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1.133 M.Eng. Concepts of Engineering Practice
Fall 2007

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1.133 Fall 2007

Assignment 2b
"Financing a CEE Project"
(From C. Martland)

Assigned: September 19, 2007
Due: Team Excel spreadsheet and Powerpoint presentation emailed to Aaron Tuesday September 25th 9pm.
Individual Excel spreadsheet emailed to Aaron by Wednesday September 26th before the in-class discussion/presentation.

Financing a Skyscraper

A simple cost model for the construction of a skyscraper could be based upon the following:

- a. The land area (acres) and the price of the land (\$0.1 to \$10 million/acre)
- b. The costs of clearing the land (\$10 to \$50,000/acre)
- c. The foundation (\$2-4 million/acre)
- d. The weight-bearing structure
- e. The exterior of the building, including windows, exterior materials, waterproofing, and insulation
- f. The elevators
- g. Heating, air-conditioning, ventilation
- h. Creation of a dramatic entry area and mini-parks
- i. Interior walls
- j. Interior finishing

For a CEE project, we are generally considering whether or not to begin a particular type of project. We probably have several basic design and location options plus numerous minor variations on these options, e.g. variations in size or quality of components. From the underlying logic of the project, we can develop a function that relates the project costs to the design and location possibilities. Separate functions can be used to estimate the initial investment costs as well as the fixed and variable operating costs. As engineers, it is our job to try to understand what options are available, including new designs or construction techniques as well as "tried & true" approaches.

Revenues

We also would like to estimate the demand for the services provided by our project, taking into account the quality of the service provided, the capacity of our project and competing facilities, and the price that we and our competitors charge. For a skyscraper, the revenues will be based upon the rental rates, commonly expressed as the annual rent per square foot. A skyscraper makes financial sense if the projected rents (net of any continuing expenses) will be sufficient to justify a mortgage sufficiently large to cover all of the costs of construction, including interest on a construction loan.

Timing and Cost Assumptions

For this assignment, let's just consider the example described by Karl Sabbagh in "Skyscraper". This is a great book describing the people and the processes involved in constructing a 50-story office building as part of a somewhat larger project covering a full block in Manhattan. This problem set considers just the office tower, which has 1.6 million square feet of rentable space.

As is the case with most engineering books, the focus is on the technical rather than the financial matters. Hence, in addition to the information presented in the note (which is about all there is in the book), we need to make some additional assumptions to evaluate various options for the project:

- a. The time between land acquisition (at the beginning of month 1) and the beginning of construction is exactly 18 months. All of the engineering and architectural work is completed during this period.
- b. The time for construction (from groundbreaking until the time that tenants can move in) is exactly 24 months (i.e. months 19 to 42 of the project if the project is completed on time).
- c. The permanent mortgage is obtained 3 months after the tenants move in (at the end of month 45 if the project is completed on time).
- d. The tenants have 4 months (to fix up the interior) before they make their first rent payment (at the end of month 46 if the project is completed on time).
- e. The fixed costs include the land acquisition (\$58 million), preparation of the case for development (\$5 million), the architects and engineers fees (assumed to be \$90 million of the \$145 million for fees and borrowing costs cited in the note), \$45 million of the construction costs (for the foundation, landscaping, entry, lobby and the roof), and \$5 million of the project management costs. These fixed costs will not vary if the number of floors is increased or decreased.

- f. The \$90 million total architect/engineering fees are paid uniformly over the first 18 months of the project; the \$145 million total construction costs are paid uniformly over the period of construction.
- g. The construction could be stretched out over 3 years with a savings in construction of \$5 million and essentially no chance of an overrun.
- h. The project costs are provided on a construction loan with interest of 10% per year charged from the point that costs are incurred, compounded monthly.
- i. The interest rate of the permanent mortgage is 8%, also compounded monthly.
- j. All invoice and loan payments are made on the last day of the month.
- k. Additional space, if available, could likely be rented at \$30/sq. ft. per year or more.

