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On Valuing Negative Cash Flows Related to Contamination, Asset Removal, or Functional Obsolescence

BY HAL B. HEATON, PHD

Appraisers are frequently faced with having to value future expected negative cash flows. This article will demonstrate that valuing negative cash flows requires a different approach from valuing positive cash flows. The concepts of valuing remediation costs, asset removal costs, and other types of functional obsolescence will be used to illustrate this concept.

In the cost approach to valuation, appraisers often must adjust for all types of depreciation, including physical and functional depreciation and economic obsolescence. Buyers are not willing to pay as high of a price for a property that exhibits physical deterioration or functional obsolescence or that has environmental clean-up expenses as for a new property without these problems. As a result, the appraiser must subtract from historical, replacement, or reproduction cost new an amount that reflects these deficiencies.

Often, the adjustments for functional or environmental problems are estimated by forecasting the additional costs created by these problems and discounting these costs back to present. For example, one type of functional obsolescence is represented by excess operating costs, perhaps due to the physical layout of an outdated facility. The appraiser may forecast these excess costs, discount them to present value, and then subtract the net present cost from the cost approach. In the case of environmental clean-up, remediation costs, or asset-removal costs, the appraiser may forecast the costs, discount them to present value, and subtract the present value from replacement cost new.

This article will show that the appropriate discount rate for valuing negative cash flows is not the same as the rate used to discount positive cash flows. It will be demonstrated that the greater the uncertainty in the negative cash flows, the *lower* the appropriate discount rate that an appraiser must use to value them. In the case of high risk, a negative discount rate could be warranted.

Although the examples given may reflect a capitalization process, the

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concepts explained are also applicable to discounting a series of cash flows. Financial Accounting Standards (FAS) Rule 143 recently issued by the Financial Accounting Standards Board (FASB) makes this topic particularly current and is also discussed.

Fundamental Problem in Valuing Negative Cash Flows

In a real estate valuation, the cost approach requires an adjustment for future reclamation or clean-up costs. For example, if a property will require substantial environmental clean-up costs at the end of a finite life, a buyer will reduce the price he or she is willing to pay today below what the buyer would be willing to pay if there were no clean-up costs. To estimate the impact on value, the future costs must be converted to a present value impact on the price the buyer is willing to pay today.

While standard discounting may be appropriate for estimating the present value of a future stream of positive cash flows, it may not be appropriate for estimating the present value of a future stream of negative cash flows or liabilities.

By "value," appraisers mean the price between a willing buyer and willing seller in an arm's-length transaction. In the case of positive cash flows, it is the price a willing buyer is willing to pay today (the present value) to receive a stream of cash flows in the future. However, in the case of negative cash flows, it is the price a *seller* of the negative cash flows is willing to pay a *buyer* who agrees to assume the future obligation of the cash outflows.

With positive cash flows, as the risk or uncertainty of the future cash flows increases, the appropriate discount rate increases and, as a result, the present value of those future cash flows decreases. In contrast, as the risk increases with negative cash flows, the buyer will require a *higher* price to assume the riskier cash flows. Conceptually, as risk increases with negative cash flows, the "discount rate" decreases and may even become negative. A negative discount rate means that the buyer requires a payment higher than the *expected* future cash flow.

As a simple example to illustrate this point, consider the following problem: A company, in order to generate cash today, sells its right to a future positive cash flow twelve months hence of $1,000. Suppose the single cash flow or payment will be $1,000 with certainty; that is, there is no risk about what the amount will be. To determine the price to pay today, a buyer will discount the $1,000 at a safe or "risk-free" rate of, say, 5 percent to arrive at the following price:

$$\$1{,}000/1.05 = \$952$$

Now suppose there is risk or uncertainty surrounding the $1,000; that is, the single cash flow is *expected* to be $1,000, but it may be more or less than $1,000. *Expected cash flow* refers to the average amount a buyer would receive if the investment were repeated many times. A buyer will discount at a higher rate to adjust for this risk. If the buyer determined that 10 percent was the higher rate that adjusted for the risk, then the buyer would be willing to pay the following:

$$\$1{,}000/1.10 = \$909$$

Note that the present value of the positive single cash flow falls as the risk increases. If the risk or uncertainty was even greater, then the buyer might use an even higher discount rate, say 20 percent, to arrive at a value today of $833.

$$\$1{,}000/1.20 = \$833$$

Therefore, the present value of the future $1,000 falls even more. A basic principle in finance is that the greater the risk of a cash flow, the less a buyer would be willing to pay today to receive it. In other words, the greater the risk, the more a buyer will discount the future cash flow to arrive at a price.

