

NET PRESENT VALUE SIMULATING WITH A SPREADSHEET

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***Abstract:** Decision making has always been a difficult process, based on various combinations of objectivity (when scientific tools were used) and subjectivity (considering that decisions are finally made by people, with their strengths and weaknesses). The IT revolution has also reached the areas of management and decision making, helping managers make better and more informed decisions by providing them with a variety of tools, from the personal computers to the specialized software. Most simulations are performed in a spreadsheet, because the number of calculations required soon overwhelms human capability.*

***Key words:** decision making, simulation, net present value*

1. NET PRESENT VALUE AND SPREADSHEET SIMULATION

Decision making has always been a difficult process, based on various combinations of objectivity (when scientific tools were used) and subjectivity (considering that decisions are finally made by people, with their strengths and weaknesses). The IT revolution has also reached the areas of management and decision making, helping managers make better and more informed decisions by providing them with a variety of tools, from the personal computers to the specialized software.

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in a spreadsheet, because the number of calculations required soon overwhelms human capability. Simulations can be performed with spreadsheets alone (without the help of special add-in software), so that there is no need for expensive software in order to perform this kind of simulations. Such an application is the Oracle Crystal Ball, used for predictive modeling, forecasting, simulation, and optimization, providing insight into the critical factors affecting risk. Using this type of simulations, the right tactical decisions can be made in order to reach the objectives set.

These types of simulations are not confined to the financial area, as they can be used in many domains of

the defense resource management process. In this paper I would like to focus on a possible financial use of the simulations, more precisely in a capital budgeting example, in order to establish some important facts about the output from a spreadsheet simulation.

1.1 OFFSHORE PATROL VESSEL: ADDING A NEW PRODUCT LINE – a case study

This kind of simulation may be used, for example, in the case of a new-product development – a new OPV. Even if the capacity of producing the OPV exists within the country, the decision makers are still faced with the dilemma of choosing between domestic and foreign producers, based on the production (and subsequently the acquisition) cost. The current production capacity of the domestic producer may generate an acceptable production cost, but the decision makers need to have an accurate idea about the financial implications of requesting more products (meaning a possible addition of a new product line).

This information can be easily obtained with the use of simulation in spreadsheets, using startup costs for the proposed new model (which include extensive research and design, building a prototype, and so on). Supposing these costs are estimated at \$150,000 (in thousands), the new OPV would

be sold at a price of \$35,000 (in thousands) per unit. Fixed costs (the costs which are not dependent on the level of activity and have to be covered even if the production is 0) are estimated to run at \$15,000 (in thousands) per year, while variable costs (costs which change in proportion with the level of activity – such as the cost of raw materials) are about 75% of revenues each year.

Tax depreciation (depreciation is first subtracted to determine before-tax profit and then added back to determine net cash flow) on the new equipment would be \$10,000 (in thousands) per year over the expected 4-year product life of the new OPV. The salvage value of the equipment at the end of the 4 years is uncertain, so we conservatively estimate it to be zero. OPV plant cost of capital is 10%, and its tax rate is 34%.

The most uncertain aspect of the proposal is the demand for the new product. In case the demand is known, the *Net Present Value* (NPV) of the proposal can be easily calculated, using a spreadsheet model.

The net present value (NPV) or net present worth (NPW) is a method for evaluating the profitability of an investment or project. The net present value of an investment is the present (discounted) value of investments in the future, also determined as the present value of an investment's

future net cash flows minus the initial investment.[1] If positive, the investment should be made (unless an even better investment exists), otherwise it should not. The present value analysis is a useful concept in decision making with positive results for guiding the inter-temporal choices, because when we study the decision-making process, we have to take into account the role of time in this process. The tie of cash flows is relevant for the decision-maker because in a period of time, the master rate, the inflation can generate gains or especially losses. This analysis regarding the time factor is also available in the case of choices involved in saving and consuming over time.

By recognizing the time value of money and equating dollars from different years, net present value makes it possible to evaluate long-term investments. Accurately estimating the cash inflows and outflows for the net present value calculation is not easy, and selecting an appropriate discount rate for net present value is also difficult. Nevertheless, net present value is a valuable tool for analyzing capital projects and other investments.

NPV is a central tool in discounted cash flow analysis, and is a standard method for using the time value of money to appraise long-term projects. Used for capital budgeting, and widely throughout economics, finance,

and accounting, it measures the excess or shortfall of cash flows, in present value terms, once financing charges are met.

