Project Analysis and Evaluation

AEM 2241 - Finance

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Outline

Evaluating NPV Estimates

- Rational investment making relies on computing NPVs (and IRRs). Alternative techniques exist, but are less common, especially in bigger firms.
- All these approaches ultimately rely on cash flow estimates, with emphasis on **estimates**.
- Indeed, in the typical case both the size and timing of the cash flows is uncertain. Sometimes even the sign of future estimated cash flows may be uncertain.
- Uncertainly should not induce decision paralysis. But what do we do?

Issues to Consider

- **Projected** cash flows will generally be different from **actual** cash flows.
- Low quality or inherently hard-to-make projections may lead to incorrect decisions: a good project may be rejected, a bad project may be accepted. This is called **forecasting** (estimation) risk.
- One should also consider alternative approaches.
  - Perhaps one can find a quantitative (numerical) model that offers an alternative, independent view of the project's outcome.
  - Can one identify **sources of value**, perhaps both for the firm (project) and - ideally - also for its clients? Qualitative or semi-qualitative arguments can powerfully support the predictions of quantitative models.

Analytical Wisdom

- An investment decision depends on (a) model assumptions and correctness; (b) data quality; (c) interpretation of results; (d) qualitative analysis.
- You model is - **at best** - as good as the weakest link in the chain above.
- Do your best to make sure that all elements above are of high quality and that you understand them at a level sufficient to gain confidence in them.
- If you do not have the right expertise, hire qualified people whom you can trust. Provide your experts the right incentives to tell you the truth. Listen to their concerns (e.g., about data quality).
- Make sure you **clean** your data and you understand what the various data items mean. Perform many data quality checks!
- Check and question everything again and again!

Analytical Wisdom (2)

- If you can, develop models based on different assumptions, and perhaps even alternative data sources.
- Make models compete - do they predict outcomes that broadly point in the same decision?
- Can you build a **credible** qualitative explanation that supports your model's predictions? If not, you may have a problem. However, **beware of self-deceiving spin**!
- If your model(s) and qualitative analyses point agree, you should gain confidence in the correctness of your decision.
- If your model(s) and qualitative analyses diverge, your should skeptically review your work and try to reconcile the differences. This may not always be possible. Proceed cautiously!

Analytical Wisdom (3)

- If you use the same class of models, watch them over time. In time, you may understand which one(s) provide better forecasts for certain types of projects and/or in certain economic conditions. Trust these models more when similar situations arise!
- Modeling is both a science and an art. Knowledge, intuition, and experience are essential.
- As more data becomes available, modeling is gaining prominence in the business world.

Scenarios

- A model may be seen as a series of calculations that links a series of inputs to a series of outputs. As implemented by many business people, e.g., in Excel, models may seem static - once set up, nothing changes.
- A model without some flexibility built into it is a misused model.
- Scenarios allow one to select groups of model inputs that capture a variety of possible future situations. Scenarios are routinely labeled with terms "best case," "worst case," "average," "most likely," or "expected." Examining the corresponding model outputs is supposed to provide information about the range of possible outcomes, from the best to the worst, as well as about the in-between cases.

Scenarios (2)

- The best and worst case scenarios will not capture truly the most extreme favorable and unfavorable outcomes, respectively. They will typically be confined to situations that may arise with a reasonable probability (say, 5% or 10%, or once in 20 or 10 years, respectively).
- The best case inputs will not all necessarily be highest (most favorable), and the worst case inputs will not necessarily be lowest from among the possibilities considered. Subtle interactions should not be overlooked (e.g., think of substitution effects).
- "Expected" is a loose term - who "expects" what precisely? Is a scenario the expectation of the CEO, the board of directors, a consensus of experts?
- "Expectation" is used in the sense of "most likely", often assumed to be the same as "average." These values could be very different, however!