Questions

1. Project Cost (30 points) - Construct a spreadsheet that can be used to calculate the costs of construction, including interest costs on the construction loan. Structure the spreadsheet so that it shows the various cost categories across the top and the months (1 to 48 down the side). Have a column for total monthly cost and another column for the PW of the monthly cost (use discreet discounting compounded monthly). Have an area at the top of the spreadsheet where you can enter key parameters (including interest rate on the construction loan, length of the construction period, and the owner's discount rate) when doing sensitivity analysis. Use the spreadsheet to answer the following questions:

- a. What will the total project cost be as of the end of month 45 when - if all goes well - the permanent mortgage is secured (i.e. estimate the interest costs paid on construction and add it to the other costs to come up with a total budgeted cost comparable to the \$370 million shown in the note).
- b. What is the present worth of the total project cost as of the beginning of month 1 assuming a discount rate of 15% per year (i.e. 15%/12 per month).

2. Project Revenue (20 points) - Assume that the project has one major tenant who pays \$26/sq. ft. for 600,000 sq. ft. and another who pays \$29/sq.ft for 200,000 sq. ft., while all other space is rented at \$30/sq.ft. (these are annual rates per square foot for long-term leases)

- a. Calculate the monthly revenue assuming that the building is fully leased from the outset
- b. Calculate the PW of the total revenue received over a 30-year project life as of the beginning of the first month in which rents are received (use the owner's discount rate of 15%)
- c. Calculate the PW of the revenue as of the beginning of month 1 (using the owner's discount rate of 15%)

d. Compare the PW of the costs (from 1b) and the PW of the revenue (from 2c) and discuss whether this is a worthwhile project (from the owner's perspective).

3. Refinancing (10 points) - Once the building is up and rented, the owner can refinance the building at a lower interest rate, because the bankers now can see the completed building and the paying tenants.

a. Assume that the bank will provide a 30-year mortgage with the maximum amount equal to 80% of the net present value of the rents (calculated with a discount rate equal to the interest rate on the loan). What would the maximum amount of the mortgage be and what would the monthly mortgage payment be?

b. Considering the **owner's** cash flows and the **owner's** discount rate (15%), what is the project now worth to the owner (at the beginning of the first month), assuming that financing will be available?

4. Sustainability (10 points) – Identify two major issues related to the social and environmental sustainability of a skyscraper. Discuss how the design of the project could be altered to make the project more sustainable from both a social and an environmental perspective. (maximum: 1 page)

Questions 1-4 should be answered by each student. Each student should develop their own spreadsheet and email it to Aaron by class on September 26th. After completing their analyses, students within each team may compare their answers to be sure that they have reasonable results before pursuing question 5, which is a team project.

5. Other Issues (30 points) – Group project, to be presented in class. Group assignments are listed at the end of the assignment. Each group will deal with ONE of the following sets of issues:

Question 5 should be submitted as a Team in a separate spreadsheet, along with a Powerpoint presentation (September 25th 9pm). Please email Aaron the group Powerpoint presentations (roughly 4-5 minute duration) and Team spreadsheet by 9pm the night before Wednesday's class (9pm on 25th September).

5A. Sensitivity to cost assumptions: how would the total project cost (as calculated in part 1a) and the PW (as calculated in part 3b) vary if the:

- Construction costs were higher or lower
- Interest rates for the construction loan were higher or lower
- The time required for construction were higher or lower
- The owner's discount rate were higher or lower

Discuss the implications of this sensitivity analysis.

5B. Sensitivity to revenue assumptions and selling the building:

- How would the PW of the project vary (as calculated in part 3b) if the rents increased or declined over the 30-year life of the building? Discuss the implications of this analysis.
- Once the building is refinanced, the owners may get bored simply collecting rents and making mortgage payments. What price should they offer and what is the minimum price that they should accept? (Please think carefully about what factors influence a price and remember that the price must be large enough to pay off your mortgage. “Beauty is in the eye of the beholder.”)

