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Capital Budgeting and Initial Cash Outlay (ICO) Uncertainty

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Abstract

According to recent surveys, most companies use discounted-cash-flow (DCF) methods to evaluate capital budgeting decisions. DCF methods typically assume that a project's initial cash outlay (ICO) is known with certainty. However, many types of initial outlays have substantial uncertainty, especially those involving the construction of a new facility. This risk affects not only the ICO, but it also affects subsequent depreciation tax shields. A proper capital budgeting analysis should incorporate the additional risk that is due to an uncertain ICO. We show that neither the typical practices employed by corporations nor two common techniques advocated in the finance literature, risk-adjusted discount rates and certainty equivalents, satisfactorily address ICO risk. Sensitivity analysis is an effective way to address ICO risk, but the finance literature often overlooks the adjustments needed to satisfactorily address ICO risk within a sensitivity analysis. We fill this gap in the literature by showing the impact of ICO risk on the standard deviation of a project's NPV. We then apply sensitivity analysis with the appropriate adjustments in a numerical example to illustrate the impact of ICO risk.

I. Introduction

According to surveys, most companies use discounted-cash-flow (DCF) methods to evaluate capital budgeting decisions.[1] DCF methods typically assume that a project's initial cash outlay (ICO) is known with certainty. However, many types of initial outlays have substantial uncertainty, especially those involving the construction of a new facility. In addition, this risk affects not only the ICO, but it also affects subsequent depreciation tax shields. A proper capital budgeting analysis should incorporate all of the additional risk that is due to an uncertain ICO. Unfortunately, the typical "contingency" approach employed by many corporations does not satisfactorily address ICO risk. The academic literature also has not satisfactorily addressed ICO risk. For example, two common techniques advocated in the finance literature, the use of certainty equivalents and risk-adjusted discount rates, require too much subjectivity to be useful. Sensitivity analysis is an effective way to address ICO risk, but the finance literature often overlooks the adjustments needed to satisfactorily address ICO risk within a sensitivity analysis. Following is a more detailed discussion of the practitioner and academic shortcomings related to assessing the risk of an uncertain ICO.

A recent survey by the CFO Executive Board indicates that companies believe ICO uncertainty is important and that companies try to address it in their capital budgeting analyses.[2] Most

[1] For example, see Bierman (1993) or Graham and Harvey (2001).
[2] See CFO Executive Board (2005).

companies adjust the estimated initial cash outlay by adding a "contingencies" amount to the original cost estimate.[3] For example, if the estimated cost of the project is $10 million, then the firm might create a contingencies account equal to $100,000, resulting in a total adjusted initial cost of $1.1 million, which is used when computing the project's net present value and internal rate of return. If actual costs exceed the adjusted ICO, based either upon a dollar basis or a percentage of the adjusted ICO, then many companies require the project to go through a re-approval process. There are two shortcomings to this practice. First, the trigger for re-approval analysis should be based upon the expected net present value of the project (given the cost overrun) and not upon a pre-determined dollar amount or percentage. For example, a cost overrun of 10 percent might cause one project's NPV to become very negative, while it might have only a small impact on another project's NPV. Second, because there is no theoretical basis for estimating the appropriate amount that should be included in the contingencies account, the contingencies account becomes only an educated guess.

The academic literature for assessing risk includes the certainty equivalent approach, the risk-adjusted discount rate approach, and sensitivity analysis.[4] A "certainty equivalent" is the certain amount that one would be willing to take in lieu of a risky cash flow. For example, consider a coin toss in which you must pay $100 for heads and $200 for tails. The expected cost is $150, but it is very risky. To avoid this risk, you might be willing to pay a sure $155 rather than take the risky coin toss, even though the sure $155 costs more than the expected $150 cost of the coin toss. With respect to ICO risk, one could, in theory, estimate the certainty equivalent cash outflow for each uncertain (risky) ICO component, based on the expected cash flow and its risk, and use this certainty equivalent rather than the estimated ICO when estimating the project's NPV.[5] Notice that this is very similar to the common practice described above of increasing the ICO by a contingencies account, where the adjusted ICO is essentially a certainty equivalent. In the example above, the adjusted cost of $1.1 million is equivalent to a certainty equivalent for the risky $1 million cost.

