity, the general method of analysis presented here is applicable to more complex situations in the environmental arena. The most challenging aspect of this approach is assessing what future unknown remediation or liability costs might be, or at least bracketing the range of these costs for a project, in order for a firm to be able to evaluate what amount of option it is willing to pay. In this way a firm can set limits today on its future potential liabilities and option out of paying. Of course, to maximize corporate profit in complex situations, a firm will have to evaluate all of the risk-reducing alternatives in order to assess which one or which combination of alternatives provides the optimum coverage for the least expenditure.

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