The NPV is calculated using the following formula:

$$\frac{R_t}{(1+i)^t} \quad (1)$$

where

t - the time of the cash flow

i - the discount rate (the rate of return that could be earned on an investment in the financial markets with similar risk.)

R_t - the net cash flow (the amount of cash, inflow minus outflow) at time t .

The uses of money also implies in time a certain opportunity cost. A key concept in economics, the opportunity cost is the next-best choice available when having a choice between several mutually exclusive choices. Opportunity cost has been described as expressing "the basic relationship between scarcity and choice." [2], playing a key role in ensuring that scarce resources are used efficiently, at company, ministry or country level. Opportunity costs are not restricted to monetary or financial costs: the real cost of output forgone, lost time or any other benefit that provides utility should also be considered opportunity costs. In this respect, managers prefer only projects with returns, which exceed the cost of

After generating a *random demand* for this probability distribution in Crystal Ball, and repeating this a few times, we find that on some trials we obtain a negative NPV.

The Fig. 3 shows that the NPV corresponding to a random sequence of demands is \$184.57, about 98% less than the NPV if demand were constant at 10 per year. If we repeat the process, we get a different sample of demands, and hence thus possibly a different NPV. Because the demands can vary from sample to sample, the NPV can also vary. Put more technically, the demands are random variables. So the NPV is also a random variable.

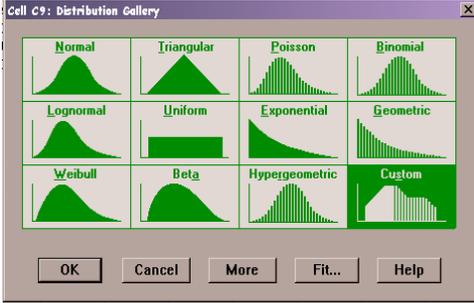


Fig. 2 NPV distribution gallery

Assumptions		Demand Distribution			
	Value	Probability			
Startup Costs	\$ 150,000	Variable Costs	75% of Revenue		
Selling Price	\$ 35,000	Cost of Capital	10%		
Fixed Costs	\$ 15,000	Tax Rate	34%		
Depreciation/Yr	\$ 10,000	Demand/Yr	11,0 units	10	0,2
			11	0,2	
			12	0,2	
	Year 0	1	2	3	4
Demand		9,0	12,0	8,0	8,0
Revenue		315,000	420,000	280,000	280,000
Fixed Cost		15,000	15,000	15,000	15,000
Variable Cost		236,250	315,000	210,000	210,000
Depreciation		10,000	10,000	10,000	10,000
Profit before Tax		53,750	80,000	45,000	45,000
Tax		18,275	27,200	15,300	15,300
Profit after Tax		35,475	52,800	29,700	29,700
Net Cash Flow	(150,000)	45,475	62,800	39,700	39,700
Net Present Value		\$184,57			

Fig. 3 Net Present Value Simulation

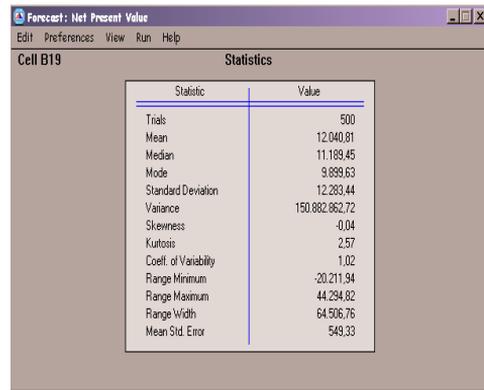
We need to build a simulation model to answer two questions:

- *What is the mean or expected value of the NPV?*
- *What is the probability that the NPV assumes a negative value?*

The larger the mean NPV – and perhaps even more important – the less likely is that the NPV is negative, the more attractive the proposal to add the new OPV to the OPV product line.

The next step is to run the simulation automatically a number of times and capture the resulting NPV. This can be done much more easily with Crystal Ball than the spreadsheet alone.

The numbers generated will not exactly match those shown in Figure 4, as the procedure shown here generates a random sample of 500 trials from an infinite number of possible outcomes. Hopefully, the overall characteristics of the sample should be similar to the ones shown here. Based on this sample the results indicate that the estimated mean NPV is \$12,040.81 and the standard deviation is a rather large \$12,283.44. This is much closer to the true mean NPV than you would generally get with the limited number of trials you would run with the spreadsheet alone.



