

Capital Budgeting: Applications and Pitfalls

(Welch, Chapter 13)

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Did you bring your calculator? Did you read these notes and the chapter ahead of time?

Expected Cash Flow Distributions

At age 25, male life expectancy is about 52.5 years, female life expectancy is about 57 years. (Life is not fair!)

If you expect to earn \$100,000 per year **extra** because of your degree, if the applicable interest rate / (opportunity) cost of capital is 5%/year, what is your degree worth?

You expect to earn \$300,000/year. Holding money for a drug-dealer would earn you an extra \$100,000 per year if you do not get caught, which is highly unlikely, in any case. Maybe 1 in 1,000. 999 out of 1,000 times, you make a lot more. Morals aside, should you?

Averaging (Opportunity) Cost of Capital

A firm has an (opportunity) cost of capital (hurdle rate) of 10%. It can find a project that offers an expected rate of return of 20% over the same time interval. Does this project add value?

Can firms create value by reducing risk through diversification?

Setup

- ▶ Assume a perfect market. Big deal! Perfect also for TGT.
- ▶ ACQ conglomerate is thinking about taking over TGT corporation.
- ▶ For example simplicity sake, ACQ and TGT both will last only one more year.
- ▶ ACQ expects cash flows of \$500 million.
- ▶ TGT corporation expects cash flows of \$300 million.
- ▶ Companies with characteristics like ACQ offer an expected rate of return of 5% per year.
- ▶ Companies with characteristics like TGT offer an expected rate of return of 8% per year.

ACQ's executives evaluate potential takeover targets by using their *own* cost of capital, not the target's cost of capital. They do however recognize the correct expected cash flows. What do they think the value of TGT is?

TGT True Worth: $\$300/[1 + 8\%] = \277.78 .

ACQ imagines TGT to be Worth: $\$300/[1 + 5\%] = \285.71 .

ACQ would believe that TGT at \$277.78 is undervalued by \$7.94.

Note: in a perfect capital market (and sometimes in an imperfect one, too), the (opportunity) cost of capital is what investors can earn elsewhere in similar projects (similar given risk class, etc.). Thus, they would be willing to give capital also to the firm at this same expected rate of return, too. We can thus infer that the cost of capital should be the expected rate of return (as used in NPV). And, in turn, the firm should take projects as long as this opportunity cost of capital is lower than its own projects, all assuming same risk-etc. class, of course.

ACQ executives make a takeover offer for \$280, which is accepted. What is the value gain/loss to the two shareholders?

Does it matter whether ACQ executives believe the cost of capital is 1%, 3%, or 6%, etc., given their offer of \$280?

ACQ executives finance this takeover offer by issuing a new \$280 million from new shareholders. How much *expected rate of return* do they have to promise to the new shareholders, given that they will hold ACQTGT stock?

ACQ is truly worth $\$500/1.05 \approx \476.19 .

TGT is truly worth $\$300/1.08 \approx \277.78 .

Net Firm Value is truly: $\$476.19 + \$277.78 = \$753.97$.

If no overpayment occurs, ACQ and TGT should truly represent (63.16%; 36.84%) of the firm's \$753.97.

PS: Merged cost of capital is $0.6316 \times 0.05 + 0.3684 \cdot 0.08 \approx 6.1\%$.

(PS: same conclusions on cash offer.)

What share of the overall new firm ACQTGT needs to be given to TGT shareholders to be the equivalent (raising of) \$280 million?

- ▶ The total expected cash flow is $\$500 + \$300 = \$800$.
- ▶ The new TGT shareholders need to be promised $\$280/\$753.97 \approx 37.14\%$ of the new firm.
- ▶ Compare 37.14% to the 36.84% that TGT *should* have gotten.
- ▶ Therefore, old ACQ shareholders own only 62.86% of ACQTGT.
- ▶ Now ACQ own $62.85\% \cdot \$753.97 = \473.97 . Before, it was $\$476.19$. The difference is the $\$2.22$ that the acquiring shareholders have lost in share value.
- ▶ All of this works because TGT had higher CoC due to term or risk, not due to less perfect capital market. If ACQ can improve capital access (and not harm TGT), the acquisition could add value.

More CoC Different-Rate Intuition

Acquiring the target increases the cost of capital for the whole firm from 5% to 6.1%. Buying a more risky (higher beta) firm with a higher expected rate of return is almost like a “negative externality” that the acquiring shareholders need to take into account.

This rejects the “logic” that the new firm can raise capital at 5%. It no longer can!