Unfortunately, there are no theoretical guidelines for estimating the certainty equivalents that would be chosen by the firm's shareholders. In other words, there is no way to determine the sure, but more costly, cash flow that a shareholder would be willing to pay in lieu of the risky ICO.

An additional complication to the certainty equivalent approach is that many initial outlay components add to the depreciable basis of the project. If the depreciable basis of the project changes due to a change in the ICO, then the future tax-shield benefits due to depreciation will also change. This means that the certainty equivalent becomes the sure amount you are willing to pay now to avoid the combination of a risky cash flow (the ICO) and the present value of the

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[3] Some companies use the term "contingencies" as a catch-all for many estimated small costs. In other words, some companies would rather list a single account called "contingencies" rather than numerous small accounts. Other companies use the term "contingencies" for unknown costs that might occur. It is this second use that we address.

[4] Scenario analysis and simulation are two other techniques to assess risk. We focus upon sensitivity analysis, but our adjustments can easily be extended to scenario analysis and simulation.

[5] If the ICO occurs at some other time than zero, then the certainty equivalent would be discounted at the risk-free rate.

depreciation tax shield. This multiple-period spillover effect further complicates any realistic use of certainty equivalents when dealing with uncertain ICO components.

A second technique often advocated in the finance literature is the use of risk-adjusted discount rates. For example, if two future expected cash flows have different degrees of risk, then a higher (i.e., risk-adjusted) discount rate might be applied to the riskier cash flow. Similar to the problem with certainty equivalents, there is often no way to determine the risk-adjustment that would be preferred by shareholders.[6] A second problem is that the ICO is by definition assumed to occur at time zero (or at least it is assumed to occur one year prior to the cash flow at the end of the project's first year). Even if one were to assume that the initial cash flow occurs over some fraction of the project's first year, the present value of a cash flow occurring a short time in the future is close to the actual value of the cash flow irrespective of discount rates.[7] Therefore, the risk-adjusted discount rate technique does not satisfactorily address ICO risk.

In a traditional sensitivity analysis, the estimated expected values of input variables are varied one at a time with a series of "what if" questions. The original set of estimates for input variables is called the *base case*. As an input variable's estimate is changed from its value, its impact on a project's performance measures, such as net present value (NPV) or internal rate of return (IRR), can be determined. For example, a typical sensitivity analysis might involve changes in the number of units sold, the price per unit, the cost per unit, etc. As we show in this paper, it is possible for a sensitivity analysis to capture the impact of ICO risk, but only if the analysis properly accounts for the multi-year spillover effect due to the depreciation tax shield.[8]

In summary, the typical corporate practice of using contingency accounts fails to satisfactorily address ICO risk. The certainty equivalent approach and the risk-adjusted discount rate approach are inappropriate. Sensitivity analysis can accommodate ICO risk if the depreciation tax shield is appropriately incorporated, but existing textbooks do not articulate this

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[6] In some circumstances it is possible to make a theoretically correct adjustment. See Daves and Ehrhardt (2000).
[7] This assumes a reasonable discount rate (for example, one between 3% and 25%) is used.
[8] Virtually all finance textbooks include examples of sensitivity analysis, but, to the best of our knowledge, only a couple even tangentially address ICO in a sensitivity analysis. Those exceptions typically provide a numerical example showing variation in NPV with respect to changes in several variables, including the ICO. However, their explanation and discussion do not explain the impact that the resulting depreciation tax shield has on NPV and risk.

aspect of risk in their examples. We fill this gap in the literature by showing how ICO risk affects the standard deviation of NPV.

Section II provides a more detailed discussion of the sources of ICO uncertainty. Section III explicitly identifies the risk due to the multi-year spillover of the depreciation tax shield. Section IV illustrates appropriate sensitivity analysis with a numerical example.

II. Dealing with ICO Uncertainty

For many capital budgeting analyses, the assumption of a "certain" ICO is valid – e.g., the purchase of a certain piece of equipment for a fixed price. However, even here, if this equipment purchase were to require setup and installation, those capitalized expenses could be both sizeable and uncertain at the time the project is being evaluated. In fact, the larger the project, the more likely it is to involve a host of uncertain ICO component costs.

