

I want to understand how the various process variables, such as wind and skill and alloy and bullet weight and barrel maker, affect cast bullet group size.

Chance or Luck affects about all outcomes of processes where there is variation. Cast bullet weight has variation, and there is a probability that one might cast eleven bullets in a row with the same weight to .1 grains. The chance or probability of doing so one hundred and eleven times is less.

Here I call the set of shooter, equipment and conditions the "Shooter".

Each and every Shooter has a jillion group average group size, the population average group size. This population average group size is called "X bar".

The standard deviation of group size is determined by the number of shots in the group and the group size. For 5 shot groups the standard deviation is .269 times group size-a 1" population average group size has a standard deviation of .269".

This standard deviation is called "Sigma X".

Sets of groups, such as those at CBA National Matches, are averaged into an "aggregate" or "agg", and a Shooter agg has an average and standard deviation.

The number of groups in the set is called "n", so that when 4 groups are averaged, $n = 4$.

The "Central Limit Theorem" tells us that:

The agg average = X bar.

The agg standard deviation = $\text{Sigma X bar} / \text{the square root of } n$ and is called "Sigma X bar".

And the distribution of agg X bar is "normal" or "bell-shaped".

The aggs of a Shooter are distributed normal, with average X bar and standard deviation Sigma X bar; and when we know the shape, average and standard deviation of a variable we know everything about it.

"Monte Carlo Simulation" is a method of calculating results when the relationship between variables is understood. In EXCEL we can tell the computer to write a random, normally distributed value with a certain average and standard deviation. I used an average or X bar of 1 and a standard deviation or Sigma X bar of $.269/n^{.5}$, and told the computer to calculate many thousands of these values. And it did.

These thousands of values are the aggs when a Shooter with X bar = 1 and Sigma X bar = $.269/n^{.5}$, a Shooter that averages 1 size groups, fires thousands of f group aggs. Some are >1, some are <1. some are < .5, some are > .8. They vary.

Shooter 1 X bar < Shooter 2 X bar < Shooter 3 X bar < Shooter 4 X bar < Shooter 5 X bar. I estimated X bars for 4 other shooters, I'll explain below, and made the computer calculate the Monte Carlo estimates for all five shooters with different X bars and Sigma X bars. These are in 5 columns labeled "Shooter 1" through "Shooter 5".

In the next 5 columns to the right the computer calculated the minimum value in the row of the 5 columns of Monte Carlo estimates/the value of the Shooter 1 row; then over Shooter 2 row, etc.

The values might be, for example (no decimals for simplicity):

S1 S2 S3 S4 S5

3 2 4 7 6 for the Monte Carlo estimates.

In the next 5 columns we calculate the minimum of 3,2,4,7,6; which is 2, and then calculate the minimum/estimate, which is $3/2$, $2/2$, $4/2$, $7/2$, $6/2$ or 1.5, 1, 2, 3.5, 3.

Only one of these values = 1, and that 1, in this example, is in a column headed "Shooter 2 Wins". In this case, one of thousands, the Shooter 2 agg is the lowest of all 5.

At the top of the columns we ask the computer to count the number of 1s in the column below, and get the number of match wins for each shooter.

Monte Carlo simulations are commonly done with hundreds of thousands or millions of iterations. I used 10,000 and recorded the results so, for example:

S1 S2 S3 S4 S5

8135 1343 394 86 42

Recalculated and recorded the results 10 times, and averaged the results.

Because I used "1" for the Shooter 1 X bar or average group size, all the results are in percent.

This was done for both 4 and 5 group aggs, that's where the table comes from.

This is in "CHANCE OR LUCK.xls"

How about those other X bars? Where did they come from?

For the CBA NM results for HVY, PRO, PBB, UNR, for 2000 to 2013, I extracted the 1st through 5th agg; averaged each way, and ended up with a set of numbers.

Shooter 2 X bar was 1.2 times Shooter 1 X bar.

Shooter 3 X bar was 1.33 times Shooter 1 X bar

Shooter 4 X bar was 1.47 times Shooter 1 X bar

Shooter 5 X bar was 1.55 times Shooter 1 X bar.

So, I used 1.2, 1.33, 1.47 and 1.55 as the Shooter 2 through 5 X bars in the Monte Carlo simulations.

This is in "CBA NATIONAL MATCH GROUP 5 SHOT 12345.xls"