Risk Analysis

Introduction

Many business situations involve uncertainty. Such situations arise frequently when trying to do budgeting, project planning, investment planning, etc. Whenever we have uncertainty, this implies some amount of risk in our decision-making process. So business managers attempt to come up with a reasonable estimate or "best guess" for uncertain outcomes (variable values).

There are several methods of risk analysis that managers could typically consider, e.g.:

- Best-Case/Worst-Case Analysis
- What-If Analysis
- Simulation Modeling

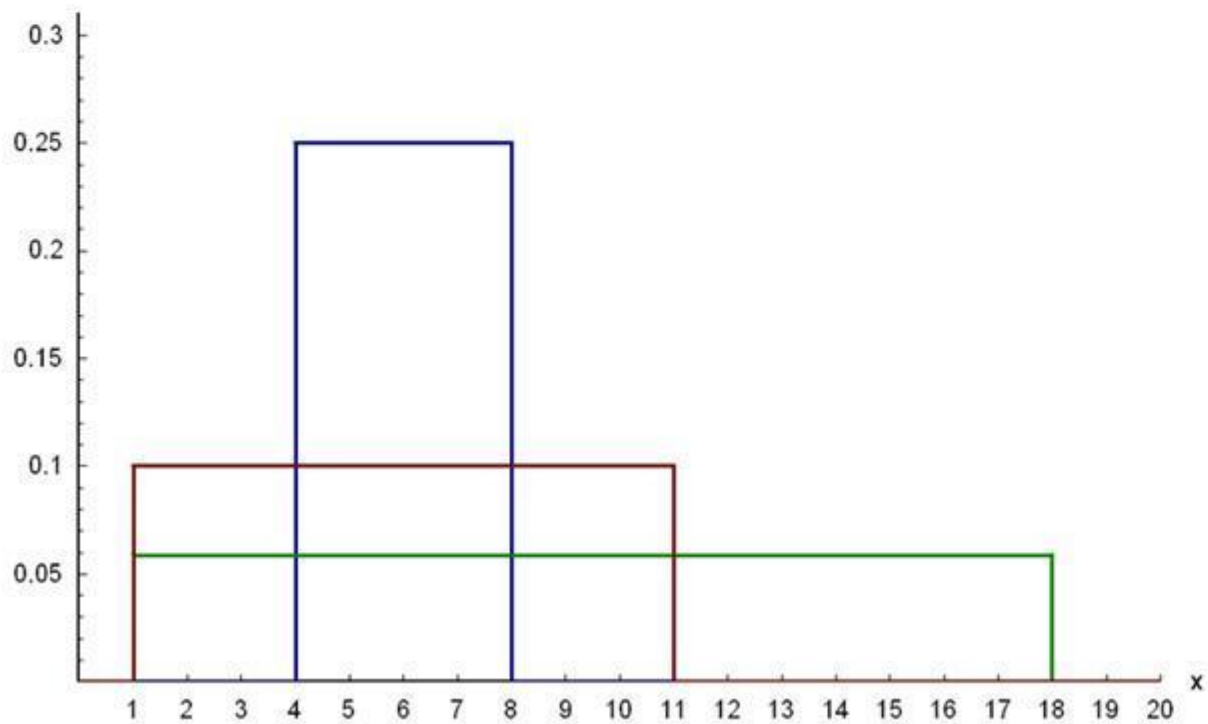
Let's examine each of these approaches.

