branching OUT

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DECISION TREES OFFER A REALISTIC APPROACH TO RISK ANALYSIS.

Risk management involves looking into the future, trying to understand what might happen—and whether or not it matters. In pursuit of realistic information on project risk, project managers are increasingly relying on quantitative methods, such as decision tree analysis. This technique can help project managers make decisions where the implications are not entirely certain.

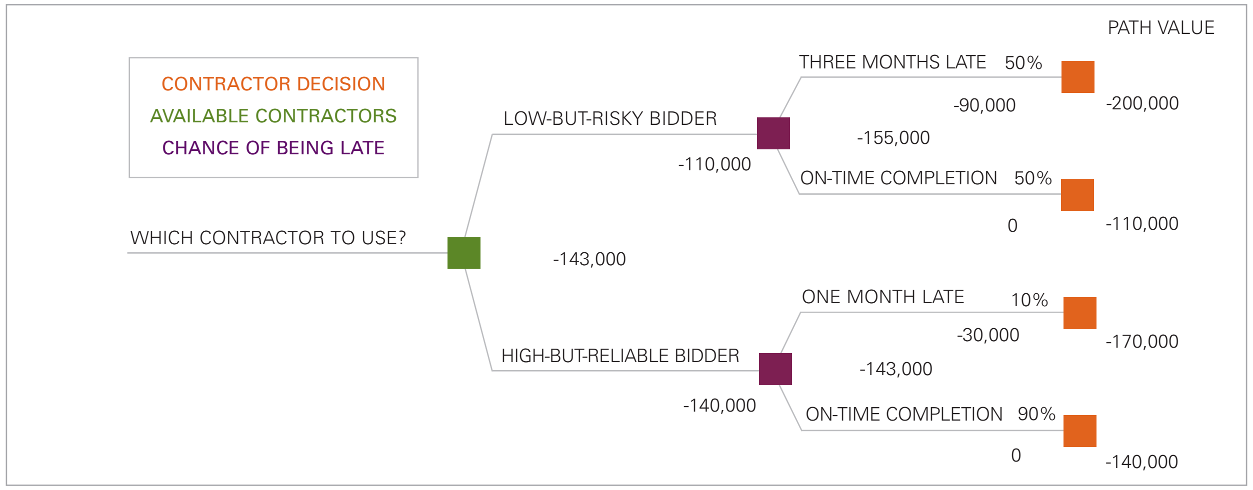
A Simple Decision

Consider this common project decision: You're the prime contractor facing a $1,000 penalty for every calendar day you deliver late. You must decide which subcontractor to use for a critical activity, and the goal is to minimize your expected cost.

One subcontractor, the "low-but-risky bidder," comes in with a $110,000 bid, but you estimate a 50 percent chance it will be 90 days late. Another subcontractor bids $140,000, and you assess a 10 percent chance of it being late and only 30 days at that. This is the "high-but-reliable bidder." A decision tree can help decide which one to use:

- **Identify the major decisions** (decision nodes) and the major uncertainties (event nodes).
- **Construct the decision tree** starting from the decision and charting its main consequences. Simply diagramming the decision analytically sometimes leads to more informed decisions, because it forces the project manager to consider the elements that go into a decision. Because each decision or event node has at least two alternatives, the structure of the decision looks like a tree placed on its side with the root on the left and the branches on the right.
- **Estimate the costs and benefits** of each alternative decision. The final result of the decision tree analysis will depend largely on the accuracy of these figures.
- **Calculate the value for each path**, beginning with the first decision and cumulating the values to the final branch tip. This process is called "rolling forward." Take the top-most branch, for example. If the low bidder comes in at $110,000 and the project is delivered 90 days late because the subcontractor missed its deadline, the customer will charge you $90,000 in penalties, putting the total cost at $200,000.
- **Estimate the probability** of each uncertain outcome. This process is not as easy as it might appear, because there are often no useful databases from which to extract the information. Care should be taken in data collection because sometimes the decision can be poorly informed or biased. Expert judgment is required.
- **Solve the decision tree.** Start with the path values at the far right-hand end of the tree and then moving left, calculate the value of each node as it is encountered. This process is called "folding back" the tree. (See Contractor Decision chart.) Because event nodes

CONTRACTOR DECISION



represent alternatives over which you have no control, you find their value by calculating the expected monetary value (EMV). To do this, multiply the values of the uncertain alternatives by their probabilities. The value of a decision node is the highest value of the succeeding branches leading from that node, because the rational organization will choose that alternative when it's offered.

The folding back calculations for our example are:

The low-but-risky bidder:
-$200,000 x 50% = -$100,000
-$110,000 x 50% = -$55,000
Add these numbers: -$155,000

The high-but-reliable bidder:
-$170,000 x 10% = -$17,000
-$140,000 x 90% = -$126,000
Add these numbers: -$143,000

Clearly, the reliable high bidder has the edge here. It is expected to cost less ($143,000 versus $155,000) because its greater on-time reliability offsets its higher initial bid.

The Full Value of Folding Back

Many project decision trees contain embedded decision nodes. The value of each one depends on the values of those nodes to its right.

