

Excel Self-Assessment Exercise -- ESD 70

Exercise prepared by: Prof. Richard de Neufville and Tao Wang.

Last updated: August 28, 2008

Problem inspired by Copeland, T. (2002) "The Growth Ladder," Harvard Business School Case N9-202-098, Rev: March 8.

Instructions:

- Read and think about the exercise only, there is no need to complete it.
- If you are sufficiently proficient in Excel, you should be able to complete this exercise in a morning.
- If you feel that it is beyond you or would take a long time, you need to gain the proficiency needed for ESD 71 – Engineering Systems Analysis for Design. You should follow ESD 70 – either for credit or as a listener.

Exercise: Big or small?

A manufacturer is considering two investment programs to supply a new PC. Market research anticipates rapid market growth: sales are expected to be 300,000 the first year, 600,000 the second, and 900,000 the third. However, the company recognizes that actual sales may differ by plus or minus 50%.

The company has two plans to produce 900,000 units:

- **Plan A.** Build a single plant that could produce 900,000 units. Construction would cost \$900 million and be finished in a year. The company would net \$2,000 per computer sold, and the incremental manufacturing costs beyond the capital cost of the plant is expected to be \$1,280 per computer.
- **Plan B.** Build three 300,000 unit plants, one each year, in an effort to match expected annual demand. The capital expenditure for each small plant is \$300 million. The smaller plant has a unit manufacturing cost of \$1,500. This plan gives the company the flexibility not to build successive plants if the demand falls short in the first or second year.

Note that both plans have drawbacks:

- Plan A involves a large amount of excess capacity in the first two years until market demand grows; and there is always a chance that demand falls short of expectations. Thus the demand in year 3 might be as high as 1.35 million or as low as 450 thousand units.
- Plan B is less efficient. Also, if the demand grows faster than expected, it cannot take advantage of it.

The CFO asks you to prepare spreadsheets to analyze this decision. As the company will want to carry out extensive sensitivity analyses on the spreadsheet, all the input variables must be set in an input sheet, so that the rest of the spreadsheet will be an automated black-box that generates the required results.

Step 1: Based on the forecast demand expectation without variability, set up a spreadsheet to calculate the net present values (NPVs) for Plan A, and Plan B with an inflexible expansion plan (build one plant each year regardless of market demand). Based on this first analysis, which plan is better? See end of exercise for assumptions you should use for the NPV analysis.

Step 2: Now consider the effect of uncertain market demand. Assuming that the market forecast is evenly distributed over the range, simulate the performance of Plan A, and Plan B without the flexibility.

- Generate random demand scenarios and use “Data Table” function to simulate 2000 scenarios for both plans;
- Get the maximum, minimum, and expected NPVs for both plans;
- Draw the histogram for the distribution of NPVs and the cumulative distribution function (i.e, the Value at Risk and Gain (VARG) curve) and
- Determine the probability that the company loses money (NPV is less than 0) for each plan.

Step 3: Embed flexibility into Plan B, that is, give the company the opportunity to decide not to construct one or two smaller plants, into the sheet for Plan B. Use the decision rule that the next small plant is not built if the demand is less than capacity.

- Simulate the performance of Plan B with this flexibility;
- Get the maximum, minimum, and expected NPVs ;
- Draw histogram for the expected NPVs and the VARG curve;
- Determine the probability that the company loses money;
- Comparing the results for Plans A, B with and B without flexibility, what are your observations and recommendation?

Step 4: Now, suppose the Chief Engineer reports that the manufacturing cost per computer for the big plant can be reduced. Determine the maximum of this cost such that Plan A is still favored, using the “Goal Seek” function.

Assumptions for NPV analysis:

- Use a discount rate of 9% for Plan A, and 8% for Plan B.
- No salvage value for Plan A at year 3. Salvage value for Plan B is \$300 million at year 3.
- No corporate overhead or selling costs allocated to the projects.
- For simplicity, assume that a new PC line will replace the product in the 4th year so that there will be no sales in year 4 and beyond.