

Definitions of Accuracy, Errors, Precision, and Confidence

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“How precise and accurate are your forecast results?”

Make sure that you do not confuse several related but very different terms: *accuracy*, *error*, *precision*, and *confidence*. Albeit people tend to use them interchangeably and the concepts are related, they are different and should not be incorrectly used as synonyms.

A simple illustration is in order. Suppose you are a taco shell manufacturer and are interested in finding out how many broken taco shells there are on average in a box of 100 shells. One approach is to collect a sample of prepackaged boxes of 100 taco shells, open them, and count how many of them are actually broken. You manufacture 1 million boxes a day (this is your *population*) but you randomly open only 10 boxes (this is your *sample* size, also known as your number of *trials* in a simulation). The number of broken shells in each box is as follows: 24, 22, 4, 15, 33, 32, 4, 1, 45, and 2. The calculated average number of broken shells is 18.2. Based on these 10 samples or trials, the average is 18.2 units, while based on the sample, the 80% confidence interval is between 2 and 33 units (that is, 80% of the time, the number of broken shells is between 2 and 33 *based on this sample size or number of trials run*). However, how sure are you that 18.2 is the correct average? Are 10 trials sufficient to establish this? The confidence interval between 2 and 33 is too wide and too variable. Suppose you require a more accurate average value where the error is ± 2 taco shells 90% of the time—this means that if you open all 1 million boxes manufactured in a day, 900,000 of these boxes will have broken taco shells on average at some mean unit ± 2 taco shells. How many more taco shell boxes would you then need to sample (or trials run) to obtain this level of precision? Here, the 2 taco shells is the error level while the 90% is the level of precision. If sufficient numbers of trials are run, then the 90% confidence interval will be identical to the 90% precision level, where a more precise measure of the average is obtained such that 90% of the time, the error and, hence, the confidence will be ± 2 taco shells. As an example, say the average is 20 units, then the 90% confidence interval will be between 18 and 22 units with this interval being precise 90% of the time, where in opening all 1 million boxes, 900,000 of them will have between 18 and 22 broken taco shells. The number of trials required to hit this precision is based on the sampling error equation of $\bar{x} \pm Z \frac{s}{\sqrt{n}}$, where $Z \frac{s}{\sqrt{n}}$ is the error of 2 taco shells, \bar{x} is the sample

average, Z is the standard-normal Z-score obtained from the 90% precision level, s is the sample standard deviation, and n is the number of trials required to hit this level of error with the specified precision.

In addition, we can further define the difference between accuracy and precision through a visual example as shown in Figure 1. In this figure, assume that the large circles represent a target where the center of the target is the correct answer. *Accuracy* measures how close the forecast or prediction results are to the real answer. *Precision*, in contrast, measures how tightly clustered is the forecast dispersion. Of course, we would like something to be both accurate and precise, but accuracy can only be measured from historical or comparable data (e.g., Root Mean Square Error or R-Squared Coefficient of Determination, applying backcasting and matching historical data with backcast-fitted predictions), whereas precision can be controlled in Risk Simulation through adding additional simulation trials. So, simulating more trials will add precision, but not guarantee accuracy.

Errors and Precision Control in Risk Simulator

One very powerful tool in Monte Carlo risk simulation is that of precision control. For instance, how many trials are considered sufficient to run in a complex model? Precision control takes the guesswork out of estimating the relevant number of trials by allowing the simulation to stop if the level of prespecified precision is reached. The precision control functionality lets you set how precise you want your forecast to be. Generally speaking, as more trials are calculated, the confidence interval narrows and the statistics become more accurate. The precision control feature in *Risk Simulator* uses the characteristic of confidence intervals to determine when a specified accuracy of a statistic has been reached. For each forecast, you can set the specific confidence interval for the precision level.

Figures 2, 3, and 4 illustrate how precision control can be performed on multiple simulated forecasts in *Risk Simulator*. This feature prevents the user from having to decide how many trials to run in a simulation and eliminates all possibilities of guesswork. Figures 2-4 illustrate the forecast chart with a 95% precision level set in *Risk Simulator*.

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A Visual Representation of Accuracy versus Precision

Figure 1. Accuracy measures how close the forecasts or predictions are to the real answer (center of the target). Precision, in contrast, measures how tightly clustered the forecast dispersion is.