Upon announcement of the deal, what happens to the shares of ACQ corporation? What happens to the shares of TGT corporation?

TGT shares appreciate from \$277.78 to \$280, i.e., up by \$2.22. ACQ's shares go down by \$2.22 million. (The old shareholders will own 62.85% of a \$753.97 company.)

This is an example in which an acquiring firm loses value because it takes a bad project. We could also construct examples in which an acquirer loses value because it passes up a good project.

For example, if you can invest in some T-bond equivalents at a 5% rate if the market T-bond rate is only 3%, this creates value—but if you use your firm-wide 10% cost of capital that applies to risky projects, then you would incorrectly pass up on this great opportunity.

Terminology: Cost of Capital or Hurdle Rate?

The 8% is called the “cost of capital” for B. This is somewhat misleading, but it is the convention.

Sometimes, it is called the “opportunity cost of capital,” to emphasize that instead of investing in this project, a CEO could spend existing cash balances on other projects with this rate of return. A better name would have been “opportunity rate of return elsewhere.”

Also, it could well be that investors look at the CEO, consider him/her stupid, and ask for 25% if this idiot wants to raise funds from them—and (s)he is stupid enough to take it. In this case, the cost of capital would be 25%. The projects’ cash flows should still have their “appropriate discount rate” of 6%. A better name would have been “appropriate discount rate.”

Now, in a perfect market, we can call it the “cost of capital” because it is assumed to be the cost at which a very smart CEO can raise funding for this project in isolation. Every project [of this risk class] has the same $E(r)$. There is no difference here.

As a manager, in a perfect market: [a] should you use the cost of capital unique to each project and to each project component (8%); or [b] should you use the overall corporate cost of capital at which you last raised capital with (5%), or [c] what you could be raising capital post-acquisition (6.1%)

In a **perfect** capital market: [a] 8%. [b] 5%. [c] 6.1% ?

Everything except 8% leads to a wrong conclusion.

You must use each specific cost of capital. This can be very tedious. If it does not matter too much, then do what most corporations do—fudge numbers.

If a firm raises capital for a construction project that is to-be-built over the next 5 years, and invests the unused cash in Treasuries, how does the fact that the Treasuries offer a lower expected rate of return hurt the company?

Should all General Motors projects have the same hurdle rate?

What about the cost of capital of the manager's desk vs.
the cost of capital of the secretary vs. ...

A.D. 1675 — The spice must flow

- ▶ It is the year of our “lord,” Anno Domini 1675. Spices are worth (way) more than gold. Nutmeg, mace, and cloves only grow in the Moluccas Island (today’s Indonesia).
- ▶ If you buy a ship and set sail, there is a 60% chance that your ship will not return.
- ▶ If the ship does not sink, you can sell your cargo (spices) when it returns (in one year). If the ship makes it back, you expect to sell the spices for \$30,000 (uncertain, depends on market) and you can sell the ship for \$10,000 (for certain, for argument’s sake), too.
- ▶ Upfront, the spices cost \$1,000; the ship costs \$10,000.
- ▶ The spice business has costs of capital of 25%. The ship business has a cost of capital of 5%.

(Think $\beta = 2$, $E(R_M) = 15\%$, $R_F = 5\%$.)

Should you get into the spice trade?

A.D. 1675

Cost of Capital — More detail — Omit

- ▶ In a perfect market, the cost of capital for a zero-systematic-risk but risky project is still the risk-free rate. This is not a mistake. It is because such a project is infinitely parcel-able among many investors. Each investor diversified the risk away.
- ▶ The expected amount of money on the spice trade covaries—that is, you get \$30,000 about when the market turns out as expected, but less if there is a stock market bust. Note that there are two components of uncertainty, the idiosyncratic risk of sinking and the systematic risk of the spice trade. Together, they create one beta today, cited in the example. In fact, because there is no covariance if the ship sinks, conditional on the ship not sinking, the beta must be even higher: $0.6 \times 0 + 0.4 \times \beta = 2 \Rightarrow \text{beta} = 5$.
- ▶ Conditional on the ship returning (or not returning), the underlying cash flows are independent. This is why you can add them. If the ship together with the spices were worth more, i.e., there would be synergies (e.g., to sell them together), if they return, we could not add the cash flows.
- ▶ Nowadays, this kind of problem is more common in the context of R&D or satellite launches.