Statistic	Value
Trials	500
Mean	12,040.81
Median	11,189.45
Mode	9,899.63
Standard Deviation	12,283.44
Variance	150,882,862.72
Skewness	-0.04
Kurtosis	2.57
Coeff. of Variability	1.02
Range Minimum	-20,211.94
Range Maximum	44,294.82
Range Width	64,506.76
Mean Std. Error	549.33

Fig. 4 NPV simulation statistics

We also need to know what are the best possible outcome as well as the worst. We can see in figure 6 that the largest NPV was \$44,294.82 and the smallest was -\$20,211.94, which gives a better idea about the range of possible NPVs that could occur (almost \$65,000).

Although this information offers more insight than just the base case NPV, there other factors that should be taken into consideration. How likely are these extreme outcomes (best case, worst case) to occur? In order to answer this question, we need to know something about the shape of the distribution of the NPV, with the help of some built-in features of Crystal Ball.

One of the interesting features of Crystal Ball is that it has already tabulated a tremendous amount of statistical and graphical information. Some of the information is automatically displayed; other pieces of information must be asked for. As an example of some information we

have to ask for, suppose we want to determine the exact probability that the NPV will be no positive (≤ 0). Crystal Ball can automatically return the percentage number in the corresponding percentile cell labeled “Certainty_____%”. In this case it returns 17.0%, meaning that 17% of the observed NPV values were less than or equal to 0. In like manner we could find out percentage fell below or was above any arbitrary dollar amount.

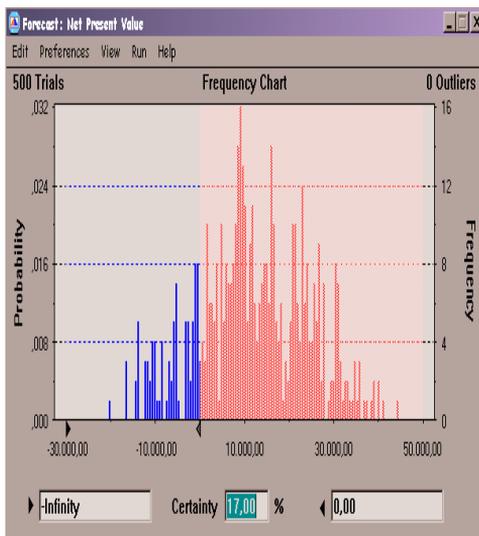


Fig. 5 Frequency chart

Now we have the answers to the questions about NPV distribution:

- What is the mean value of the NPV? (Answer: \$12,040.81)
- What is the probability that the NPV assumes negative value? (Answer: 17.0%)

But other questions arise: How much confidence do we have in the answers we came up with? Would we have more confidence if we ran

more trials?

Certainly, it is intuitive that the more trials we run the more confidence we should have in the answers. But how much confidence can we have in the 500 iterations we have actually sampled? From the world statistics, we remember that we can construct confidence intervals based on the results obtained. For example, we can have 95% confidence that the true mean NPV is contained in an interval of ± 1.96 standard deviation about the estimated mean. In this case, the standard deviation of the mean is the reported standard deviation of the sample divided by the square root of the number of trials.

	A	B	C	F
1	Crystal Ball Results			
2				
3	Mean	\$12,040.81		
4	Std Dev	\$12,283.44		
5	# Iterations	500		
6				
7	95% Confidence Interval			
8	Upper Limit	\$ 13,117.50		
9	Lower Limit	\$ 10,964.12		
10				

Fig. 6 NPV with 95% confidence

This 95% confidence interval for the mean was calculated and is reported in Figure 6 as (\$10,964.12; \$13,117.50). In other words, we can have 95% confidence that the true mean NPV is somewhere between \$10,964.12 and \$13,117.50, with the current best guess that it is \$12,040.81. This interval is tighter than the one we generally develop with a spreadsheet alone where a

smaller number of iterations would generally be used.

3. CONCLUSIONS

We must be careful to avoid falling in the “expected value” trap. Apparently, the true mean NPV can always be calculated by setting all the random values to their means (set all the demands to 10 in this example). This is what we had in our initial spreadsheet, but there is no guarantee that the NPV obtained in this manner will always be true simulated mean. Although it may seem logical, there are some potential weaknesses in this reasoning. First of all, the way in which the random demand values are used to calculate yearly cash flows and then turned into a single NPV number (or any another performance measure) could be highly nonlinear.

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