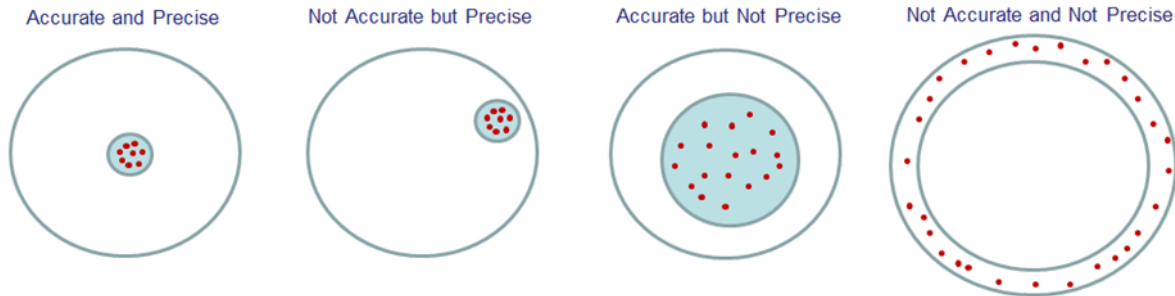


Figure 2 (Left) and Figure 3 (Right). Figures 2 and 3 illustrate precision computations on the simulated forecast chart in *Risk Simulator*. This feature prevents the user from having to decide how many trials to run in a simulation and eliminates all possibilities of guesswork. In this example, the mean is 0.8267, with a 95% error precision of $\pm 2.3796\%$. This means that the 95% confidence interval of the mean is 0.8267 ± 0.0196 (this 0.0196 value is obtained by taking $2.3796\% * 0.8267$) or between 0.8071 and 0.8463.

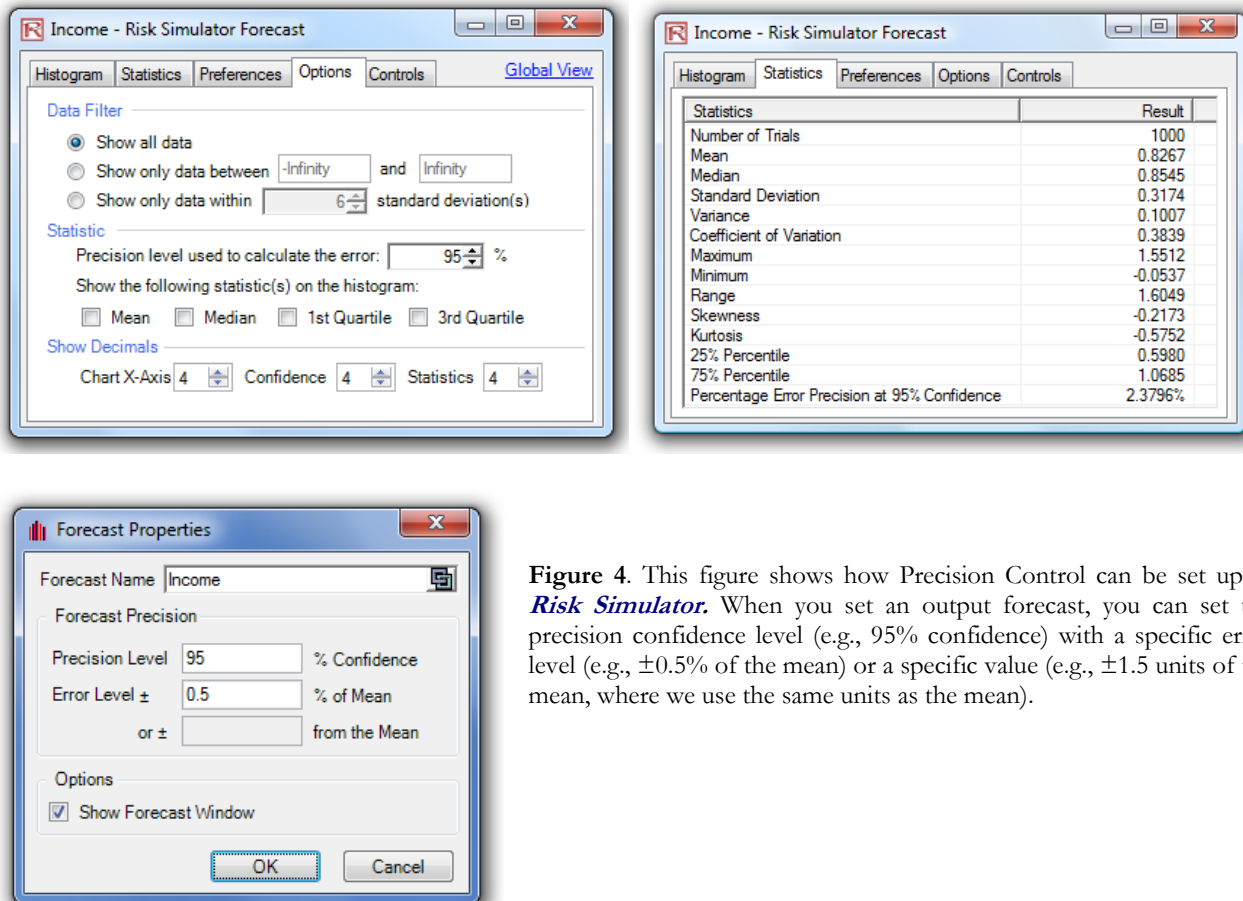


Figure 4. This figure shows how Precision Control can be set up in *Risk Simulator*. When you set an output forecast, you can set the precision confidence level (e.g., 95% confidence) with a specific error level (e.g., $\pm 0.5\%$ of the mean) or a specific value (e.g., ± 1.5 units of the mean, where we use the same units as the mean).