Best-Case/Worst-Case Analysis

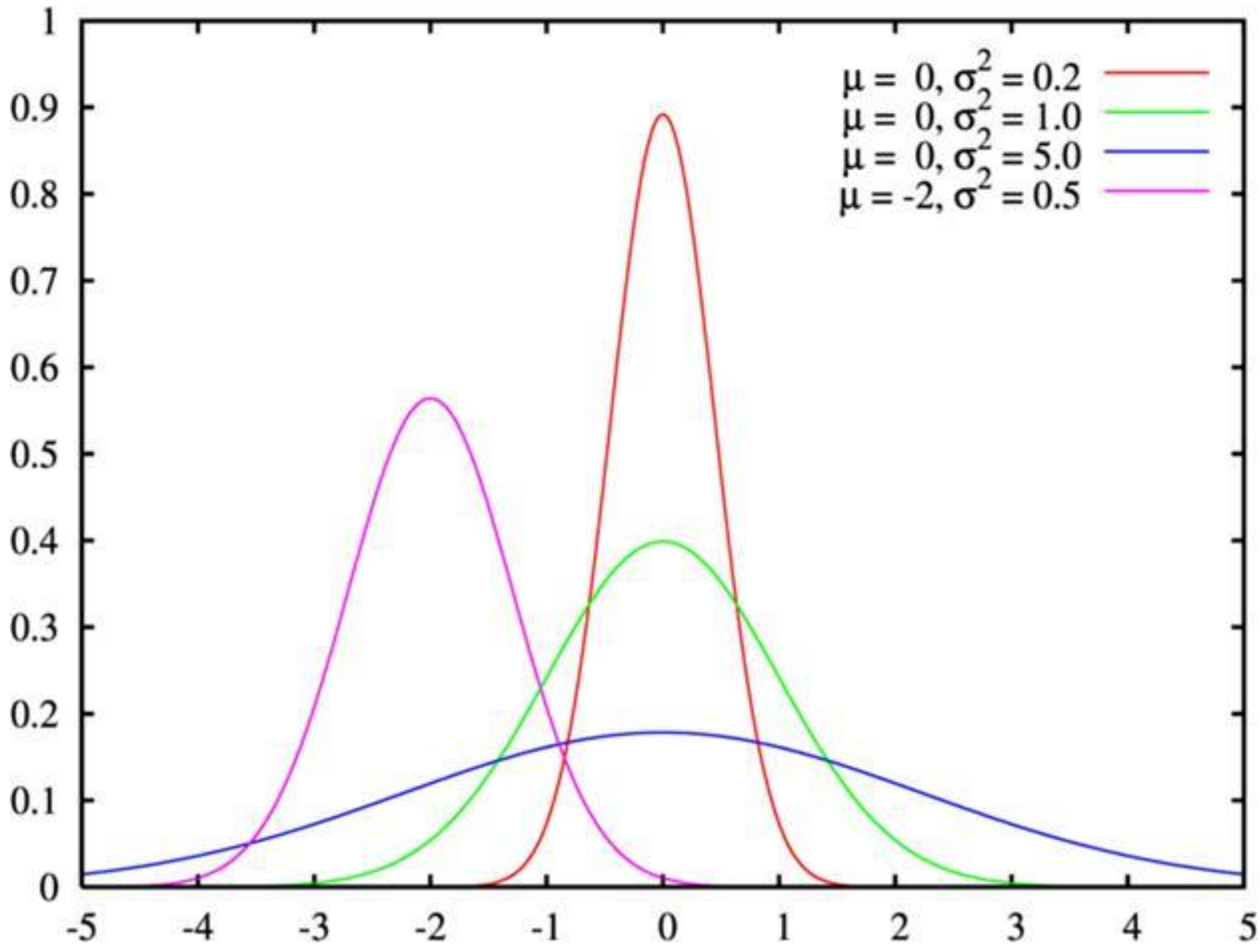
This method begins with a "most likely" or "base case" value that we might expect for a variable. And because we recognize that the actual value may turn out to be somewhat different from what we believe is the most likely value, we also try to specify "worst case" and "best case" values to give us a range of possible values around the base case.

But there are problems inherent in this approach to risk analysis. Simply knowing the "best case" and "worst case" outcomes doesn't give us any useful information about the distribution of possible values within this range. It also doesn't tell us the probabilitity with which either the "best case" or "worst case" outcome might occur. Shown below are just a few examples of how the distribution of probable outcomes might look, depending on the underlying nature of the data.

