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Subjective Value at Risk
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include determining capital requirements, capital allocation, or performance-based compensation.

Each process entails risk assessment. Accordingly, each is subjective. If we wish to apply the objective tool VaR to any of these, we must first ask what role VaR is to play. In each case, some mechanism must be found that will enable VaR to support subjective human judgment—without replacing it. For market risk management, the answer was risk limits. For other possible applications, the question remains open.

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END NOTES

1. See the J.P. Morgan CreditMetrics Technical Document and "VaR in Operation" by Duncan Wilson, *Risk*, December 1995.
2. See "CIBC Gets Commercial," *Risk*, August 1996.
3. See "Modeling of Operations Risk," by M. Yone, et al., in the Financial Risk Management Discussion Group (March 1997).
4. See "The World According to Nassim Taleb," *Derivatives Strategy*, December/January 1997.
5. See "Value at Risk: Implementing a Risk Management Standard," by Chris Marshall and Michael Siegel, *Journal of Derivatives*, Spring 1997.

Applying Insurance Company Quantitative Techniques for Improved Capital Budgeting

by Tony Dardis and Andrew Berry

The insurance industry has always used sophisticated quantitative techniques for appraising capital investment. The same, however, cannot always be said of other industries. In a 1994 study, the Confederation of British Industry found that only about one quarter of manufacturing companies use quantitative methods to assess project risk, with the majority relying on subjective judgment. It is generally thought that manufacturers in the United States have similarly been slow to adopt quantitative techniques in appraising projects. So, could some of these insurance industry techniques be applied to help organizations in other fields? In particular, should consideration be given to the use of these techniques for appraisals of capital projects?

This article recognizes and acknowledges the work of both the U.K. Institute of Actuaries and the Society of Actuaries in this area, in particular the important paper authored by a working party set up by the U.K. Institute entitled "Capital Projects," published in the *British Actuarial Journal* (Volume 1, Part II, 1995, pages 155–300). Many of the definitions used in the introductory sections of what follows are taken directly from the Institute paper. We take the discussion somewhat further, however, in looking at some of the more state-of-the-art techniques currently in use today within the insurance industry. A similar SOA working party is in its formative stages in the United States.

We have defined a capital project in the same fashion as the Institute working party, that is, "any project where the investment has significant physical, social, or organizational consequences and is not merely to secure a transfer of ownership of an existing asset [such as portfolio investment]." This definition therefore includes such schemes as:

- Physical construction, such as building a factory, bridge, or road
- Starting a new business producing goods or services, or a new product line in an existing business
- Taking over and modernizing an existing business or physical asset
- Developing a new asset for an existing business
- Repairing or renewing an existing asset.

Current Capital Budgeting Techniques

Capital projects are most commonly evaluated using pay-back period, net present value, or internal rate of return. Again, using the Institute paper definitions:

- ***Pay-back Period Technique***: A project is accepted if the number of years of projected cash flow required to return the initial investment is less than a pre-set maximum cut-off period (no account taken of the time value of money).
- ***Internal Rate of Return***: Find the interest rate (IRR) that equates the present value of expected future cash flows with initial costs and accept the project if the IRR exceeds the opportunity cost of capital.
- ***Net Present Value***: Find the present value (NPV) of the expected future cash flows of a project discounted at the opportunity cost of capital and accept the project if the NPV is greater than zero.

IRR and NPV incorporate the time value of money through discounting to present values and try to incorporate the notion of risk through the use of the relevant discount rate. Risk in this context means that actual returns from the project (revenues less costs) may be

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different than expected. This volatility of returns will be different between different projects.

The relative riskiness of the project is incorporated into the discount rate by adding a risk premium to the "risk-free" interest rate as reflected by a Treasury bill. This risk premium is necessary to compensate investors for the risk they are taking by providing higher returns. The key questions are how large should the risk premium be and how do we calculate it? The answer to these questions requires an assessment of the risks in the project. In most cases this assessment is arbitrary.

Rather than try to estimate the risk costs inherent in a capital project, organizations will use their cost of capital (that is, the rate at which they can raise capital) as the discount rate. The reason for this is that this is the rate of return that the financial markets require to compensate them for taking the risk of investing in the organization. This macro approach to estimating risk premiums assumes that the financial markets are efficient in estimating risk. Applying this rate to new capital projects also assumes that the capital project will have the exact same risk profile as the organization's existing risk profile, an assumption that is clearly unreliable for investments in new areas or operations such as new product lines or major construction projects. In these situations, appropriate discount/cost of capital rates may be obtained from two sources:

- ***Comparative Data***. Use a cost of capital figure from a comparable organization or project. For large capital projects, comparable data simply isn't available. Projects such as Boston's Central Artery project are of such a size and unique nature that there are no historical indicators of their risk profiles. Entering new markets also presents problems. Should a company with no expertise in a particular industry expect to have a risk profile similar to the industry as a whole?
- ***Subjectively apply a loading to the organization's own cost of capital.*** Launching new product lines or acquisitions may have a required discount rate above the organization's existing cost of capital, as both revenue and cost projections are subject to volatility. Cost reduction projects may have a required discount rate below the existing cost of capital.