From a ML interviewing question: You are a consultant to a gas exploration company. Gas is a very pro-cyclical commodity and has a high beta. (How would you get it?) You are exploring a field and you are certain that it has a capacity of x million cubic meters of gas. You have sold the production schedule in the forward market for \$20 million. It costs \$10 million to set up the drill, and 9 out of 10 times, this works the first time. 1 out of 10 times, you must try again, and this again has a 90% chance of success (and so on). In 3 minutes or less, face-to-face with the client: how would you advise the client to value this project? What is the rough value?

Externalities and Additivity

(class session break)

When can you add the NPV of two projects?

What are examples of negative externalities?

What do you do if a project has a negative externality on another project?

What are examples of positive externalities?

Diversion

- ▶ What is a **public good**? The **tragedy of the commons**
- ▶ What are humanity's biggest challenges?
- ▶ How should society charge **public goods**?

Why do firms exist? Why not just contract with vendors in the market?

What is the correct capital-budgeting project rule?

Our company produces revenues of \$1,400,000/year. The company will exist forever. The discount rate is 10%/year. It has office staff which costs \$300,000/year. It rents 40,000 square feet of space at a price of \$800,000/year, but 10,000 square feet remains unused. What is the cost per square-foot of rent per year?

Our company is contemplating expansion. A new division, using the remaining 10,000 square feet, would cost \$500,000 to develop, and bring in \$210,000 per year forever. What should be the implicit rent of the new division?

Taking the rent into account, what is the profit of the new division?

At the noted one-time cost of \$500,000, should the firm expand?

What will the existing division chair argue?

How do most corporations allocate overhead?

Omitted

- ▶ Chapter 13 in the book has examples of the marginal perspective vs. the total perspective.
Should you invest in an additional project? The answer is yes only if it increases the value of your operations.

$$\text{Test} = \text{PV with project} - \text{PV without project}$$

If $\text{Test} > 0$ take on the project. If $\text{Test} < 0$ reject the project. This is equivalent to adding/subtracting externalities where appropriate. If one project is already given, you can think of adding a project “on the margin.” For adding projects, always think of marginal contributions, not average contributions.

- ▶ The book has an example of economies of scale. Read.
- ▶ The book has an example of overhead allocation. Read.

ABC has already invested \$20 million in opening its new flagship factory. Finishing it will only require another \$5 million. But demand has recently dropped, and expected revenues are only \$400 thousand per year. The appropriate cost of capital is 10%. Should ABC finish its half-finished factory?

Longer Example

- ▶ A business produces 100,000 gadgets.
- ▶ A gadget costs \$1 each to produce.
- ▶ The market price of gadgets is \$1.80 each.
Demand is perfectly elastic.
- ▶ To produce another 100,000 gadgets requires running the machine at night. These extra 100,000 gadgets however cost not \$1 but \$2 to produce.
- ▶ You own the factory for exactly one year.
- ▶ The gadget price process is:
 - ▶ With 10% probability, the output price doubles after exactly one year.
 - ▶ With 10% probability, the output price halves after exactly one year.
 - ▶ With 80% probability, the output price stays the same.

So, **the expected price is \$1.89.**

- ▶ Shutting down the plant, doubling production, or reopening it costs nothing.
- ▶ The cost of capital is a constant 0% per year—for illustration.

What is the value of this plant? Is it $\$1.89 \cdot 100,000$?

What is the value of this plant? How do you go about solving this?

Is it difficult to do this calculation for 5 years? 30 years?
With more than one or two choices?

As before, but assume that switching the plant costs \$20,000. The cost of capital is a constant 5% per year. What is the value of this plant? How do you go about solving this?

As an owner of a real option, do you like volatility?

What are other strategic (real) options?

Most projects have many embedded strategic options:

- ▶ The ability to leverage a product into future markets. The ability to find product spinoffs. The ability to learn about (how to do) future products.
- ▶ The ability to stop the project if conditions are bad.
- ▶ The ability to delay or mothball-restart the project if conditions are bad.
- ▶ The ability to accelerate the project if conditions are good.
- ▶ The ability to expand the project if conditions are good.

What is the value of unbuilt land in the boonies?

What is the value of R&D?

Real Options Use in the Real World

A real option is the flexibility to change in the future, depending on the then-prevailing conditions. This flexibility adds value and is one reason why you cannot take the expected price and multiply it by the expected quantity of output.

- ▶ 52% of managers do sensitivity analysis (not scenario analysis).
- ▶ 27% work with real options.
- ▶ 14% do simulations.

NOTE: In the web appendix to Chapter 12 (posted in the companion), there are a lot more examples of real options and decision trees.

