

Assignment-1 DMS624

Monte Carlo Simulation: Expected Profit

Why Monte Carlo?

When dealing with many varying parameters, calculating the expected value directly can be very difficult. Calculating profits contains many varying parameters such as No. of leads per sale, cost of single lead etc.

Monte Carlo method approximates the expected value by simulating many random samples from the system and averaging the results. It handles high-dimensional problems by focusing on random samples rather than exhaustive calculation.

Problem statement:

Predicting the expected value of profit based on various parameters.

Parameter:	Range:
• Profit per sale(P)	- 47-53
• Number of leads per month(L)	- 1200-1800
• Conversion rate in percentage(R)	- 1%-5%
• Cost of single lead(C)	- 0.2-0.8
• Fixed overhead(F)	- 800

Simulating Using Excel

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1															
2															
3	Variables	Min	Max											Iteration	Average
4	P	47	53											10	604.274111
5	L	1200	1800											100	772.3819024
6	R	1%	5%											1000	656.6088141
7	C	0.2	0.8											10000	691.1763909
8														100000	697.944385
9	Constant														
10	F	800													
11															
12															
13															
14															
15															
16															
17															
18															
19															
20															

Simulation						
S.No.	L	R	P	F	C	Y
1	1307.546	4.1144964043314500%	51.70056	800	0.55386	1257.237
2	1628.983	3.5972704078834800%	48.19918	800	0.402336	1369.021
3	1735.402	4.7771580504088600%	49.0953	800	0.480473	2436.329
4	1490.824	4.0009933909580800%	48.30994	800	0.439747	1425.994
5	1274.411	1.1330998873347000%	49.92748	800	0.221503	-361.316
6	1425.645	1.2828480678261900%	51.43972	800	0.625923	-751.571
7	1772.58	2.2526716672333600%	47.46802	800	0.586814	55.24271
8	1465.053	2.5317035457218000%	50.29006	800	0.573737	224.7423
9	1257.356	2.2060758056366700%	49.78066	800	0.649716	-236.097
10	1693.433	2.2583751510809500%	51.83875	800	0.330315	623.1587
11	1255.613	1.1636993414197000%	49.07298	800	0.53168	-750.551

Legends	
P	Profit Per Sale
L	Number of leads per month
R	Conversion Rate in percentage
C	Cost of Single lead
F	Fixed Overhead
Y	Profits

Theoretical Method

$$\begin{aligned}
 E\left(L \cdot \left(\frac{R}{100}\right) \cdot P - (F + L \cdot C)\right) &= E\left(L \cdot \left(\frac{R}{100}\right) \cdot P\right) - E(F + L \cdot C) \\
 &= E(L) \cdot E\left(\frac{R}{100}\right) \cdot E(P) - E(F) - E(L) \cdot E(C) \\
 &= 1500 \cdot \frac{3}{100} \cdot 50 - 800 - 1500 \cdot 0.5 \\
 &= 700
 \end{aligned}$$

Note In above equation random variables L, R, P, C are independent that's why we can use $E(X.Y) = E(X).E(Y)$ where X and Y are random variables. And also the expected value of a uniformly distributed random variable X is $E(X) = (a+b)/2$ where $X \sim U(a,b)$.

Result

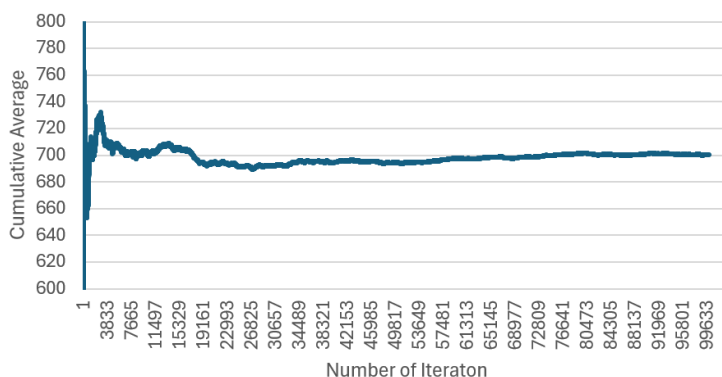
The monte carlo simulation yielded an expected profit of approximately **699.39**. This was calculated by averaging the profit outcomes from all **1,00,000** simulation runs.

The theoretical method yields an expected value of **700**.

Justification

Monte Carlo Simulation relies on this principle by generating a large number of random samples and using the average of these samples to estimate the expected value. The **Law of Large Numbers** ensures that this average becomes increasingly accurate as the number of simulations grows.

We considered the result from 1,00,000 simulations as the expected profit because when we conducted the simulations, we observed that the profit value did not change significantly between 1,000, 10,000 and 1,00,000 simulations.



$$\bar{X}_n \xrightarrow{\text{a.s.}} \mu \quad \text{when } n \rightarrow \infty.$$

$$\Pr\left(\lim_{n \rightarrow \infty} \bar{X}_n = \mu\right) = 1.$$

The cumulative average graph stables after a particular number of iterations which supports the law of large numbers.

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