In Exhibit 1, we list some of the common items included in the acquisition cost of a firm's major property, plant, and equipment (PP&E) accounts. Additions to one or more of these accounts would normally be related to a typical investment project's ICO. Notice how many of the items listed under the four major PP&E categories – land, land improvements, buildings, machinery and equipment – could very well have uncertain estimates at the time the project is being evaluated. Weather conditions, for example, could easily affect land site preparation costs, building construction costs, and installation costs of equipment involved in a construction project. In fact, it is the avoidance of just this type of uncertainty that often leads firms to consider leasing (with its fixed/certain costs) as opposed to building/purchasing with its potential for cost overruns.

In addition, another typical component of an ICO might be an investment in working capital, such as inventory. The dollar amounts of such items are unlikely to be known with certainty at the project evaluation stage, which introduces uncertainty into the ICO.

It is important that managers be able to correctly assess the risk of a potential project, including the risk due to ICO uncertainty. If the risk is too high, a manager might well choose to forego a project, even if the expected NPV is positive. The results of an appropriate risk analysis also allow a manager to identify any appropriate levels of cost overruns that should "trigger" a complete project re-evaluation. Armed with this information, a manager can then decide whether any estimates need refining or reviewing, and whether any are not worth investigating further before deciding on project acceptance/rejection. Based on this analysis, a manager might decide to remove the uncertainty surrounding a particular ICO input variable by negotiating a fixed price for some service or outsourcing some in-house, uncertain cost item (like equipment installation) so as to make it into a certain cost expense. The manager can also identify the critical levels of cost overruns that endanger the economic viability of the project.

The following section identifies the impact of ICO uncertainty on project risk.

Exhibit 1.
Common Items Included in the Acquisition Cost of Property, Plant, and Equipment

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Land -- Capitalization of land costs include the following -- all of which are **not** subject to tax depreciation:

- Purchase price
- Commissions, permits, or fees paid by the buyer
- Closing costs
- Cost of real estate surveys
- Special assessments for local improvements (e.g., such as pavements, street lights, sewers, and drainage systems)
- Cost necessary to prepare land for its intended use (e.g., grading, filling, draining, and clearing)

Land Improvements -- Capitalization of land improvement costs include the following -- all of which are subject to tax depreciation:

- Paving
- Fencing
- Landscaping
- Outdoor lighting

Buildings -- Capitalization of building costs include the following -- all of which are subject to tax depreciation:

- Purchase price of an existing building (old or new), or construction costs from excavation to completion
- Expenses incurred in remodeling or altering a purchased building to prepare it for its intended use
- Professional fees (e.g., architectural, engineering, and legal costs) and construction permits

Machinery and Equipment -- Capitalization of machinery and equipment costs include the following -- all of which are subject to tax depreciation:

- Purchase price
- Shipping costs (e.g., freight, import duties, handling charges and insurance on the equipment while it is in transit)
- Sales, use and other taxes imposed on the purchase
- Installation costs, including special foundations or plant modifications
- Reconditioning (used equipment) and testing for use (used and new equipment)

III. ICO Uncertainty and Project Risk: The Impact of the Depreciation Tax Shield Spillover

Consider a project with an initial cash outlay and expected cash flows at t denoted by CF_t. If the project lasts N years and has a cost of capital of r, then the project NPV is:

$$NPV = -ICO + \sum_{t=1}^{N} \frac{CF_t}{(1+r)^t} \qquad (1)$$

The initial cash outlay is comprised of a depreciable "Basis" and a portion that might be nondepreciable, denoted by NonDepr:

$$ICO = Basis + NonDepr \qquad (2)$$

The cash flow at year t is determined by the project's expected earnings before interest, taxes, depreciation and amortization ($EBITDA_t$), its depreciation ($Depr_t$), the tax rate (T), and the required investment (i.e., the change) in working capital (ΔWC_t):

$$CF_t = (EBITDA_t - Depr_t)(1-T) + Depr_t - \Delta WC_t \qquad (3)$$

This can be rewritten to separate the impact of EBITDA, the depreciation tax shield benefit, and the change in working capital:

$$CF_t = (EBITDA_t)(1-T) + Depr_t\, T - \Delta WC_t \qquad (4)$$

Let F_t denote the depreciation factor for the t^{th} year for an asset placed in service at t=0. Let n denote the depreciation life of the asset, which may be different from the project life N. For example, under straight line depreciation, the depreciation factor is 1/n. The depreciation factors for the MACRS tax depreciation method are provided by the U.S. Treasury for each asset class. For clarity of exposition, we assume that n<=N (i.e., the asset is fully depreciated by the end of the project life) and that there is no salvage value. The depreciation expense at time t is the product of the basis and the depreciation factor:

$$Depr_t = Basis(F_t) \qquad (5)$$

The project's NPV can be expressed in terms of the project's ICO, its after-tax EBITDA, the depreciation tax shield benefits, the investments in working capital, and the project's cost of capital, r:[9]

[9] In theory, each source of cash flow (e.g., sales revenue, costs of goods sold, depreciation, etc.) should be discounted at a rate that is appropriate for the particular risk of that particular cash flow source. In practice (and in most textbooks), all usual project cash flows are discounted at the project cost of capital. Therefore, we discount all of the project's cash flows at r. For situations with unusual cash flows, see Daves and Ehrhardt (2003).

$$\text{NPV} = \text{- NonDepr - Basis} + \sum_{t=1}^{N} \frac{\text{EBITDA}_t (1-T)}{(1+r)^t} + \sum_{t=1}^{n} \frac{\text{Basis}\,(F_t)(T)}{(1+r)^t} - \sum_{t=1}^{N} \frac{\Delta \text{WC}_t}{(1+r)^t} \tag{6}$$

Grouping terms associated with the basis yields:

$$\text{NPV} = \text{- NonDepr - Basis}\left(1 - \sum_{t=1}^{n} \frac{F_t (T)}{(1+r)^t}\right) + \sum_{t=1}^{N} \frac{\text{EBITDA}_t (1-T)}{(1+r)^t} - \sum_{t=1}^{N} \frac{\Delta \text{WC}_t}{(1+r)^t} \tag{7}$$

Notice the second term in Equation (7) shows that a dollar change in the basis does not cause a dollar change in NPV, due to the present value of the tax savings due to depreciation. Thus, a dollar change in the basis produces less than a dollar change in NPV. The depreciation tax shield also has an impact on the project's risk, as measured by its variance. As we show below, the tax shield also affects risk. Using Equation (7), the variance of the NPV is:

$$\begin{aligned}
\sigma^2_{\text{NPV}} = \sigma^2_{\text{NonDepr}} &+ \left(1 - \sum_{t=1}^{n} \frac{F_t T}{(1+r)^t}\right)^2 \sigma^2_{\text{Basis}} + \sum_{t=1}^{N} \left(\frac{(1-T)\,\sigma_{\text{EBITDA}_t}}{(1+r)^t}\right)^2 \\
&- \sum_{t=1}^{N} \left(\frac{1}{(1+r)^t}\right)^2 \sigma^2_{\Delta \text{WC}_t} + 2\left(1 - \sum_{t=1}^{n} \frac{F_t T}{(1+r)^t}\right) \text{COV[NonDepr, Basis]} \\
&+ 2\sum_{t=1}^{N} \left(\frac{(1-T)}{(1+r)^t}\right) \text{COV[NonDepr}, \text{EBITDA}_t] \\
&+ 2\sum_{t=1}^{N} \left(\frac{1}{(1+r)^t}\right) \text{COV[NonDepr}, \Delta \text{WC}_t] \\
&+ 2\left(1 - \sum_{t=1}^{n} \frac{F_t T}{(1+r)^t}\right) \sum_{t=1}^{N} \left(\frac{(1-T)}{(1+r)^t}\right) \text{COV[Basis}, \text{EBITDA}_t] \\
&+ 2\left(1 - \sum_{t=1}^{n} \frac{F_t T}{(1+r)^t}\right) \sum_{t=1}^{N} \left(\frac{1}{(1+r)^t}\right) \text{COV[Basis}, \Delta \text{WC}_t] \\
&+ \sum_{t=1}^{N} \sum_{j}^{N} \left(\frac{(1-T)}{(1+r)^t}\right)\left(\frac{1}{(1+r)^t}\right) \text{COV[EBITDA}_t, \Delta \text{WC}_t]
\end{aligned} \tag{8}$$

where σ_k denotes the variance of the k^{th} source of cash flow and COV denotes the covariance between the sources of cash flow.