Combinatorial Explosion

- Scenarios typically capture a small number of cases, and one may be left with little intuition about what happens in the in-between cases.
- For each input variable, one can select a number of representative values from its respective range. One can generate all possible combinations of input values, and examine the output of the model for the respective combination.
- If there are two inputs, each associated with a low value (L), a middle value (M), and a high value (H), the following 8 combinations are possible: (L,L), (L,M), (L,H), (M,L), (M,M), (M,H), (H,L), (H,M), (H,H).
- As the number of parameters and the number of representative values increases, the number of combinations grows very fast, leading to a **combinatorial explosion**.

Simulation Analysis

- Simulation can deal with two major problems:
  - It avoids combinatorial explosion by providing meaningful insight into the model without examining a prohibitive number of cases.
  - It deals with Jensen's inequality. "The expectation of a function is **not** equal to the function of the expectation."
- In simulations, inputs are chosen randomly from the set of possible values and the respective outputs are then generated.
- In simple cases or in low-quality simulations, inputs are selected independently of one another. In realistic, good-quality simulations inputs are chosen randomly, but jointly, from **joint distributions**.
- Simulations can be augmented by examining corner cases that may be overlooked by a completely random process (e.g. best case/worst case).

Simulation Analysis (2)

- Simulation provides information about the average outcome of the model, as well as about the **distribution** of the possible outcomes.
- The output is much richer than a simple scenario analysis, as one can reason probabilistically about individual outcomes, or ranges of possible outcomes.
- Many tools exist that can be used to implement simulations of various degrees of sophistication. Some of these tools are accessible even in Excel (@Risk, Crystal Ball). Excel itself provides limited support for simulation.
- Simulation can be oversold: just because somebody mumbles "Monte Carlo" under their breath, their model can still be mostly garbage.

Sensitivity Analysis

- In sensitivity analysis, all but one (or two) parameters are kept constant, and the remaining parameter is changed in small steps, often around a central value. One can then estimate how big the influence of the changing parameter is on the outputs of the model.
- As the saying goes, "it matters not where we are, but where we are headed."
- Sensitivity analysis provides information on how the output will change if the inputs vary. We can estimate what will happen to our predictions if our inputs are affected by (small) errors.

Sensitivity Analysis (2)

- If a model's sensitivity to inputs is low, then the model is robust, and its predictions may be credible even if the inputs are somewhat rough estimates.
- If a model is sensitive to its inputs, this makes it necessary for these inputs to be estimated very accurately (why?) If this is not possible, the model's outputs may be affected by large errors.
- If a model is **extremely** sensitive to its inputs, especially to values that are hard to determine in practice, then it is often unusable or wrong. E.g., if the model's outcomes will change dramatically if one of its inputs changes by 0.01%, then you should probably not trust it.

Break-Even Analysis

- A project (firm) faces fixed and variable costs.
- Fixed costs are (effectively) independent of the level of production and they are unchangeable over the short term.
- Variable costs are the costs that are directly proportional to the level of production.
- Fixed and variable costs depend on the time horizon, as well as on the nature of the business/project. A cost that is fixed in the short term may be variable in the longer term.
- Some costs may be variable, but depend on the level of production in more complicated ways. For example, you may have to purchase raw materials in bulk; even if you need only 2 yards of cloth, say, you may have to buy 100 yards for the next suit you are making. The leftover cloth will not be used until more suits will be made.

Total, Average, and Marginal Costs

- Notation: total cost = TC; total variable cost = VC; variable cost per unit = v; total fixed cost = FC; average cost = AC; marginal cost = MC.
- Marginal cost is the cost of producing the next (batch) of products or services, given a certain level of production.
- Let q be the level of production (e.g., q could be the number of widgets produced, the volume of soft drinks sold, the number of software packages sold). We have:

$$TC(q) = FC + VC(q)$$

$$AC(q) = \frac{TC(q)}{q} = \frac{FC}{q} + v$$

$$MC = v < AC(q)$$

- These relationships are simplifications. For example, if production level (q) were very high, then $AC(q) \approx v$. In practice, FC would have to increase (e.g., more production plants would have to be built).