5C. Redesigning the building: suppose that, early in the planning stage, the city planning department offers you a chance to increase the floor area ratio to 15 (which would allow you to add 3 stories and 100,000 sq. ft. of rentable space). All you have to do is provide enclosed, all weather walkways to neighboring buildings as part of a "downtown mall" concept. Building the walkways and adding the extra stories would delay the entire project for 2 months. How much additional cost would you be willing to incur to build the walkways, given that you would also be able to construct and rent the extra space? (Be sure to consider effects on both cost and revenue.)

Request from Board of Directors

We have reviewed our plans for evaluating the new skyscraper with our board of directors. They think the project is pretty good, but they are very worried about risks. They therefore are anxious to hear the conclusions and recommendations of your sensitivity analyses. In fact, they worry that the sensitivity analysis fails to go far enough, so they would like you to consider two rather dramatic changes in design:

Our real estate marketing expert is Ken B. Least, whose firm owns several office buildings and is building two new buildings on the other side of town. He fears that the demand for office space is weakening. He suggests that we also evaluate a smaller project with only 800,000 sq. feet of rentable space, which would be sufficient for the two major clients we already have and much less risky. Our project management team indicates that they could finish construction of the smaller building six months earlier with substantial cost savings.

M. I Green, who helps us with our environmental impact assessments, highlighted the growing interest in “sustainability”. She would like to add some features to the building and its construction to make it more sustainable and therefore a more significant contribution to the city. She suggests that our major tenant might be willing to pay 20-40% additional rent in order to benefit from the positive publicity associated with an innovative building. Yu-Pei Me, our architect (and a cousin of I.M. Pei), loves the idea, and she is excited about designing a “very green” building. Con Kreet, our chief engineer, is less excited, as he believes it would take an extra \$100 million and an extra 6 months to construct the “very green” building, while saving only \$10 million per year in utilities. He claims that we could save occupants \$5 million per year in utilities simply by cutting back on some of the more grandiose architecture in the current plan. We could then build the building with no increase in construction time or expense.

We therefore need to expand the scope of our analysis.

Name	Group	Task
Angeles, Kathryn Patricia Bajoria, Ankur Chauhan, Siddharth	1	5A for base case plus redo 1-4,5A for the smaller building
Ching, Kenneth Dantata, Sanusi DeRogatis, Austin Eid, Serge	2	5B for base case plus redo 1-4,5B for the "very green option"
Fitzpatrick, Daniel Fuller, Pierre Fund, Ariane	3	5C (redo 1-4 for the redesigned building)
Gamaliel, Renard Ghisbain, Pierre Green, Vanessa Harding, Mary	4	5A for base case plus redo 1-4,5A for the "very green option"
Herrero Lopez, Sergio Hodge, Matt Hopkins, Thomas	5	5B for base case plus redo 1-4,5B for the "very green option"
Kamal, Sameer Kikkawa, Izumi Lame, Ali Lavallee, Phillip	6	5C (redo 1-4 for the redesigned building)
Link, Percy Losleben, Tamar Mazzei, David	7	5B for base case plus redo 1-4,5B for the smaller building
Mikelonis, Anne Nazarchuk, Alex Rahimi, Navid Sgardeli, Georgia-Chrysouli	8	5A for base case plus redo 1-4,5A for the smaller building
St. Hilaire, Shaun Stevenson, Matthew Swanton, Andrew	9	5B for base case plus redo 1-4,5B for the smaller building
Sweeney, Raymond Vater, Katherine Wood, Elizabeth	10	5A for base case plus redo 1-4,5A for the "very green option"

The teams should include results for the base case (the building in the Sept. 19th assignment) and for the alternative design in their presentations.

The board did not give specific instructions about what to consider or how to report results. They clearly would like to know if either option is superior to the original plan. The analysis will at least have to consider the information they provided, including:

For smaller building: fewer floors will be needed, so construction costs can be reduced. Rents will only come from two tenants. Construction takes less time.

For very green building: construction will cost \$100 million more and take 6 months longer. Tenants pay for utilities, and may be willing to pay higher rents.