To focus upon the relative contributions to risk due to the ICO and the operating cash flows, suppose that σ_{NonDepr} and $\sigma_{\Delta \text{WCt}}$, are equal to zero. To simplify the exposition, suppose that σ_{EBITDA} is constant for all t. Also assume that all covariances are equal to zero. Under these simplifying assumptions, project risk can be written as:

$$\sigma^2_{NPV} = \left(1 - T \sum_{t=1}^{n} \frac{F_t}{(1+r)^t}\right)^2 \sigma^2_{Basis} + \sigma^2_{EBITDA} \quad (1-T)^2 \left(\sum_{t=1}^{N}\left(\frac{1}{(1+r)^t}\right)\right)^2 \tag{9}$$

Notice in this simplified example, the summation in the second term of Equation (9) is the present value factor for an annuity of N periods when discounted at the rate r, denoted by $PVIFA_{N,r}$. Therefore, the risk due to EBITDA is scaled up or down by the present value factor due to the timing of EBITDA. The longer the life of the project is, the larger the present value factor is, and the higher the risk due to EBITDA.

Let $PVDepr_{N,r}$ denote the summation in the first parentheses above. For the special case of straight-line depreciation over n years (note that the deprecation life n maybe different from the project life N), $F_t = (1/n)$ for $n \le N$ and zero otherwise. For straight-line depreciation, $PVDepr_{N,r}$ is equal to T/n multiplied by the present value factor for an annuity of n years when discounted at the rate r: $PVDepr_{N,r} = (T/n)\ PVIFA_{n,r}$. For MACRS depreciation, there is no simple closed form formula for $PVDepr_r$. Using this notation, the variance of expected NPV can be written:

$$\sigma^2_{NPV} = \left(1 - T\ PVDepr_{n,r}\right)^2 \sigma^2_{Basis} + (1-T)^2\ (PVIFA_{N,r})^2\ \sigma^2_{EBITDA} \tag{10}$$

The contribution of ICO risk has two components. The first is due to the initial cash flow. The second is due to the tax shield benefit provided by depreciation; i.e., $T(PVDepr_{N,r})$. Notice that this tax shield benefit dampens the risk due to the basis. For example, if the basis becomes larger, there is a larger cash outflow at time zero, but there is a larger value of the tax shield benefit. The opposite is true if the basis turns out to be smaller than expected.

Equation 10 provides several insights. First, if an analyst simply ignores the ICO risk (which implicitly assumes that σ_{Basis} is zero), Equation 10 becomes:

$$\sigma^2_{NPV} = (1-T)^2\ (PVIFA_{N,r})^2\ \sigma^2_{EBITDA} \tag{11}$$

In this case, the resulting estimate of project risk will be biased downward with respect to the true risk given in Equation 10.

Second, if an analyst incorporates the ICO risk due to the initial purchase but ignores the subsequent impact of the depreciation tax shield generated by the ICO (which implicitly assumes $PVDep_{N,r} = 0$), then Equation 10 becomes:

$$\sigma^2_{NPV} = \sigma^2_{Basis} + (1-T)^2\ (PVIFA_{N,r})^2\ \sigma^2_{EBITDA} \tag{12}$$

In this case, the resulting estimate of project risk will be biased upward with respect to the true risk given in Equation 10. Therefore, to appropriately incorporate ICO risk, the analyst must explicitly consider the depreciation tax shield benefit.

IV. An Illustrative Example of a Modified Sensitivity Analysis for ICO Uncertainty

To illustrate the use of modified sensitivity analysis as it applies to ICO uncertainty in a capital budgeting analysis, consider the potential purchase of some equipment to be used in a project. The purchase price is known with certainty to be $600,000. The equipment has a useful life of five years and is in the three-year property class for MACRS tax-depreciation purposes. Shipping and installation costs are "estimated" to be $100,000 and $200,000, respectively, and the equipment has a zero expected final salvage value, five years from now. No additional "net" working capital is needed. The new equipment will generate estimated additional annual net operating cash flows, before consideration of depreciation and taxes, of $300,000 a year for five years. Assuming that the marginal tax rate equals 40 percent, we can estimate the project's relevant incremental cash flows for the "base case."