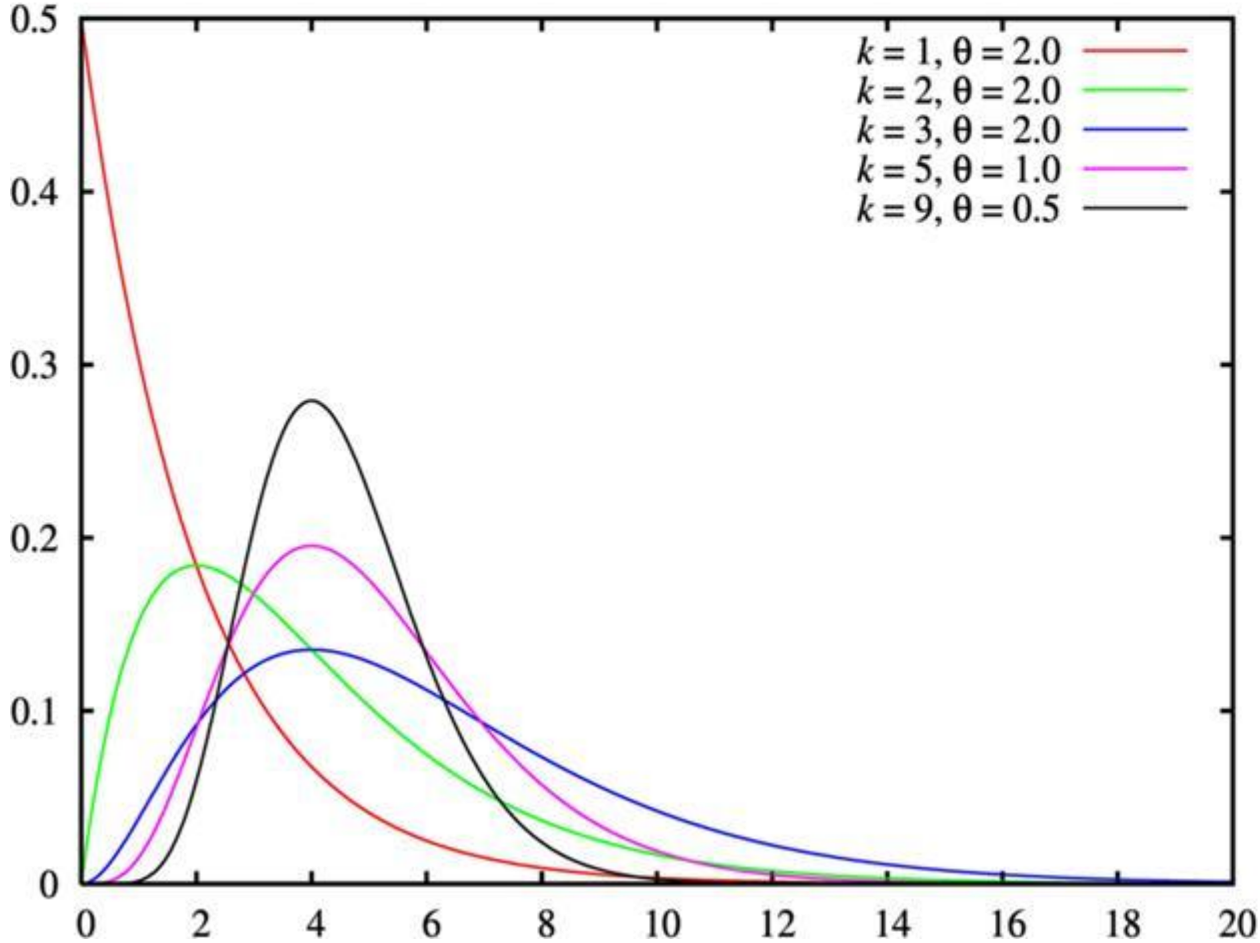
Here are three different uniform probability distributions, in which all possible outcomes (on the X axis) have equal probabilities:



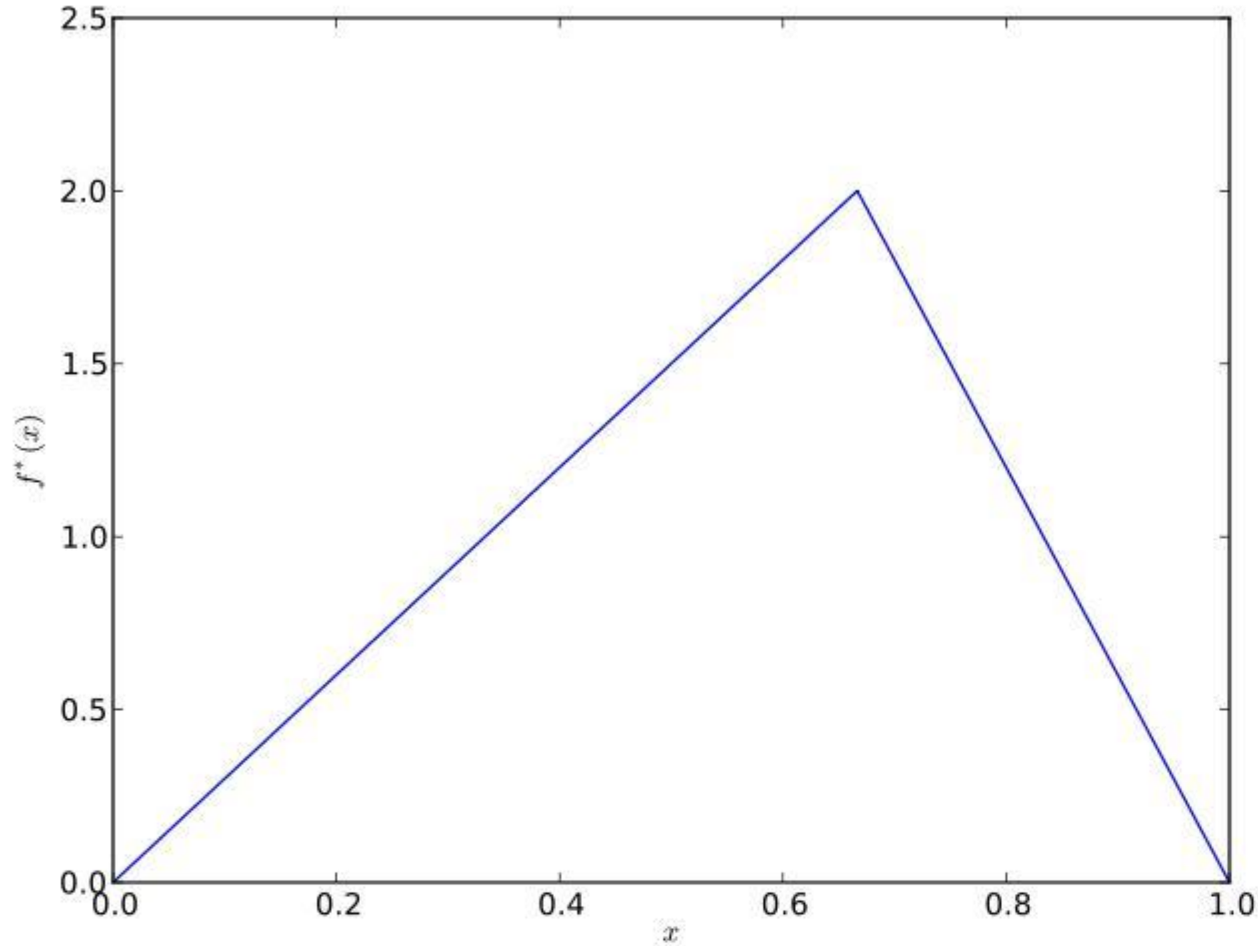
Here are four examples of normal ("bell curve") probability distributions, in which the highest probabilities occur nearest the horizontal center of the distributions, but then tail off as we approach the extremes:



Here are five examples of the Gamma distribution, where higher probabilities are concentrated asymmetrically somewhat more toward the left end of the horizontal axis, gradually tailing off as we move to the right:



And here is an example of an asymmetric triangular distribution:



In addition to the above examples, there are many other types of probability distribution; and each type can have many different shapes. So a best-case/worst-case method of defining only two possible extreme outcomes is a rather imprecise method that does not reflect reality very well. Knowing, or at least being able to surmise the shape of the probability distribution, will tend to be a much more accurate and successful approach to assessing and managing risk.

What-If Analysis

This method is still popular among many business managers. It typically involves the testing of many more scenarios than just "base case," "worst case" and "best case" outcomes, so it tends to be somewhat more accurate. But there are several problems associated with this approach. For example, the values of the input variables are usually selected based on the manager's judgment, which may lead to a substantially biased output variable. And managers simply don't have the time to select a large number of random values to test manually for all of the input variables across the entire presumed ranges of the variables.

In addition, even if a manager could take the time to create a large number of scenarios, the resulting output from all these scenarios would be difficult to interpret, explain and justify to management, who must make a single, final decision. And finally, this approach suffers from the same limitation we saw in connection with the best-case/worst-case method: it doesn't provide a sufficiently formal way to estimate the probability distributions of either the input variables or the output variable.

Simulation

Because of the severe limitations of the other two major approaches to risk analysis, managers are increasingly turning to the more sophisticated and accurate simulation approach. Simulation allow us to factor in the influences of many random input variables to determine the likely impact on a random outcome variables. This method insures that the values of the input variables are assigned in an unbiased way, and without the manager's having to spend a lot of time trying to decide what all these values should be.

With the use of modern computers, we can randomly generate a large number of sample values for each input variable, and then determine the impact of these various values on the output variable(s), or "performance measure(s)," of interest to us. This approach also provides us with useful statistics to help guide our decision, e.g.:

- A probability distribution of the possible values of the performance measure
- An estimate of the mean and variance of the probability distribution
- An estimate of the probability that the value of the performance measure will be greater than or less than a particular value
- A statistical confidence interval constructed around the expected value of the performance measure, that shows us how much error there might be in our calculation, and what the true range of the performance measure could be

All of these features of simulation analysis tend to provide managers with a much more realistic estimate of risk and probable outcomes, and this tends to lead to more accurate and successful decisions.

This link takes you to an example demonstrating the application of Monte Carlo simulation risk analysis to a budgeting problem.

And here is an example that combines Monte Carlo risk simulation with Nonlinear Programming to optimize the assignment of management consultants to consulting projects and maximize

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