More on Costs

- It is often unclear what costs should be allocated to what products and services. If you are producing low-fat milk and butter, say, and some processing steps are shared, what costs should be allocated to these products individually?
- Example: Assume you produce specialty pencils. Leasing a plant costs \$5,000/month, with contracts renewable yearly. Producing a single pencil **as part of a bigger batch** costs \$0.55. You produce 100,000 pencils per year, with capacity to spare. Should you accept an unexpected order of 5,000 pencils at \$0.75 per pencil?

$$VC(q) = v \times q = 0.55 \times 100,000 = \$55,000$$
$$TC(q) = FC + VC(q) = 12 \times 5,000 + 55,000 = \$115,000$$
$$AC(q) = \frac{TC(q)}{q} = \frac{FC}{q} + v = \frac{12 \times 5,000}{100,000} + 0.55 = \$1.15$$
$$MC = v = \$0.55 < \$0.75 = \textit{sale price}$$

- Yes, you should accept the new order.

Accounting Break-Even

- The accounting break-even point is the level of production that results in project net income of \$0.
- For a business to be viable long-term, the selling cost per unit should exceed the marginal cost. This then allows for each additional unit of production to pay for a share of the fixed costs and other expenses (e.g., depreciation).
- The higher the production level, the more non-marginal costs are covered; profit becomes possible at production levels above the accounting break-even point.
- A project may be undertaken even if accounting break-even is not reached every year. For example, (projected) depreciation costs may not be recovered in every year individually, but overall.
- These are simplifications, for example, we ignore tax savings/refunds and subsidies.

Accounting Break-Even: Algebra

- Additional notation: NI = net income; S = total sales; P = selling price per unit; D = depreciation; T_c= tax rate.
- We have:

$$
\begin{aligned}
NI &= (S(q) - VC(q) - FC - D) \times (1 - T_c) \\
0 = NI &\implies S(q) - VC(q) - FC - D = 0 \\
S(q) - VC(q) &= FC + D \\
P \times q - v \times q &= FC + D \\
(P - v) \times q &= FC + D \\
q &= \frac{FC + D}{P - v}
\end{aligned}
$$

- Example: We trade in hard drives. $v = \$3.00$; $P = \$5.00$; $FC = \$500$; $D = \$300$. Then $q = \frac{FC+D}{P-v} = \frac{500+300}{5-3} = 400$. We must sell 400 hard drives to break even on an accounting basis.

Cash Break-Even

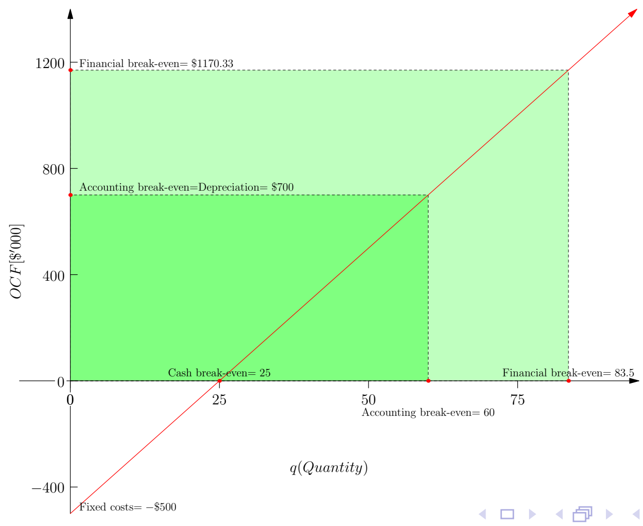
- Depreciation is a non-cash expense, as such we do not need cash to finance it (after the capital investment was made).
- We may be interested in the production level at which the project generates positive cash flow, even if depreciation is not covered. Setting $D = 0$ in the formulas above we get:

$$q = \frac{FC + D}{P - v} = \frac{FC}{P - v} = \frac{500}{5 - 3} = 250.$$

- Note that the production level for cash break-even is **below** the production level for accounting break-even.
- Projects that do not reach cash break-even must find sources of financing to cover the missing cash. This is difficult to sustain in the long term.
- Businesses may be kept "alive" if they are cash-flow positive, even if they never pay for their initial capital investments (which become sunk costs, and may be written off as losses).