This approach to dealing with risk or uncertainty does *not* work when the future cash flows are negative. In fact, the relationship will run in the opposite direction: As the risk increases, then the price a buyer will require to assume the liability will go up, not down.

Because the term *buyer* is awkward when referring to future liabilities, I will refer to the entity assuming the future liability as the "insurer" and the current payment required by the insurer as the premium.

If the single negative cash flow were known with certainty (i.e., had no risk), then an insurer could value the $1,000 at the 5 percent risk-free rate shown above:

$$\$1,000/1.05 = \$952$$

The insurer could simply deposit the $952 into a safe account and use the $1,000 proceeds in one year to meet the obligation. However, if there is risk surrounding the $1,000, then the insurer would not use a higher rate to discount the cash flow to determine the present value. For example, suppose a higher rate were used, say 10 percent, to obtain a price of $909.

$$\$1,000/1.10 = \$909$$

It would be nonsense to believe that an insurer would accept a lower price to assume a riskier obligation. It would be even more nonsensical for an insurer to use an even higher discount rate and be willing to receive only $833 (using 20 percent) to assume an even riskier cash flow obligation.

$$\$1,000/1.20 = \$833$$

This approach would imply that if the risk was great enough, the discount rate would be huge and the insurer would be willing to take it on for almost no compensation. This is clearly absurd.

Insurance companies accept payment today in exchange for uncertain payoffs in the future. Thus, effectively valuing potential liabilities is their greatest challenge. The present value of a future liability may actually exceed the expected cash outlay; insurance premiums can and often do exceed the future expected or probability-weighted costs of an accident. The greater the risk, the greater the present value or insurance premium that must be paid; in other words, the discount rate goes even lower for greater risk liabilities.

As early as 1733, mathematician Daniel Bernoulli noticed that people do not value potential uncertain positive and negative cash flows in the same way (Bernstein 1996). People will pay a higher price to avoid a negative cash flow than they would pay to receive the same uncertain positive cash flow. This economic analysis ultimately stems from the way in which a person's sense of well-being changes at different income levels. A loss of $100,000 for most individuals creates greater pain than the gain of $100,000 adds in greater utility; that is, people are willing to pay a greater price to avoid a risky liability that averages $100,000 than they would be willing to pay to receive a potential payoff that averages $100,000.

The technical economic literature refers to this phenomenon as a *concave utility function.* A utility function expresses a person's sense of well-being (i.e., utility) as it depends on wealth. As a person's wealth increases, his or her sense of well-being increases, but at a declining rate. Thus, when graphed, total utility "curves off." This curvature is referred to as a concave function. (See Bodie, Kane, and Marcus [2005, Chapter 5, Appendix B] for a more detailed explanation.) Expected cash flow is defined mathematically as the mean of the probability distribution; expected cash flow is the cash flow, on average, that would occur if the situation occurred many, many times. For example, the expected cash flow of a $10 accident that occurs with 10 percent probability is $1.

.10 x $10 = $1

Similarly, the expected cash flow of a $100,000 accident that occurs with a probability of .001 percent is $1.

.00001 x $100,000 = $1

Even though the expected or average negative cash flow is the same $1 for both accidents, people would be willing to pay a higher premium for the insurance company to assume the liability of the second accident than the first (Pratt 1964). One might pay an insurer $2 to assume the potential $100,000 liability but only $1.10 to assume the potential $10 liability even though the expected cost is $1 for both. This result is equivalent to saying that the expected discount rate for the second, riskier cash flow is lower (i.e., more negative) because it results in a higher present value. If the insurance premium exceeds the expected cash flow of $1, then the discount rate is negative.

In short, an appraiser must not value negative cash flows with the same discounting techniques that are used to value positive cash flows.