Even incorporating appropriate risk premiums, most NPV or IRR estimates focus on single deterministic point estimates for making investment decisions. A simple extension of this is to use some sort of scenario analysis to include a number of different potential outcomes (for example, optimistic, pessimistic and most likely). In the absence of any information about the probability of each scenario occurring, investments are chosen according to some decision rules which usually involve minimizing the possible losses from the pessimistic scenarios.

"Where DFA is especially useful is in allowing the user to build a sophisticated model that incorporates the interrelationship between variables."

Introducing Probability Distributions

Scenario analysis can be extended to assign probability estimates against the different scenarios to develop an expected outcome and standard deviations for each result. Although scenario analysis begins to include probability estimates, it is still a macro top-down approach to estimating risk. Rather than relying exclusively on this approach, an organization should also be building a bottom-up risk profile. This will identify the potential sources of risk (risk factors), the impact they will have on potential cash flows, and develop a probability distribution for each of the variables. Risk factors can have an impact on both the cost and revenue side of the project financials—demand is lower than expected, project delays increase the cost of the initial investment, and so on. Some of these variables may be related. For example, a new product failing field trials may increase the R&D costs in launching it, but it will also reduce the potential sales revenues if the delay causes the company to miss a product season or a competitor beats it to market. Similarly, an economic downturn could increase financing costs in construction of a new sports stadium and reduce demand for tickets. Other variables may be independent or act as natural hedges.

With faster computer run times, simulation of potential net returns should be easier. These techniques are being used in insurance settings by actuaries and could be adapted to capital budgeting. These simulation techniques make bottom-up risk profiling possible and recognize the volatility of individual risk factors, their impact on returns, and the degree to which they are interrelated.

Covariance is not the only consideration in developing a project risk profile: investment decisions are not static. In many cases, management has some options over the future direction of the investment. It can abandon the project, increase its investment, or have an option to revise the project at a later date. This situation calls for a dynamic analysis.

Dynamic Financial Analysis (DFA) is a sophisticated simulation model developed in an insurance industry setting. Multiple scenarios are performed to examine the fortunes of a company enabling a thorough understanding of the impact of the risks to which the organization is exposed. In particular, by looking at "extreme point" results, the analysis may tell us a great deal about our organization's susceptibility to a "disaster-type" situation which may be hidden in normal mean/variance type analysis. DFA also incorporates future management decisions, or options, by building certain decision rules into the simulation. For example, if returns are below x, we abandon the project, or if field trials show y demand, we increase or reduce the investment in launching a product.

Where DFA is especially useful is in allowing the user to build a sophisticated model that incorporates the

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interrelationship between variables. A model used for capital project purposes could incorporate a myriad of interrelationships.

As an extension of the DFA approach, insurance practitioners are also looking at the banking concept of "value-at-risk" (VAR). The basic idea of VAR is to look at the extreme points in a loss distribution and to determine essentially what is the most amount of money that can be lost. One definition might be "VAR is the maximum amount of money by which the value of my portfolio may decline in the next week, or time *t*, with 95% confidence." Clearly, the tools of DFA could be used to determine a value for VAR.

The DFA and VAR techniques could be of use in a construction project context. For example, consider a capital construction project, requiring $100 up-front costs, which has an expected payback of approximately $110, but with some uncertainty in this return. The distribution of potential income is shown below. There is a small probability of there being a negative return, and an extremely small probability of us losing all our money:

Income	Probability
0	0.0001
80	0.0099
102	0.2400
110	0.5000
118	0.2500

The standard deviation of returns does not really bring out the fact that there is a small possibility of a very large loss as shown in Table 1.

DFA and VAR allow us to hone in on the extreme points and analyze further the scenarios that produce large losses. Therefore, we could define the VAR as the most amount (in money or percentage terms) that could possibly be lost, with a 99% confidence level (that is, at the loss level where cumulatively 99% of returns are above). In this instance it would be 20%. This then might be defined as our level of "risk" for the project. We may then say that this project has an expected return of 9.77% with a risk level of −20%.

TABLE 1

Returns (X)	Probability (p)	pX	pX^2
−100%	0.0001	−0.01	1.00
−20%	0.0099	−0.198	3.96
2%	0.2400	0.48	0.96
10%	0.5000	5.00	50.00
18%	0.2500	4.50	81.00
	1.0000	9.77	136.92

Mean = 9.77%
Variance = 136.92 − 9.77 × 9.77 = 41.47%
SD = 6.44%

Choosing Between Investments

One of the problems with probabilistic models is the interpretation of the data for decision making. Unlike the single deterministic point estimates, there is no simple decision rule. DFA tells us our expected return is 9.77% with risk of –20%, but what is it telling us to do? Should we accept the project or not? The answer is to establish the expected "risk" and "return" of all possible investment opportunities open to us, and to see how the particular project under consideration fits in with this complete picture. This is essentially an extension of the Markowitz portfolio selection model, a "classical" concept in financial economics, and its by-product, the efficient frontier. The original Markowitz idea is that for a given level of risk, defined as the standard deviation of "returns" on a portfolio of assets, there is a combination of assets that will maximize expected return. The generalized version of the Markowitz model is that for any given level of risk, there is a strategy, or project that will maximize return.