Biases

(class session break)

Are you overconfident? (Affects proper volatility estimates in real options.)

Give a 90% confidence interval for the age of your instructor.

Nine out of ten times, your range should contain the correct answer.

This is not a question about your best guess, but about your uncertainty. Regardless of whether you have no clue, or whether you know the answer very precisely, you should be able to reach 90%. If you do not know the answer, you should just expand your confidence range.

In the example, 0-100 years is too big. You know that I am not under 20 years of age or over 80 years of age. So, 0-100 years is a 100% confidence interval.

(45 years, 2 months, 1 day) to (45 years, 2 months, 2 days) would be too narrow. Almost surely, you would miss.

Are you going to be overconfident? Warning!

1. When was LvBeethoven baptized?
2. When did Andy Warhol (or Muhammed) die?
3. How far can swarms of desert locusts migrate?
4. How many member states does the UN have?
5. What is the operating empty weight of a 747-8?

6. What was Michael Jordan's highest number of points in one regular season basketball game?
7. In what year was UCLA founded?
8. What was Anderson's full-time MBA class of 2017 acceptance rate?
9. How many people lived in Los Angeles County in 2010, according to the U.S. census?
10. MSFT NI for the Q ending June 30, 2015.

Are you more likely to drive 2 hours to save 50% (special sale!) on 20 LED bulbs costing \$5 each, or to reduce the price of your brand-new Model S from \$74,000 to \$73,900?

You bought a ticket to the UCLA basketball game for \$80. As you want to hand it over, you realize that you forgot to bring it. The Box Office is still selling tickets like your own for the same price. Will you buy one?

As you walk back to your car, you see that you got a parking ticket. Actually, your car was parked right, and you could prove it in court. But, you parked incorrectly the entire last week, and got no parking ticket, so you “saved” 5 tickets that you really deserved. How does this change your inclination of going to court?

A New Access Road

Consider a decentralized firm that is considering to build an access road (or computer system or ...) that benefits all divisions. The CEO cannot (and would not want to) prevent divisions from using the road after it has been built.

The Cost: \$50 million. The division benefits are not known to the CEO.

	Division Size	Public Guess
A	\$30 million	\$8m \pm \$3m
B	\$300 million	\$3m \pm \$3m
C	\$3 million	\$8m \pm \$3m
D	\$30 million	\$15m \pm \$3m
E	\$300 million	\$5m \pm \$3m
F	\$3 million	\$10m \pm \$3m

(Really, only the public guess matters.) I am the main CEO. You division managers report to me. I exist because I need to coordinate actions. You exist because I don't know everything—you know your business better than I do. I need to decide whether to build the road or not; and how to charge you (or not).

A Project

- ▶ Whether to build the road for \$50 million.
- ▶ How to allocate the cost. The CEO can ask division mgrs how much the road is worth to them. There is no necessary rule linking reports size, profits, or anything else to cost allocation. It is the CEO's decision.
 - ▶ Here is one possible rule. For example, if A reports \$50 million, B reports \$70 million in gain, and everyone else says \$0, then the CEO can allocate $\$40/(\$40 + \$70) = 1/3$ of the cost to A and the rest (2/3) to B, i.e., \$17m and \$33m, respectively.
- ▶ Division bonuses are calculated based on the percentage on the overall profits (which will be inclusive project if the project is taken) minus the cost allocation.
 - ▶ For example, without the project, A's manager is expected to take home $10\% \cdot \$10m = \$1m$, B's manager is expected to take home \$2 million, and so on. With the project, if it truly is worth \$8m, then A produces \$18m (= \$10m base + \$8m in road gains), is charged the \$17m, and the mgr of A gets a bonus of $10\% \cdot (\$18m - \$17m) = \$100k$.
- ▶ Usually, over time, the largest and/or most profitable division managers are promoted to become CEOs themselves.

Set To Play?

Can you give me advice what to do?

Who should the CEO trust?

How do you think managers and employees might act not in your interest? Would you worry about it?

In what kind of projects/firms are these problems most rampant?

What can you do to alleviate these concerns?

Conclusion

- ▶ See the NPV checklist at the end of the chapter.
- ▶ NPV is as much a way of thinking about all sorts of business problems as it is a formula. The formula is easy; the application (and guessing the right inputs) is hard.
- ▶ To put it in even starker terms: the theory is easy, real-world practice is hard. Students sometimes think it is the theory that is hard and the practice that is easy, but it surely ain't so.