As exploration and production companies increase their use of portfolio management techniques to realize maximum value from assets and projects, measuring and managing risk become essential.

The statistical methods central to risk assessment are sophisticated and complex. Modern computing technology has made them accessible to all but the smallest companies, however. Anyone involved in E&P decision-making must understand the basic concepts, even managers who might not personally perform the mathematics.

To quantify risk, portfolio management requires a valuation measure more sophisticated than net present value (NPV), the traditional basis for assessing E&P investment. The measure preferred by the author is expected monetary value (EMV), the calculation of which weighs risk by accounting for the probabilities of success (OGJ, Nov. 1, 1999, p. 49).

A three-stage analytical approach based on EMV and using the well-known Monte Carlo probabilistic method can help companies manage risks of their E&P portfolios (see related article, p. 70).

Portfolio methods

Portfolio management performs economic evaluation and modeling on the combined entity or portfolio as well as for each individual project. The results provide valuable quantitative assistance to decision-making and can be directly linked to corporate strategy to forecast probability of achieving the strategic targets specified by the company. They integrate financial, risk, and statistical analysis techniques and concepts that are theoretically well-established and have been extensively applied during the past 50 years.

The methods include portfolio theory, Monte Carlo simulation, cost and productivity of capital using discounting techniques, and EMV.

The power of modern computer hardware and software makes it possible to crunch the vast arrays of numbers involved rapidly and apply portfolio methods on workstations and personal computers. This technological development helps explain the flurry of recent applications in portfolio management becoming available to the E&P industry.

The tools have become available to managers and even board members of some companies rather than—as once was the case—languishing at arm’s length and considered as black boxes for the exclusive use of programming experts or specialist analysts.

A general acceptance that value can be added to corporations by actively managing risk internally rather than leaving it to external markets is also responsible for the development of portfolio diversification techniques during the past decade.

Risk assessment

Quantifying risk, particularly the downside risk of a portfolio value falling below a specified target value of a strategic goal, is central to modern portfolio methods.

Risk is measured in a number of ways, including the mean deviation of all value outcomes from a Monte Carlo simulation that fall below the target value or the semistandard deviation of value outcomes that fall below the target values.

These measures extend portfolio theory, which as originally applied to the financial sector sought to minimize risk by focusing on the lowest standard deviations of portfolio value distributions.

In the financial sector, the values of stock portfolios predominantly conform to normal distributions. Portfolios of natural resource projects (and projects in

Three-stage approach proposed for managing risk in E&P portfolios

**Stage 1:** Perform conventional risk analysis on individual projects.

**Stage 2:** Establish economic risks for the portfolio that are independent of corporate capitalization and fiscal factors.

**Stage 3:** Integrate the Stage 2 analysis with a corporate financial model and strategic performance targets.
Applying Monte Carlo simulation to three-stage E&P risk analysis

Monte Carlo simulation, a cornerstone technique of continuous probabilistic analysis, involves a large number of repeated trials in which equations assessing reserves, production rates, or economic values are calculated in each trial with input variables treated either as single-number estimates or probability distributions where uncertainty is involved.

Random numbers between 0 and 1 are used to sample cumulative probability distributions of the input variables. The values of the key dependent variables calculated by each trial themselves form probability distributions that may be analyzed and presented statistically rather than as single or a limited number of point outcomes.

Several commercially available programs are available to perform Monte Carlo simulations, some as spreadsheet add-ins. However, it is not difficult for analysts to write their own spreadsheet macros to perform complex simulations rapidly to analyze day-to-day decisions from prospect viability to portfolio analysis.

Monte Carlo model

The logic for the Monte Carlo simulation model requires careful attention when applied to portfolios rather than individual projects. It is important to ensure that realistic dependencies between the projects of the portfolio are accounted for and that the input distributions are appropriately defined and applied to the projects during the simulation.