IV.A. The Base Case: Net Present Value

Exhibit 2 shows the project's $900,000 initial cash outflow under the "base case."

Exhibit 2.
The Expected Initial Cash Outflow

	Equipment cost (certain)	=	$600,000		
+	Capitalized expenditures:				
	Shipping cost (estimate)	=	100,000		
	Installation cost (estimate)	=	200,000		
=	Initial cash outlay (ICO)	=	**$900,000**	=	depreciable basis for tax purposes

Exhibit 3 shows the expected the incremental future cash flows.

Exhibit 3.
Expected Incremental Future Cash Flows

		END OF YEAR (in $000s)				
		1	**2**	**3**	**4**	**5**
	Net change in operating revenue, excluding depreciation	300.00	300.00	300.00	300.00	300.00
−	Net increase in tax depreciation	(299.97)	(400.05)	(133.29)	(66.69)	--
=	Net change in income before taxes	.03	(100.05)	166.71	233.31	300.00
− (+)	Net increase (decrease) in taxes (40% rate)	(.01)	40.02	(66.68)	(93.32)	(120.00)
=	Net change in income after tax	.02	(60.03)	100.03	139.99	180.00
+	Net increase in tax depreciation	299.97	400.05	133.29	66.69	--
=	Incremental net cash flow for years 1 to 5	**299.99**	**340.02**	**233.32**	**206.68**	**180.00**

Exhibit 4 combines the ICO from Exhibit 2 with the annual operating cash flows from Exhibit 3, resulting in the total expected net incremental cash flows from the project**.**

Exhibit 4.
Expected Annual Cash Flows

	END OF YEAR (in $000s)					
Period	**0**	**1**	**2**	**3**	**4**	**5**
Net cash flows	**(900.00)**	**299.99**	**340.02**	**233.32**	**206.68**	**180.00**

For an estimated initial cash outlay of $900,000, the firm expects to generate net cash flows of $299,990, $340,020, $233,320, $206,680, and $180,000 over the next five years. The firm's weighted-average cost of capital is 13 percent. Given this "base case" data, the net present value is $17,920. The typical capital budgeting response to the project's positive net present value would be to signal project acceptance. However, given the uncertain estimates for two of the three ICO components, i.e., shipping and installation, we suggest that the capital budgeting analyst should defer an accept/reject decision until those uncertain estimates and their multi-year spillover effects are subjected to sensitivity analysis.

IV.B. Sensitivity Analysis

Sensitivity analysis can be applied to our equipment purchase's uncertain ICO components to answer a few "what if" questions. What if, for example, our $100,000 estimate for shipping cost turns out to be higher/lower? And, what if installation is higher/lower than the $200,000 we originally thought?

To answer those "what if" questions, we first perform new NPV calculations in which we change our two variables of concern (shipping and installation) *individually* by, for example, -30%, -20%, -10%, +10%, +20%, and +30%. Note that changes in these variables have multi-period spillover effects on depreciation, which affects taxes and future cash flows. Thus, the change in the ICO not only affects the Year-0 cash flow, but it also affects the cash flows in the subsequent years.

Exhibit 5 compares the estimated NPVs for the different levels of ICOs.