Let's say you're choosing between an experimental technology and a commercial-off-the-shelf (COTS) one. If successful, the experimental technology promises greater rewards, but you estimate an 80 percent probability of problems. However, even the COTS technology has a 10 percent chance of problems. If major problems occur, you must decide whether to fix the problem or to "limp along." Because you're faced with this secondary decision, there is an embedded decision node in each branch after the chance node. Unlike the earlier example when the objective was to minimize expected cost, in this case, the goal is to maximize the expected value of net rewards.

As in the previous example, the folding back process starts at the right-hand side of the tree. On each branch, you encounter a decision node first. Two scenarios are explored in the example: limping along and the fixing the problem. (See Technology Decision chart.)

With both technologies, the decision would be to fix the problem if major problems occur because limping along provides small rewards. The folding back method reveals the value of the decision node is $800,000 in the case of the COTS and $1 million for the experimental technology.

The values of the embedded decision nodes then are carried to the left and used in the EMV calculations that provide the value of the two event nodes.

For the COTS branch:

- Multiply the value of the major problems node by its probability ($800,000 x 10%) for the value $80,000
- Multiply the path value of the minor problems by its probability ($1,000,000 x 90%) for a value of $900,000
- Add the two values together for the EMV: $980,000.

For the experimental technology:

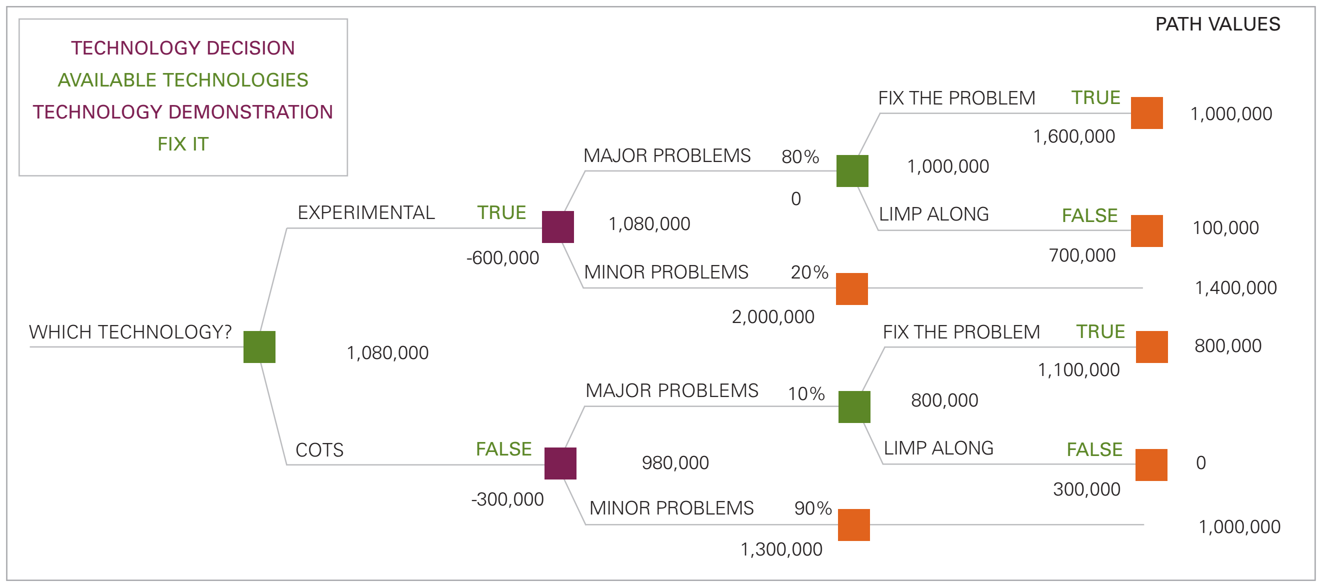
- Multiply the value of the major problems branch by its probability ($1,000,000 x 80%) for a total of $800,000
- Multiply the path value of the minor problems branch by its probability ($1,400,000 x 20%) for a total of $280,000
- Add these two values together for the EMV: $1,080,000.

Comparing the EMVs of the two technologies—$1,080,000 versus $980,000—indicates it's a close call, but you should choose the experimental technology. Although there is an 80 percent probability of major problems, the technology's EMV is higher than that for the COTS choice.

When constructing the decision tree and inserting the data, you must try to:

- **Make your estimates as accurate as possible.** This often means that data collection constitutes the largest

TECHNOLOGY DECISION



part of the decision tree analysis effort.

- **Evaluate factors not included in the decision tree** if they could be important. For example, proving the experimental technology on this project might lead to future licensing revenues, and could affect your choice.

Determine Your Risk Aversion

A risk-neutral organization prefers the decision that maximizes its EMV or minimizes its expected cost. It may have many projects and can thrive if it succeeds on average. A risk-averse organization shies away from project decisions that would cause large losses if they were to fail—even if such decisions also offer a possibility of large gains. A risk-averse organization's choice may be more conservative than that of a risk-neutral organization. This does not imply that the decision is irrational or counter-intuitive, just that the organization is more risk-averse, perhaps because it is smaller or more reliant on one source of income. Most decision tree software allows the user to design a utility function that reflects the organization's degree of aversion to large losses.

Project decisions, even quite simple ones, can be difficult because their implications are often not certain. Decision trees offer a powerful way of describing, understanding and analyzing that risk.

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