Financial Break-Even

- Financial break-even is reached when the NPV of the operating cash flows is equal to the NPV of investments.
- This is the most interesting quantity to examine, as it marks the turning point that ultimately makes the business viable.
- Wettway example from textbook (section 11.4):



Operating Cash Flows and Break-Even

- $OCF = EBIT + D$ (we ignore taxes!)
- $EBIT = S(q) - VC(q) - FC - D$
- $OCF = [(P - v) \times q - FC - D] + D = (P - v) \times q - FC$
- Production level that corresponds to a given OCF: $q = \frac{FC+OCF}{P-v}$.
- Accounting break-even = OCF just equals depreciation: $q = \frac{FC+D}{P-v}$.
- Cash break-even = fixed costs, but not depreciation are covered: $q = \frac{FC}{P-v}$.
- Financial break-even = OCF is set to the value required for the NPV to be equal to 0: $q = \frac{FC+OCF^*}{P-v}$. In a realistic case this would be a multi-year calculation.

Example: Costs and Break-Even

A firm produces sunglasses. The variable materials cost is \$11.13 per unit, the variable labor cost is \$7.29 per unit. The company incurs incurs fixed costs of FC=\$875,000 during a year in which total production is q=190,000. The selling price is S=\$44.99 per unit; depreciation is D=\$435,000 per year.

- What is the variable cost per unit?
  $v = 11.13 + 7.29 = \$18.42.$
- What are the total costs for the year?
  $VC = q \cdot v = 190,000 \cdot 18.42 = \$3,499,800.$
  $TC = FC + VC = 875,000 + 3,499,800 = \$4,374,800.$
- What is the average cost? Marginal cost?
  $AC = \frac{TC}{q} = \frac{FC}{q} + v = \frac{875{,}000}{190{,}000} + 18.42 = 4.61 + 18.42 = 23.03.$
  $MC = v = \$18.42.$

Example: Costs and Break-Even (2)

- What is the cash break-even production level?
  $q = \frac{FC}{S-v} = \frac{875{,}000}{44.99-18.42} = 32,931.88 \approx 32,932$ units.
- What is the accounting break-even production level?
  $q = \frac{FC+D}{S-v} = \frac{875{,}000+435{,}000}{44.99-18.42} = 49,303.73 \approx 49,304$ units.
- Note that the production level that corresponds to the accounting break-even is higher than that of the cash break-even. This is because the former also has to cover depreciation.
- Financial break-even, when the NPV of the project becomes 0, corresponds to an even higher production level.

Example: Sensitivity Analysis

- What is the sensitivity of the average production cost to changes in the production level for the current yearly production of $q = 190,000$ units?
- We pick q' "close" to the given q. Let $q' = 190,100$ units. We compute $AC' = \frac{TC'}{q'} = \frac{FC}{q'} + v = \frac{875{,}000}{190{,}100} + 18.42$. We get $AC' = \$23.0228$.
- Sensitivity of the average cost to changes in production levels $s = \frac{AC' - AC}{q' - q} = \frac{23.0228 - 23.0253}{100} = -\$0.000025/\text{unit}$.
- The sensitivity is negative, since the per-unit cost is decreasing.
- Interpretation: In the vicinity of the current production level, **each** additional unit produced reduces the **average** cost of all units by s. This is a non-linear sensitivity - it will be different at different production levels.

To Do!

- Read and understand the slides that may have not been covered in lecture (if any).
- Read the following sections of your textbook:
  - Section 11.4: "Operating Cash Flow, Sales Volume, and Break-Even";
  - Section 11.5: "Operating Leverage";
  - Section 11.6: "Capital Rationing".
- As always, use lectures and office hours to ask questions about anything that you may have not understood.