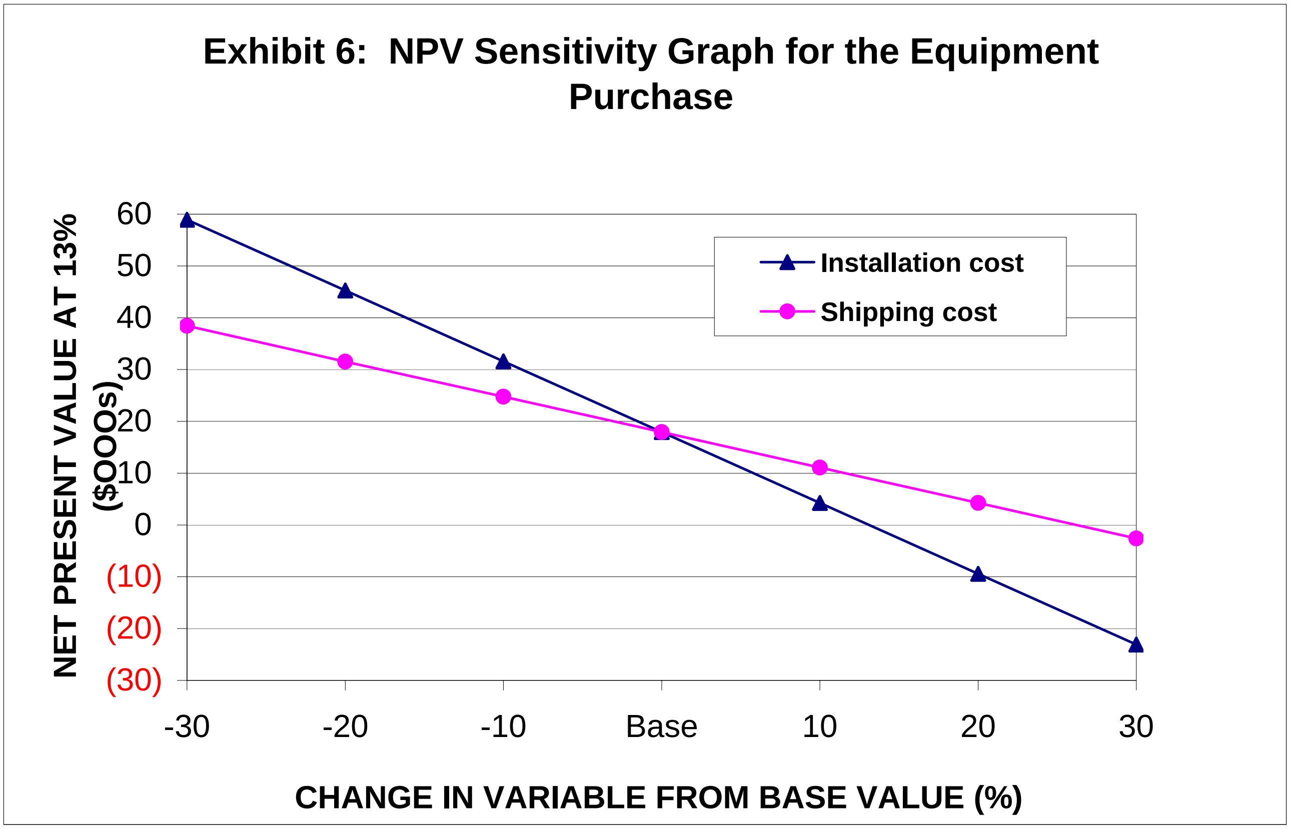
Exhibit 5.
Sensitivity analysis for the equipment purchase showing the impact of individual changes in two initial cash outlay components on the project's net present value (NPV) in thousands of dollars

	CHANGE IN ORIGINAL INSTALLATION COST						
	-30%	-20%	-10%	Base	+10%	+20%	+30%
Resulting NPV	58.93	45.27	31.58	17.92	4.25	(9.43)	(23.09)

	CHANGE IN ORIGINAL SHIPPING COST						
	-30%	-20%	-10%	Base	+10%	+20%	+30%
Resulting NPV	38.43	31.53	24.75	17.92	11.08	4.25	(2.59)

From Exhibit 5, we can see that if estimated installation cost were to increase by roughly 13 percent or more from the base case, our project's net present value turns negative. For shipping cost, however, the increase would need to be roughly 28 percent or more before the project has a negative net present value.

The data contained in Exhibit 5 can also be presented graphically in an *NPV sensitivity graph* – see Exhibit 6. Notice the two "sensitivity lines" in the NPV sensitivity graph. The "installation cost" line has the steepest slope. Therefore, NPV is more sensitive to equal percentage changes in that variable than in "shipping cost." Based on this information, management may want to concentrate more control efforts on the seemingly more critical "installation cost" variable. It may even want to try and negotiate a fixed-cost price contract for installation from a third party.