By plotting the risk/return point of our construction project on a chart with all other potential investment opportunities—including the risk free Treasury bill return—we can see whether our project falls on the efficient frontier. If it does, then the project might be accepted; if not, then we might wish to look at other project opportunities.

One additional problem needs to be addressed. Even if the project lies on

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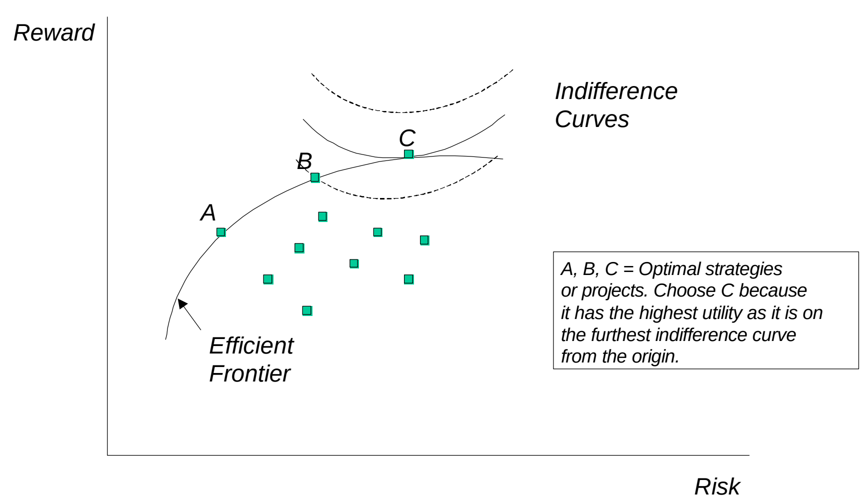
Exhibit 1: Utility and the Efficient Frontier



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the efficient frontier, the question remains as to whether the riskiness of the project is acceptable. In this respect, there is another curve that needs to be drawn, representing the investor's "utility." If the project lies sufficiently close to the utility curve, then the project may be deemed acceptable.

The concepts involved in the above discussion are illustrated graphically in Exhibit 1. The utility curve is the most subjective element of all, and in practice may indeed be assessed purely on the basis of judgement.

Insurance practitioners have been using the efficient frontier in the area of asset-liability management for some years now, particularly to assist in establishing asset allocation in the context of a certain liability profile. Moreover, the insurance industry has taken the whole process a few steps further, defining an efficient frontier as being any business strategy the practitioner wishes to test out (for example, to test the introduction of a new product line or using a new marketing outlet). In this way, reward can be defined as any performance objective that is most relevant to the successful management of the organization and is basically what we wish to maximize. Risk then represents what we wish to minimize (or at least control) and might be defined as the probability of insolvency over the next five years. Under the new definitions, strategies that might previously have been thought of as not-so-risky may have some element of risk that might concern us (Treasury bills, for example, may indeed be quite "risky" in certain instances).

In this way, the assessment of a capital project need not just be in terms of expected returns and standard deviation of returns, but may use much more sophisticated definitions to really get to the heart of the nature of the practitioner's business. For example, in the context of building a sports stadium with taxpayers' money, perhaps return needs to consider the many possible spin-off effects in terms of employment and other benefits to the community; the risks might incorporate the potential collapse of neighborhoods and additional traffic congestion. In this way, the true impact to all stakeholders of the organization can be considered. For government-sponsored capital projects these social costs and benefits can be as important as the financial measures of risk and return.

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Capital Projects Working Party—Recruitment Drive

The Society of Actuaries Finance Practice Area is in the process of resurrecting the Capital Projects Working Party. Tony Dardis is acting as chairperson and is keen to hear from anyone who would like to join the group.

Tony and Andrew Berry have an article "Applying Insurance Company Quantitative Techniques for Improved Capital Budgeting" in this edition of *Risks and Rewards* that gives some background to the subject matter covered under the banner of "capital projects." We think this is an exciting potential growth area for actuaries in the United States.

The initial work of the group will focus on the following areas:

- Identification of actuaries working in the capital projects area interviews with those actuaries about the nature of their work
- Making contact with the business schools about quantitative techniques currently used by U.S. industry for capital budgeting purposes
- Preparation of a Capital Projects Specialty Guide, or reading list.

If you are interested in joining Tony's group, you can contact him at 972–701–2739, 972–701–2575 (fax) or dardist@tillinghast.com (e-mail).