Techniques for Appropriately Valuing Negative Cash Flows

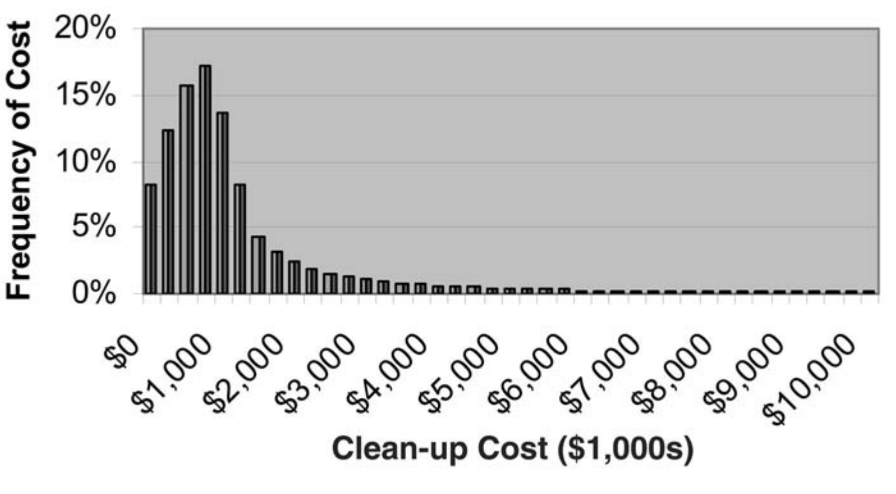
What determines the price, or value, that the insurer will demand to assume future liabilities?

Insurance companies are in the business of receiving payment today to assume a future, uncertain liability. To estimate the present value of, say, an environmental cleanup, an appraiser must ask, "How much would I have to pay someone to get them to agree to accept the burden of paying for the environmental cleanup?" That someone who is accepting this liability will value the future liability in the same way that an insurance company values negative cash flows.

To understand the insurance approach, consider the following example: Suppose the expected environmental clean-up cost is $1 million, but sometimes it is only $500,000 and sometimes it is $10 million. This uncertainty could be reflected in a frequency table similar to figure 1.

Suppose an insurance company was created for the sole purpose of insuring this single project; we'll deal with multiple projects later. If a discounting approach was used and the discount rate was 6 percent, then the insurance

Figure 1. Environmental Clean-up Cost Example



company would collect $943,000 today to assume the environmental liability.

$$\text{Present Value} = \$1{,}000{,}000/(1.06) = \$943{,}000$$

The insurance company would then place the $943,000 in an investment that earns 6 percent, which would produce $1 million in one year.

$$\$943{,}000 \times (1.06) = \$1{,}000{,}000$$

On average, this would be enough to perform the environmental clean-up. However, if the average is $1 million, then a large percentage of the time the cleanup will cost more than $1 million. What if this cleanup were to cost $2 million? The insurance company would have only $1 million and be forced into bankruptcy. Bankruptcy would occur whenever the liability exceeded $1 million, which would occur almost 50 percent of the time. No person or company would accept a deal that would cause it to be bankrupt with high probability nor would anyone pay the insurance company to accept the liability if the insurer were likely to be bankrupt with high probability.

The issue of valuing an environmental clean-up cost is even worse than this simple example suggests due to the uncertainty about the probability distribution for cleanup if there are not enough historical statistics to measure the probabilities. In addition, environmental regulations keep changing, so, even if there were historical examples, they may underestimate future costs under regulations that may become even more stringent.

To set the premium for assuming an environmental clean-up risk, an insurance company would estimate the frequency or probability distribution as best it can. It would then establish a risk threshold that it would be willing to accept.

For example, suppose, using the probability distribution shown in figure 1, the insurance company sets 5 percent as the probability of ruin or risk threshold it is willing to accept. It will determine the cost at which a higher cost will only occur 5 percent of the time. Suppose that this dollar amount is $2 million. To determine the premium it will charge, the insurance company will next determine what rate of return it can earn on a safe investment; suppose that is 6 percent. The company will then discount the $2 million by 6 percent and charge $1,887,000 to assume the liability.

$$\$2{,}000{,}000/1.06 = \$1{,}887{,}000$$

Note that, although the process did involve discounting, the insurance company did not discount the “expected” $1 million cost. Rather, it first determined the amount that would ensure its survivability with 95 percent probability and then discounted *that* amount.

Of course, insurance companies try to insure many similar risks so that projects that go over cost are offset by projects that are under cost. But, even if there were a number of clients wanting environmental cleanup so the insurance company could diversify the risk across many clients, the law of large numbers would only reduce the risk: It would not remove this risk. When there are several projects that are insured, the law of large numbers means that the insurance company can offer a more favorable rate. When there are many projects, the insurance company first calculates the standard deviation of the average cost as follows:

$$\text{Standard deviation of average} = (\text{Standard deviation of individual cleanup})/\sqrt{n}$$

where n is the number of projects insured.

