value. A common probability distribution used in business decision making is the triangular distribution. To describe a triangular distribution for an input variable, one simply must provide the lowest, highest, and most likely value a variable might possibly take. For example, the high, low, and most likely milk price might be specified as $16.60, $13.60, and $15.60/cwt.

Once the probability distributions of inputs are described, simulation modeling calculates the spreadsheet repeatedly. Each time the spreadsheet is calculated, a new value for each input, based on its specified probability distribution, is used. After numerous calculations, a range of output values can be generated for one or more selected measures of investment desirability (e.g., NPV, ROR, total net cash flow). This process allows the analyst to make probability statements about the output values (e.g., there is a 25% chance the NPV of the dairy investment will be below $0).

Table 2, capital expenditures, shows the values (low, high, and most likely) for milk sold per cow, and milk price used in an example simulation of the spreadsheet model. All other input values were kept constant at those values shown in Exhibit 2. The computer simulation program used in this example is called @RISK™ (available from Palisade Corporation, 31 Decker Rd., Newfield, NY 14867). This program allows the user to specify the probability distribution for any input variable in the spreadsheet capital budget model and to forecast the value of any cell dependent upon the value of one or more input variables. The simulation was set to forecast total and yearly undiscounted after-tax, net cash flows, IRR, and NPV. Table 3 shows the results of the simulation analysis.

The minimum and maximum values in Table 3 indicate the range within which the analyst is 100% sure the actual value will fall, given the assumptions of the particular simulation. For example, the actual NPV would never be expected to exceed $3,338,858 or fall below ($1,979,570). The mean value is simply the average value. The simulated average NPV was $1,192,013, which is over $800,000 lower than the NPV obtained from the non-simulated spreadsheet model of $1,996,159. The far right column in Table 3 shows the percentage of simulated values for each measure that fell below zero. Thus, there is over a 13% chance that the NPV will be negative. The simulation also shows that, given the milk sold/cow and milk price assumptions, the cash flow situation may be much more serious than the non-simulated spreadsheet analysis indicated. The non-simulated spreadsheet indicated a cash flow in year 1 of $15,715; however, the simulation analysis (Table 3) indicated that this cash flow could potentially go as low as ($600,839) and that there is only about a 2.7% chance of it being positive. Furthermore, on average the cash flows for years 1 through 5 will all be negative.

The advantages of simulation modeling lie in its ability to handle a range of values for input data and the calculation of multiple values for the measures of investment value. For example, in the non-simulated spreadsheet analysis the results were predicated on the capital expenditures budget ($4,905,910), milk sold per cow (19,300 lbs.), and milk price ($15.60/cwt) being 100% accurate. Simulation allows more freedom in specifying these input values and provides additional information (e.g., range, percentiles, probabilities, etc.) on the measures of investment value (e.g., NPV, net cash flow, etc.). The addition of two uncertain inputs to this model indicates that the investment is much more risky than the original spreadsheet analysis would have suggested. In the end, this provides the decision maker with more information with which to make the difficult investment decision.

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