One potential problem with our sensitivity analysis, so far, is that it has looked at sensitivity "one variable at a time." We can also judge the sensitivity of NPV to simultaneous changes in two variables by constructing an *NPV sensitivity matrix*. Exhibit 7 is one such sensitivity matrix that depicts NPV results for combinations of changes in our two input estimates – "shipping cost" and "installation cost." Note that a simultaneous cost increase approaching 10 percent for both shipping and installation costs would result in a negative net present value.

Exhibit 7.
Sensitivity matrix for the equipment purchase showing the impact of simultaneous changes in two initial cash outlay components on the project's net present value (NPV) in thousands of dollars

CHANGE IN INSTALLATION COST	CHANGE IN SHIPPING COST: -30%	-20%	-10%	Base	+10%	+20%	+30%
-30%	79.44	72.60	65.77	58.93	52.10	45.27	38.43
-20%	65.77	58.93	52.10	45.27	38.43	31.58	24.75
-10%	52.10	45.27	38.43	31.58	24.75	17.92	11.08
Base	38.43	31.58	24.75	17.92	11.08	4.25	(2.59)
+10%	24.75	17.92	11.08	4.25	(2.59)	(9.43)	(16.25)
+20%	11.08	4.25	(2.59)	(9.43)	(16.25)	(23.09)	(29.93)
+30%	(2.59)	(9.43)	(16.25)	(23.09)	(29.93)	(36.77)	(43.60)

Sensitivity analysis, as we have seen, provides useful and easily understood insights into how a project's NPV responds to a change in one (or more) uncertain ICO input variables. Thus, the analysis provides insights into the risk-return trade-off for the project. Given the risk-return profile in Exhibit 7, should the project be taken? In other words, is the expected NPV of $17,920 worth the risk of two simultaneous 30% cost overruns, which would result in $43,600 loss? Although there is no theoretically definitive answer, if the possible loss is small relative to the size of the company, then the risk is probably worth taking, given that the project has a positive expected value. If the loss is so large that it is a "bet the company" proposition, then the board of directors should make the final decision.

Sensitivity analysis does not provide any absolute rules for deciding whether or not to accept the project, but it does provide some clear guidelines regarding the need for a project to be re-evaluated. For the project in this example, a re-approval analysis should be triggered when the combined shipping and installation cost overrun is $26,213 or more, since this leads to an expected negative NPV.[10] In fact, if cost overruns approach $26,213, then the company's managers should consider possible interventions that might help salvage the value of the project.

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[10] A $26,213 combined shipping/installation cost overrun corresponds to the region in grey in Exhibit 7 which indicates negative NPVs. This "break-even" overrun can be calculated as:

$$(\text{Base NPV})/[1 - T(\text{PVDepr}_{n,r})].$$

V. Summary and Conclusions

In a typical capital budgeting analysis, a project's initial cash outlay (ICO) is generally treated as a single, certain cash outflow. However, upon closer inspection, one or more of the following conditions may hold true in "real life":

- The ICO may have several cash outflow components – e.g., land, land improvements, buildings, machinery and equipment.
- Some of the ICO components may be certain cash flows and some may be uncertain/risky cash flows.
- Some ICO components may be capitalized, but ***not*** subject to tax depreciation (e.g., land). An outflow like this is already "after-tax" and provides no depreciation tax-shield benefits that would affect future after-tax operating cash inflows.
- Other ICO components may also be capitalized, but would be subject to tax depreciation (e.g., land improvement, buildings, machinery and equipment). These outflows will have spillover effects on future operating cash inflows because of their depreciation tax shield.
- Some ICO component flows may occur after time period zero.

Given these "real life" complicating factors involving a project's ICO, we recommend that sensitivity testing be applied to uncertain ICO components at the project-evaluation stage. Based on this sensitivity testing, the firm can then better decide whether to: a) subject any ICO component estimates to further refining/review; b) remove any ICO component uncertainty by negotiating a fixed price contract for some service; c) outsource some in-house, uncertain ICO cost item; or d) accept/reject the project based on the currently available information. The firm can also identify the critical levels of cost overruns that should trigger a formal re-approval of the project.

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