This equation stems from the Central Limit Theorem. The smaller standard deviation when estimating the average cost rather than the cost of an individual project means that the probability distribution is much "tighter" around the $1 million average than it is for any individual project. Suppose that the frequency distribution of the average cost was such that, with 95 percent probability, the *average* cost would be less than, say, $1.2 million rather than the $2 million for an individual occurrence. Then the insurance company would set the cost or premium for the group of insured at $1,132,000 per project insured.

$$\$1,200,000/1.06 = \$1,132,000$$

This would be a substantial savings over the $1,887,000 premium when there was a single project, but it is still more than the expected cost of $1 million.

Note that charging $1,132,000 for an expected liability of $1 million is equivalent to discounting the expected cash flow of $1 million at a *negative* 13.2 percent.

It should be clear from this example that the introduction of enough risk into the problem will cause the appropriate discount rate to become negative. The cash flow to be discounted should be adjusted upward to reflect the risk; the greater the risk, the greater should be the upward dollar adjustment.

Even if there are a large number of projects to be covered, insurers also must recognize the additional need to adjust for whether the individual insured projects have correlated or uncorrelated risk. The willingness of people to supply insurance depends on the ability to diversify the risk. The more correlated the risks, the less diversification helps. For automobile insurance, whether or not one insured person has an accident has little to do with whether another insured person has an accident; the risks are independent and diversifiable. But, for example, with hurricane insurance, the risks are not independent. If one person has a home destroyed by the hurricane then usually several people do. In the cases of correlated risks such as hurricanes, earthquakes, or floods, the insurance company must charge even more than the expected or average cost to make sure that there is enough available to cover all the costs, which will tend to arrive for several of the insured at the same time.

The cost to cure environmentally damaged property usually demonstrates much more predictability than hurricanes or earthquakes, but the economic principles are the same. The present value of the cash flows is the price the owner of the property must pay someone to assume the responsibility of the clean-up costs in the future. If the costs were known with certainty, then someone would charge based on the return they could earn on a reserve account. However, environmental clean-up costs are much more unpredictable. Even worse, the future costs tend to be correlated because when the federal government or one state adopts a change in regulations, most other states adopt similar rules. This is due to the fact that rule changes tend to be the result of a study or new findings about the hazards. An insurer's reduced ability to diversify will increase the present value, which is the price that an insurer would charge to accept the liability.

Functional Obsolescence Discounting Process

Technologies and production processes change over time and as a result, a facility's existing design may cause the owner to incur additional labor, transportation, administrative, or other costs above what a facility with a new design would require. These excess operating costs reduce the value of the existing facility.

However, these excess operating costs not only reduce the margin, but they also increase the volatility or risk of earnings. As a result, the cash flows of the company with excess operating costs must be discounted at a higher rate to reflect this risk. Increasing the discount rate on positive cash flows reduces the present value of these cash flows. To reflect both the reduced margin and the increased risk, these excess operating costs must be discounted at a much lower rate than the rate used for positive cash flows. Decreasing the discount rate on costs (negative cash flows) also reduces the present value of these cash flows. Increasing discount rates for benefits (positive cash flows) and decreasing discount rates for costs (negative cash flows) both reduce the value of the property which is the expected outcome.

To illustrate this, consider the following example in which excess operating costs are fixed each period and do not fluctuate. Suppose the operation with excess operating costs must pay $1,200 in costs regardless of what happens to revenues, but the efficient operation only incurs fixed costs of $1,000. The additional $200 in costs reflects the functional obsolescence of the inefficient property. Suppose the efficient operation cost $4,000 to build. As table 1 illustrates, the income approach for the efficient operation produces a value just equal to the cost of $4,000.

The fact that the inefficient operation has a 300 percent fluctuation around its average while the efficient operation has only a 150 percent fluctuation around its average means that the cash flows of the inefficient operation (the one with functional obsolescence as evidenced by the additional $200 of costs) are riskier. Riskier cash flows must be discounted at a higher rate. If that rate is 20 percent, then the inefficient operation is worth

Table 1. Comparison of Income Approach Valuations for Lower-risk and Higher-risk Companies

	Efficient Operation Company		Excess Operating Costs Company	
	Good Market	Bad Market	Good Market	Bad Market
Quantity	1,000	800	1,000	800
Price	$3.00	$2.00	$3.00	$2.00
Variable Cost/Unit	$1.00	$1.00	$1.00	$1.00
Fixed Cost	$1,000	$1,000	$1,000	$1,000
Excess Cost due to Functional Obsolescence			$200	$200
Revenues	$3,000	$1,600	$3,000	$1,600
Costs	$2,000	$1,800	$2,200	$2,000
Profits	$1,000	($200)	$800	($400)
Average Profits	$400		$200	
Deviation from Average	+150%	-150%	+300%	-300%
Capitalization Rate	10%		20%	
Present Value	$400/.10 = $4,000		$200/.20 = $1,000	

only $1,000 compared to the $4,000 value of the efficient operation. This indicates that there is $3,000 of functional obsolescence.