The model has 15 steps in its development. They are:

1. Construct economic analysis models (spreadsheet or otherwise) for each project in the portfolio to calculate annual (or other period) cash flows on a deterministic basis.
2. Apply risk factors to cash flows to derive expected values (Stage 1 of the risk analysis process).
3. Apply corporate discount factors and deflation rates to calculate net present values (NPVs) and expected monetary values (EMVs) in real terms for each period.
4. Define input variable distributions for Monte Carlo simulation to generate a probabilistic model for each project that can be integrated to represent the whole portfolio.
5. Select how the input variables are to be sampled by the simulation for each project.
6. Define the number of iterations that will be calculated by the simulation.
7. Define the output parameters that will be recorded for each iteration of the simulation.
8. Analyze statistically the output parameters for each project (for each period and the total planning horizon) and the whole portfolio.
9. Establish a provisional efficient frontier for the portfolio that is on a pretax basis and independent of corporate capitalization, debt, and tax (Stage 2 of the risk analysis process).
10. Analyze the effects of project timing on portfolio values.
11. Integrate the portfolio with the corporate financial model—such as profit-and-loss and balance-sheet metrics—to calculate net income for the portfolio and establish the impact of corporate debt and tax on post-tax portfolio cash flow.
12. Select the planning horizon for corporate analysis.
13. Analyze statistically each output metric for the portfolio (for each period and the total), and compare them with performance targets defined by corporate strategy (Stage 3 of the risk analysis process).
14. Establish corporate efficient frontiers for the portfolio on a post-tax basis that include corporate overheads, capitalization, debt, and tax.
15. Use the portfolio model developed above as an ongoing tool for decision-making, strategy-setting, sensitivity analysis, and performance-monitoring.

This article is condensed and adapted from an Oil & Gas Journal Executive Report entitled Three Stages of Risk Analysis: Improving E&P Portfolio Management and Its Links to Corporate Strategy, by David A. Wood, which elaborates on concepts described here and demonstrates the related statistical methods using a worked hypothetical E&P portfolio example. Cost is $299. For information, contact Megan Tran at +1 (713) 963-6274, or fax +1 (713) 963-6285. Please refer to Item #OGJER11.
The concepts can and have been demonstrated statistically and in industry practice. From experience with these tools, the following observations can be drawn:

• Three stages of risk analysis, including two with Monte Carlo simulations, aid portfolio analysis and management by providing calculated values linked to probabilities of occurrence and quantitative measures of downside risk.

• Combining project risk and economic risk results in more-realistic risked, post-tax values for portfolios than if the project risks are ignored.

• As more corporations appreciate the advantages of being measurement-managed, the probabilistic approach can establish probabilities for achieving a range of corporate targets and provide valuable performance yardsticks.

• Portfolio optimization is best performed through use of both cash flow and net income-based values. Analyzing post-tax and pretax cash flow measurement with net income and capital expenditure requirements helps to explain why optimizing portfolio cash flow does not necessarily optimize portfolio net income.

• Integrating downside risk measurements with pretax and post-tax analysis provides more insight to the key portfolio drivers than using a single stage risk process. Calculating downside risk for discounted cash flow and net income and using those values, together with their ratios to investment to define efficient frontiers, aids the decisions required to establish well-balanced portfolios.

• It is worthwhile analyzing portfolios and their constituent projects initially on a pretax basis, which is independent of corporate capitalization and fiscal factors that may distort values. Trends established on a pretax basis are often easier to interpret. Valuations independent of corporate factors are useful for establishing what range of sale prices potential purchasers may pay for a group of assets.

• Visual Basic macros linked to spreadsheet workbooks can be used to conduct efficient analysis of portfolios including simulation and detailed statistical analysis. Simulation, sensitivity, and statistical analysis macros or add-ins can be easily combined with existing economic analysis spreadsheets in varying formats to link them for portfolio evaluation.

The possibilities
Illustration of the mathematics central to these methods lies outside the scope of this article, the purpose of which is merely to introduce the basic concepts of risk assessment as they apply to portfolio management.

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References