To use the cost approach for the inefficient facility, an appraiser must first value the efficient operation at a cost of $4,000 and then subtract an adjustment for the functional obsolescence reflected by the excess operating costs. To value functional obsolescence, the excess operating cash flows must be discounted at a lower rate than the rate used on the efficient operation's positive cash flows. In this case, the appropriate rate is 6.67 percent, which produces the more appropriate value of the operation with excess operating costs.

$$\$4,000 - (\$200/.0667) =$$
$$\$4,000 - \$3,000 = \$1,000$$

If, however, an appraiser were to make the error of using 10 percent to value the excess operating cash flows, the same rate as that used on the positive cash flows of the efficient operation, then a significant overvaluation of the property would result:

$$\$4,000 - (\$200/.10) =$$
$$\$4,000 - \$2,000 = \$2,000$$

The $2,000 estimated value produced by this erroneous approach is twice the appropriate value of the property. The mistake of using the same rate to discount excess operating cash flows can lead to significant overvaluations.

FAS Rule 143

A recent accounting ruling has made the issue of valuing the negative cash flows associated with environmental cleanup or asset removal particularly current and critical. The recently passed *FAS 143: Accounting for Asset Retirement Obligations* (FASB 2001) requires that, for some assets, an adjustment for the future retirement cost of the asset be included in the financial statements. Appraisers may be asked to determine the current value of future retirement costs for accounting purposes. A cursory reading of the pronouncement seems to indicate a discounting process. However, the wording in the document indicates that the accounting profession is aware of the above difficulties and the "discounting" discussed in the document may refer to the previously described technique that insurance companies use.

Paragraph 8 of the rule explicitly indicates that

> *In addition, an asset retirement obligation will usually have uncertainties in both timing and amount. In that circumstance, employing a traditional present value technique, where uncertainty is incorporated into the rate, will be difficult, if not impossible. (FASB 2001)*

Although the effective meaning and impact of the standard will not be known for several years, this statement probably reflects the issue discussed earlier that increasing risk implies a lower (and perhaps negative) discount rate, not a higher one.

In addition, the discounting process discussed in the rule may be the one described in the earlier discussion of the insurance approach. In this approach, the risk-adjusted cash flow is discounted, not the expected cash flow. Indeed, the wording of paragraph 8 of the rule may indicate exactly this:

> *Concepts Statement 7 discusses two present value techniques: a traditional approach, in which a single set of estimated cash flows and a single interest rate (a rate commensurate with the risk) are used to estimate fair value, and an expected cash flow approach, in which multiple cash flow scenarios that reflect the range of possible outcomes and a credit-adjusted risk-free rate are used to estimate fair value. (FASB 2001)*

It is much too early to know for sure the effect FAS Rule 143 will have, but the "credit-adjusted risk-free rate" may be the conceptual equivalent of the negative 13.2 percent in the example in which insurance companies discounted the cash flow, which ensured survival with 95 percent probability. The insurance approach described above does involve a discounting process, which Rule 143 refers to, but it is much more complex than a simple present value technique.

Of course, there is no implication in any of this discussion that the accounting treatment imposed by Rule 143 equals the impact on market value. Accounting rules can have an impact, but the value of impact should always be measured by direct market observation.

Summary

In the cost approach to valuation, appraisers must adjust the cost approach for functional obsolescence, environmental cleanup, or other asset removal costs. Usually, this involves valuing a set of future negative cash flows. As the risk or uncertainty of these negative cash flows increases, the appropriate discount rate should decrease, not increase. There is a significant probability that the correct discount rate should be negative if the uncertainty, or risk, is great enough. This fact may explain the high discounts associated with contaminated property (Mundy 1992).

Of course, the basic concept that a different discount rate is required on negative cash flows than positive cash flows may be applicable to more than just the cost approach. There are, of course, other situations in which an appraiser must value negative cash flows in which the concepts of this article may be applicable.

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